RK VISION ACADEMY

RK Vision Academy
Grade 12
Previous Year Question Papers With Solutions

Physics

2023 - 2025

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General Instructions :

Read the following instructions very carefully and strictly follow them :

(i) _This question paper contains **35** questions. **All** questions are **compulsory**._

(ii) _This question paper is divided into **five** Sections – **A, B, C, D** and **E**._

(iii) _In **Section A** – Questions no. **1** to **18** are Multiple Choice (MCQ) type questions, carrying **1** mark each._

(iv) _In **Section B** – Questions no. **19** to **25** are Very Short Answer (VSA) type questions, carrying **2** marks each._

(v) _In **Section C** – Questions no. **26** to **30** are Short Answer (SA) type questions, carrying **3** marks each._

(vi) _In **Section D** – Questions no. **31** to **33** are Long Answer (LA) type questions carrying **5** marks each._

(vii) _In **Section E** – Questions no. **34** and **35** are case-based questions carrying **4** marks each._

(viii) _There is no overall choice. However, an internal choice has been provided in 2 questions in Section B, 2 questions in Section C, 3 questions in Section D and 2 questions in Section E._

(ix) _Use of calculators is **not** allowed._

Use the following values of physical constants, if required :

$c = 3 \times 10^8$ m/s

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8{\cdot}854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

Mass of electron (m_e) = $9{\cdot}1 \times 10^{-31}$ kg

Mass of neutron = $1{\cdot}675 \times 10^{-27}$ kg

Mass of proton = $1{\cdot}673 \times 10^{-27}$ kg

Avogadro's number = $6{\cdot}023 \times 10^{23}$ per gram mole

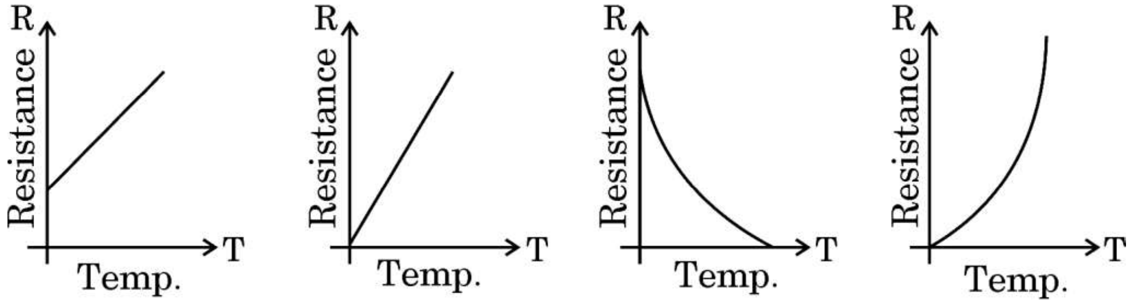
Boltzmann constant = $1{\cdot}38 \times 10^{-23}$ JK^{-1}

SECTION A

1. A point charge situated at a distance ‘r’ from a short electric dipole on its axis, experiences a force $\vec{F}$. If the distance of the charge is ‘2r’, the force on the charge will be :

(a) $\frac{\vec{F}}{16}$ (b) $\frac{\vec{F}}{8}$ (c) $\frac{\vec{F}}{4}$ (d) $\frac{\vec{F}}{2}$

2. For a metallic conductor, the correct representation of variation of resistance R with temperature T is :

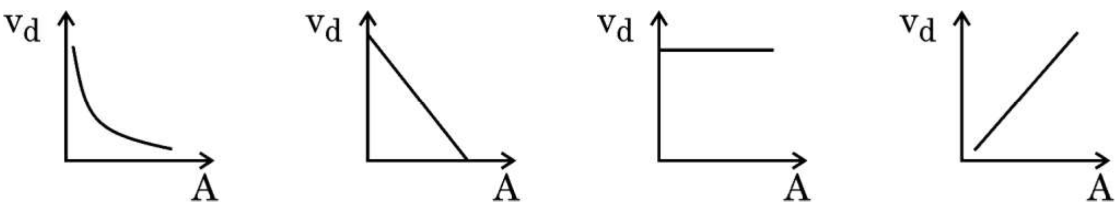


(a) (b) (c) (d)

3. The potential difference across a cell in an open circuit is 8 V. It falls to 4 V when a current of 4 A is drawn from it. The internal resistance of the cell is :

(a) 4 Ω (b) 3 Ω (c) 2 Ω (d) 1 Ω

4. A steady current flows through a metallic wire whose area of cross-section (A) increases continuously from one end of the wire to the other. The magnitude of drift velocity (v_d) of the free electrons as a function of ‘A’ can be shown by :



(a) (b) (c) (d)

5. A diamagnetic substance is brought near the north or south pole of a bar magnet. It will be :

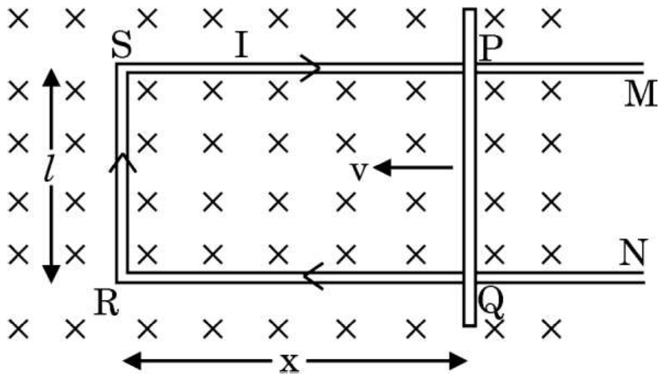
(a) repelled by both the poles.
(b) attracted by both the poles.
(c) repelled by the north pole and attracted by the south pole.
(d) attracted by the north pole and repelled by the south pole.

6. A circular coil of radius 8·0 cm and 40 turns is rotated about its vertical diameter with an angular speed of $\frac{25}{\pi}$ rad s^{-1} in a uniform horizontal magnetic field of magnitude $3 \cdot 0 \times 10^{-2}$ T. The maximum emf induced in the coil is :

(a) 0·12 V (b) 0·15 V

(c) 0·19 V (d) 0·22 V

7. Figure shows a rectangular conductor PSRQ in which movable arm PQ has a resistance 'r' and resistance of PSRQ is negligible. The magnitude of emf induced when PQ is moved with a velocity $\vec{v}$ does ***not*** depend on :



(a) magnetic field ($\vec{B}$) (b) velocity ($\vec{v}$)

(c) resistance (r) (d) length of PQ

8. In the process of charging of a capacitor, the current produced between the plates of the capacitor is :

(a) $\mu_0 \frac{d\phi_E}{dt}$ (b) $\frac{1}{\mu_0} \frac{d\phi_E}{dt}$

(c) $\varepsilon_0 \frac{d\phi_E}{dt}$ (d) $\frac{1}{\varepsilon_0} \frac{d\phi_E}{dt}$

where symbols have their usual meanings.

9. For a concave mirror of focal length 'f', the minimum distance between the object and its real image is :

(a) zero (b) f

(c) 2f (d) 4f

10. The radius of the n^{th} orbit in Bohr model of hydrogen atom is proportional to :

(a) $\frac{1}{n^2}$ (b) $\frac{1}{n}$

(c) n^2 (d) n

11. Hydrogen atom initially in the ground state, absorbs a photon which excites it to n = 5 level. The wavelength of the photon is :

(a) 975 nm (b) 740 nm

(c) 523 nm (d) 95 nm

12. The mass density of a nucleus of mass number A is :

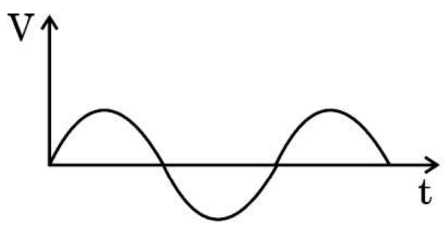
(a) proportional to $A^{1/3}$

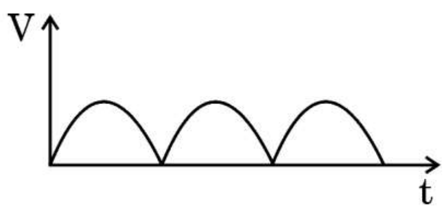
(b) proportional to $A^{2/3}$

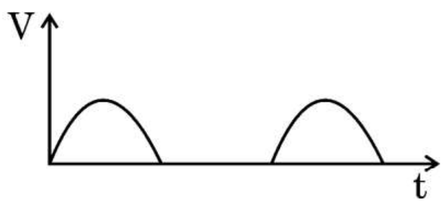
(c) proportional to A^3

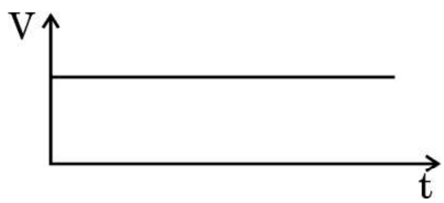
(d) independent of A

13. An ac source of voltage is connected in series with a p-n junction diode and a load resistor. The correct option for output voltage across load resistance will be :

(a)


(b)


(c)


(d)


14. When an intrinsic semiconductor is doped with a small amount of trivalent impurity, then :

(a) its resistance increases.

(b) it becomes a p-type semiconductor.

(c) there will be more free electrons than holes in the semiconductor.

(d) dopant atoms become donor atoms.

15. In the energy-band diagram of n-type Si, the gap between the bottom of the conduction band E_C and the donor energy level E_D is of the order of :

(a) 10 eV

(b) 1 eV

(c) 0·1 eV

(d) 0·01 eV

*Questions number **16** to **18** are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (a), (b), (c) and (d) as given below.*

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is ***not*** the correct explanation of the Assertion (A).

(c) Assertion (A) is true, but Reason (R) is false.

(d) Assertion (A) is false and Reason (R) is also false.

16. *Assertion (A) :* When a bar of copper is placed in an external magnetic field, the field lines get concentrated inside the bar.

Reason (R) : Copper is a paramagnetic substance.

17. *Assertion (A) :* The phase difference between any two points on a wavefront is zero.

Reason (R) : All points on a wavefront are at the same distance from the source and thus oscillate in the same phase.

18. *Assertion (A) :* Photoelectric effect demonstrates the particle nature of light.

Reason (R) : Photoelectric current is proportional to intensity of incident radiation for frequencies more than the threshold frequency.

SECTION B

19. An alpha particle is projected with velocity $\vec{v} = (3{\cdot}0 \times 10^5 \text{ m/s})\ \hat{i}$ into a region in which magnetic field $\vec{B} = [(0{\cdot}4\ \text{T})\ \hat{i} + (0{\cdot}3\ \text{T})\ \hat{j}]$ exists. Calculate the acceleration of the particle in the region. $\hat{i}$, $\hat{j}$ and $\hat{k}$ are unit vectors along x, y and z axis respectively and charge to mass ratio for alpha particle is $4{\cdot}8 \times 10^7$ C/kg. *2*

20. Consider an induced magnetic field due to changing electric field and an induced electric field due to changing magnetic field. Which one is more easily observed ? Justify your answer. *2*

21. (a) Using Huygens' principle, draw a ray diagram showing the propagation of a plane wave refracting at a plane surface separating two media. Also verify Snell's law of refraction. *2*

OR

(b) Why is a reflecting telescope preferred over a refracting telescope ? Justify your answer giving two reasons. *2*

22. Two coherent monochromatic light beams of intensities I and 4I superpose each other. Find the ratio of maximum and minimum intensities in the resulting beam. *2*

23. The ground state energy of hydrogen atom is $-13{\cdot}6$ eV. What is the potential energy and kinetic energy of an electron in the third excited state ? *2*

24. (a) Differentiate between intrinsic and extrinsic semiconductors. *2*

OR

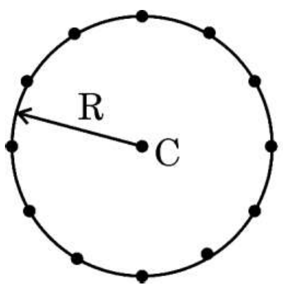
(b) Draw the circuit arrangement for studying the V – I characteristics of a p-n junction diode in forward bias and reverse bias. Show the plot of V – I characteristic of a silicon diode. *2*

25. Briefly explain how the diffusion and drift currents contribute to the formation of potential barrier in a p-n junction diode. *2*

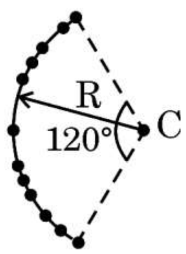
SECTION C

26. (a) Twelve negative charges of same magnitude are equally spaced and fixed on the circumference of a circle of radius R as shown in Fig. (i). Relative to potential being zero at infinity, find the electric potential and electric field at the centre C of the circle.

(b) If the charges are unequally spaced and fixed on an arc of 120° of radius R as shown in Fig. (ii), find electric potential at the centre C. *3*



(i)



(ii)

27. (a) How does the resistance differ from impedance ? With the help of a suitable phasor diagram, obtain an expression for impedance of a series LCR circuit, connected to a source $v = v_m \sin \omega t$. *3*

OR

(b) Find the condition for resonance in a series LCR circuit connected to a source $v = v_m \sin \omega t$, where ω can be varied. Give the factors on which the resonant frequency of a series LCR circuit depends. Plot a graph showing the variation of electric current with frequency in a series LCR circuit. *3*

28. A long solenoid of radius r consists of n turns per unit length. A current $I = I_0 \sin \omega t$ flows in the solenoid. A coil of N turns is wound tightly around it near its centre. What is :

(a) the induced emf in the coil ?

(b) the mutual inductance between the solenoid and the coil ? *3*

29. How does Einstein's photoelectric equation explain the emission of electrons from a metal surface ? Explain briefly.

Plot the variation of photocurrent with :

(a) collector plate potential for different intensity of incident radiation, and

(b) intensity of incident radiation. *3*

30. (a) Draw the energy level diagram for hydrogen atom. Mark the transitions corresponding to the series lying in the ultraviolet region, visible region and infrared region. *3*

OR

(b) Draw a diagram to show the variation of binding energy per nucleon with mass number for different nuclei and mention its two features. Why do lighter nuclei usually undergo nuclear fusion ? *3*

SECTION D

31. (a) (i) State Coulomb's law in electrostatics and write it in vector form, for two charges.

(ii) 'Gauss's law is based on the inverse-square dependence on distance contained in the Coulomb's law.' Explain.

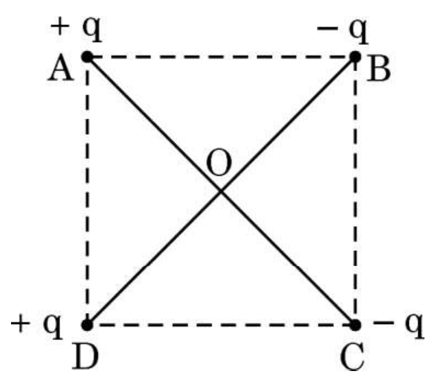
(iii) Two charges A (charge q) and B (charge 2q) are located at points (0, 0) and (a, a) respectively. Let $\hat{i}$ and $\hat{j}$ be the unit vectors along x-axis and y-axis respectively. Find the force exerted by A on B, in terms of $\hat{i}$ and $\hat{j}$. *5*

OR

(b) (i) Derive an expression for the electric field at a point on the equatorial plane of an electric dipole consisting of charges q and – q separated by a distance 2a.

(ii) The distance of a far off point on the equatorial plane of an electric dipole is halved. How will the electric field be affected for the dipole ?

(iii) Two identical electric dipoles are placed along the diagonals of a square ABCD of side $\sqrt{2}$ m as shown in the figure. Obtain the magnitude and direction of the net electric field at the centre (O) of the square. *5*



32. (a) (i) State Biot-Savart's law for the magnetic field due to a current carrying element. Use this law to obtain an expression for the magnetic field at the centre of a circular loop of radius 'a' and carrying a current 'I'. Draw the magnetic field lines for a current loop indicating the direction of magnetic field.

(ii) An electron is revolving around the nucleus in a circular orbit with a speed of 10^7 m s^{-1}. If the radius of the orbit is 10^{-10} m, find the current constituted by the revolving electron in the orbit. *5*

OR

(b) (i) Derive an expression for the force acting on a current carrying straight conductor kept in a magnetic field. State the rule which is used to find the direction of this force. Give the condition under which this force is (1) maximum, and (2) minimum.

(ii) Two long parallel straight wires A and B are 2·5 cm apart in air. They carry 5·0 A and 2·5 A currents respectively in opposite directions. Calculate the magnitude of the force exerted by wire A on a 10 cm length of wire B. *5*

33. (a) (i) (1) Write two points of difference between an interference pattern and a diffraction pattern.

(2) Name any two factors on which the fringe width in a Young's double-slit experiment depends.

(ii) In Young's double-slit experiment, the two slits are separated by a distance equal to 100 times the wavelength of light that passes through the slits. Calculate :

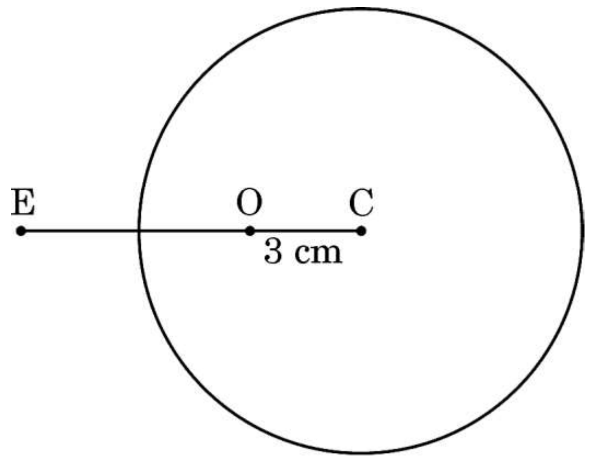
(1) the angular separation in radians between the central maximum and the adjacent maximum.

(2) the distance between these two maxima on a screen 50 cm from the slits. *5*

OR

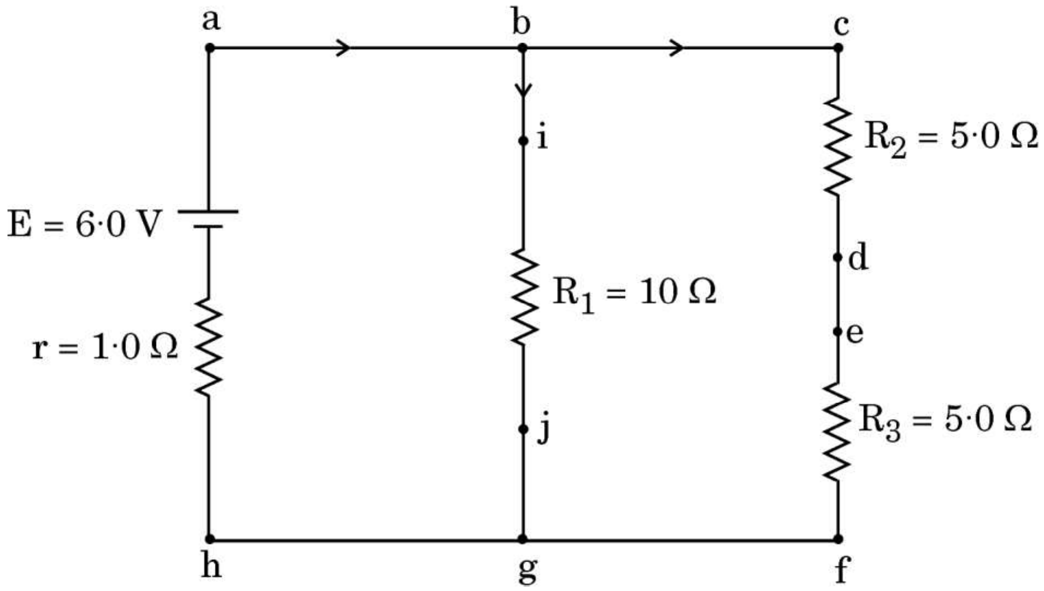
(b) (i) A spherical surface of radius of curvature R separates two media of refractive indices n_1 and n_2. A point object is placed in front of the surface at distance u in medium of refractive index n_1 and its image is formed by the surface at distance v, in the medium of refractive index n_2. Derive a relation between u and v.

(ii) A solid glass sphere of radius 6·0 cm has a small air bubble trapped at a distance 3·0 cm from its centre C as shown in the figure. The refractive index of the material of the sphere is 1·5. Find the apparent position of this bubble when seen through the surface of the sphere from an outside point E in air. *5*



SECTION E

34. The following figure shows a circuit diagram. We can find the currents through and potential differences across different resistors using Kirchhoff's rules.



Answer the following questions based on the above :

(a) Which points are at the same potential in the circuit ? *1*

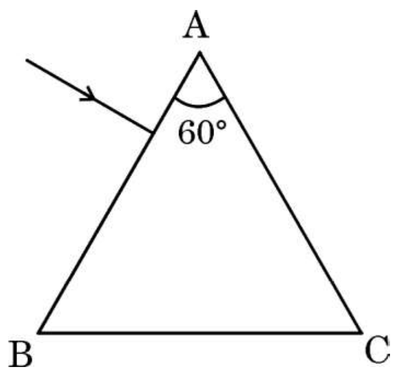
(b) What is the current through arm bg ? *1*

(c) Find the potential difference across resistance R_3. *2*

OR

(c) What is the power dissipated in resistance R_2 ? *2*

35. Strontium titanate is a rare oxide — a natural mineral found in Siberia. It is used as a substitute for diamond because its refractive index and critical angle are 2·41 and 24·5°, respectively, which are approximately equal to the refractive index and critical angle of diamond. It has all the properties of diamond. Even an expert jeweller is unable to differentiate between diamond and strontium titanate. A ray of light is incident normally on one face of an equilateral triangular prism ABC made of strontium titanate.



Answer the following questions based on the above :

(a) Trace the path of the ray showing its passage through the prism. *1*

(b) Find the velocity of light through the prism. *1*

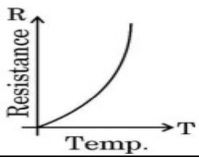
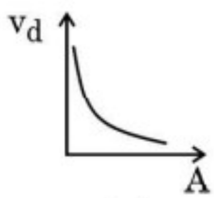
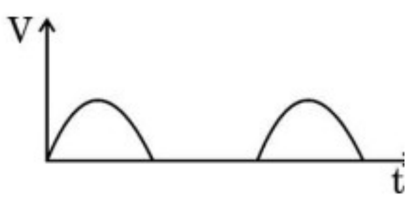
(c) Briefly explain two applications of total internal reflection. *2*

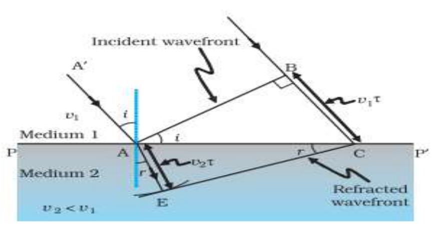
OR

(c) Define total internal reflection of light. Give two conditions for it. *2*

MARKING SCHEME: PHYSICS(042)

Code: 55/1/1

Q.No.	VALUE POINTS/EXPECTED ANSWERS	Marks	Total Marks
	SECTION –A		
1.	(b) $\frac{\vec{F}}{8}$	1	1
2.	(d) 	1	1
3.	(d) 1 Ω	1	1
4.	(a) 	1	1
5.	(a) Repelled by both the poles.	1	1
6.	(c) 0.19 V	1	1
7.	(c) Resistance (r)	1	1
8.	(c) $\in_o \frac{d\phi_E}{dt}$	1	1
9.	(a) Zero	1	1
10.	(c) n^2	1	1
11.	(d) 95 nm	1	1
12.	(d) Independent of A	1	1
13.	(c) 	1	1
14.	(b) it becomes a p-type semiconductor	1	1
15.	(d) 0.01 eV	1	1
16.	(d) Assertion (A) is false and Reason (R) is also false.	1	1
17.	(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).	1	1
18.	(b) Both Assertion (A) and Reason (R) are true but reason (R) is the **not** correct explanation of the Assertion (A)	1	1
	SECTION-B		

19.	Calculation of acceleration of alpha particle 2		
	$\vec{F}=q(\vec{v}\times\vec{B})$	½	
	$= q(3\times10^5\hat{i}\times(0.4\hat{i}+0.3\hat{j}))N$		
	$\vec{F} = q(0.9\times10^5\hat{k})N$	½	
	$\vec{F} = m\vec{a} = q(0.9\times10^5\hat{k})N$		
	$\vec{a}=\frac{q}{m}(0.9\times10^5\hat{k})ms^{-2}$	½	
	$= 4.8\times10^7\times0.9\times10^5\ \hat{k}\ ms^{-2}$		
	$= 4.32\times10^{12}\ \hat{k}\ ms^{-2}$	½	
	Note: Deduct ½ mark if a student does not mention the direction of acceleration.		2
20.	Identification 1 Justification 1		
	Induced electric field due to changing magnetic field is easily observed.	1	
	Induced electric field due to changing magnetic field can be easily produced by various ways like rotating/moving a coil in magnetic field, changing the shape of coil in magnetic field, bringing bar magnet near a coil etc.	1	2
21.	(a)		
	Ray diagram 1 Proof of Snell's law of refraction 1		
		1	
	AB is incident wave front, incident at an angle i. Let τ be time taken by the wave front to travel distance BC. BC= $v_1\tau$ where v_1 is speed of wave in medium 1. To determine shape of refracted wave front, we draw a sphere of radius $v_2\tau$, where v_2 is speed of wave in medium 2. CE represents a tangent drawn from point C on sphere, CE is the refracted wave front.		
	sin i = $\frac{BC}{AC}=\frac{v_1\tau}{AC}$	½	
	sin r = $\frac{AE}{AC}=\frac{v_2\tau}{AC}$		

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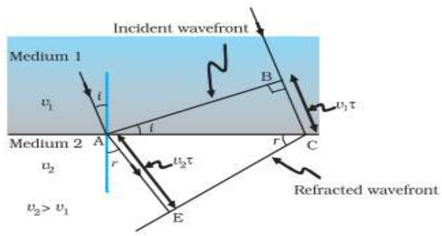
$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = n_{21}$$

Note: Give full credit if student derives Snell's law by taking incident wavefront in denser medium.



OR

(b)

<table>
<tr><td>Reason for preferring reflecting type telescope over refracting telescope ½ + ½
Justification ½ + ½</td></tr>
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1. No Chromatic Aberration - No refraction in mirrors
2. No Spherical Aberration - Due to use of parabolic reflector
3. Easy mechanical support required - Mirrors weigh less and can be supported over entire back surface.
4. High resolving power – Due to Mirror with large diameter.
5. Brighter image – Large mirrors gather more light waves.

(Any two)

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<td>½

1+1</td>
<td>2</td>
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<td>22.</td>
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<tr><td>Finding the ratio of maximum and minimum intensities 2</td></tr>
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$$\frac{I_{max}}{I_{min}} = \frac{(\sqrt{I_1}+\sqrt{I_2})^2}{(\sqrt{I_1}-\sqrt{I_2})^2}$$

$$= \frac{I_1 + I_2 + 2\sqrt{I_1 I_2}}{I_1 + I_2 - 2\sqrt{I_1 I_2}}$$

$$= \frac{5I + 4I}{5I - 4I}$$

$$= \frac{9}{1}$$

Alternatively

$$\frac{I_1}{I_2} = \frac{a^2}{b^2} = \frac{4I}{I} = \frac{4}{1}$$

$$\frac{a}{b} = \frac{2}{1}$$

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<td>½
½
½
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½</td>
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$$\frac{I_{max}}{I_{min}} = \frac{(a+b)^2}{(a-b)^2}$$ ½

$$\frac{I_{max}}{I_{min}} = \frac{(2+1)^2}{(2-1)^2} = \frac{9}{1}$$ ½ | 2

23.

Calculation of potential energy of electron	1
Calculation of kinetic energy of electron	1

$E_n = \frac{-13.6}{n^2} eV$ = Total energy

For third excited state n=4

$E_4 = \frac{-13.6}{4^2} = \frac{-13.6}{16}$ = -0.85 eV ½

Potential Energy = 2 × Total Energy = 2 × E_4

= 2 ×(-0.85) eV

= - 1.70 eV ½

Kinetic energy = - (Total Energy) = $-E_4$ ½

= 0.85 eV ½ | 2

24. (a)

Difference between intrinsic and extrinsic semiconductor	2

Intrinsic semiconductor	Extrinsic semiconductor
1. Pure semiconductor.	Semiconductor is Doped with impurities.
2. Low conductivity at room temperature.	High conductivity at room temperature.
3. $n_e = n_h$	$n_e \neq n_h$

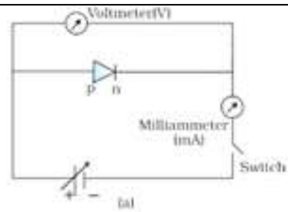
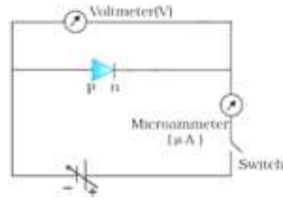
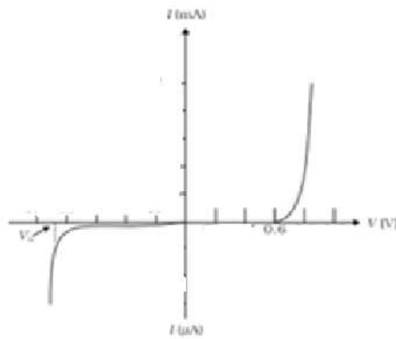
(Any one) 1+1

Note: Give full credit if a student writes any other relevant correct answer.

OR

(b)

Circuit diagram for forward and reverse biased p-n junction diode	½ + ½
V-I characteristic (Forward and Reverse bias)	½ + ½

	 Forward Bias  Reverse Bias  Characteristics of silicon Diode	½ + ½ ½ + ½	2
25.	Formation of potential barrier 2 The diffusion current due to concentration gradient at the junction forms a space charge region consisting of immobile charge carriers. Due to this an electric field is generated at the junction giving rise to drift current in a direction opposite to diffusion current. The potential at which diffusion current becomes equal to drift current is called potential barrier.	2	2
	SECTION –C		
26.	a) Finding electric potential at the centre 1 Finding electric field at the centre 1 b) Finding electric potential at the centre 1 (a) Electric potential due to point charge V= $\frac{kq}{R}$ Value of each charge = - q , Total charge = -12q Total potential V = $\frac{k(-12q)}{R}$ $V = \frac{-12kq}{R} = \frac{-12q}{4\pi \epsilon_0 R}$ By symmetry the resultant of all electric field vectors becomes zero. So electric field is zero.	½ ½ 1	

<table>
<tr>
<td></td>
<td>(b)
Electric potential is a scalar quantity and does not depend on placement of charges
Therefore $V = \frac{-12kq}{R} = \frac{-12q}{4\pi \in_0 R}$</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>27.</td>
<td>(a)

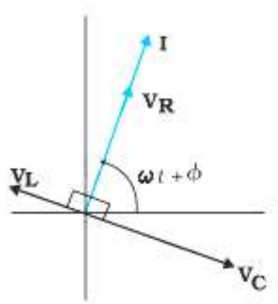
Difference between resistance and impedance	1
Obtaining expression for impedance	2

1. Resistance is the opposition offered to both alternating current and direct current while impedance is the opposition offered to alternating current only.

2. Resistance is independent of frequency of source while impedance depends on frequency.

3. Resistance is opposition offered by material of the conductor while impedance is combined opposition offered by different electrical components such as resistor, inductor or capacitor.

(Any One)
(Note: Give credit of this part if a student writes any other correct answer.)



$V_R = i_m R$, $V_c = i_m X_c$, $V_L = i_m X_L$
i_m = Peak value of current in the circuit.
$\vec{V_L} + \vec{V_R} + \vec{V_C} = \vec{V_m}$
$(V_m)^2 = V_R^2 + (V_C - V_L)^2$
$= (i_m R)^2 + (i_m X_c - i_m X_L)^2$
$= i_m [R^2 + (X_c - X_L)^2]$
$i_m = \frac{V_m}{\sqrt{R^2 + (X_c - X_L)^2}}$
$i_m = \frac{V_m}{Z}$ where $Z = \sqrt{R^2 + (X_c - X_L)^2}$ = impedance</td>
<td>1

½

½

½

½</td>
<td></td>
</tr>
</table>

OR

(b)

Finding condition for resonance	1
Factors affecting resonant frequency	1
Graph	1

$Z = \sqrt{R^2 + (X_L - X_c)^2}$ ½

For maximum current, Z should be minimum therefore to minimize Z

$X_L = X_C$ ½

Alternatively

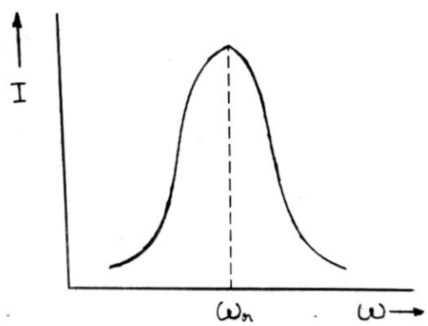
½

$X_L = X_C$

$\omega L = \dfrac{1}{\omega C}$

$\omega_r = \dfrac{1}{\sqrt{LC}}$ ½

Resonant Frequency depends on value of Inductance and Capacitance ½ + ½



1

3

28.

Finding	
a) Induced emf	2
b) Mutual inductance between solenoid and coil	1

a) magnetic field produced in the solenoid near the center

$B = \mu_o n I$ ½

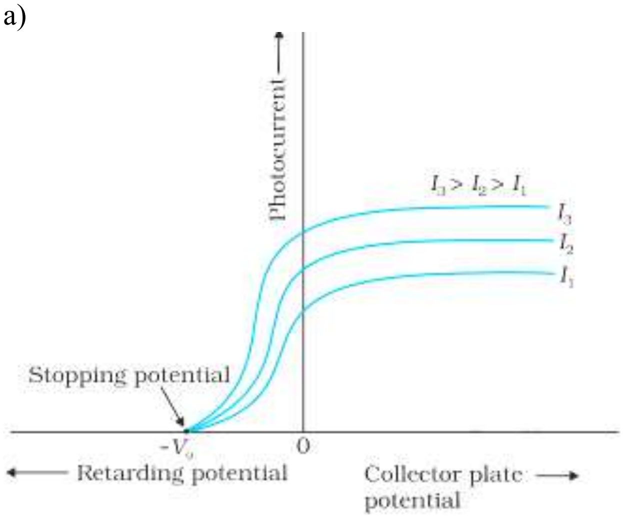
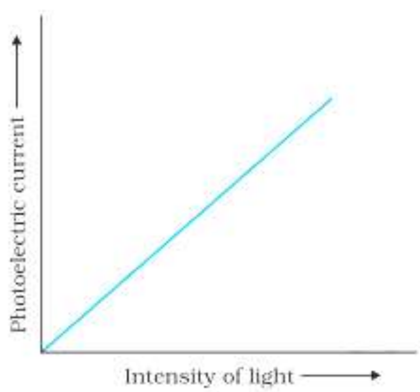
Flux linked with the coil wound over solenoid

$\phi = NBA = N \pi r^2 B$

$= N \pi r^2 \mu_o n I$ ½

Induced emf $e = \dfrac{-d\phi}{dt} = -\pi r^2 N n \mu_o \dfrac{dI}{dt}$ (i) ½

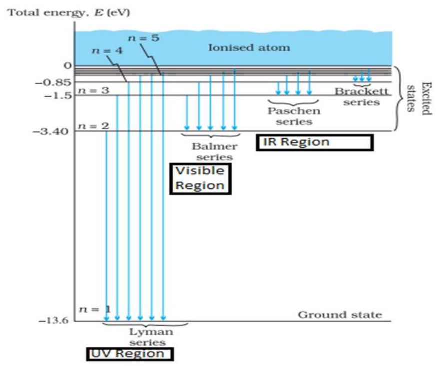
$= - \mu_o \pi r^2 n N I_o \omega \cos \omega t$ ½

	b) comparing Eq (i) with e = $-M\frac{dI}{dt}$ M = $\mu_o \pi r^2 nN$	½ ½	3
29.	Explanation of emission of electron 1 a) variation of photocurrent with collector plate potential for different intensity 1 b) variation of photo current with intensity of incident radiation 1 According to Einstein's photoelectric equation An electron absorbs a quantum of energy 'hυ' of incident radiation. If the energy of absorbed quantum exceeds the minimum energy needed by the electron to escape from the metal surface (work function φ_o), the electron is emitted. $K_{max} = h\upsilon - \varphi_o$ a)  b) 	1 1 1	3

30.

a)

Energy level diagram for hydrogen atom	1 ½
Transitions corresponding to ultraviolet region, visible region and infrared region	½ + ½ + ½



1 ½

½

½

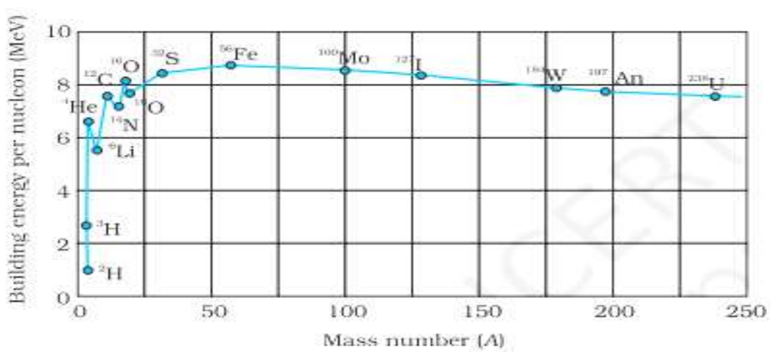
½

Note: Award 1 ½ mark for energy level diagram if the student does not show the transitions.

OR

b)

Diagram to show variation	1
Two features of diagram	½ + ½
Reason for nuclear fusion	1



1

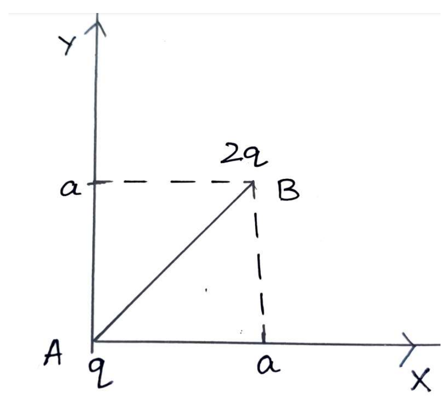
(Note: Award full credit even if a student does not mark so many elements and does not mention the values of E_{bn}.)

Features of diagram **(any two)**

1. Binding energy per nucleon is practically independent of atomic number for nuclei of middle mass number (30 <A < 170)
2. The curve has maximum of about 8.75 MeV for A= 56 and has a value of 7.6 MeV for A= 238
3. Binding energy per nucleon is lower for both light nuclei (A<30) and heavy nuclei (A>170)

½ + ½

Two lighter nuclei fuse together to form heavier nuclei as the binding energy per nucleon of fused heavier nuclei is more than the binding energy per nucleon of the lighter nuclei. Thus the final system is more tightly bound

	than initial system. **Alternatively** To attain the stability	1	3
	SECTION –D		
31.	(a) i) Statement of coulomb's law and vector form 1+1 ii) Explanation of Gauss's law based on coulomb's law 1 iii) Force exerted by charge A on charge B 2 i) Force between two point charges varies inversely with the square of distance between the charges and is directly proportional to the product of magnitude of the two charges and acts along the line joining the two charges. $$\overrightarrow{F_{12}} = \frac{1}{4\pi \in_o} \frac{q_1 q_2}{r_{12}^2} \widehat{r_{12}}$$ **Alternatively** $\overrightarrow{F_{12}} = \frac{1}{4\pi \in_o} \frac{q_1 q_2}{r_{12}^3} \overrightarrow{r_{12}}$ Where $\overrightarrow{r_{12}}$ is a vector from charge q_2 to charge q_1. ii) In derivation of Gauss's law, flux is calculated using Coulomb's law and surface area. Here coulomb's law involves $\frac{1}{r^2}$ factor and surface area involves r^2 factor. When product is taken, the two factors cancel out and flux becomes independent of r. iii)  $\vec{r} = \overrightarrow{AB} = a\hat{i} + a\hat{j}$ r = $\left\|\overrightarrow{AB}\right\| = \sqrt{a^2 + a^2} = \sqrt{2}a$ $\vec{F} = \frac{1}{4\pi \in_o} \frac{q_1 q_2}{r^2} \hat{r}$	1 1 1 ½ ½	

$$\vec{F}=\frac{1}{4\pi\in_o}\times\frac{q\times 2q}{(\sqrt{2}a)^2}\times\frac{(a\hat{i}+a\hat{j})}{\sqrt{2}a}$$

$$\vec{F}=\frac{1}{4\pi\in_o}\times\frac{2q^2}{2a^2}\times\frac{(\hat{i}+\hat{j})}{\sqrt{2}}$$ ½

$$\vec{F}=\frac{1}{4\pi\in_o}\times\frac{q^2}{\sqrt{2}a^2}\times(\hat{i}+\hat{j})$$

$$\vec{F}=\frac{q^2}{4\sqrt{2}\pi\in_o a^2}(\hat{i}+\hat{j})$$ ½

Note: Award 1 mark if a student calculates the magnitude of force only.

$$\left|\vec{F}\right|=\frac{1}{4\pi\in_o}\frac{q^2}{a^2}$$

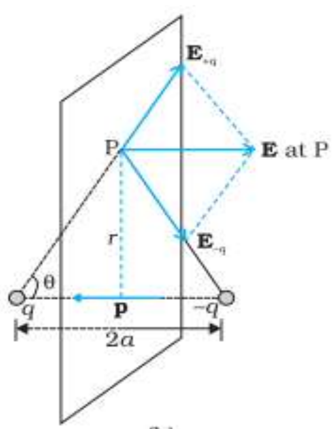
Alternatively
Give full credit if a student uses component method to solve the question.

OR

(b)

i) Derivation of electric field	2
ii) Effect on electric field	1
iii) Finding magnitude and direction of electric field	2

i)



½

$$E_{+q}=\frac{q}{4\pi\in_o}\times\frac{1}{r^2+a^2}$$

$$E_{-q}=\frac{q}{4\pi\in_o}\times\frac{1}{r^2+a^2}$$

The components normal to dipole axis cancel away. The components along the dipole axis add up. ½

Total electric field is opposite to dipole moment. ½

$$\vec{E}=-(E_{+q}+E_{-q})\cos\theta\,\hat{p}$$

$$=\frac{-2qa}{4\pi\in_o(r^2+a^2)^{3/2}}\hat{p}$$

$$= \frac{-\vec{p}}{4\pi \in_o (r^2 + a^2)^{3/2}}$$ ½

Deduct ½ mark if the expression of electric field is not in vector form.

ii) At far off point r >> a

$$\vec{E} = \frac{-\vec{p}}{4\pi \in_o r^3}$$

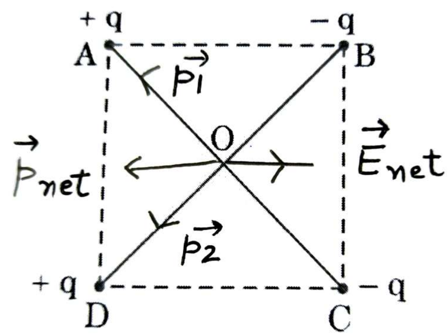
When distance is halved.

$$\vec{E} = \frac{-\vec{p}}{4\pi \in_o (\frac{r}{2})^3}$$ ½

$$= \frac{-8\vec{p}}{4\pi \in_o r^3}$$

$\vec{E}$ becomes 8 times ½

iii)



$p_1 = q \times 2Cm$ (along OA)

$p_2 = q \times 2Cm$ (along OD)

$$p_{net} = \sqrt{p_1^2 + p_2^2}$$ ½

$$= 2\sqrt{2}\, q\, Cm$$

Electric field at centre O

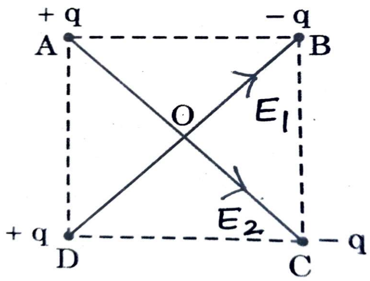
$$E = \frac{kp_{net}}{(r^2+a^2)^{3/2}}$$ ½

at point O, r = 0 , a = 1 m

$$E = \frac{k \times 2\sqrt{2}q}{1^3} = 2\sqrt{2}kq = \frac{2\sqrt{2}q}{4\pi \in_o}$$ ½

Along DC ½

Alternatively



$E = \dfrac{kq}{r^2}$ ½

AC= BD= 2m

r = OA =OB= OC=OD=1m

Electric field at O due to charges at B and D

$E_1 = E_B + E_D$

$E_1 = \dfrac{kq}{1^2} + \dfrac{kq}{1^2}$ along OB

$= 2kq$ ½

Electric field at O due to charges at A and C

$E_2 = E_A + E_C$

$E_2 = \dfrac{kq}{1^2} + \dfrac{kq}{1^2}$ ½

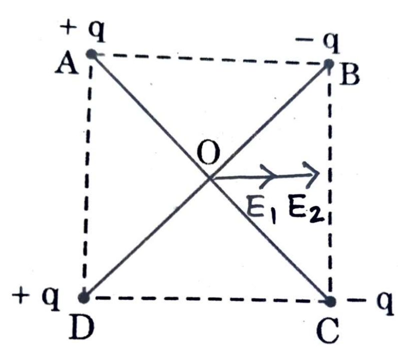
$= 2kq$ along OC

$E_{net} = \sqrt{E_1^{\ 2} + E_2^{\ 2}}$

$= 2\sqrt{2}\ kq = \dfrac{2\sqrt{2}q}{4\pi \in_o}$ ½

Along DC

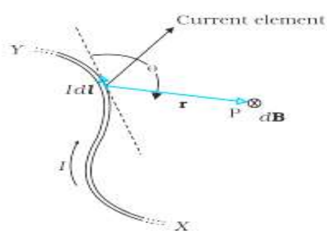
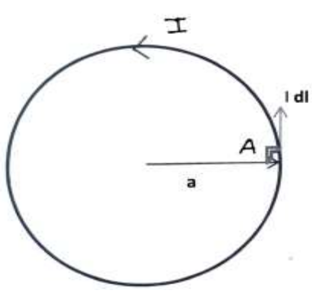
Alternatively



Considering AB as dipole, electric field at O

$E_1 = \dfrac{2kq \times a}{((\frac{1}{\sqrt{2}})^2 + (\frac{1}{\sqrt{2}})^2)^{3/2}} = \dfrac{2kqa}{(\frac{1}{2}+\frac{1}{2})^{3/2}} = 2kqa$ ½

Similarly considering DC as another dipole, electric field at O

	$E_2 = \dfrac{2kq \times a}{\left(\left(\frac{1}{\sqrt{2}}\right)^2 + \left(\frac{1}{\sqrt{2}}\right)^2\right)^{3/2}} = \dfrac{2kqa}{\left(\frac{1}{2}+\frac{1}{2}\right)^{3/2}} = 2kqa$	½	
	$E_{net} = E_1 + E_2 = 4kqa = \dfrac{1}{4\pi\epsilon_o} \times 4 \times \dfrac{1}{\sqrt{2}} \times q$	½	
	$= 2\sqrt{2}kq = \dfrac{2\sqrt{2}q}{4\pi\epsilon_o}$	½	
	Along DC		5
32.	(a)		
	i) Statement of Biot-Savart's law — 1 Expression for magnetic field — 2 Diagram for magnetic field lines — ½ ii) Finding current by revolving electron — 1 ½		
	(i) The magnetic field at a point due to a current carrying element is proportional to magnitude of current, element length and inversely proportional to the square of the distance from the element.	1	
	$\overrightarrow{dB} = \dfrac{\mu_o}{4\pi} I \dfrac{\overrightarrow{dl} \times \vec{r}}{r^3}$ $\lvert dB \rvert = \dfrac{\mu_o}{4\pi} \dfrac{Idl \sin\theta}{r^2}$		
	 		
	Consider a circular coil of radius a carrying current I.		
	 	½	
	According to Biot-Savart's law		
	$\lvert \overrightarrow{dB} \rvert = \dfrac{\mu_o}{4\pi} \dfrac{Idl \sin\theta}{r^2}$	½	
	At point A I $\overrightarrow{dl} \perp \vec{a}$		

$\therefore \theta = 90^o, \sin 90^o = 1$

Hence dB= $\dfrac{\mu_o}{4\pi}\dfrac{Idl}{a^2}$

Magnetic field at centre

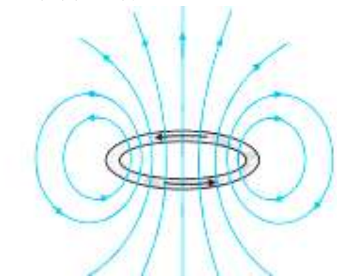
B= $\int_o^{2\pi a} dB = \int_0^{2\pi a} \dfrac{\mu_o}{4\pi}\dfrac{Idl}{a^2}$ ½

B= $\dfrac{\mu_o}{4\pi} \times \dfrac{I}{a^2} \times 2\pi a$

½

B = $\dfrac{\mu_o I}{2a}$

Note: Give full credit of 2 marks if a student derives the expression for magnetic field at the axis of the loop and then puts the distance of point as 0 from the centre.



½

ii) q=e , v=10^7ms^{-1},r=10^{-10}m

i= $\dfrac{q}{T}$ ½

= $\dfrac{qv}{2\pi r}$

= $\dfrac{ev}{2\pi r}$

= $\dfrac{1.6 \times 10^{-19} \times 10^7}{2 \times \pi \times 10^{-10}}$ ½

= $\dfrac{0.8}{\pi} \times 10^{-2} A$ ½

= 0.255 $\times 10^{-2} A$ = 2.55 mA

OR

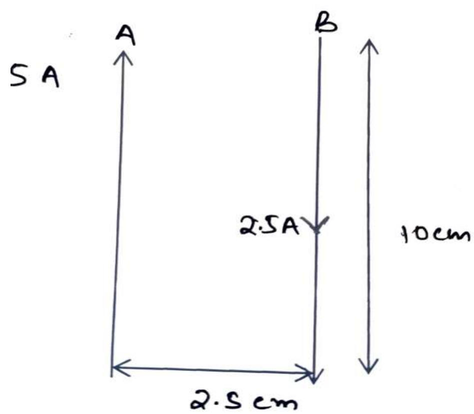
b)

i) Derivation of expression for force	2
Statement of Rule	½
Conditions for maximum and minimum force	½ + ½
ii) Calculation of magnitude of force	1 ½

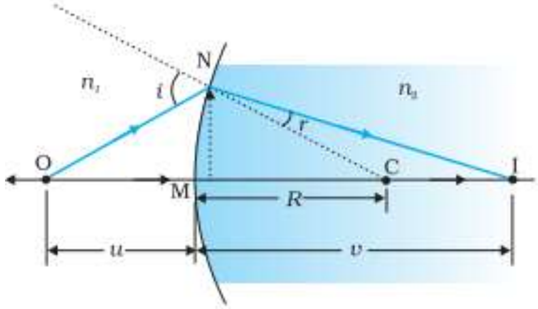
Consider a rod of uniform cross sectional area A and length *l*. Let the number density of mobile charge carriers in it be n.

Thus the total number of mobile charge carriers in it is n *l* A.

For steady current I, drift velocity of electrons $\overrightarrow{v_d}$, in the presence of ½

	external magnetic field $\vec{B}$, the force on these carriers is		
	$\vec{F} = n\,l\,Aq(\overrightarrow{v_d} \times \vec{B})$	½	
	$= \left[\vec{j}Al\right] \times \vec{B}$	½	
	$= I(\vec{l} \times \vec{B})$	½	
	Where $nq\overrightarrow{v_d}$ is current density ($\vec{j}$) and $\lvert\vec{j}A\rvert$ is current (I)		
	Fleming's left hand Rule: If forefinger, middle finger and thumb are stretched in mutually perpendicular directions, such that forefinger indicates the direction of magnetic field, middle finger indicates the direction of current in the conductor, then thumb indicates the direction of force on the conductor.		
	Alternatively		
	Right Hand Thumb Rule : If the fingers of right hand are made to rotate from $\vec{l}$ to $\vec{B}$ through angle θ, the thumb points in the direction of force on the current carrying conductor.	½	
	Condition for maximum force $\theta = 90^0$		
	$\lvert\vec{F}\rvert = I\,l\,B\sin\theta$ = I l B	½	
	Condition for minimum force $\theta = 0^o$ or 180^0		
	$\lvert\vec{F}\rvert = 0$	½	
	ii)		
			
	$F = \dfrac{\mu_o}{4\pi}\dfrac{2I_1I_2}{d}\,l$	½	
	$= \dfrac{10^{-7} \times 2 \times 5 \times 2.5}{2.5 \times 10^{-2}} \times 10 \times 10^{-2}\,N$	½	
	$= 10^{-5}$ N	½	5

33.	a)		
	i) (1) Difference between interference pattern and diffraction pattern — 1+1 (2) Two factors affecting fringe width in young's double slit experiment — ½ + ½ ii) (1) calculation of angular separation — 1 (2) calculation of distance between two maxima — 1		
	(i) (1) (a) The interference pattern has a number of equally spaced bright and dark bands while diffraction pattern has a central bright maximum which is twice as wide as the other maxima. (b) Interference pattern is obtained by superposing two waves originating from two narrow slits, while diffraction pattern is a superposition of a continuous family of waves originating from each point on a single slit. (c) The maxima in interference pattern is obtained at angle λ / a, while the first minima is obtained at same angle λ / a for diffraction pattern. (d) In interference pattern the intensity of bright fringes remain same while in diffraction the intensity falls as we go to successive maxima away from the center on either side. **(any two)**	1+1	
	(2) Factors affecting fringes width Wave length (λ) / distance of screen from slits (D) / separation between slits (d). **(any two)**	½ + ½	
	(ii) (1) $d \sin\theta = n\lambda$ n=1 $\sin\theta = \frac{\lambda}{d}$	½	
	For small angle $\sin\theta \approx \theta = \frac{\lambda}{100\lambda} = \frac{1}{100}$ radian.	½	
	(2) $\beta = \frac{\lambda D}{d} = \theta D$	½	
	$= \frac{1}{100} \times 50 \times 10^{-2}$ $= 50 \times 10^{-4} m$ $= 5$ mm	½	
	OR		
	(b)		
	i) Derivation of relation between u and v — 3 ii) Finding apparent position — 2		



1

Assume that the aperture of the surface is small as compared to other distance involved, so that small angle approximation can be made.

For small angles

for ΔNOC, i is the exterior angle

$\therefore$ i = $\angle NOM + \angle NCM$

i= $\dfrac{MN}{OM} + \dfrac{MN}{MC}$ (i) ½

Similarly r = $\angle NCM - \angle NIM$

$= \dfrac{MN}{MC} - \dfrac{MN}{MI}$ (ii)

By Snell's law

$n_1 \sin i = n_2 \sin r$

for small angles ½

$n_1 i = n_2 r$

substituting i and r from (i) and (ii) we get

$\dfrac{n_1}{OM} + \dfrac{n_2}{MI} = \dfrac{n_2 - n_1}{MC}$ ½

Applying Cartesian coordinates

OM= -u, MI= + v , MC= +R

$\dfrac{n_2}{v} - \dfrac{n_1}{u} = \dfrac{n_2 - n_1}{R}$ ½

(ii) $\dfrac{n_2}{v} - \dfrac{n_1}{u} = \dfrac{n_2 - n_1}{R}$

R= - 6 cm, u = - 3cm , n_1 =1.5 n_2 = 1

$\dfrac{1}{v} + \dfrac{1.5}{3} = \dfrac{1-1.5}{-6}$ ½

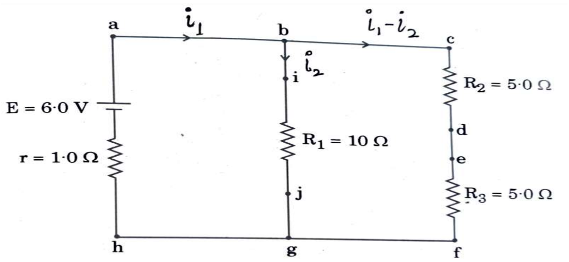
$\dfrac{1}{v} = \dfrac{0.5}{6} - \dfrac{1.5}{3}$ ½

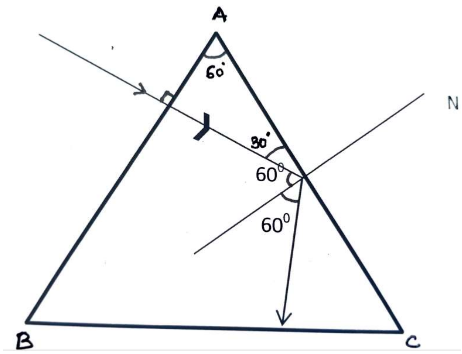
$\dfrac{1}{v} = \dfrac{0.5-3}{6}$ ½

$\dfrac{1}{v} = \dfrac{-2.5}{6}$

v = - 2.4 cm ½

from the left surface inside the sphere 5

	SECTION -E		
34.	a) Points at same potential 1 b) Current through arm bg 1 c) Potential difference across R_3 OR c) Power dissipated in R_2 2		
	a) Points (a, b, c) (d, e) (j, f, g ,h) are at same potential	1	
	Note: Give full credit if a student mentions any two points at same potential from the above. b)		
			
	According to Kirchhoff's loop rule for closed loop abgha $-6 + 10\,I_2 + I_1 = 0$ $I_1 + 10\,I_2 = 6$ (i) for closed loop acfha $-6 + 10\,(I_1 - I_2) + I_1 = 0$ $11\,I_1 - 10\,I_2 = 6$ (ii)	½	
	Adding (i) and (ii) $12\,I_1 = 12$ $I_1 = 1$ A $I_2 = 0.5$ A = current through arm bg	½	
	Note: Award 1 mark if a student calculates the current by any other method.		
	c) $V_{R3} = (I_1 - I_2) \times R_3$ $= 0.5 \times 5$	1	
	$= 2.5$ V	1	
	OR		
	(c) $P = (I_1 - I_2)^2 \times R_2 = (0.5)^2 \times 5$	1	
	$= 1.25$ W	1	4

35.	a) Tracing of path of ray 1 b) Finding velocity of light 1 c) Explanation of two application of TIR 2 OR c) Definition of TIR 1 Mentioning two conditions of TIR ½ + ½ a)  From fig. angle of incidence on second face $\angle i = 60^0$ critical angle $\angle i_c = 24.5^o$ $(\angle i) > (\angle i_c)$ $\therefore$ TIR takes place b) n= $\frac{c}{v}$ v = $\frac{c}{n} = \frac{3\times10^8}{2.41} = 1.24 \times 10^8$ m/s c) Optical Fibre / Brilliance of diamond / mirage (any two) Note: Give full credit if students mention the names of applications only. OR c) When light travels from optically denser medium to rarer medium at an interface and gets reflected back into the same medium the phenomenon is called as total internal reflection. Conditions for TIR 1. Light must travel from optically denser medium to rarer medium. 2. Angle of incidence at the interface must be greater than the critical angle for the pair of media.	1 1 1+1 1 ½ + ½	4

General Instructions :

Read the following instructions very carefully and follow them :

(i) *This question paper contains **35** questions. **All** questions are compulsory.*

(ii) *Question paper is divided into **FIVE** sections – Section **A, B, C, D** and **E**.*

(iii) *In **Section A :** Question number **1** to **18** are Multiple Choice (MCQ) type questions carrying **1** mark each.*

(iv) *In **Section B :** Question number **19** to **25** are Short Answer-1 (SA-1) type questions carrying **2** marks each.*

(v) *In **Section C :** Question number **26** to **30** are Short Answer-2 (SA-2) type questions carrying **3** marks each.*

(vi) *In **Section D :** Question number **31** to **33** are Long Answer (LA) type questions carrying **5** marks each.*

(vii) *In **Section E :** Question number **34** and **35** are Case-Based questions carrying **4** marks each.*

(viii) *There is no overall choice. However, an internal choice has been provided in **2** questions in Section–**B**, **2** questions in Section–C, **3** questions in Section–**D** and **2** questions in Section–**E**.*

(ix) *Use of calculators is NOT allowed.*

$c = 3 \times 10^8$ m/s

$h = 6.63 \times 10^{-34}$ Js

$e = 1.6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

Mass of electron (m_e) = 9.1×10^{-31} kg

Mass of neutron = 1.675×10^{-27} kg

Mass of proton = 1.673×10^{-27} kg

Avogadro's number = 6.023×10^{23} per gram mole

Boltzmann constant = 1.38×10^{-23} JK^{-1}

SECTION – A

1. The magnitude of the electric field due to a point charge object at a distance of 4.0 m is 9 N/C. From the same charged object the electric field of magnitude, $16 \frac{N}{C}$ will be at a distance of **1**

   (a) 1 m (b) 2 m
   (c) 3 m (d) 6 m

2. A point P lies at a distance x from the mid point of an electric dipole on its axis. The electric potential at point P is proportional to **1**

   (a) $\frac{1}{x^2}$ (b) $\frac{1}{x^3}$
   (c) $\frac{1}{x^4}$ (d) $\frac{1}{x^{1/2}}$

3. A current of 0.8 A flows in a conductor of 40 Ω for 1 minute. The heat produced in the conductor will be **1**

   (a) 1445 J (b) 1536 J
   (c) 1569 J (d) 1640 J

4. A cell of emf E is connected across an external resistance R. When current 'I' is drawn from the cell, the potential difference across the electrodes of the cell drops to V. The internal resistance 'r' of the cell is **1**

   (a) $\left(\frac{E-V}{E}\right)R$ (b) $\left(\frac{E-V}{R}\right)$
   (c) $\frac{(E-V)\,R}{I}$ (d) $\left(\frac{E-V}{V}\right)R$

5. Beams of electrons and protons move parallel to each other in the same direction. They **1**

   (a) attract each other.
   (b) repel each other.
   (c) neither attract nor repel.
   (d) force of attraction or repulsion depends upon speed of beams.

6. A long straight wire of radius 'a' carries a steady current 'I'. The current is uniformly distributed across its area of cross-section. The ratio of magnitude of magnetic field $\vec{B}_1$ at $\frac{a}{2}$ and $\vec{B}_2$ at distance 2a is **1**

(a) $\frac{1}{2}$ (b) 1

(c) 2 (d) 4

7. $\vec{E}$ and $\vec{B}$ represent the electric and the magnetic field of an electromagnetic wave respectively. The direction of propagation of the wave is along **1**

(a) $\vec{B}$ (b) $\vec{E}$

(c) $\vec{E} \times \vec{B}$ (d) $\vec{B} \times \vec{E}$

8. A ray of monochromatic light propagating in air, is incident on the surface of water. Which of the following will be the same for the reflected and refracted rays ? **1**

(a) Energy carried (b) Speed

(c) Frequency (d) Wavelength

9. A beam of light travels from air into a medium. Its speed and wavelength in the medium are 1.5×10^8 ms^{-1} and 230 nm respectively. The wavelength of light in air will be **1**

(a) 230 nm (b) 345 nm

(c) 460 nm (d) 690 nm

10. Which one of the following metals does not exhibit emission of electrons from its surface when irradiated by visible light ? **1**

(a) Rubidium (b) Sodium

(c) Cadmium (d) Caesium

11. A hydrogen atom makes a transition from n = 5 to n = 1 orbit. The wavelength of photon emitted is λ. The wavelength of photon emitted when it makes a transition from n = 5 to n = 2 orbit is **1**

(a) $\frac{8}{7}\lambda$ (b) $\frac{16}{7}\lambda$

(c) $\frac{24}{7}\lambda$ (d) $\frac{32}{7}\lambda$

12. The curve of binding energy per nucleon as a function of atomic mass number has a sharp peak for helium nucleus. This implies that helium nucleus is **1**

(a) radioactive

(b) unstable

(c) easily fissionable

(d) more stable nucleus than its neighbours

13. In an extrinsic semiconductor, the number density of holes is 4×10^{20} m^{-3}. If the number density of intrinsic carriers is 1.2×10^{15} m^{-3}, the number density of electrons in it is **1**

(a) 1.8×10^{9} m^{-3} (b) 2.4×10^{10} m^{-3}

(c) 3.6×10^{9} m^{-3} (d) 3.2×10^{10} m^{-3}

14. Pieces of copper and of silicon are initially at room temperature. Both are heated to temperature T. The conductivity of **1**

(a) both increases.

(b) both decreases.

(c) copper increases and silicon decreases.

(d) copper decreases and silicon increases.

15. The formation of depletion region in a p-n junction diode is due to **1**

(a) movement of dopant atoms (b) diffusion of both electrons and holes

(c) drift of electrons only (d) drift of holes only

Note : In question number **16** to **18**, two statements are given – one labelled **Assertion (A)** and the other labelled **Reason (R)**. Select the correct answer to these questions from the codes **(a)**, **(b)**, **(c)** and **(d)** as given below :

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

(b) Both Assertion (A) and Reason (R) are true and Reason (R) is NOT the correct explanation of Assertion (A).

(c) Assertion (A) is true and Reason (R) is false.

(d) Assertion (A) is false and Reason (R) is also false.

16. **Assertion (A) :** Diamagnetic substances exhibit magnetism.

Reason (R) : Diamagnetic materials do not have permanent magnetic dipole moment. **1**

17. **Assertion (A) :** Work done in moving a charge around a closed path, in an electric field is always zero.

Reason (R) : Electrostatic force is a conservative force. **1**

18. **Assertion (A) :** In Young's double slit experiment all fringes are of equal width.

Reason (R) : The fringe width depends upon wavelength of light (λ) used, distance of screen from plane of slits (D) and slits separation (d). **1**

SECTION – B

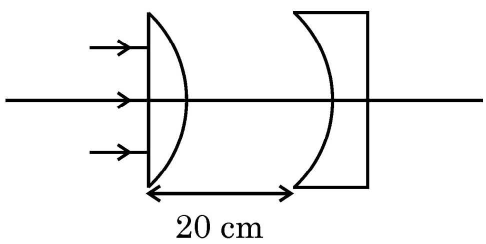
19. Briefly explain why and how a galvanometer is converted into an ammeter. **2**

20. (a) How are infrared waves produced ? Why are these waves referred to as heat waves ? Give any two uses of infrared waves. **2**

OR

(b) How are X-rays produced ? Give any two uses of these.

21. In the given figure the radius of curvature of curved face in the plano-convex and the plano-concave lens is 15 cm each. The refractive index of the material of the lenses is 1.5. Find the final position of the image formed. **2**



22. What happens to the interference pattern when two coherent sources are

(a) infinitely close, and

(b) far apart from each other **2**

23. (a) What is meant by ionisation energy ? Write its value for hydrogen atom. **2**

OR

(b) Define the term, mass defect. How is it related to stability of the nucleus ?

24. Draw energy band diagram for an n-type and p-type semiconductor at $T > 0$ K. **2**

25. Answer the following giving reasons : **2**
   (i) A p-n junction diode is damaged by a strong current.
   (ii) Impurities are added in intrinsic semiconductors.

SECTION – C

26. (a) Two charged conducting spheres of radii a and b are connected to each other by a wire. Find the ratio of the electric fields at their surfaces. **3**

OR

(b) A parallel plate capacitor (A) of capacitance C is charged by a battery to voltage V. The battery is disconnected and an uncharged capacitor (B) of capacitance 2C is connected across A. Find the ratio of
   (i) final charges on A and B.
   (ii) total electrostatic energy stored in A and B finally and that stored in A initially.

27. Define current density and relaxation time. Derive an expression for resistivity of a conductor in terms of number density of charge carriers in the conductor and relaxation time. **3**

28. A series CR circuit with $R = 200\ \Omega$ and $C = (50/\pi)\ \mu F$ is connected across an ac source of peak voltage $\varepsilon_0 = 100$ V and frequency $\nu = 50$ Hz. Calculate (a) impedance of the circuit (Z), (b) phase angle (ϕ), and (c) voltage across the resistor. **3**

29. Define critical angle for a given pair of media and total internal reflection. Obtain the relation between the critical angle and refractive index of the medium. **3**

30. (a) (i) Distinguish between nuclear fission and fusion giving an example of each.

(ii) Explain the release of energy in nuclear fission and fusion on the basis of binding energy per nucleon curve. **3**

OR

(b) (i) How is the size of a nucleus found experimentally ? Write the relation between the radius and mass number of a nucleus.

(ii) Prove that the density of a nucleus is independent of its mass number.

SECTION – D

31. (a) (i) Use Gauss' law to obtain an expression for the electric field due to an infinitely long thin straight wire with uniform linear charge density λ.

(ii) An infinitely long positively charged straight wire has a linear charge density λ. An electron is revolving in a circle with a constant speed v such that the wire passes through the centre, and is perpendicular to the plane, of the circle. Find the kinetic energy of the electron in terms of magnitudes of its charge and linear charge density λ on the wire.

(iii) Draw a graph of kinetic energy as a function of linear charge density λ. **5**

OR

(b) (i) Consider two identical point charges located at points (0, 0) and (a, 0).

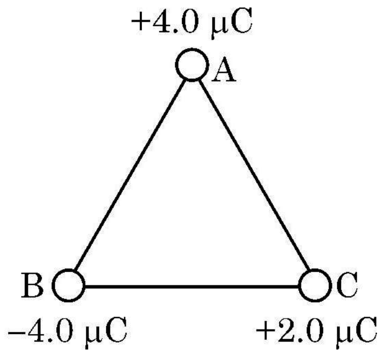
(1) Is there a point on the line joining them at which the electric field is zero ?

(2) Is there a point on the line joining them at which the electric potential is zero ?

Justify your answers for each case.

(ii) State the significance of negative value of electrostatic potential energy of a system of charges.

Three charges are placed at the corners of an equilateral triangle ABC of side 2.0 m as shown in figure. Calculate the electric potential energy of the system of three charges.



32. (a) (i) Define coefficient of self-induction. Obtain an expression for self-inductance of a long solenoid of length l, area of cross-section A having N turns.

(ii) Calculate the self-inductance of a coil using the following data obtained when an AC source of frequency $\left(\frac{200}{\pi}\right)$ Hz and a DC source is applied across the coil. **5**

AC Source		
S.No.	V (Volts)	I (A)
1	3.0	0.5
2	6.0	1.0
3	9.0	1.5

DC Source		
S.No.	V (Volts)	I (A)
1	4.0	1.0
2	6.0	1.5
3	8.0	2.0

OR

(b) (i) With the help of a labelled diagram, describe the principle and working of an ac generator. Hence, obtain an expression for the instantaneous value of the emf generated.

(ii) The coil of an ac generator consists of 100 turns of wire, each of area 0.5 m^2. The resistance of the wire is 100 Ω. The coil is rotating in a magnetic field of 0.8 T perpendicular to its axis of rotation, at a constant angular speed of 60 radian per second. Calculate the maximum emf generated and power dissipated in the coil.

33. (a) (i) State Huygen's principle. With the help of a diagram, show how a plane wave is reflected from a surface. Hence verify the law of reflection. **5**

(ii) A concave mirror of focal length 12 cm forms a three times magnified virtual image of an object. Find the distance of the object from the mirror.

OR

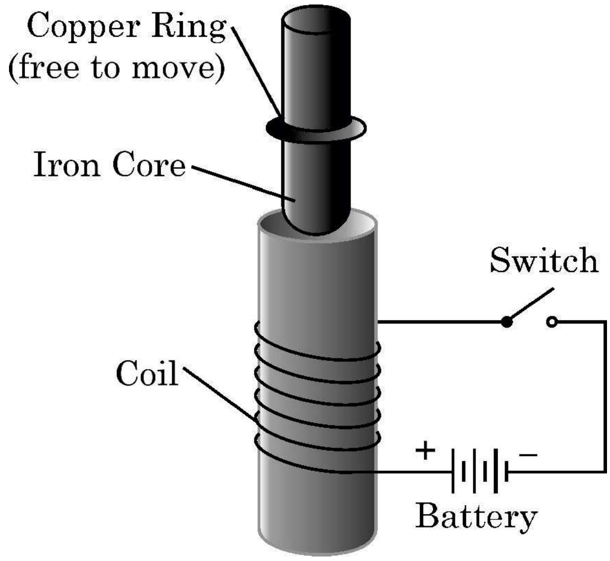
(b) (i) Draw a labelled ray diagram showing the image formation by a refracting telescope. Define its magnifying power. Write two limitations of a refracting telescope over a reflecting telescope.

(ii) The focal lengths of the objective and the eye-piece of a compound microscope are 1.0 cm and 2.5 cm respectively. Find the tube length of the microscope for obtaining a magnification of 300.

SECTION – E

Note : Questions number **34** and **35** are Case Study based questions. Read the following paragraph and answer the questions.

34. (a) Consider the experimental set up shown in the figure. This jumping ring experiment is an outstanding demonstration of some simple laws of Physics. A conducting non-magnetic ring is placed over the vertical core of a solenoid. When current is passed through the solenoid, the ring is thrown off.



Answer the following questions :

(i) Explain the reason of jumping of the ring when the switch is closed in the circuit.

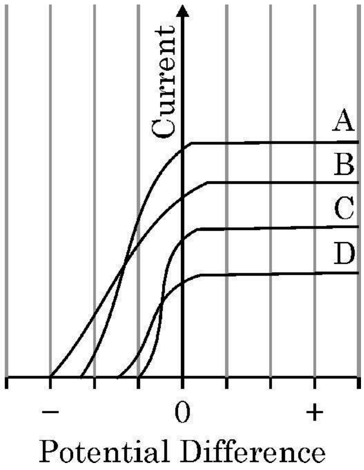
(ii) What will happen if the terminals of the battery are reversed and the switch is closed ? Explain.

(iii) Explain the two laws that help us understand this phenomenon. **4**

OR

(b) Briefly explain various ways to increase the strength of magnetic field produced by a given solenoid.

35. (a) Figure shows the variation of photoelectric current measured in a photo cell circuit as a function of the potential difference between the plates of the photo cell when light beams A, B, C and D of different wavelengths are incident on the photo cell. Examine the given figure and answer the following questions :



(i) Which light beam has the highest frequency and why ?

(ii) Which light beam has the longest wavelength and why ?

(iii) Which light beam ejects photoelectrons with maximum momentum and why ? **4**

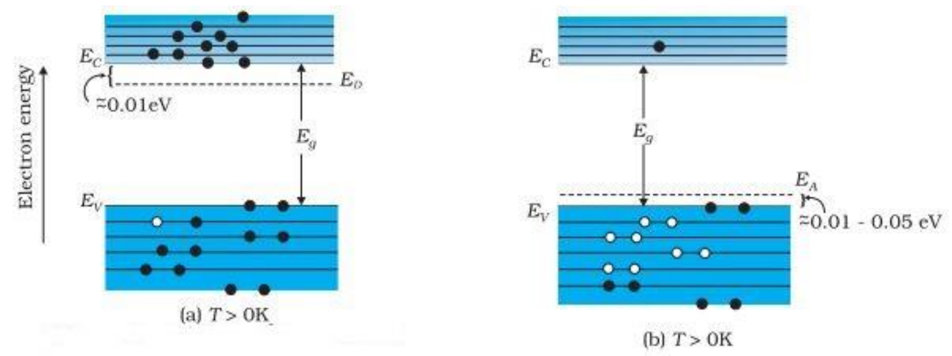
OR

(b) What is the effect on threshold frequency and stopping potential on increasing the frequency of incident beam of light ? Justify your answer.

MARKING SCHEME: PHYSICS(042)			
Code:55/2/1			
Q.No.	**VALUE POINTS/EXPECTED ANSWERS**	**Marks**	**Total Marks**
	SECTION **A**		
1	(c) 3 m	1	1
2	(a) $\frac{1}{x^2}$	1	1
3	(b) 1536 J	1	1
4	(d) $\left(\frac{E-V}{V}\right)R$	1	1
5	(b) Repel each other	1	1
6	(b) 1	1	1
7	(c) $\vec{E} \times \vec{B}$	1	1
8	(c) Frequency	1	1
9	(c) 460 nm	1	1
10	(c) Cadmium	1	1
11	(d) $\frac{32}{7}\lambda$	1	1
12	(d) More stable nucleus than its neighbours.	1	1
13	(c) 3.6×10^{9} m^{-3}	1	1
14	(d) Copper decreases and silicon increases	1	1
15	(b) Diffusion of both electrons and holes.	1	1
16	(b) Both assertion (A) and Reasons (R) are true and Reason(R) is not the correct explanation of assertion (A)	1	1
17	(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion(A).	1	1
18	(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).	1	1

	SECTION - B		
19	Explanation of conversion of galvanometer into an ammeter • Why 1 • How 1 • Due to very high sensitivity **Alternatively** It has large resistance and hence will change the value of current in circuit. • A galvanometer can be converted into an ammeter of desired range by connecting a shunt of proper value across its coil.	1 1	2
20	(a) Production of infrared waves - ½ Reason of calling Infrared waves as heat waves - ½ Two uses of Infrared waves - (½ + ½) Infrared waves are produced by hot bodies and vibrations of molecules. They are referred as heat waves because they are readily absorbed by water molecules and increase their thermal energy and heat them. **Uses** 1) Dehydration of fruits. 2) In greenhouse Effect. 3) In remote switches. (any other relevant two uses) OR (b) Production of X- rays - 1 Two uses of X- rays - ½+½ When fast moving electrons strike a heavy target like tungsten, X-rays are produced. Two uses – 1. Used as a diagnostic tool in medicine, 2. Treatment for certain forms of cancer. 3. To study crystal structure. (Any two uses from above or other uses)	½ ½ ½ + ½ 1 ½ + ½	2
21	Finding final position of image formed - 2 Using the formula $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ • Focal length of plano-convex lens = +30 cm Focal length of plano-concave lens = -30 cm • For plano-convex lens As object is at ∞, its real image will be formed at its focus i.e +30 cm v_1 = +30 cm • For plano-concave lens u = +(30-20) cm = +10 cm $\frac{1}{f_2} = \left(\frac{1}{v_2} - \frac{1}{u_2}\right)$	½ ½ ½	

	$\frac{1}{-30}=\left(\frac{1}{v_2}-\frac{1}{10}\right)$ $\therefore v_2 = 15$ cm	½	2
22	Effect on interference pattern when two coherent sources are a) Infinitely close - 1 b) Far apart from each other - 1 (a) When '*d*' is very small , $\beta \propto \frac{1}{d}$, β will be very large and a single patch will occupy the whole field of view hence pattern cannot be observed. **Alternatively** Give full credit if a candidate writes that the fringe width will increase or the fringes will not be observed. (b) When sources are far apart, i.e *d* is very large, then fringe width will be so small that the fringes are not resolved and cannot be seen separately. **Alternatively** Give full credit if a candidate writes that the fringe width will decrease or the fringes may not be observed.	1 1	2
23	(a) Meaning of ionization energy - 1 Value of ionization energy for hydrogen atom - 1 Ionization energy is the minimum energy required to remove an electron from an isolated atom of an element. **Alternatively** It is the energy required to excite an electron from energy level n = 1 to n = ∞ from an isolated atom of an element. The ionization energy for hydrogen atom is 13.6 eV. **OR** (b) Definition of mass defect - 1 Its relation with stability - 1 Mass defect is the difference between the actual mass of the nucleus and the sum of the masses of its nucleons. Greater the mass defect, greater will be the binding energy and the nucleus will be more stable **Alternatively** Give full credit (1 mark) if a candidate writes, mass defect ∝ stability of the nucleus.	1 1 1 1	2
24	Drawing of energy band diagrams at T > 0 K for • n-type semiconductor - 1 • p-type semiconductor - 1		

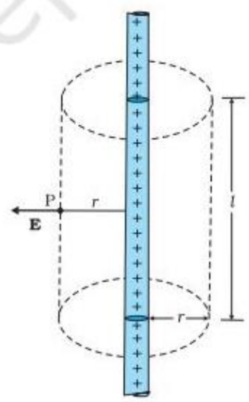
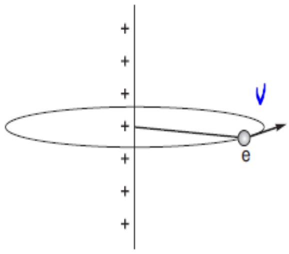
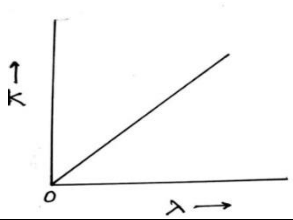
	 (a) n-type semiconductor (b) p-type semiconductor	1+1	2
25	Reasons for i) Damage of a p-n junction diode by a strong current - 1 ii) Adding impurities in intrinsic semiconductor - 1 i) Due to strong current, a junction diode gets heated, consequently large number of covalent bonds are broken and the junction is damaged. ii) Deliberate addition of impurity atoms in intrinsic semiconductor increases its conductivity and is suitable for making electronic devices. **Alternatively** Give full credit if a student writes that no electronic device can be developed using intrinsic semiconductor because of their low conductivity.	1 1	2
SECTION - C			
26	(a) Finding ratio of the electric fields at their surfaces - 3 When connected by a conducting wire both spheres will be at the same potential. $\therefore \quad k\frac{q_1}{a} = k\frac{q_2}{b}$ $\therefore \frac{q_1}{q_2} = \frac{a}{b}$ $\frac{E_1}{E_2} = \frac{k\frac{q_1}{a^2}}{k\frac{q_2}{b^2}}$ $\frac{E_1}{E_2} = \frac{b}{a}$ **OR** (b) Finding the ratio of final charges on two capacitors A & B - ½ + ½ Ratio of electrostatic energy stored in A initially and in A and B finally - 1+1 i) Initially $Q = CV$ Finally $q_A = C_A V_1$ & $q_B = C_B V_1$	½ ½ ½ 1 ½ ½	

	$\frac{q_A}{q_B}=\frac{C_A}{C_B}=\frac{1}{2}$ ii) $q_A+q_b=Q$ $\therefore\ q_A=\frac{Q}{3}$ & $q_B=\frac{2Q}{3}$ $\frac{U_f}{U_i}=\frac{U_A+U_B}{U_{Ai}}$ $=\frac{\frac{q_A^2}{2C_A}+\frac{q_B^2}{2C_B}}{\frac{Q^2}{2C_A}}$ $=\frac{1}{3}$ **Alternatively ,** Common potential $V_1=\frac{Q_1+Q_2}{C_1+C_2}$ $=\frac{Q}{3C}=\frac{V}{3}\qquad\left[\because\ \frac{Q}{C}=V\right]$ $\frac{U_f}{U_i}=\frac{\frac{1}{2}C_{eq}V_1^2}{\frac{1}{2}C_AV^2}$ $=\frac{\frac{1}{2}3C\times\left(\frac{V}{3}\right)^2}{\frac{1}{2}CV^2}=\frac{1}{3}$	½ ½ 1 ½ 1 ½ ½	3
27	Definition of Current density - ½ Relaxation time - ½ Derivation for resistivity of a conductor - 2 Current density is defined as the current flowing per unit area of cross section of a conductor. **Alternatively** Give full credit if a candidate writes j=I/A in place of definition Relaxation time is the average time interval between two successive collisions for drifting electrons in a conductor. From I= $nAev_d$ but $v_d=\frac{eE}{m}\tau$ $\therefore\ I=nAe.\frac{eE}{m}\tau$	½ ½ ½ ½ ½	

	$j = \frac{I}{A} = \frac{ne^2 E\tau}{m}$ But $j = \frac{E}{\rho}$ $\therefore \quad \rho = \frac{m}{ne^2\tau}$	½	3
28	Calculating a) Impedance of the circuit (Z) - 1 b) Phase angle(ϕ) - 1 c) Voltage across the resistor - 1 (a) $Z = \sqrt{R^2 + X_c^2} = \; = \sqrt{R^2 + \left(\frac{1}{2\pi\nu C}\right)^2}$ $X_c = \frac{1}{2\pi\nu C} = \frac{1}{2\times\pi\times 50\times\frac{50}{\pi}\times 10^{-6}} = 200\Omega$ $Z = \sqrt{(200)^2 + (200)^2} = 200\sqrt{2}\Omega$ $\approx 282\ \Omega$ (b) tan $\phi = \frac{X_c}{R} = \frac{200}{200}$ $\phi = 45^0$ or $\frac{\pi}{4} rad$ (c) $V_{rms} = I_{rms}R = \frac{V_{rms}}{Z}R$ $= \frac{100}{\sqrt{2}\times 200\sqrt{2}}\times 200$ $= 50V$	½ ½ ½ ½ ½ ½	3
29	Definition of • Critical angle - 1 • Total internal reflection - 1 Obtaining relation between the critical angle and refractive index of the medium - 1 **<u>Critical angle</u>** - When a ray of light passes from a denser to a rarer medium, the value of angle of incidence for which the angle of refraction becomes 90^0 is called critical angle for that pair of media. **<u>Total internal Reflection</u>** – When a ray of light passes from a denser to rarer medium and the angle of incidence exceeds the critical angle for pair of media, the ray under goes reflection. This is called total internal reflection. From Snell's law $\frac{\sin i}{\sin r} = \mu_{rd}$ When angle of incidence is equal to critical angle ($\angle i = \angle i_c$) , $\angle r = 90^0$	1 1 ½	

	$\therefore \quad \dfrac{\sin i_c}{\sin 90^0} = \dfrac{1}{\mu_{dr}}$ $\therefore \quad \mu_{dr} = \dfrac{1}{\sin i_c}$	½	3
30.	(a) (i) Difference between nuclear fission and nuclear fusion — 1 Examples of each — ½ + ½ (ii) Explanation of release of energy in nuclear fission & fusion — ½ + ½ **Nuclear fission** – It is a process in which a heavy nucleus when excited (say on bombarding by a slow moving neutron) splits into two lighter nuclei of nearly comparable masses with a release of large amount of energy. Example of nuclear fission ${}_0^1n + {}_{92}^{235}U \rightarrow {}_{92}^{236}U \rightarrow {}_{56}^{144}Ba + {}_{36}^{89}Kr + 3\,{}_0^1n + Q$ **Nuclear Fusion** - It is a process in which two lighter nuclei fuse (at extremely high temperature) to form a heavy nucleus and large amount of energy is released. Examples of nuclear fusion (i) ${}_1^1H + {}_1^1H \rightarrow {}_1^2H + e^+ + \nu + Q_1$ (ii) ${}_1^2H + {}_1^2H \rightarrow {}_2^3H + n + Q_2$ (iii) ${}_1^2H + {}_1^2H \rightarrow {}_1^3H + {}_1^1H + Q_3$ (any other possible reaction equation) (ii) The binding energy per nucleon of the products in the nuclear reactions (nuclear fission and nuclear fusion) is greater than that of the reactants . OR (b) (i) Experimental determination of size of nucleus of an atom - ½ Relation between radius and mass number of nucleus - 1 (ii) Proof of independence of density of nucleus on its mass number - 1 ½ (i) Size of nucleus of an atom is determined by scattering experiments in which fast electrons are used to bombard targets. Relation between radius and mass number of nucleus. $R = R_0 A^{1/3}$ (ii) Density of nucleus $\rho = \dfrac{mass}{volume}$ $\rho = \dfrac{m \times A}{\frac{4}{3}\pi R^3}$ $\rho = \dfrac{m\,A}{\frac{4}{3}\pi\left(R_0 A^{1/3}\right)^3}$ $\rho = \dfrac{3m}{4\pi R_0{}^3}$ Hence, density of nucleus is independent of mass number (*A*).	½ ½ ½ ½ 1 ½ 1 ½ ½ ½	3

SECTION - D

31	(a) (i) Derivation of the expression - 2 (ii) Finding kinetic energy of electron - 2 (iii)Graph - 1		
	(i) 	½	
	Flux through the Gaussian surface $\emptyset = E.2\pi rl$	½	
	According to Gauss's law $E.2\pi rl = \frac{q}{\epsilon_0}$	½	
	$\because \quad q = \lambda l$ $E = \frac{\lambda}{2\pi \epsilon_0 r}$	½	
	(i) $E = \frac{\lambda}{2\pi \epsilon_0 r}$ 	½	
	$\frac{mv^2}{r} = eE$	½	
	$\therefore$ Kinetic energy $K = \frac{1}{2}mv^2$ $= \frac{1}{2}eEr$	½	
	$= \frac{1}{2}e\frac{\lambda.r}{2\pi \epsilon_0 r} = \frac{e\lambda}{4\pi \epsilon_0}$	½	
	(ii) Kinetic energy $K = = \frac{e\lambda}{4\pi \epsilon_0}$ $\therefore \ K \propto \lambda$		
		1	

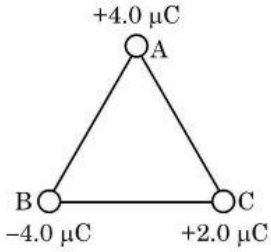
OR

(b)

(i) Answers of (1) and (2) with justification	-	2
(ii) Significance of negative value	-	1
Determining electric potential energy	-	2

(i) (1) Yes , electric field is zero at mid point.
Electric field being a vector quantity , its resultant is zero.
(2) No, potential cannot be zero on line joining the charges. ½
Electric potential being a scalar quantity, the net potential due to two ½
identical charges cannot be zero. ½

(ii) Negative value of electrostatic potential energy of a system signifies that the system has attractive forces. ½
Alternatively
Give full credit , if a candidate writes the system is stable /bound. 1



$$U = \frac{1}{4\pi \in_0} \times \frac{q_1 q_2}{r}$$ ½

$$U = \frac{1}{4\pi \in_0}\left[\frac{q_A q_B}{r} + \frac{q_B q_c}{r} + \frac{q_c q_A}{r}\right]$$ ½

$$= \frac{9\times10^9}{2}\left[-16-8+8\right]\times10^{-12}$$ ½

$$= -7.2\times10^{-2} J$$ ½ 5

32 (a)

(i) Definition of coefficient of self induction	-	1
Derivation of expression for coefficient of self induction	-	2
(ii) Determining coefficient of self induction	-	2

(i) Coefficient of self induction is defined as the amount of magnetic flux associated with a coil when unit current flows through it. 1

Alternatively

It is defined as the magnitude of emf induced in a coil when current changes at the rate of 1 A/s through it.

(ii) The magnetic field due to a current I flowing in solenoid is

$$B = \frac{\mu_0 N I}{l}$$ ½

The total magnetic flux linked with solenoid

$$N\phi_B = (N)\left(\frac{\mu_0 N I}{l}\right)(A)$$ ½

$$= \frac{\mu_0 N^2 I A}{l}$$

The self inductance is

$$L = \frac{N\phi_B}{I}$$ ½

$$L = \frac{\mu_0 N^2 A}{l}$$ ½

(iii)From the table , Z=6 Ω , R = 4Ω

$$Z^2 = R^2 + X_L^2$$ ½

$$X_L^2 = Z^2 - R^2 = 36 - 16 = 20$$

$$X_L = 2\sqrt{5} \approx 4.5\ \Omega$$ ½

$$2\pi\nu L = 4.5$$ ½

$$L = \frac{4.5}{2\times\pi\times\frac{200}{\pi}}$$ ½

$$L = 1.1\times10^{-2} H = 11 mH$$

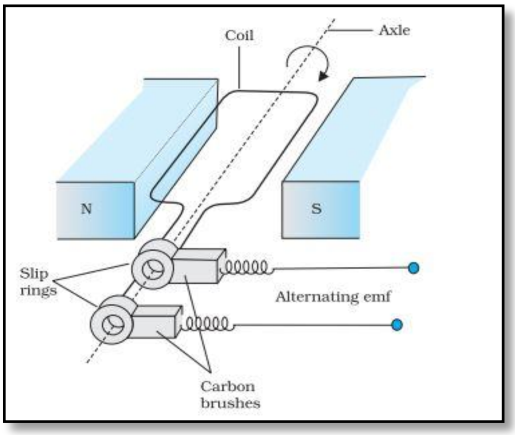
Note : Please do not deduct marks if a student writes answer as $0.5\sqrt{5}\times10^{-2}$ H

OR

(b)

(i) Labelled diagram	-	1
Principle	-	½
Working	-	½
Obtaining expression of emf	-	1
(ii) Determining		
Maximum emf	-	1
Power dissipated	-	1

(i) Diagram



1

Principle – It is based on the principle of electromagnetic induction.
Whenever there is a change in magnetic flux linked with a coil , an emf is induced in the coil.

Alternatively

Give full credit if a candidate writes ,it is based on the principle of electromagnetic induction. ½

Working - When a rectangular coil is rotated in a magnetic field, the magnetic flux changes continuously which induces an emf and the direction of current changes periodically.

$$\varepsilon = \frac{-Nd\phi}{dt}$$ ½ ½

$$= -NBA\frac{d}{dt}(\cos\omega t)$$

$$\varepsilon = NBA\omega\sin\omega t$$ ½

(ii) $\varepsilon_0 = NBA\omega$ ½

$= 100 \times 0.8 \times 0.5 \times 60$

$= 2400$ V ½

Power dissipated , $P = \dfrac{\varepsilon_{rms}^2}{R}$ ½

$= \dfrac{\left(\dfrac{2400}{\sqrt{2}}\right)^2}{100}$

$= 28.8$ kW ½

Alternatively

Give full credit if a candidate calculates power dissipated using formula $\varepsilon_{rms} I_{rms}$ or $I_{rms}^2 R$.

5

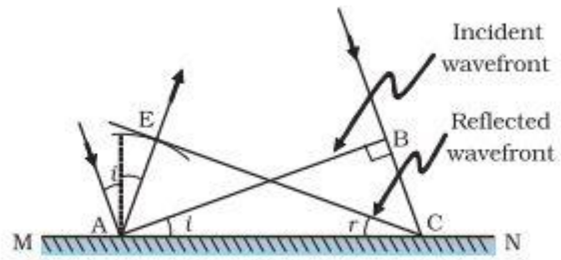
---

33 (a)

(i) Statement of Huygen's principle	-	1
Diagram showing reflected wavefront	-	1
Verification of law of reflection	-	1
(ii) Finding distance of object from the mirror	-	2

(i) Huygen's principle

Each point of the wavefront is the source of a secondary disturbance and the wavelets emanating from these points spread out in all directions with the speed of the wave. These wavelets emanating from the wavefront are usually referred to as secondary wavelets, a common tangent to all these spheres gives the new position of the wavefront at a later time. 1



1

Verification of law of reflection

In ΔAEC & ΔCBA

EC = AB (c x t each)

∠ AEC = ∠ CBA (90^0 each)

AC = AC (common side)

By RHS congruency ΔAEC ≅ ΔCBA ½

$\Rightarrow \angle i = \angle r$ ½

(ii) $m = +3$, f = -12 cm , $u = ?$

$m = -\dfrac{v}{u} = 3 \Rightarrow v = -3u$ ½

using mirror formula

$\dfrac{1}{v} + \dfrac{1}{u} = \dfrac{1}{f}$ ½

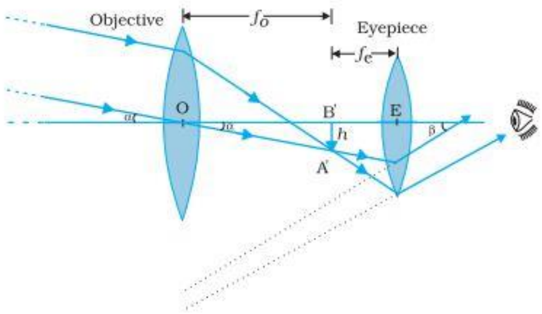
$\dfrac{1}{-3u} + \dfrac{1}{u} = \dfrac{1}{-12}$ ½

$u = -8$ cm ½

OR

(b)

(i) Labelled diagram	-	1½
Definition of magnifying power	-	1
Two limitations	-	½ + ½
(ii) Finding tube length of microscope	-	1½

(i) 

1½

(Note deduct ½ mark if a student does not show the direction of propagation of the light.)

Alternatively

Give full credit for ray diagram if a candidate draws ray diagram for final image at the near point.

Magnifying power of a telescope – It is defined as the ratio the angle subtended at the eye by the final image to the angle subtended by the object at the lens or the eye. 1

Two limitations of a refracting telescope over a reflecting telescope.

(i) Less resolving power.
(ii) Difficult mechanical support.
(iii) Less bright image.
(iv) Suffers chromatic aberration.
(v) Image suffers with spherical aberration. ½ + ½

(Any two of the above)

$f_0 = 1.0$ cm , $f_e = 2.5$ cm , m = 300 , D=25 cm , L=?

$$|m| = \frac{L}{f_0} \cdot \frac{D}{f_e}$$ ½

$$300 = \frac{L}{1.0} \cdot \frac{25}{2.5}$$ ½

$$L = 30 \text{ cm}$$ ½ 5

SECTION - E

34

(i) Explanation of a jumping of ring	-	1
(ii) Explanation of outcome on changing terminals of battery	-	1
(iii) Explanation of two laws	-	1+1
OR		
(b) Two ways to increase strength of magnetic field produced by solenoid	-	1+1

(i) The direction of induced current in the ring is such that the polarity developed in the ring is same as that of the polarity on the face of the coil , hence it will jump up due to repulsive force. 1

(ii) The polarity of the induced current in the ring will get reversed on changing the terminals of the battery, so the ring will jump again. 1

(iii) **Lenz's law** It states that the polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produces it. 1

Faraday's law of EMI

Whenever there is change in magnetic flux through a coil, an emf is induced.

	The magnitude of the induced emf in a coil is equal to the time rate of change of magnetic flux through the coil. **OR** Ways to increase strength of magnetic field produced by a solenoid. • By inserting soft iron core inside the solenoid. • By increasing current in the solenoid.	1 1 1	 4
35.	(i) Identification of highest frequency beam and reason - ½ + ½ (ii) Identification of longest wavelength beam and reason - ½ + ½ (iii) Identification of beam ejecting photoelectrons with maximum momentum and reason - 1+1 **OR** (b) Effect on threshold frequency and stopping potential on the increasing frequency and justification - 1+1 (i) The light beam B because it requires maximum retarding potential to reduce the photoelectric current to zero. (ii) The light beam C because it requires minimum retarding potential to reduce photoelectric current to zero. (iii)The light beam B ejects photoelectrons with maximum momentum. because highest frequency light beam ejects photoelectrons with highest kinetic energy and hence highest momentum. **OR** There is no effect on threshold frequency since it is characteristic of the metal. With increase in freqquency of incidents beam of light , stopping potential increases because to stop the photoelectrons of higher kinetic energy, larger retarding potential is required. **Alternatively** Give full credit if a candidate explains the effect of frequency on stopping potential using the following formula. $eV_0 = h(\nu - \nu_0)$	 ½ + ½ ½ + ½ 1 1 ½ + ½ ½ + ½	 4

General Instructions :

Read the following instructions very carefully and strictly follow them :

(i) *This question paper contains **35** questions. **All** questions are **compulsory**.*

(ii) *This question paper is divided into **five** Sections – **A, B, C, D** and **E**.*

(iii) *In **Section A** – Questions no. **1** to **18** are Multiple Choice (MCQ) type questions, carrying **1** mark each.*

(iv) *In **Section B** – Questions no. **19** to **25** are Very Short Answer (VSA) type questions, carrying **2** marks each.*

(v) *In **Section C** – Questions no. **26** to **30** are Short Answer (SA) type questions, carrying **3** marks each.*

(vi) *In **Section D** – Questions no. **31** to **33** are Long Answer (LA) type questions carrying **5** marks each.*

(vii) *In **Section E** – Questions no. **34** and **35** are case-based questions carrying **4** marks each.*

(viii) *There is no overall choice. However, an internal choice has been provided in 2 questions in Section B, 2 questions in Section C, 3 questions in Section D and 2 questions in Section E.*

(ix) *Use of calculators is **not** allowed.*

Use the following values of physical constants, if required :

$c = 3 \times 10^{8}$ m/s

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8{\cdot}854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^{9}$ N m^2 C^{-2}

Mass of electron (m_e) = $9{\cdot}1 \times 10^{-31}$ kg

Mass of neutron = $1{\cdot}675 \times 10^{-27}$ kg

Mass of proton = $1{\cdot}673 \times 10^{-27}$ kg

Avogadro's number = $6{\cdot}023 \times 10^{23}$ per gram mole

Boltzmann constant = $1{\cdot}38 \times 10^{-23}$ JK^{-1}

SECTION A

1. An electron experiences a force $(1 \cdot 6 \times 10^{-16}\ \text{N})\ \hat{i}$ in an electric field $\vec{E}$. The electric field $\vec{E}$ is :

(a) $(1 \cdot 0 \times 10^{3}\ \frac{N}{C})\ \hat{i}$ (b) $-(1 \cdot 0 \times 10^{3}\ \frac{N}{C})\ \hat{i}$

(c) $(1 \cdot 0 \times 10^{-3}\ \frac{N}{C})\ \hat{i}$ (d) $-(1 \cdot 0 \times 10^{-3}\ \frac{N}{C})\ \hat{i}$

2. Which one of the following is ***not*** a scalar quantity ?

(a) Electric field (b) Voltage

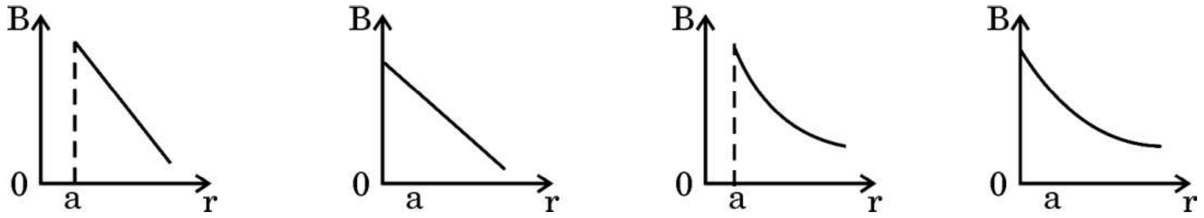
(c) Resistivity (d) Power

3. The current density due to drift of electrons in a conductor is given by : (symbols have their usual meanings)

(a) $n\, e\, A\, v_d$ (b) $\frac{n\, A\, v_d}{e}$

(c) $\frac{n\, v_d}{e\, A}$ (d) $n\, e\, v_d$

4. Which of the following graphs correctly represents the variation of the magnitude of the magnetic field outside a straight infinite current carrying wire of radius 'a', as a function of distance 'r' from the centre of the wire ?



(a) (b) (c) (d)

5. A particle of mass m and charge q moving with a uniform velocity $\vec{v} = v_{0x}\ \hat{i} + v_{0y}\ \hat{j}$ enters a region with a magnetic field $\vec{B} = B_0\ \hat{j}$. After some time, an electric field $\vec{E} = E_0\ \hat{j}$ is also switched on in the region. The resulting path described by the particle will be :

(a) a circle in x-z plane

(b) a parabola in x-y plane

(c) a helix with constant pitch

(d) a helix with increasing pitch

6. An inductor, a capacitor and a resistor are connected in series across an ac source of voltage. If the frequency of the source is decreased gradually, the reactance of :

(a) both the inductor and the capacitor decreases.

(b) inductor decreases and the capacitor increases.

(c) both the inductor and the capacitor increases.

(d) inductor increases and the capacitor decreases.

7. The electromagnetic radiations used to kill germs in water purifiers are called :

(a) Infrared waves

(b) X-rays

(c) Gamma rays

(d) Ultraviolet rays

8. In the wave picture of light, the intensity I of light is related to the amplitude A of the wave as :

(a) $I \propto \sqrt{A}$

(b) $I \propto A$

(c) $I \propto A^2$

(d) $I \propto \frac{1}{A^2}$

9. In a single-slit diffraction experiment, the width of the slit is halved. The width of the central maximum, in the diffraction pattern, will become :

(a) half

(b) twice

(c) four times

(d) one-fourth

10. A graph is plotted between the stopping potential (on y-axis) and the frequency of incident radiation (on x-axis) for a metal. The product of the slope of the straight line obtained and the magnitude of charge on an electron is equal to :

(a) h

(b) $\frac{h}{c}$

(c) $\frac{2h}{c}$

(d) $\frac{h}{2c}$

11. Light of frequency $6{\cdot}4 \times 10^{14}$ Hz is incident on a metal of work function $2{\cdot}14$ eV. The maximum kinetic energy of the emitted electrons is about :

(a) 0·25 eV

(b) 0·51 eV

(c) 1·02 eV

(d) 0·10 eV

12. The ratio of maximum frequency and minimum frequency of light emitted in Balmer series of hydrogen spectrum, in Bohr's model is :

(a) $\frac{11}{9}$

(b) $\frac{9}{5}$

(c) $\frac{11}{7}$

(d) $\frac{16}{7}$

13. At a certain temperature in an intrinsic semiconductor, the electrons and holes concentration is $1{\cdot}5 \times 10^{16}$ m^{-3}. When it is doped with a trivalent dopant, hole concentration increases to $4{\cdot}5 \times 10^{22}$ m^{-3}. In the doped semiconductor, the concentration of electrons (n_e) will be :

(a) 3×10^{6} m^{-3}

(b) 5×10^{7} m^{-3}

(c) 5×10^{9} m^{-3}

(d) $6{\cdot}75 \times 10^{38}$ m^{-3}

14. If a p-n junction diode is reverse biased,

(a) the potential barrier is lowered.

(b) the potential barrier remains unaffected.

(c) the potential barrier is raised.

(d) the current is mainly due to majority carriers.

15. A voltage signal is described by :

$$v = V_0 \quad \text{for } 0 \le t \le \frac{T}{2}$$

$$= 0 \quad \text{for } \frac{T}{2} \le t \le T$$

for a cycle. Its rms value is :

(a) $\dfrac{V_0}{\sqrt{2}}$

(b) V_0

(c) $\dfrac{V_0}{2}$

(d) $\sqrt{2}\ V_0$

*Questions number **16** to **18** are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (a), (b), (c) and (d) as given below.*

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is ***not*** the correct explanation of the Assertion (A).

(c) Assertion (A) is true, but Reason (R) is false.

(d) Assertion (A) is false and Reason (R) is also false.

16. *Assertion (A) :* The internal resistance of a cell is constant.

Reason (R) : Ionic concentration of the electrolyte remains same during use of a cell.

17. *Assertion (A) :* When radius of a circular loop carrying a steady current is doubled, its magnetic moment becomes four times.

Reason (R): The magnetic moment of a circular loop carrying a steady current is proportional to the area of the loop.

18. *Assertion (A):* The nucleus ${}_{3}^{7}X$ is more stable than the nucleus ${}_{3}^{4}Y$.

Reason (R): ${}_{3}^{7}X$ contains more number of protons.

SECTION B

19. A wire of length l is in the form of a circular loop A of one turn. This loop is reshaped into loop B of three turns. Find the ratio of the magnetic fields at the centres of loop A and loop B for the same current through them. *2*

20. What is meant by the term 'displacement current' ? Briefly explain how this current is different from a conduction current. *2*

21. (a) State Huygens' principle. How did Huygens explain the absence of the backwave ? *2*

OR

(b) Use Huygens' principle to show reflection/refraction of a plane wave by (i) concave mirror, and (ii) a convex lens. *2*

22. The refractive indices of two media A and B are 2 and $\sqrt{2}$ respectively. What is the critical angle for their interface ? *2*

23. (a) Draw a graph showing the variation of binding energy per nucleon as a function of mass number A. The binding energy per nucleon for heavy nuclei (A > 170) decreases with the increase in mass number. Explain. *2*

OR

(b) Using Bohr's postulates, obtain the expression for radius of n^{th} stable orbit in a hydrogen atom. *2*

24. Explain the roles of diffusion current and drift current in the formation of the depletion layer in a p-n junction diode. *2*

25. Explain the property of a p-n junction which makes it suitable for rectifying alternating voltages. Differentiate between a half-wave and a full-wave rectifier. *2*

SECTION C

26. A potential difference V is applied across a conductor of length l and uniform cross-section area A. How will the (i) electric field E, (ii) drift velocity v_d, and (iii) current density j be affected when (a) V is doubled and (b) l is halved (keeping other factors constant) ? *3*

27. What is meant by the term 'mutual inductance' of a pair of coils ? Obtain an expression for the mutual inductance of two long coaxial solenoids, each of length l but having different number of turns N_1 and N_2 and radii r_1 and r_2 ($r_2 > r_1$). *3*

28. (a) An ac source $v = v_m \sin \omega t$ is connected across an ideal capacitor. Derive the expression for the (i) current flowing in the circuit, and (ii) reactance of the capacitor. Plot a graph of current i versus ωt. *3*

OR

(b) A series combination of an inductor L, a capacitor C and a resistor R is connected across an ac source of voltage in a circuit. Obtain an expression for the average power consumed by the circuit. Find power factor for (i) purely inductive circuit, and (ii) purely resistive circuit. *3*

29. Calculate the wavelength of de Broglie waves associated with a proton having $\left(\frac{500}{1 \cdot 673}\right)$ eV energy. How will the wavelength be affected for an alpha particle having the same energy ? *3*

30. (a) (i) Prove that the nuclear density is same for all nuclei.

(ii) Draw a plot of potential energy of a pair of nucleons as a function of their separation. Draw two inferences from this plot. *3*

OR

(b) (i) Draw a graph to show the variation of the number of scattered particles detected (N) in Geiger-Marsden experiment as a function of scattering angle (θ).

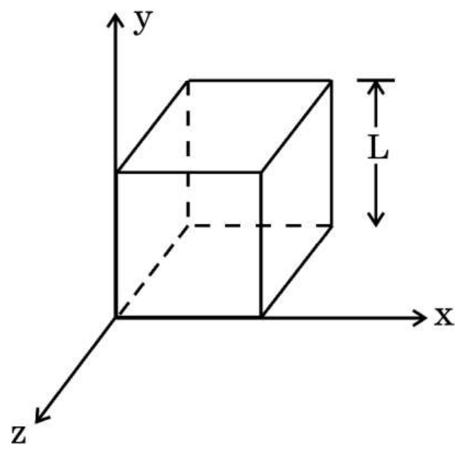
(ii) Discuss briefly two conclusions that can be drawn from this graph and how they lead to the discovery of nucleus in an atom. *3*

SECTION D

31. (a) (i) Define electric flux and write its SI unit.

(ii) Use Gauss' law to obtain the expression for the electric field due to a uniformly charged infinite plane sheet.

(iii) A cube of side L is kept in space, as shown in the figure. An electric field $\vec{E} = (Ax + B)\,\hat{i}\,\frac{N}{C}$ exists in the region. Find the net charge enclosed by the cube. *5*



OR

(b) (i) Define electric potential at a point and write its SI unit.

(ii) Two capacitors are connected in series. Derive an expression of the equivalent capacitance of the combination.

(iii) Two point charges + q and – q are located at points (3a, 0) and (0, 4a) respectively in x-y plane. A third charge Q is kept at the origin. Find the value of Q, in terms of q and a, so that the electrostatic potential energy of the system is zero. *5*

32. (a) (i) Write the principle and explain the working of a moving coil galvanometer. A galvanometer as such cannot be used to measure the current in a circuit. Why ?

(ii) Why is the magnetic field made radial in a moving coil galvanometer ? How is it achieved ? *5*

OR

(b) (i) Derive an expression for magnetic field on the axis of a current carrying circular loop.

(ii) Write any two points of difference between a diamagnetic and a paramagnetic substance. *5*

33. (a) (i) Draw a ray diagram showing the formation of a real image of an object placed at a distance 'u' in front of a concave mirror of radius of curvature 'R'. Hence, obtain the relation for the image distance 'v' in terms of u and R.

(ii) A 1·8 m tall person stands in front of a convex lens of focal length 1 m, at a distance of 5 m. Find the position and height of the image formed. *5*

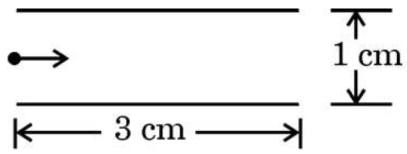
OR

(b) (i) Draw a ray diagram showing refraction of a ray of light through a triangular glass prism. Hence, obtain the relation for the refractive index (μ) in terms of angle of prism (A) and angle of minimum deviation (δ_m).

(ii) The radii of curvature of the two surfaces of a concave lens are 20 cm each. Find the refractive index of the material of the lens if its power is – 5·0 D. *5*

SECTION E

34. A beam of electrons moving horizontally with a velocity of 3×10^7 m/s enters a region between two plates as shown in the figure. A suitable potential difference is applied across the plates such that the electron beam just strikes the edge of the lower plate.



Answer the following questions based on the above :

(a) How long does an electron take to strike the edge ? *1*

(b) What is the shape of the path followed by the electron and why ? *1*

(c) Find the potential difference applied. *2*

OR

(c) Find the magnitude and direction of the magnetic field which should be created in the space between the plates so that the electron beam goes straight undeviated. *2*

35. Diffraction of light is bending of light around the corners of an object whose size is comparable with the wavelength of light. Diffraction actually defines the limits of ray optics. This limit for optical instruments is set by the wavelength of light. An experimental arrangement is set up to observe the diffraction pattern due to a single slit.

Answer the following questions based on the above :

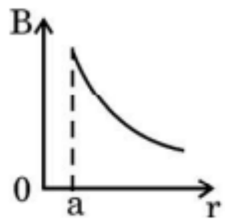
(a) How will the width of central maximum be affected if the wavelength of light is increased ? *1*

(b) Under what condition is the first minimum obtained ? *1*

(c) Write two points of difference between interference and diffraction patterns. *2*

OR

(c) Two students are separated by a 7 m partition wall in a room 10 m high. If both light and sound waves can bend around obstacles, how is it that the students are unable to see each other even though they can converse easily ? *2*

MARKING SCHEME: PHYSICS(042)			
Code: 55/3/1			
Q.No.	**VALUE POINTS/EXPECTED ANSWERS**	**Marks**	**Total Marks**
	SECTION A		
1.	(b) $-(1.0\times10^{3}\frac{N}{C})\hat{i}$	1	1
2.	(a) Electric Field	1	1
3.	(d) nev_d	1	1
4.	(c) 	1	1
5.	(d) a helix with increasing pitch.	1	1
6.	(b) inductor decreases and the capacitor increases	1	1
7.	(d) ultraviolet	1	1
8.	(c) $I \propto A^2$	1	1
9.	(b) twice	1	1
10.	(a) h	1	1
11.	(b) 0.51eV	1	1
12.	(b) $\frac{9}{5}$	1	1
13.	(c) $5 \times 10^9\ m^{-3}$	1	1
14.	(c) the potential barrier is raised	1	1
15.	(a) $\frac{V_o}{\sqrt{2}}$	1	1
16.	(d) Assertion (A) is false and Reason (R) is also false.	1	1
17.	(a) Both Assertion(A) and Reason (R) are true and Reason(R) is the correct explanation of the Assertion (A)	1	1
18.	(c) Assertion (A) is true, but Reason (R) is false	1	1

	SECTION B		
19.	Ratio of magnetic fields at the centres of loop A & loop B 2 $B = \frac{\mu_o NI}{2r}$ $l = 2\pi r$; $2\pi r_A = 3(2\pi r_B)$ $r_B = \frac{r_A}{3}$ $\frac{B_A}{B_B} = \frac{\mu_o N_A I}{2r_A} \text{X} \frac{2r_B}{\mu_0 N_B I}$ $\frac{B_A}{B_B} = \frac{1}{9}$	½ ½ ½ ½	2
20.	Definition of Displacement Current 1 Difference 1 Displacement current: It is the current that arises due to the rate of change of electric field/flux. **Alternatively:-** $I_d = \varepsilon_0 \left(\frac{d\phi_E}{dt} \right)$ **Alternatively:** The term with units of current to explain the continuity of current in a region. **Difference:** Displacement current is due to change in electric flux. Conduction current is due to flow of electrons. **Alternatively:** $I_d = \varepsilon_0 \left(\frac{d\phi_E}{dt} \right)$ $I_c = \frac{dq}{dt}$	1 1	2
21.	(a) Statement of Huygen's Principle 1 Explanation 1 Statement: Each point of the wavefront is the source of secondary disturbance in all directions.	 ½	

Common tangent to all the secondary wavelets gives new position of the wavefront. ½

Explanation: Light energy cannot travel in backward direction. 1

Alternatively:

It was an adhoc assumption .

Alternatively:

For back wave: $I = \frac{1}{2}(1 + \cos\theta)$

at $\theta = 180^o$; contribution is zero.

Alternatively:

Amplitude of secondary wavelets is maximum in forward direction and zero in backward in direction.

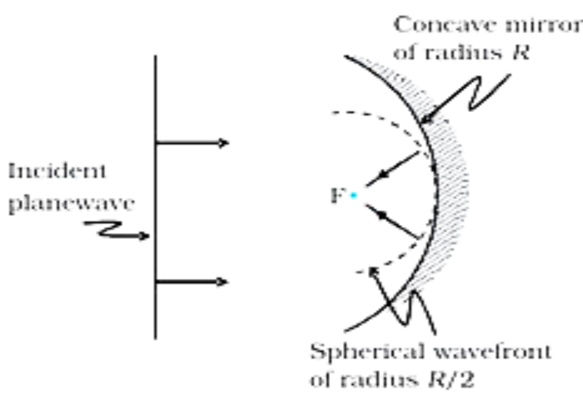
Note: If any other relevant explanation given, give full credit.

OR

(b)

(i)	Diagram for concave mirror	1
(ii)	Diagram for convex lens	1

(i)



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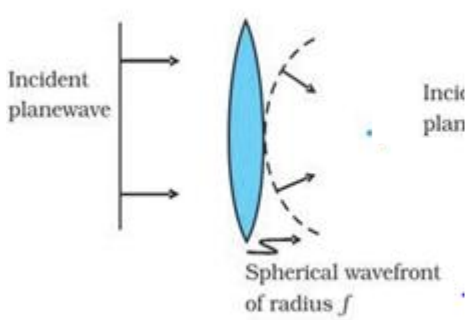
(ii)



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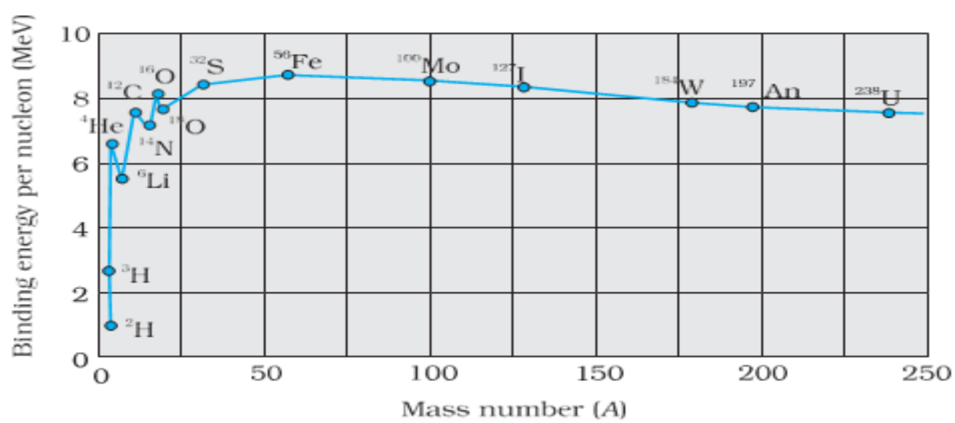
2

22.	Calculation of critical angle 2		
	From Snell 's law:-		
	$\mu_A \sin i_c = \mu_B \text{Sin}\, 90°$	½	
	$2 \times \sin i_c = \sqrt{2} \times 1$	½	
	$\sin i_c = \frac{1}{\sqrt{2}}$	½	
	$i_c = 45°$	½	
	Alternatively:		
	$\sin i_c = \frac{1}{{}^{B}\mu_A}$	1	
	$\sin i_c = \frac{1}{\sqrt{2}}$	½	
	$i_c = 45^o$	½	2
23.	(a)		
	Graph of binding energy per nucleon as a function of mass number A 1 Explanation 1		
		1	
	Explanation:-Nuclear forces are short range & show saturation, while the electrostatic force are neither short range nor show any saturation. Hence for heavier nuclei (A>170) the electrostatic force of repulsion becomes predominant, decreasing the binding energy per nucleon.	1	
	Alternatively:-As the size of the nucleus increases, the nucleus becomes unstable.		
	Note: No deduction of marks if values of elements are not shown in the graph.		

	OR (b) Expression for radius of the n^{th} orbit in a hydrogen atom 2 $\frac{mv^2}{r_n} = \frac{kq^2}{{r_n}^2} = \frac{e^2}{4\pi \in_o r_n^2}$ -----(1) $mvr_n = \frac{nh}{2\pi}$ -----(2) Using equation (1) &(2) $r_n = \frac{n^2 h^2 4\pi\varepsilon_o}{m(2\pi)^2 e^2}$ = 0.53 x $10^{-10} n^2$ m	½ ½ 1	2
24.	Roles of diffusion current and drift current 1+1 During the formation of p-n junction ,and due to the concentration gradient across p-,and n-sides, holes diffuse from p-side to n-side ($p \rightarrow n$) and electrons diffuse from n-side to p-side($n \rightarrow p$).When an electron diffuses from ($n \rightarrow p$), it leaves behind an ionized donor(positive charge) on n-side which is immobile. Similarly, when a hole diffuses from ($p \rightarrow n$) due to the concentration gradient, it leaves behind an ionised acceptor (negative charge) which is immobile. This space–charge region on either side of the junction together is known as depletion region. As a result, an electric field is developed across the junction. Due to this field, an electron on p-side of the junction moves to n-side and a hole on n-side of the junction moves to p-side. The motion of charge carriers due to the electric field is called drift .Initially, diffusion current is large and drift current is small. As the diffusion process continues, the electric field strength & hence drift current increases .This process continues till diffusion & drift current becomes equal.	1 1	2

25.	Explanation of property 1 Difference between half wave and full wave rectifier. 1 pn-junction conducts in forward bias. **Alternatively:-**pn-junction is a uni-directional device. The half-wave rectifier gives output only for half of the input cycle .The full-wave rectifier gives output for both the halves of the input cycles. **Alternatively:-**If output waveform of both the rectifiers shown diagrammatically, then full credit to be given.	1 1	2
	SECTION C		
26.	(a) When V is doubled, effect on (i) Electric field ½ (ii) Drift velocity ½ (iii) Current density ½ (b) When l is halved, effect on (i) Electric field ½ (ii) Drift velocity ½ (iii) Current density ½ (a) When V is doubled, (i) Electric field is doubled. (ii) Drift velocity is doubled. (iii) Current density is doubled (b) When l is halved, (i) Electric field is doubled. (ii) Drift velocity is doubled. (iii) Current density is doubled **Alternatively:** (i) $E = \frac{V}{l}$; $\therefore E' = 2E$	 ½ ½ ½ ½ ½ ½	

(ii) $v_d = \left(\frac{eE}{m}\right)\tau = \frac{e\tau}{m}\left(\frac{V}{l}\right)$

$v_d \ \alpha \ V$; $v'_d = 2v_d$

(iii) Current density $J = \frac{I}{A} = \frac{V}{RA}$

$\therefore$ J is also doubled.

(a) When l is halved

(i) $E = \frac{V}{l}$; $\therefore E' = 2E$

(ii) $v_d = \left(\frac{eE}{m}\right)\tau = \frac{e}{m}\left(\frac{V}{l}\right)\tau$

$\therefore v'_d = 2v_d$

(iii) $J = \frac{I}{A} = \frac{V}{RA} = \frac{V}{A}\left(\frac{A}{\rho l}\right) = \frac{V}{\rho l}$

$\therefore$ J is also doubled.

3

27.

Definition /Meaning of Mutual Inductance	1
Expression for Mutual Inductance	2

Mutual Inductance-It is the magnetic flux in the secondary coil due to the flow of unit current in the primary coil. 1

Alternatively:

It is the emf induced in the secondary coil when rate of change of current in the primary coil is unity.

Expression for Mutual Inductance

Let N_1 and N_2 be the total number of turns of coils S_1 &S_2, respectively.

When a current I_2 is set up through S_2, it in turn sets up a magnetic flux through $S_1 \Rightarrow N_1\phi_1 = M_{12}I_2$ ---------(1) ½

M_{12} is the mutual inductance of solenoid S_1 w.r.t. S_2.

Magnetic field due to I_2 in S_2 $= \mu_o(\frac{N_2}{l})I_2$ ½

$N_1\phi_1 = (N_1)(\pi r_1^2)(\mu_o \frac{N_2}{l} I_2)$ ---------(2) ½

From equation (1) & equation (2)

$M_{12} = \frac{\mu_o N_1 N_2 \pi r_1^2}{l}$ ½

3

28.

(a)

(i) Expression for current	1
(ii) Reactance of the capacitor	1
Graph of i versus ωt	1

(i) $V_m \text{ Sin } \omega t = \frac{q}{C}$

$I = \frac{dq}{dt} = \frac{d}{dt}(CV_m \sin \omega t)$ ½

$I = \omega C V_m c\text{os}\, \omega t$ ½

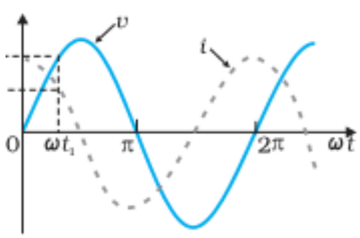
Alternatively:-

$I = \frac{V_m}{1/\omega C} \cos \omega t = I_m \sin(\omega t + \pi/2)$

(ii) $I = \frac{V_m}{1/\omega C} \sin(\omega t + \pi/2) = I_m \sin(\omega t + \pi/2)$

Comparing with $I_m = \frac{V_m}{1/\omega C}$

Reactance of the capacitor; $X_c = \frac{1}{\omega C}$ 1



1

OR

(b)

Expression for average power consumed	2
Power Factor for	
(i) Purely Inductive circuit	½
(ii) Purely Resistive Circuit	½

	Instantaneous Power;		
	$P = VI = (V_m \sin\omega t) \times I_m \sin(\omega t + \phi)$	½	
	$P = \frac{V_m I_m}{2} \left[\cos\phi - \cos(2\omega t + \phi)\right]$ ----(1)	½	
	The average power over a cycle is given by the average of the two terms in the R.H.S of equation (1). It is only the second term which is time dependent .Its average is zero (the positive half of the cosine cancels the negative half). Therefore,	½	
	$P_{avg} = \frac{V_m I_m}{2} \cos\phi = \frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}} \cos\phi$ $P_{avg} = V_{rms} I_{rms} \cos\phi$	½	
	Alternatively:- If the expression is deduced using integration, then full credit to be given.		
	(i) Power factor for purely inductive circuit, $\phi = \frac{\pi}{2} \Rightarrow \cos\phi = 0$		
	(ii) Power factor for purely resistive circuit; $\phi = 0 \Rightarrow \cos\phi = 1$	½	
		½	3
29.	Calculation of wavelength 2 Effect on wavelength 1		
	$\lambda = \frac{h}{\sqrt{2mK}}$	½	
	$K = \left(\frac{500}{1.673}\right) eV$		
	$= \frac{500 \text{ x } 1.6 \text{ x } 10^{-19}}{1.673} J$	½	
	$\lambda_p = \frac{6.63 \text{ x } 10^{-34}}{\sqrt{2 \text{ x } 1.673 \text{ x } 10^{-27} \text{ x } \left(\frac{500 \text{ x } 1.6 \text{ x } 10^{-19}}{1.673}\right)}}$	½	
	$= 1.65 \text{ x } 10^{-12} m$	½	
	$\lambda \alpha \frac{1}{\sqrt{m}}$	½	

For α particle; $m_\alpha = 4m_p$

$$\Rightarrow \lambda_\alpha = \frac{\lambda_p}{2}$$ ½

3

30.

(a)

(i) Prove that nuclear density is constant	1
(ii) Graph between potential energy & separation	1
Two Inferences	½ + ½

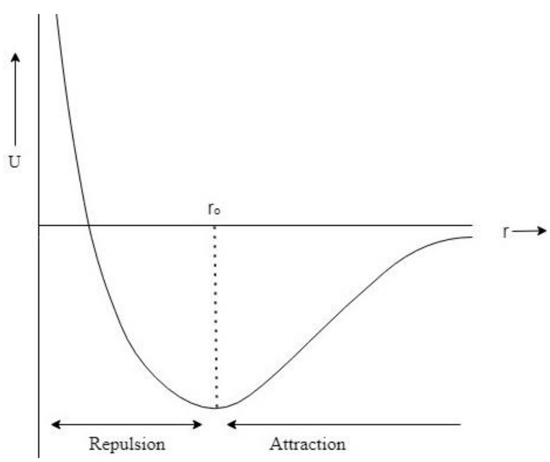
(i) $\rho = \frac{mass}{volume}$

$$= \frac{\text{mass number} \times \text{mass of nucleon}}{volume\ of\ nucleus}$$ ½

$$\rho = \frac{A \times \text{m}}{\frac{4}{3}\pi\left(R_0 A^{1/3}\right)^3} = \frac{3m}{4\pi R_o^3}$$ ½

Hence, density is independent of mass number.

(ii)



1

Inferences

-The force is attractive for distances larger than $r_{o.}$ ½

- The force is repulsive for distance less than $r_{o.}$ ½

Alternatively:-

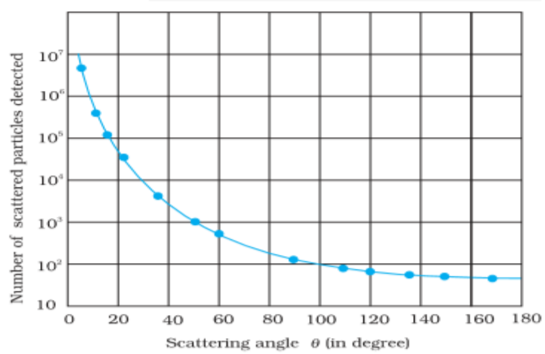
Any other relevant inference drawn from the graph should be given full credit.

OR

(b)

(i) Graph to show the variation of the number of scattered particles as a function of scattering angle.	1
(ii) Two conclusions	½ + ½
Discovery of nucleus	1

(i) 1



(ii)- The entire positive charge and most of the mass of the atom are concentrated in a small space. ½

-Many of the α-particles pass through the foil. It means that they do not suffer any collisions. ½

To deflect the α-particle backwards, a large repulsive force is required, which is provided only if the greater part of the mass of the atom & its positive charge were concentrated tightly at its centre. This lead to the discovery of the nucleus in the atom. 1

3

SECTION D

31.

(a)

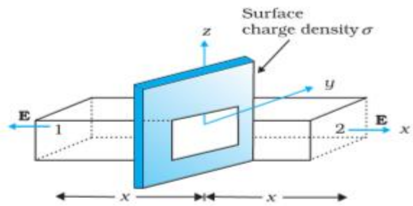
(i) Definition & SI Unit of Electric Flux	½+ ½
(ii) Deriving the expression for electric field due to a uniformly charged infinite plane sheet.	2
(iii) Net charge enclosed by the cube	2

(i) $\phi = \vec{E}.\vec{A}$ ½

Alternatively: Electric flux is the number of electric field lines passing through an area normally.

S.I. unit of electric flux Nm^2/C or V-m. ½

(ii)



½

From Gauss's law:- $\phi = \oint \vec{E} \,.\, \vec{dA} = \frac{q}{\varepsilon_o}$ ½

$2EA = \frac{\sigma A}{\varepsilon_o}$ ½

$E = \frac{\sigma}{2\varepsilon_o}$ ½

Alternatively: If the shape of the Gaussian surface is taken cylindrical, full credit to be given.

(iii)

$\phi_L = Eds\cos 180^o = -Eds$ ½

$= -BL^2$

$\phi_R = Eds\cos 0^0 = Eds$ ½

$= (AL + B)L^2 = AL^3 + BL^2$

Net flux $= \phi_L + \phi_R$

$= (AL^3 + BL^2) - BL^2$ ½

Net flux $= AL^3 = \frac{q}{\epsilon_o}$

$\Rightarrow q = AL^3 \epsilon_o$ ½

OR

(b)

(i) Definitions & S.I. Unit of electric potential	½ + ½
(ii) Derivation of expression of Equivalent capacitance	2
(iii) Calculation of Electrostatic Potential Energy	2

(i) Electrical Potential – Electrostatic potential at any point in a region with electrostatic field is the work done in bringing a unit positive charge (without acceleration) from infinity to that point. ½

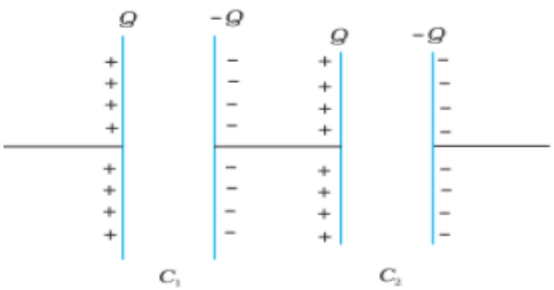
Alternatively:-

$$V = \frac{Work\ Done}{q}$$

$$V = -\int \vec{E} \cdot \vec{dl}$$

S.I. unit of electrostatic potential is volt. ½

Alternatively:-
S.I. unit is J/C.



½

$$V = V_1 + V_2 = \frac{Q}{C_1} + \frac{Q}{C_2}$$ ½

$$\frac{Q}{Ceq.} = Q\left(\frac{1}{C_1} + \frac{1}{C_2}\right)$$ ½

$$\frac{1}{Ceq.} = \frac{1}{C_1} + \frac{1}{C_2}$$ ½

(iii)

Potential energy of the system = $K\left[\frac{Q(-q)}{4a} + \frac{Qq}{3a} - \frac{q^2}{5a}\right]$ ½

Potential energy of the system = 0

$$\Rightarrow K\left[\frac{-Qq}{4a} + \frac{Qq}{3a} - \frac{q^2}{5a}\right] = 0$$ ½

$$\Rightarrow \frac{-Q}{4} + \frac{Q}{3} - \frac{q}{5} = 0$$

$$\Rightarrow +\frac{Q}{12} - \frac{q}{5} = 0$$

$$\Rightarrow Q = +\frac{12q}{5}$$ 1

5

15

32. (a)

(i) For a moving coil galvanometer	
Principle	1
Working	1
Reason it cannot be used as such	1
(ii) Reason for radial field	1
How radial field is achieved	1

(i) Principle – When a rectangular loop carrying current I is placed in a uniform magnetic field, it experiences a torque. 1

Working:-

When a current flows through the coil of a galvanometer, a torque acts on it.

$\tau = NiAB\sin\theta$

For radial magnetic field; $\sin\theta = 1$

The spring provides a counter or restoring toqrue $k\phi$.

$$k\phi = NiAB$$

In equilibrium; $\phi = \left(\frac{NAB}{k}\right)i$ 1

Galvanometer cannot be used as such to measure current because:

-It has large resistance and hence will change the value of current in the circuit. 1

-It is a sensitive device.

(Any one of the above)

(ii) The magnetic field is made radial in a moving coil galvanometer so that the magnetic dipole moment $(\vec{m})$ is always perpendicular to the magnetic field $(\vec{B})$ Hence, $\sin\theta = 1$ always 1

Alternatively: The magnetic field is made radial in a moving coil galvanometer to make the scale linear.

It is achieved by using curved magnetic poles.

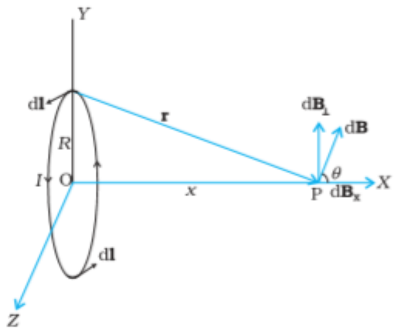
Alternatively:-By using soft iron cylindrical core. 1

OR

(b)

(i) Derivation of expression for magnetic field on the axis of a current carrying loop.	3
(ii) Two differences between diamagnetic and paramagnetic substance.	1+1

(i)



½

$$dB = \frac{\mu_0}{4\pi}\frac{I|d\mathbf{l}\times\mathbf{r}|}{r^3}$$ ½

$$= \frac{\mu_o i dl \sin 90^o}{4\pi\left(x^2+R^2\right)}$$ ½

$dB_\perp$ cancels out.

Net B = $\int dB_x = \int dB\cos\theta$ ½

$$= \frac{\mu_o}{4\pi}\int\frac{idl}{\left(x^2+R^2\right)}\times\frac{R}{\left(x^2+R^2\right)^{1/2}}$$

$$= \frac{\mu_o iR}{4\pi\left(x^2+R^2\right)^{3/2}}\int dl$$

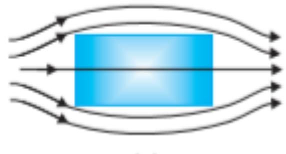
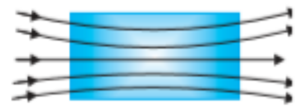
$$= \frac{\mu_o iR}{4\pi\left(x^2+R^2\right)^{3/2}}(2\pi R)$$ ½

$$\mathbf{B} = B_x\hat{\mathbf{i}} = \frac{\mu_0 I R^2}{2\left(x^2+R^2\right)^{3/2}}\hat{\mathbf{i}}$$ ½

(ii) Differences

Diamagnetic Materials	Paramagnetic Materials
(i) Susceptibility is between -1 and 0.	(i) Susceptibility is a small positive number.(slightly greater than zero.)
(ii) Relative permeability is between 0 and 1.	(ii) Relative permeability is slightly greater than 1.
(iii) $\mu < \mu_o$	(iii) $\mu > \mu_o$
(iv) Tendency to move from stronger to weaker part of external magnetism.	(iv) Tendency to move from region of weak to strong magnetic field.
(v) is repelled by a magnet.	(v) is weakly attracted by a magnet.
(vi) Field inside the material is reduced.	(vi) Field inside is slightly enhanced.

1+1

(vii)	(vii)
	

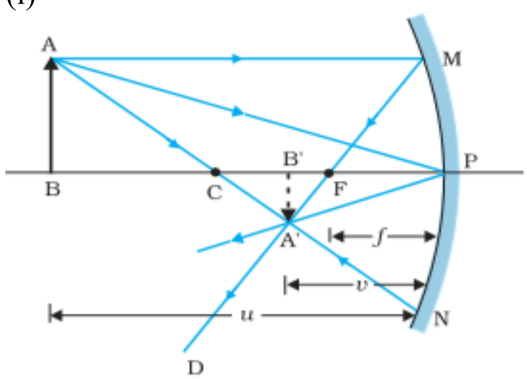
Any two of the above mentioned differences. 5

33.

(a)

(i) Ray diagram showing formation of real image in a concave mirror.	1
Obtaining the relation between u,v and R	2
(ii) Position of image formed	1
Height of image formed	1

(i)



1

From Fig. the two right-angled triangles A′B′F and MPF are similar. (For paraxial rays, MP can be considered to be a straight line perpendicular to CP.) Therefore,

$$\frac{B'A'}{PM} = \frac{B'F}{FP}$$

$$\text{or } \frac{B'A'}{BA} = \frac{B'F}{FP} \quad (\because PM = AB) \qquad \text{-----(i)}$$ ½

Since ∠ APB = ∠ A′PB′, the right angled triangles A′B′P and ABP are also similar. Therefore,

$$\frac{B'A'}{BA} = \frac{B'P}{BP} \qquad \text{-----(ii)}$$ ½

Comparing equations (i) and (ii)

$$\frac{B'F}{FP} = \frac{B'P - FP}{FP} = \frac{B'P}{BP} \qquad \text{-----(iii)}$$ ½

B′ P = – v, FP = – f, BP = – u;

Using these in Eq.(iii) we get $\frac{1}{v} + \frac{1}{u} = \frac{1}{f} = \frac{2}{R}$ ½

Alternatively:- If the result derived by any other method, full credit to be given.

(ii) For lens: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ ½

$u = -5m; \quad f = +1m$

$\frac{1}{v} - \frac{1}{-5} = \frac{1}{(+1)}$

$\Rightarrow v = \frac{5}{4}m = 1.25m$ ½

$m = \frac{I}{O} = \frac{v}{u} = \frac{\left(+\frac{5}{4}\right)}{(-5)}$ ½

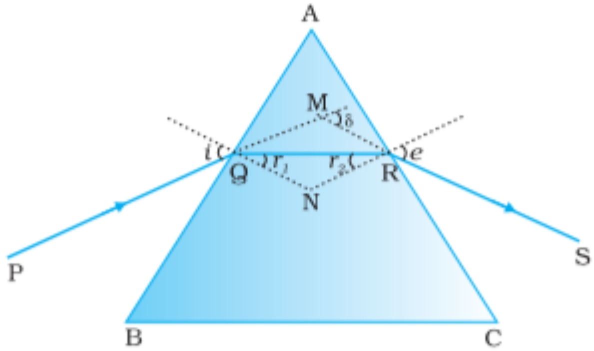
I = (- 0.25) × (1.8)
I = - 0.45 m ½

OR

(b)

(i) Ray diagram showing refraction of a ray of light through a rectangular glass prism.	1
Obtaining the relation between $\mu, A \& \delta_m$	2
(ii) Finding Refractive Index of material of the lens.	2

(i)

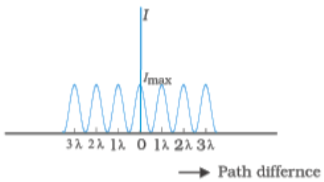
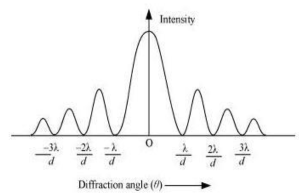


1

	In the quadrilateral AQNR, two of the angles (at the vertices Q and R) are right angles. Therefore, the sum of the other angles of the quadrilateral is 180º. $\angle A + \angle QNR = 180^o$ From the triangle QNR, $r_1 + r_2 + \angle QNR = 180^o$ Comparing these two equations, we get $r_1 + r_2 = A$ -------(i) The total deviation δ is the sum of deviations at the two faces, $\delta = (i - r_1) + (e - r_2)$ that is, $\delta = i + e - A$ -------(ii) When $\delta = \delta_m$; $i = e$ & $r_1 = r_2$ From (i); 2r = A or r = A/2 From (ii); $\delta_m = 2i - A$ or $i = \frac{A+\delta_m}{2}$ $\mu = \frac{\sin i}{\sin r} = \frac{\sin(\frac{A+\delta_m}{2})}{\sin A/2}$ (ii) Given; P = - 5D f (in cm) $= \frac{100}{(-5)} = -20$ cm Using Lens Maker's formula ; $\frac{1}{f} = (\mu-1)[\frac{1}{R_1} - \frac{1}{R_2}]$ $\frac{1}{(-20)} = (\mu-1)[\frac{1}{(-20)} - \frac{1}{(+20)}]$ $\frac{1}{(-20)} = (\mu-1)[-\frac{1}{10}]$; $\mu - 1 = \frac{1}{2}$ $\Rightarrow \mu = \frac{3}{2} = 1.5$	½ ½ ½ ½ ½ ½ ½ ½	5
	SECTION E		
34.	(a) Time taken by the electron to strike the edge. 1 (b) Shape of path followed by the electron and it's reason ½+ ½ (c) Potential Difference applied 2 OR (c) Magnitude and Direction of magnetic field 1+1 (a) Electron strikes the edge after travelling 3 cm horizontally (along x-axis). $S_x = v_x \times t$ $3 \times 10^{-2} = (3 \times 10^7) \times t$ $t = 10^{-9}$ s	 ½ ½	

	(b) Shape of the path is parabola. Reason: Force/acceleration is in a fixed direction perpendicular to the initial velocity.	½ ½	
	(c) Along y-direction $S_y = u_y t + \frac{1}{2} a_y t^2$ $-0.5 \times 10^{-2} = 0 + \frac{1}{2} a_y (10^{-9})^2$ $a_y = -10^{16}$ m/s^2	½	
	Magnitude of acceleration $(a_y) = \frac{eE}{m} = \frac{e}{m}\left(\frac{V}{l}\right)$	½	
	$V = \frac{10^{16} \times 9.1 \times 10^{-31} \times 1 \times 10^{-2}}{1.6 \times 10^{-19}}$	½	
	$V = 568.75$ V	½	
	OR		
	(c) $\lvert qE \rvert = \lvert qvB \rvert$; $B = \frac{E}{v} = (\frac{m a_y}{e})(\frac{1}{v})$	½	
	Along y-direction $S_y = u_y t + \frac{1}{2} a_y t^2$ $-0.5 \times 10^{-2} = 0 + \frac{1}{2} a_y (10^{-9})^2$ $a_y = -10^{16}$ m/s^2	½	
	$B = \left(\frac{9.1 \times 10^{-31} \times 10^{16}}{1.6 \times 10^{-19}}\right) \times \left(\frac{1}{3 \times 10^7}\right)$ $B = 1.9 \times 10^{-3} T$	½	
	Direction of magnetic field will be out of the plane of the paper.	½	
			4
35.	(a) Effect on width of central maximum — 1 (b) Condition for first minimum — 1 (c) Differences between interference and diffraction patterns — 2 OR Reason — 2		
	(a) $\beta_o \ \alpha \ \lambda$ β_o will increase with increase in wavelength.	1 1	
	(b) When path difference $a\theta = \lambda$ or at an angle ; $\theta \approx \lambda / a$		

(c) Differences

Interference Pattern	Diffraction Pattern
(i) All the maxima are equally spaced. (ii)The dark fringe is having zero intensity. (iii) All the maxima are of the same intensity. (iv)  **Alternatively:-** -It is obtained by the superposition of two waves originating from two sources/slits.	(i) Width of Central bright maxima is twice the width of the other maxima. (ii) The dark fringe is not completely dark. (iii) There is a sharp decrease in the intensity of maxima after the central bright maxima. (iv)  It is obtained by the superposition of waves from points on a single slit.

1+1

Any two of the above differences.

OR

(c) The opening (slit) is 3m; which is of the order of the wavelength of sound waves whereas it is very large compare to the wavelength of light.
Hence, sound can bend around the obstacle while light cannot.

2

4

General Instructions :

Read the following instructions very carefully and strictly follow them :

*(i) This question paper contains **35** questions. **All** questions are **compulsory**.*

*(ii) This question paper is divided into **five** Sections – **A, B, C, D** and **E**.*

*(iii) In **Section A** – Questions no. **1** to **18** are Multiple Choice (MCQ) type questions, carrying **1** mark each.*

*(iv) In **Section B** – Questions no. **19** to **25** are Very Short Answer (VSA) type questions, carrying **2** marks each.*

*(v) In **Section C** – Questions no. **26** to **30** are Short Answer (SA) type questions, carrying **3** marks each.*

*(vi) In **Section D** – Questions no. **31** to **33** are Long Answer (LA) type questions carrying **5** marks each.*

*(vii) In **Section E** – Questions no. **34** and **35** are case-based questions carrying **4** marks each.*

(viii) There is no overall choice. However, an internal choice has been provided in 2 questions in Section B, 2 questions in Section C, 3 questions in Section D and 2 questions in Section E.

*(ix) Use of calculators is **not** allowed.*

Use the following values of physical constants, if required :

$c = 3 \times 10^{8}$ m/s

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8{\cdot}854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^{9}$ N m^2 C^{-2}

Mass of electron (m_e) = $9{\cdot}1 \times 10^{-31}$ kg

Mass of neutron = $1{\cdot}675 \times 10^{-27}$ kg

Mass of proton = $1{\cdot}673 \times 10^{-27}$ kg

Avogadro's number = $6{\cdot}023 \times 10^{23}$ per gram mole

Boltzmann constant = $1{\cdot}38 \times 10^{-23}$ JK^{-1}

SECTION A

1. Two charges q_1 and q_2 are placed at the centres of two spherical conducting shells of radius r_1 and r_2 respectively. The shells are arranged such that their centres are d [> $(r_1 + r_2)$] distance apart. The force on q_2 due to q_1 is :

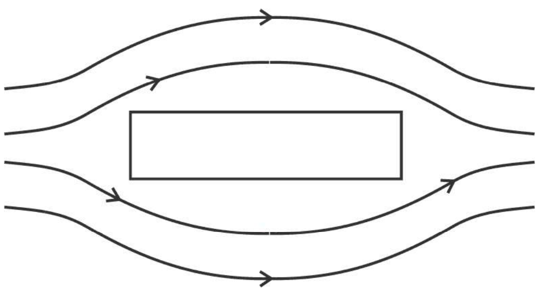
(a) $\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{d^2}$ (b) $\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{(d-r_1)^2}$

(c) Zero (d) $\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{[d-(r_1+r_2)]^2}$

2. An electron enters a uniform magnetic field with speed v. It describes a semicircular path and comes out of the field. The final speed of the electron is :

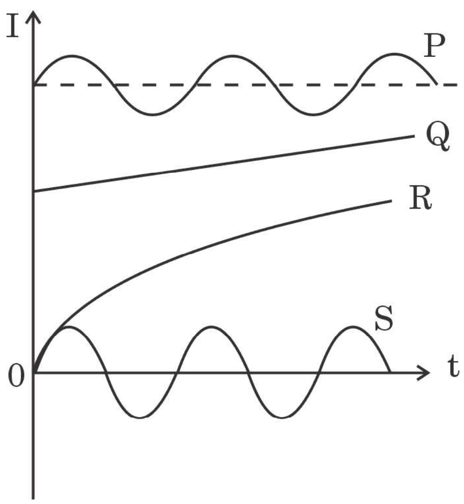
(a) Zero (b) v (c) $\frac{v}{2}$ (d) 2v

3. The magnetic field lines near a substance are as shown in the figure. The substance is :



(a) Copper (b) Iron (c) Sodium (d) Aluminium

4. The figure shows variation of current (I) with time (t) in four devices P, Q, R and S. The device in which an alternating current flows is :



(a) P (b) Q (c) R (d) S

5. The electromagnetic waves used in radar systems are :

(a) Infrared waves (b) Ultraviolet rays

(c) Microwaves (d) X-rays

6. In a Young's double-slit experiment, the fringe width is found to be β. If the entire apparatus is immersed in a liquid of refractive index μ, the new fringe width will be :

(a) β (b) $\mu\beta$ (c) $\frac{\beta}{\mu}$ (d) $\frac{\beta}{\mu^2}$

7. Photons of energy 3·2 eV are incident on a photosensitive surface. If the stopping potential for the emitted electrons is 1·5 V, the work function for the surface is :

(a) 1·5 eV (b) 1·7 eV (c) 3·2 eV (d) 4·7 eV

8. Which of the following statements is ***not*** true for nuclear forces ?

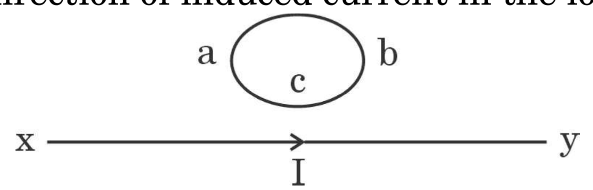
(a) They are stronger than Coulomb forces.

(b) They have about the same magnitude for different pairs of nucleons.

(c) They are always attractive.

(d) They saturate as the separation between two nucleons increases.

9. The direction of induced current in the loop abc is :



(a) along abc if I decreases

(b) along acb if I increases

(c) along abc if I is constant

(d) along abc if I increases

10. An ac voltage $v = v_0 \sin \omega t$ is applied to a series combination of a resistor R and an element X. The instantaneous current in the circuit is $I = I_0 \sin (\omega t + \frac{\pi}{4})$. Then which of the following is correct ?

(a) X is a capacitor and $X_C = \sqrt{2}\ R$

(b) X is an inductor and $X_L = R$

(c) X is an inductor and $X_L = \sqrt{2}\ R$

(d) X is a capacitor and $X_C = R$

11. A plane wavefront is incident on a concave mirror of radius of curvature R. The radius of the refracted wavefront will be :

(a) 2R (b) R (c) $\frac{R}{2}$ (d) $\frac{R}{4}$

12. A proton and an alpha particle have the same kinetic energy. The ratio of de Broglie wavelengths associated with the proton to that with the alpha particle is :

(a) 1 (b) 2 (c) $2\sqrt{2}$ (d) $\frac{1}{2}$

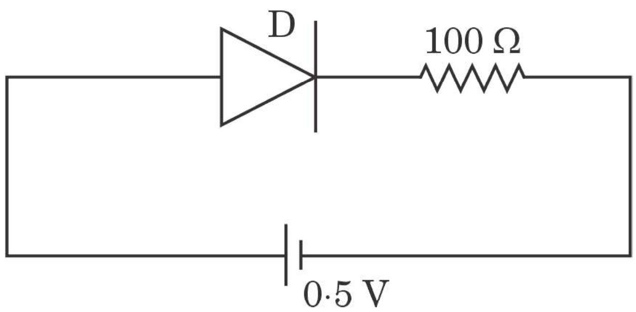
13. The potential energy of an electron in the second excited state in hydrogen atom is :

(a) – 3·4 eV (b) – 3·02 eV (c) – 1·51 eV (d) – 6·8 eV

14. The difference in mass of ^7X nucleus and total mass of its constituent nucleons is 21·00 u. The binding energy per nucleon for this nucleus is equal to the energy equivalent of :

(a) 3 u (b) 3·5 u (c) 7 u (d) 21 u

15. The threshold voltage for a p-n junction diode used in the circuit is 0·7 V. The type of biasing and current in the circuit are :



(a) Forward biasing, 0 A (b) Reverse biasing, 0 A

(c) Forward biasing, 5 mA (d) Reverse biasing, 2 mA

*Questions number **16** to **18** are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (a), (b), (c) and (d) as given below.*

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is ***not*** the correct explanation of the Assertion (A).

(c) Assertion (A) is true, but Reason (R) is false.

(d) Assertion (A) is false and Reason (R) is also false.

16. *Assertion (A) :* When three electric bulbs of power 200 W, 100 W and 50 W are connected in series to a source, the power consumed by the 50 W bulb is maximum.

Reason (R) : In a series circuit, current is the same through each bulb, but the potential difference across each bulb is different.

17. *Assertion (A) :* A current carrying square loop made of a wire of length L is placed in a magnetic field. It experiences a torque which is greater than the torque on a circular loop made of the same wire carrying the same current in the same magnetic field.

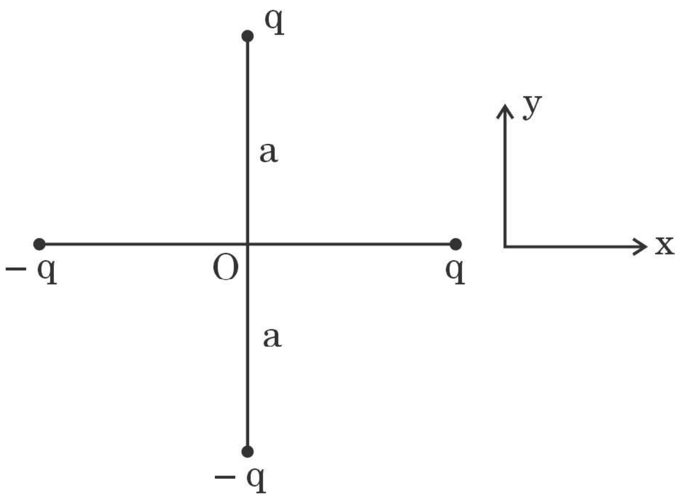
Reason (R) : A square loop occupies more area than a circular loop, both made of wire of the same length.

18. *Assertion (A) :* In 'n' type semiconductor, number density of electrons is greater than the number density of holes but the crystal maintains an overall charge neutrality.

Reason (R) : The charge of electrons donated by donor atoms is just equal and opposite to that of the ionised donor.

SECTION B

19. Two identical dipoles are arranged in x-y plane as shown in the figure. Find the magnitude and the direction of net electric field at the origin O. *2*



20. Write two differences between the emf and terminal potential difference of a cell. What is the most important precaution that one should take while drawing current from a cell ? *2*

21. A small magnetised needle P is placed at the origin of x-y plane with its magnetic moment pointing along the y-axis. Another identical magnetised needle Q is placed in two positions, one by one.

Case 1 : at (a, 0) with its magnetic moment pointing along x-axis.
Case 2 : at (0, a) with its magnetic moment pointing along y-axis.

(a) In which case is the potential energy of P and Q minimum ?

(b) In which case is P and Q not in equilibrium ?

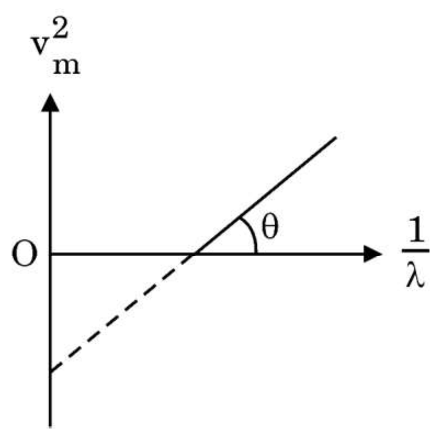
Justify your answers. *2*

22. (a) What is a displacement current ? How is it different from a conduction current ? *2*

OR

(b) Write any two characteristics of an electromagnetic wave. Why are microwaves used in radar systems ? *2*

23. The figure shows v_m^2 versus $\frac{1}{\lambda}$ graph for photoelectrons emitted from a surface where v_m is the maximum speed of electrons and λ is the wavelength of incident radiation. Using this graph and Einstein's photoelectric equation, obtain the expression for Planck's constant and work function of the surface. *2*



24. Draw the graph showing the variation of binding energy per nucleon with mass number A of nuclei ($2 < A < 170$). Use this graph to explain the release of energy in nuclear fission. *2*

25. (a) Obtain an expression for electrostatic potential energy of a system of three charges q, 2q and –3q placed at the vertices of an equilateral triangle of side a. *2*

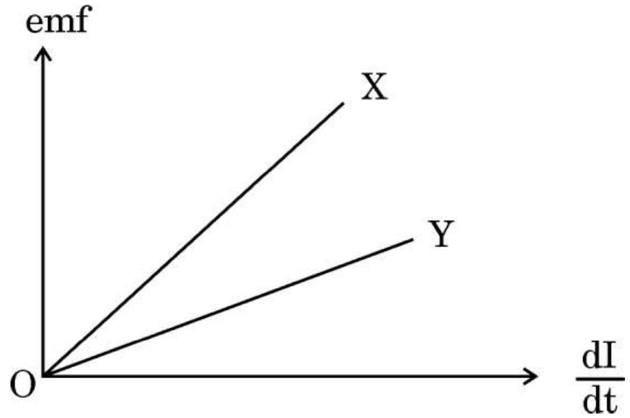
OR

(b) Two small conducting balls A and B of radius r_1 and r_2 have charges q_1 and q_2 respectively. They are connected by a wire. Obtain the expression for charges on A and B, in equilibrium. *2*

SECTION C

26. Two circular loops A and B, each of radius 3 m, are placed coaxially at a distance of 4 m. They carry currents of 3 A and 2 A in opposite directions respectively. Find the net magnetic field at the centre of loop A. *3*

27. (a) The figure shows the variation of induced emf as a function of rate of change of current for two identical solenoids X and Y. One is air cored and the other is iron cored. Which one of them is iron cored ? Why ?



(b) Obtain an expression for self-inductance of a long solenoid of length L and cross-sectional area A having N turns. *3*

28. (a) A resistor of 30 Ω and a capacitor of $\frac{250}{\pi}$ μF are connected in series to a 200 V, 50 Hz ac source. Calculate (i) the current in the circuit, and (ii) voltage drops across the resistor and the capacitor. (iii) Is the algebraic sum of these voltages more than the source voltage ? If yes, solve the paradox. *3*

OR

(b) A series LCR circuit with R = 20 Ω, L = 2 H and C = 50 μF is connected to a 200 volts ac source of variable frequency. What is (i) the amplitude of the current, and (ii) the average power transferred to the circuit in one complete cycle, at resonance ? (iii) Calculate the potential drop across the capacitor. *3*

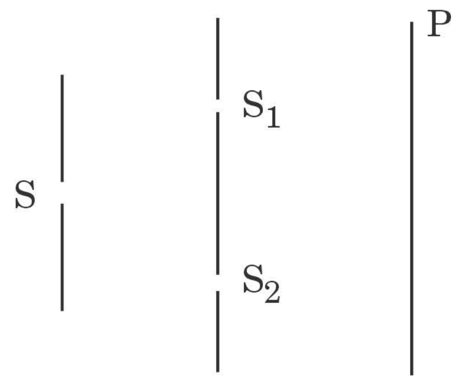
29. (a) (i) In diffraction due to a single slit, the phase difference between light waves reaching a point on the screen is 5π. Explain whether a bright or a dark fringe will be formed at the point.

(ii) What should the width (a) of each slit be to obtain eight maxima of two double-slit patterns (slit separation d) within the central maximum of the single slit pattern ?

(iii) Draw the plot of intensity distribution in a diffraction pattern due to a single slit. *3*

OR

(b) (i) In a Young's double-slit experiment $SS_2 - SS_1 = \frac{\lambda}{4}$, where S_1 and S_2 are the two slits as shown in the figure. Find the path difference $(S_2P - S_1P)$ for constructive and destructive interference at P.



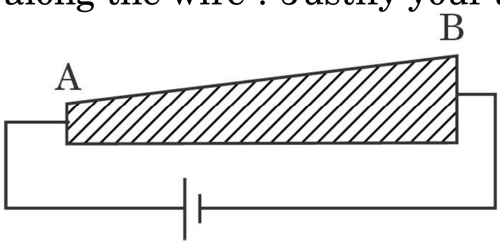
(ii) What is the effect on the interference fringes in a Young's double-slit experiment, if the monochromatic source S is replaced by a source of white light ? *3*

30. Briefly explain Geiger-Marsden experiment. Show the variation of the number of particles scattered (N) with scattering angle (θ) in this experiment. What is the main conclusion that can be inferred from this plot ? *3*

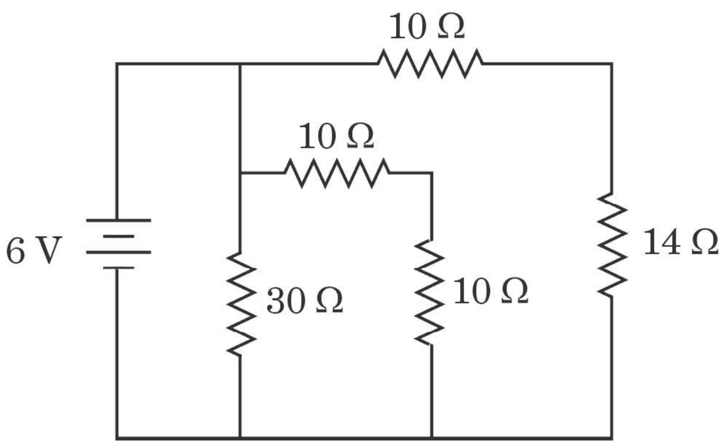
SECTION D

31. (a) (i) Define mobility of electrons. Give its SI units.

(ii) A steady current flows through a wire AB, as shown in the figure. What happens to the electric field and the drift velocity along the wire ? Justify your answer.



(iii) Consider the circuit shown in the figure. Find the effective resistance of the circuit and the current drawn from the battery. *5*

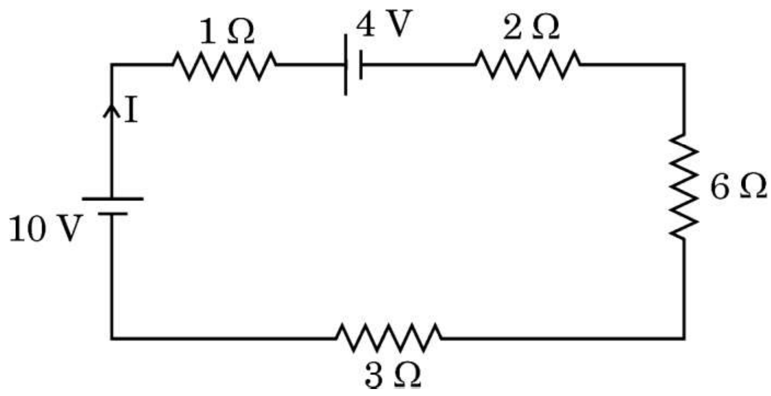


OR

(b) (i) Define electrical conductivity of a wire. Give its SI unit.

(ii) High current is to be drawn safely from (1) a low-voltage battery, and (2) a high-voltage battery. What can you say about the internal resistance of the two batteries ?

(iii) Calculate the total energy supplied by the batteries to the circuit shown in the figure, in one minute. *5*



32. (a) (i) Draw a ray diagram to show how the final image is formed at infinity in an astronomical refracting telescope. Obtain an expression for its magnifying power.

(ii) Two thin lenses L_1 and L_2, L_1 being a convex lens of focal length 24 cm and L_2 a concave lens of focal length 18 cm are placed coaxially at a separation of 45 cm. A 1 cm tall object is placed in front of the lens L_1 at a distance of 36 cm. Find the location and height of the image formed by the combination. *5*

OR

(b) (i) Explain the working principle of an optical fibre with the help of a diagram. Mention one use of a light pipe.

(ii) A ray of light is incident at an angle of 60° on one face of a prism with the prism angle A = 60°. The ray passes symmetrically through the prism. Find the angle of minimum deviation (δ_m) and refractive index of the material of the prism. If the prism is immersed in water, how will δ_m be affected ? Justify your answer. *5*

33. (a) (i) A germanium crystal is doped with antimony. With the help of energy-band diagram, explain how the conductivity of the doped crystal is affected.

(ii) Briefly explain the two processes involved in the formation of a p-n junction.

(iii) What will the effect of (1) forward biasing, and (2) reverse biasing be on the width of depletion layer in a p-n junction diode ? *5*

OR

(b) (i) With the help of a circuit diagram, briefly explain the working of a full-wave rectifier using p-n junction diodes.

(ii) Draw V – I characteristics of a p-n junction diode. Explain how these characteristics make a diode suitable for rectification.

(iii) Carbon and silicon have the same lattice structure. Then why is carbon an insulator but silicon a semiconductor ? *5*

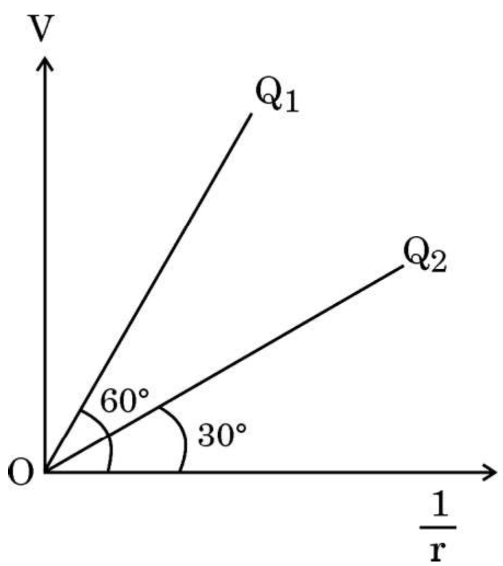
SECTION E

34. Electrostatics deals with the study of forces, fields and potentials arising from static charges. Force and electric field, due to a point charge is basically determined by Coulomb's law. For symmetric charge configurations, Gauss's law, which is also based on Coulomb's law, helps us to find the electric field. A charge/a system of charges like a dipole experience a force/torque in an electric field. Work is required to be done to provide a specific orientation to a dipole with respect to an electric field.

Answer the following questions based on the above :

(a) Consider a uniformly charged thin conducting shell of radius R. Plot a graph showing the variation of $|\vec{E}|$ with distance r from the centre, for points $0 \le r \le 3R$. *1*

(b) The figure shows the variation of potential V with $\frac{1}{r}$ for two point charges Q_1 and Q_2, where V is the potential at a distance r due to a point charge. Find $\frac{Q_1}{Q_2}$. *1*



(c) An electric dipole of dipole moment of 6×10^{-7} C-m is kept in a uniform electric field of 10^4 N/C such that the dipole moment and the electric field are parallel. Calculate the potential energy of the dipole. *2*

OR

(c) An electric dipole of dipole moment $\vec{p}$ is initially kept in a uniform electric field $\vec{E}$ such that $\vec{p}$ is perpendicular to $\vec{E}$. Find the amount of work done in rotating the dipole to a position at which $\vec{p}$ becomes antiparallel to $\vec{E}$. *2*

35. The lens maker's formula is useful to design lenses of desired focal lengths using surfaces of suitable radii of curvature. The focal length also depends on the refractive index of the material of the lens and the surrounding medium. The refractive index depends on the wavelength of the light used. The power of a lens is related to its focal length.

Answer the following questions based on the above :

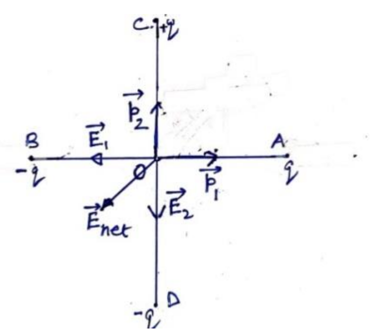
(a) How will the power of a lens be affected with an increase of wavelength of light ? *1*

(b) The radius of curvature of two surfaces of a convex lens is R each. For what value of μ of its material will its focal length become equal to R ? *1*

(c) The focal length of a concave lens of $\mu = 1{\cdot}5$ is 20 cm in air. It is completely immersed in water of $\mu = \frac{4}{3}$. Calculate its focal length in water. *2*

OR

(c) An object is placed in front of a lens which forms its erect image of magnification 3. The power of the lens is 5 D. Calculate the distance of the object and the image from the lens. *2*

MARKING SCHEME: PHYSICS(042)			
Code:55/4/1			
Q.No.	**VALUE POINTS/EXPECTED ANSWERS** **SECTION - A**	**Marks**	**Total Marks**
Q1.	(c) zero	1	**1**
Q2.	(b) ν	1	**1**
Q3.	(a) Copper	1	**1**
Q4.	(d) S	1	**1**
Q5.	(c) Microwaves	1	**1**
Q6.	(c) $\frac{\beta}{\mu}$	1	**1**
Q7.	(b) 1.7 eV	1	**1**
Q8.	(c) They are always attractive	1	**1**
Q9.	(d) along abc if I increases	1	**1**
Q10.	(d) X is capacitor and X_c= R	1	**1**
Q11.	(c) $\frac{R}{2}$ **for students who have opted to answer the question in Hindi medium only.** **English medium students-**There is misprint in the English version of the question as the word '**reflected**' appear as '**refracted**'. **Therefore full mark to be awarded to each student who have opted to answer the question in English medium.**	1	**1**
Q12.	(b) 2	1	**1**
Q13.	(b) – 3.02 eV	1	**1**
Q14.	(a) 3u	1	**1**
Q15.	(a) Forward biasing, 0 A	1	**1**
Q16.	(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).	1	**1**
Q17.	(d) Assertion (A) is false and Reason (R) is also false.	1	**1**
Q18.	(a) Both Assertion (A) and Reason (R) are true, and Reason (R) is the correct explanation of the Assertion (A). **SECTION -B**	1	**1**
Q19.	Finding the magnitude of electric field 1 ½ Finding direction of net Electric field ½ 		

Dipole moment due to dipole BA is $\overrightarrow{p_1}$ & dipole moment due to dipole DC is $\overrightarrow{p_2}$.

Electric field $\vec{E_1}$ due to $\overrightarrow{p_1}$ is along OB.

Electric field $\overrightarrow{E_2}$ due to $\overrightarrow{p_2}$ is along OD. ½

Magnitude of resultant Electric field

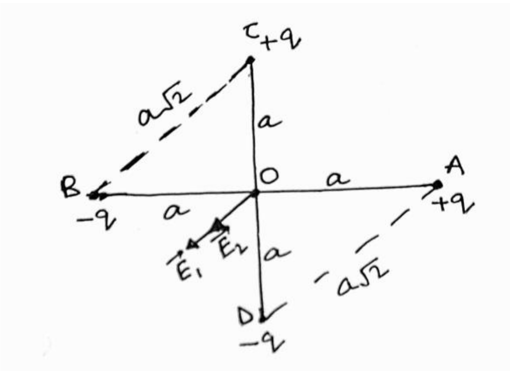
$$\left|\overrightarrow{E_{net}}\right| = 2\sqrt{2}E$$ ½

Since $\left|\overrightarrow{E_1}\right| = \left|\overrightarrow{E_2}\right| = E = \dfrac{1}{4\pi \in_0}.\dfrac{q}{a^2}$

$$\vec{E}_{net} = \frac{1}{4\pi \in_0}.\frac{2\sqrt{2}\ q}{a^2}$$ ½

Direction of $\overrightarrow{E_{net}}$ is 225° to x-axis. ½

Alternatively:



Considering CB as dipole, electric field at O

$$E_1 = \frac{2kq\times(a/\sqrt{2})}{\left[\left(\frac{a}{\sqrt{2}}\right)^2 + \left(\frac{a}{\sqrt{2}}\right)^2\right]^{3/2}}$$

$$E_1 = \frac{\sqrt{2}kq\times a}{a^3\left(\frac{1}{2}+\frac{1}{2}\right)^{3/2}}$$

$$E_1 = \frac{\sqrt{2}kq}{a^2}$$ ½

Similarly considering AD as another dipole, electric field at O

$$E_2 = \frac{2kq\times(a/\sqrt{2})}{\left[\left(\frac{a}{\sqrt{2}}\right)^2 + \left(\frac{a}{\sqrt{2}}\right)^2\right]^{3/2}}$$

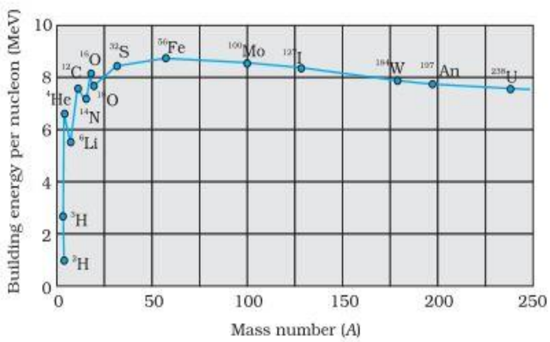
	$E_2 = \dfrac{\sqrt{2}kq \times a}{a^3\left(\dfrac{1}{2}+\dfrac{1}{2}\right)^{3/2}}$ $E_2 = \dfrac{\sqrt{2}kq}{a^2}$ $E_{net} = E_1 + E_2$ $= \dfrac{\sqrt{2}kq}{a^2} + \dfrac{\sqrt{2}kq}{a^2}$ $= \dfrac{2\sqrt{2}kq}{a^2}$ Direction of $\overrightarrow{E_{net}}$ is 225° to x-axis.	½ ½ ½	2
Q20.	Two differences ½+ ½ Important precaution 1 **Two differences** 1. The potential difference across the electrodes in open circuit is e.m.f. (ε) and in closed circuit is terminal potential difference (V). 2. V depends on r and ε is independent of r. **Precaution-** 1. Some external resistance should be connected to cell in series. 2. Short circuiting should be avoided.	½ ½ 1	2
Q21.	(a) Identification of case and justification ½ + ½ (b) Identification of case and justification ½ + ½ (a) Potential energy is minimum in case 2, since Q is placed along the direction of P / stable equilibrium. (b) P and Q are not in equilibrium in case 1. In this case Q is at the normal bisector of P /not in equilibrium. **Alternatively**: (a) Since U = - MB cos θ and θ = 0° so P.E. is minimum. (b) Case 1, not in equilibrium, since τ = MB sin θ and θ = 90°, τ = MB. **OR** (b) Since two needles are perpendicular they experience torque.	½+½ ½+½ ½+½ ½+½ ½+½	2
Q22.	(a) Definition of displacement current 1 Difference with conduction current 1 Displacement current is the current produced due to changing electric	1	

	field/ electric flux in a region. **Alternatively** $i_d = \in_0 \dfrac{d\phi_E}{dt} \quad \& \ I = \dfrac{dq}{dt}$ **Difference**: Current carried by a conductor due to flow of charges is called conduction current. Displacement current is not due to flow of charges but due to changing electric field/electric flux. **OR** (b) Two characteristics ½+½ Reason for using microwave 1 **Any two characteristics:** 1) No medium is required for their propagation. 2) Transverse in nature. 3) Consist of Electric and Magnetic field perpendicular to each other. 4) Energy is equally shared by electrical and magnetic field. 5) Travel with speed of light in vacuum. **Reason:** Short wavelength, do not diffract/ unidirectional property.	1 ½ + ½ 1	**2**
Q23.	Einstein Photoelectric equation ½ Identification of expression for slope and intercept ½ Expression for Planck's constant ½ Expression for work function ½ $\frac{1}{2}mv_m^2 = \frac{hc}{\lambda} - \phi_0$ $v_m^2 = \left(\frac{2hc}{m}\right)\frac{1}{\lambda} - \frac{2}{m}\phi_0$ According to this equation a plot of v_m^2 versus (1/λ) is a straight line. Slope of the graph = $\frac{2hc}{m}$ Intercept = $\frac{2}{m}\phi_0$ Slope and intercept can be found from the graph h = $\frac{m}{2c}$ × slope $\phi_0 = \frac{m}{2}$ × intercept	½ ½ ½ ½	**2**

Q24.

Graph of Binding Energy per nucleon versus mass number (A)	1
Explanation for release of energy in nuclear fission	1

Graph :



1

Note: Full marks to be awarded even if values are not marked.

Explanation: A very heavy nucleus has lower binding energy per nucleon compared to that of lighter nuclei. Thus if a heavier nucleus breaks into two nuclei, nucleons get more tightly bound. This implies, energy would be released in the process. 1

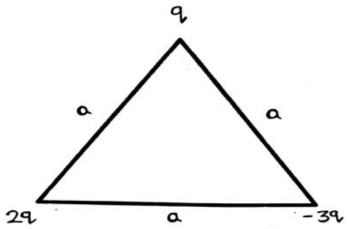
Alternatively
In nuclear fission, a heavy nucleus breaks B.E/nucleon increases. So energy is released. 1

2

Q25.

(a)

Obtaining expression for electric potential energy of the system	2



OR a similar diagram with different order of charges

$$U = \frac{1}{4\pi \in_0} \cdot \frac{q_1 q_2}{r}$$ ½

$$U = \frac{1}{4\pi \in_0}\left[\frac{2q^2}{a} - \frac{6q^2}{a} - \frac{3q^2}{a}\right]$$ 1

$$U = \frac{1}{4\pi \in_0}\frac{\left(-7q^2\right)}{a}$$ ½

OR

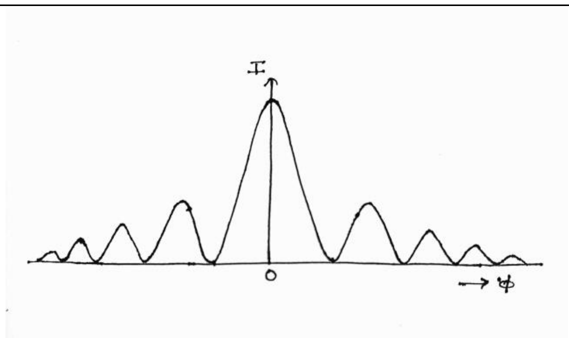
(b)

Relation between initial and final charges on balls A and B	½
Equality of potential on two balls after they are connected	½
Expression for final charge on A	½
Expression for final charge on B	½

	According to law of conservation of charge $q_i = q_f$ $q_1 + q_2 = q_1' + q_2' = Q$ When two balls are connected with wire $V_1 = V_2$ $\frac{kq_1'}{r_1} = \frac{kq_2'}{r_2}$ or $\frac{q_1'}{r_1} = \frac{q_2'}{r_2}$ $q_1' r_2 = q_2' r_1$ $q_1' r_2 = (Q - q_1') r_1$ $q_1' r_2 = Q r_1 - q_1' r_1$ $q_1'(r_1 + r_2) = Q r_1$ $q_1' = \frac{Q r_1}{r_1 + r_2} = \frac{(q_1 + q_2) r_1}{r_1 + r_2}$ $q_2' = Q - q_1'$ $= Q - \frac{Q r_1}{r_1 + r_2}$ $= \frac{Q r_2}{r_1 + r_2} = \frac{(q_1 + q_2) r_2}{r_1 + r_2}$ **Note: Give full credit if done by any other method.** **SECTION- C**	 ½ ½ ½ ½	 **2**
Q26.	Calculation of magnetic field due to loop A 1 Calculation of magnetic field due to loop B 1 Net magnetic field 1 $B_1 = \frac{\mu_0 I}{2r}$ $B_1 = \frac{4\pi \times 10^{-7} \times 3}{2 \times 3} = 2\pi \times 10^{-7} T = 6.28 \times 10^{-7} T$ $B_2 = \frac{\mu_0 I R^2}{2(R^2 + x^2)^{3/2}}$ $= \frac{2\pi \times 10^{-7} \times 2 \times 9}{(3^2 + 4^2)^{3/2}}$, opposite to B_1 $B_2 = \frac{36\pi \times 10^{-7}}{125} T = 0.9 \times 10^{-7} T$ $B_{net} = B_1 - B_2$ $= 6.28 \times 10^{-7} - 0.9 \times 10^{-7}$ $B_{net} = 5.38 \times 10^{-7} T$	 1 1 1	 **3**

Q27.	(a) Identification of core ½ Reason ½ (b) Derivation of expression for self-Inductance 2 (a) X is iron cored. **Reason**- From the graph- Slope of the graph $= \dfrac{\varepsilon}{\left\|dI/dt\right\|} = L$ Slope of X is more than that of Y. Hence X is iron cored because Inductance of iron cored coil is more than that of air cored coil. (b) Magnetic field due to solenoid (axis) $B = \dfrac{\mu_0 NI}{l}$ Magnetic flux through the solenoid $\phi_B = N\phi = \dfrac{\mu_0 N^2 A}{L} I$ Since self-inductance $= \dfrac{\phi_B}{I}$ $= \dfrac{\mu_0 N^2 A}{L}$	½ ½ ½ ½ ½ ½	**3**
Q28.	(a) (i) Calculation of current in the circuit 1 (ii) Calculation of voltage drop across C and R ½+½ (iii) Resolving the Paradox 1 $\because X_C = \dfrac{1}{\omega C}$ $\omega = 2\pi\upsilon = 100\pi$ $X_C = \dfrac{1}{100\pi \times 250/\pi \times 10^{-6}}$ $= 40\Omega$ Impedance of the circuit $Z = \sqrt{X_C^2 + R^2}$ $= \sqrt{(40)^2 + (30)^2} = 50\Omega$ (i) Current in the circuit $I_{rms} = \dfrac{V_{rms}}{Z} = \dfrac{200}{50} = 4\,A$ (ii) Voltage drops across the Capacitor, $V_C = I_{rms} X_C = 4 \times 40 = 160V$ Voltage drops across the Resistor, $V_R = I_{rms} \times R = 4 \times 30 = 120V$ (iii) The algebraic sum of the two voltages V_R and V_C is 280V, which	 1 ½ ½	

	is more than the source voltage of 200V. This paradox can be removed by considering impedance triangle because V_R and V_C are out of phase by 90°, therefore $V=\sqrt{V_R^2+V_C^2}=\sqrt{(120)^2+(160)^2}=\sqrt{14400+25600}=200V$ This is equal to the source voltage. **OR** (b) (i) Calculation of amplitude of the current at resonance 1 (ii) Calculation of average power at resonance 1 (iii) Calculation of potential drop across the capacitor 1 (i) At resonance, Z=R $I_{rms}=\frac{200}{20}=10A$ Amplitude of the current $I_0=\sqrt{2}\times I_{rms}$ $I_0= 1.414\times10= 14.14$ A (ii) Average power transferred to the circuit in one complete cycle at resonance $P=I_{rms}^2R=(10)^2\times20$ P = 2000 W (iii) Resonant frequency $\omega_r=\frac{1}{\sqrt{LC}}=\frac{1}{\sqrt{2\times50\times10^{-6}}}=100$ rad/s $X_C=\frac{1}{\omega_r C}=\frac{1}{100\times50\times10^{-6}}$ $V_c=I_{rms}X_C=10\times\frac{1}{100\times50\times10^{-6}}=2000\,V$	½ ½ ½ ½ ½ ½ ½ ½	 3
Q29.	(a) (i) Explanation 1 (ii) Calculation of width 1 (iii) Plot of Intensity distribution in a diffraction pattern 1 (i) For Bright fringe , $\phi=(2n+1)\pi=5\pi$ for n=2 **Alternatively**: $\Delta\phi=\frac{2\pi}{\lambda}\times\Delta x$ $\Delta x=\frac{5}{2}\lambda$ (ii) We want , aθ =λ, θ = λ/a $8\frac{\lambda}{d}=2\frac{\lambda}{a}\Rightarrow a=\frac{d}{4}$	 1 1	

(iii) 

1

OR

(b)

(i) Finding the path difference for constructive and destructive interference	2
(ii) Effect on interference fringes	1

(i) Net path difference between two waves reaching on the screen through two slits is given as

$$SS_2P - SS_1P = (SS_2 - SS_1) + (S_2P - S_1P)$$

$$\Delta x = \frac{\lambda}{4} + (S_2P - S_1P)$$

For constructive interference $\Delta x = n\lambda$ — 1

$$\therefore (S_2P - S_1P) = n\lambda - \frac{\lambda}{4} = \lambda\left(n - \tfrac{1}{4}\right)$$

For destructive interference

$$\Delta x = (2n-1)\frac{\lambda}{2}$$

$$\Delta x = \frac{\lambda}{4} + (S_2P - S_1P)$$ — 1

$$S_2P - S_1P = (2n-1)\frac{\lambda}{2} - \frac{\lambda}{4}$$

$$= \frac{\lambda}{4}[4n-3]$$

(ii) If monochromatic source is replaced by a source of white light the centre bright fringe is white. — 1

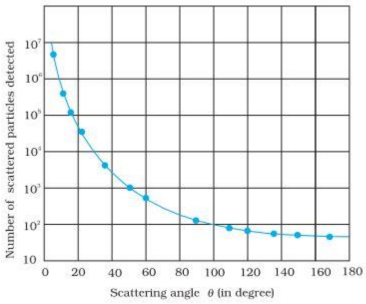
3

Q30.

Brief explanation of Geiger-Marsden Experiment	1
Graph	1
Conclusion from the graph	1

Alpha-particles emitted by a radioactive source were allowed to fall on a thin foil of gold .The scattered alpha-particles were observed through a rotatable detector consisting of zinc sulphide screen and a microscope. The scattered alpha-particles on striking the screen produced brief light flashes or scintillations. — 1

Note: **Give full credit of 1 mark if a student draws the labeled diagram of Geiger Marsden experiment.**



1

Note: Full marks to be given even if values are not marked.

Conclusion:
The existence of positively charged nucleus inside an atom and provide an upper limit to the size of the nucleus. 1 **3**

SECTION- D

Q31. (a)

(i) Definition & S.I. Unit	1+½
(ii) Change in Electric field and drift velocity along the wire	½+½
Justification	½+½
Effective resistance and current	1 ½

(i) Mobility: Mobility is defined as the magnitude of the drift velocity per unit electric field. 1

S.I. Unit: $\frac{m^2}{V.s}$ or $\frac{C.s}{kg}$ ½

(ii) Both electric field and the drift velocity decreases. ½ + ½

Justification:

$$v_d = \frac{I}{neA}$$

As area increases across the wire, drift velocity decreases. ½

$$v_d = \frac{eE}{m}\tau$$

As drift velocity decreases, electric field decreases (since e ,m and τ are constant). ½

(iii) From the diagram
10Ω and 14 Ω are in series R_1=10 Ω + 14 Ω = 24 Ω
10 Ω and 10 Ω are in series R_2=10 Ω+ 10 Ω = 20 Ω
24 Ω, 20 Ω and 30 Ω are in parallel.

$$\frac{1}{R} = \frac{1}{24} + \frac{1}{20} + \frac{1}{30} = \frac{5+6+4}{120} = \frac{15}{120}$$

R= 8 Ω ½

Electric current in the circuit

$$I = \frac{V}{R} = \frac{6}{8} = \frac{3}{4}A \qquad 1$$

Note: Full credit of 1 ½ marks is to be awarded for part (iii) even if a student does not attempt this part.

OR

(b)

(i) Definition & S.I. Unit	1½
(ii) Explanation of internal resistance for low voltage and high voltage battery	1+1
(iii) Total energy	1½

(i) Definition : Electrical conductivity is defined as the measure of a material's ability to carry a current through it. — 1

Alternatively: It is the reciprocal of the resistivity.

Alternatively: It is defined as the current density per unit electric field.

S.I. Unit: $(\text{ohm})^{-1}\text{-m}^{-1}$ or S-m^{-1} — ½

(ii) **Low voltage Battery-**

Internal resistance should be low. — 1

High voltage Battery –

Internal resistance should be high. — 1

(iii) Applying Kirchhoff's loop rule

$10 - I \times 1 - 4 - 2I - 6I - 3I = 0$ — ½

$12I = 6 \quad \Rightarrow I = 0.5\text{ A}$

Heat energy $H = I^2Rt$ — ½

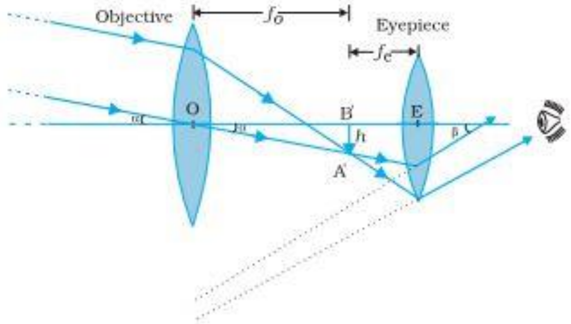
$H = 0.25 \times 12 \times 60 = 180J$ — ½

5

Q32. (a)

(i) Labelled ray diagram	1 ½
Derivation of expression for magnifying power	1 ½
(ii) Calculation of location and height of the image	2

(i)



1 ½

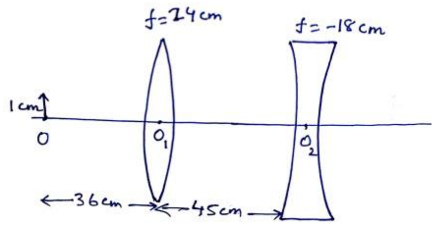
Note: **Deduct ½ mark, if the direction of propagation of light is not marked.**

From the diagram $\beta = \frac{h}{f_e}$ ½

and $\alpha = \frac{h}{f_o}$ ½

Magnifying Power $= \frac{f_O}{f_e}$ ½

(ii)



For lens L_1,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$ ½

$$\frac{1}{v} - \frac{1}{-36} = \frac{1}{24}$$

$$\frac{1}{v} = \frac{1}{24} - \frac{1}{36}$$

$$\frac{1}{v} = \frac{3-2}{72} = \frac{1}{72}$$

$$v = 72cm$$ ½

For lens L_2 :

$$\frac{1}{v'} - \frac{1}{u'} = \frac{1}{f'}$$

$$\frac{1}{v'} - \frac{1}{(72-45)} = \frac{1}{-18}$$

$$\frac{1}{v'} = \frac{1}{-18} + \frac{1}{27}$$

$$\frac{1}{v'} = \frac{-3+2}{54} = \frac{-1}{54}$$

$$v' = -54cm$$ ½

Final distance $v_1' = -54 - (-45)$

$v_1' = -9cm$ (to the left of convex lens)

Magnification $\frac{h_i}{h_o} = \frac{v_1'}{u}$

$$\frac{h_i}{1} = \frac{-9}{-36} \Rightarrow h_i = +\frac{1}{4}cm$$ ½

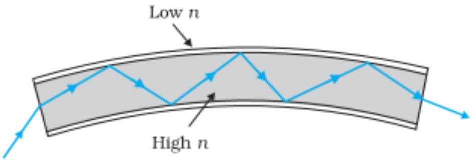
OR

(b)

(i)Working principle of an optical fibre with one use	2
(ii)Finding the angle of minimum deviation and refractive index	1+1
Effect of δ_m when the prism is immersed in water	1

(i) Working Principle:

Optical fibre uses the optical principle of total internal reflection to capture the light transmitted in an optical fibre and confine the light to the core of the fibre. **1**



½

Uses : Transmission of audio and video signal / Examination of internal organs / Endoscopy ½

(ii) $\delta_m = i + e - A$ ½

$\delta_m = 2i - A$

$\delta_m = 60^\circ$ ½

Refractive Index

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin A/2}$$ ½

$$\mu = \frac{\sin\frac{120^o}{2}}{\sin\frac{60^0}{2}}$$

$$\mu = \frac{\sin 60^0}{\sin 30^0} = \frac{\sqrt{3}/2}{1/2}$$

$$\mu = \sqrt{3}$$ ½

If the prism is immersed in water μ decreases and consequently angle of minimum deviation decreases. Since δ_m depends on μ through equation given above. 1

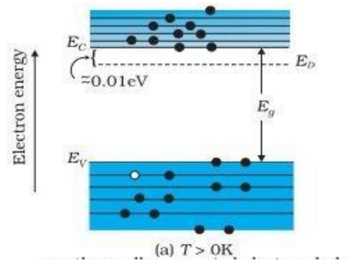
5

Q33.

(a)

(i) Explanation with band diagram	2
(ii) Brief explanation of the two processes	2
(iii) Effect on width of depletion layer	1

(i) With proper level of doping, the number of conduction electrons can be made much larger than the number of holes. Due to this conductivity of the doped crystal increases. 1



1

(ii)Two processes

(a) Diffusion (b) drift

Diffusion: Due to concentration gradient majority charge carrier that is electron moves from $n \rightarrow p$ side and holes to $p \rightarrow n$ side. This movement of charges is called diffusion. 1

Drift: Due to the junction field, an electron on p-side of the junction moves to n- side and a hole on n- side of the junction moves to p- side. The motion of the charge carrier due to electric field is called drift. 1

(iii) (1) decreases ½

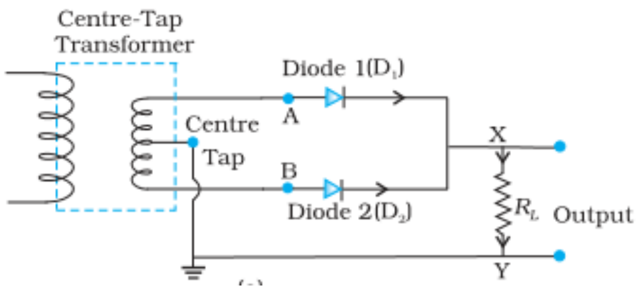
(2) increases ½

OR

(b)

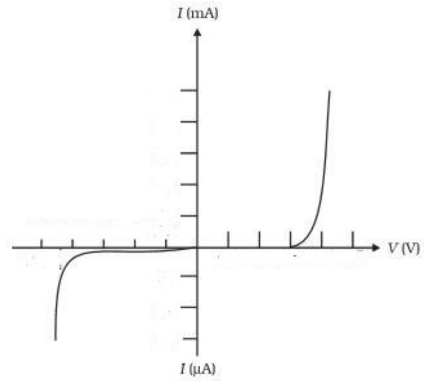
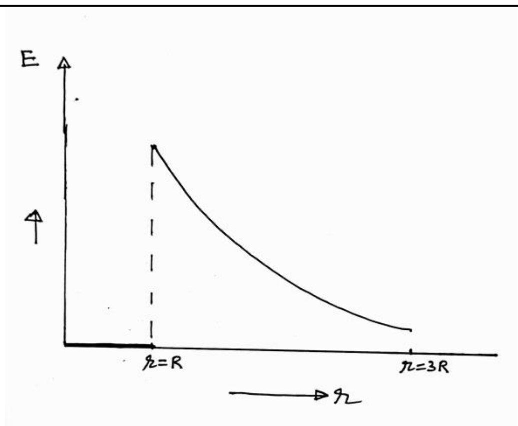
(i) Circuit diagram	1
Working	1
(ii) V-I characteristics	½+½
Explanation	1
(iii) Reason	1

(i)



1

Working: Suppose the input voltage to A with respect to the centre tap at any instant is positive. At that instant voltage at B, being out of phase will be negative. So diode D_1 gets forward biased and conducts, while D_2 being reverse biased does not conduct. Similarly during second half of the cycle polarity get reversed so only D_2 will conduct. 1

	(ii)V-I characteristics  This diagram shows that the diode conducts when forward biased and does not conduct when reverse biased. This characteristics makes it suitable for use for rectification. (iii)The 4 bonding of electrons of C and Si lie respectively, in the second and third orbit. Hence energy required to take out an electron from their atoms will be much less than that for C. Hence number of free e^- for conduction in Si significant but negligibly small for C. **SECTION - E**	½ + ½ 1 1	**5**
Q34.	(a) Graph — 1 (b) Finding the ratio Q_1/Q_2 — 1 (c) Calculation of potential energy — 2 OR Finding the work done — 2 (a)  (b) ∵ V= k Q/r Slope of graph is proportional to Q $\frac{Q_1}{Q_2} = \frac{\tan 60^0}{\tan 30^0} = 3$ (c) U= - p E cosθ $\theta = 0^0$ U= - $(6 \times 10^{-7}) \times (10^4)$ U= - 6×10^{-3} J **OR**	1 ½ ½ ½ ½ 1	

	$\because$ Work done $W = -pE(\cos\theta_2 - \cos\theta_1)$ where $\theta_2 = 180^\circ$, $\theta_1 = 90^\circ$ $\Rightarrow W = -pE(\cos 180^\circ - \cos 90^\circ)$ $W = +pE$	½ ½ ½ ½	4
Q35.	(a) Effect on Power 1 (b) Calculation of μ 1 (c) Calculation of focal length 2 OR Calculation of object distance and image distance 1+1 (a) $P = \frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ $\mu \propto \frac{1}{\lambda} \Rightarrow P \propto \frac{1}{\lambda}$ So P decreases as λ increases. (b) $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ $\frac{1}{R} = (\mu - 1)\frac{2}{R}$ $(R_1 = R, R_2 = -R)$ $\Rightarrow \mu = 3/2$ (c) $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ $\frac{1}{20} = \left(\frac{3}{2} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ When the lens is immersed in water $\frac{1}{f_{unknown}} = \left(\frac{9}{8} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ $\frac{\frac{1}{20}}{\frac{1}{f}} = \frac{1/2}{1/8} = \Rightarrow f = 80 \text{ cm}$ **OR** $m = 3 = \frac{v}{u} \Rightarrow v = 3u$ $f = \frac{100}{+5} = +20 \text{ cm}$ $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$	 1 ½ ½ ½ ½ ½ ½ ½ ½	

	$\frac{1}{3u}-\frac{1}{u}=\frac{1}{20}$ $\frac{1-3}{3u}=\frac{1}{20}$ $u=-(40/3)$ cm $v=-40\,\text{cm}$	 ½ ½	 **4**

General Instructions :

Read the following instructions very carefully and follow them :

(i) *This question paper contains **35** questions. **All** questions are compulsory.*

(ii) *Question paper is divided into **FIVE** sections – Section **A, B, C, D** and **E**.*

(iii) ***In section – A :** question number **1** to **18** are Multiple Choice (MCQ) type questions carrying **1** mark each.*

(iv) ***In section – B :** question number **19** to **25** are Short Answer-1 (SA-1) type questions carrying **2** marks each.*

(v) ***In section – C :** question number **26** to **30** are Short Answer-2 (SA-2) type questions carrying **3** marks each.*

(vi) ***In section – D :** question number **31** to **33** are Long Answer (LA) type questions carrying **5** marks each.*

(vii) ***In section – E :** question number **34** and **35** are case-based questions carrying **4** marks each.*

(viii) *There is no overall choice. However, an internal choice has been provided in 2 questions in Section – **B**, 2 questions in Section – **C**, 3 questions in Section – **D** and 2 questions in Section – **E**.*

(ix) *Use of calculators is NOT allowed.*

$c = 3 \times 10^8$ m/s

$h = 6.63 \times 10^{-34}$ Js

$e = 1.6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

Mass of electron (m_e) = 9.1×10^{-31} kg

Mass of neutron = 1.675×10^{-27} kg

Mass of proton = 1.673×10^{-27} kg

Avogadro's number = 6.023×10^{23} per gram mole

Boltzmann constant = 1.38×10^{-23} JK^{-1}

SECTION – A

1. An electric dipole of length 2 cm is placed at an angle of 30° with an electric field 2×10^5 N/C. If the dipole experiences a torque of 8×10^{-3} Nm, the magnitude of either charge of the dipole, is **1**

(A) 4 μC (B) 7 μC
(C) 8 mC (D) 2 mC

2. Two long parallel wires kept 2 m apart carry 3A current each, in the same direction. The force per unit length on one wire due to the other is **1**

(A) 4.5×10^{-5} Nm^{-1}, attractive (B) 4.5×10^{-7} N/m, repulsive
(C) 9×10^{-7} N/m, repulsive (D) 9×10^{-5} N/m, attractive

3. Which of the following has its permeability less than that of free space ? **1**

(A) Copper (B) Aluminium
(C) Copper chloride (D) Nickel

4. A square shaped coil of side 10 cm, having 100 turns is placed perpendicular to a magnetic field which is increasing at 1 T/s. The induced emf in the coil is **1**

(A) 0.1 V (B) 0.5 V
(C) 0.75 V (D) 1.0 V

5. Which one of the following electromagnetic radiation has the least wavelength ? **1**

(A) Gamma rays (B) Microwaves
(C) Visible light (D) X-rays

6. In a Young's double-slit experiment, the screen is moved away from the plane of the slits. What will be its effect on the following ? **1**

(i) Angular separation of the fringes.
(ii) Fringe-width.

(A) Both (i) and (ii) remain constant.
(B) (i) remains constant, but (ii) decreases.
(C) (i) remains constant, but (ii) increases.
(D) Both (i) and (ii) increase.

7. The energy of a photon of wavelength λ is **1**

(A) $hc\lambda$ (B) hc/λ

(C) λ/hc (D) $\lambda h/c$

8. The ratio of the nuclear densities of two nuclei having mass numbers 64 and 125 is **1**

(A) $\frac{64}{125}$ (B) $\frac{4}{5}$

(C) $\frac{5}{4}$ (D) 1

9. During the formation of a p-n junction : **1**

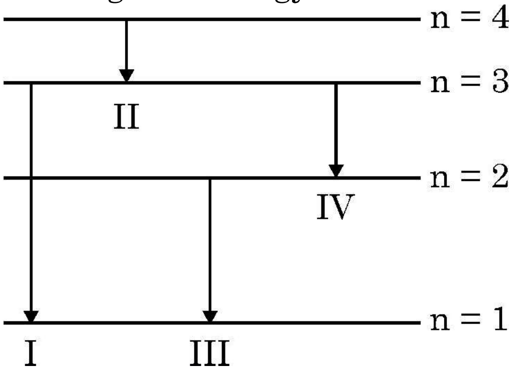
(A) diffusion current keeps increasing.

(B) drift current remains constant.

(C) both the diffusion current and drift current remain constant.

(D) diffusion current remains almost constant but drift current increases till both currents become equal.

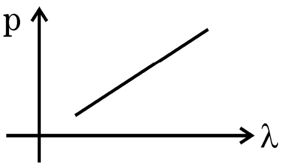
10. The diagram shows four energy level of an electron in Bohr model of hydrogen atom. Identify the transition in which the emitted photon will have the highest energy. **1**

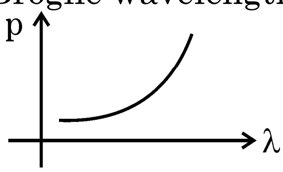


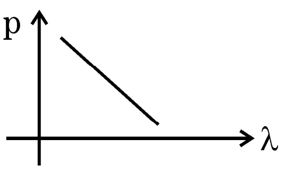
(A) I (B) II

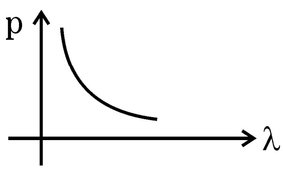
(C) III (D) IV

11. Which of the following graphs correctly represents the variation of a particle momentum with its associated de-Broglie wavelength ? **1**

(A)


(B)


(C)


(D)


12. The capacitors, each of 4 μF are to be connected in such a way that the effective capacitance of the combination is 6 μF. This can be achieved by connecting **1**

(A) All three in parallel

(B) All three in series

(C) Two of them connected in series and the combination in parallel to the third.

(D) Two of them connected in parallel and the combination in series to the third.

13. Which of the following statements about a series LCR circuit connected to an ac source is correct ? **1**

(A) If the frequency of the source is increased, the impedance of the circuit first decreases and then increases.

(B) If the net reactance $(X_L - X_C)$ of circuit becomes equal to its resistance, then the current leads the voltage by 45°.

(C) At resonance, the voltage drop across the inductor is more than that across the capacitor.

(D) At resonance, the voltage drop across the capacitor is more than that across the inductor.

14. According to Huygens principle, the amplitude of secondary wavelets is **1**

(A) equal in both the forward and the backward directions.

(B) maximum in the forward direction and zero in the backward direction.

(C) large in the forward direction and small in the backward direction.

(D) small in the forward direction and large in the backward direction.

15. The radius of the n^{th} orbit in Bohr model of hydrogen atom is proportional to **1**

(A) n^2 (B) $\frac{1}{n^2}$

(C) n (D) $\frac{1}{n}$

Note : In question number **16** to **18** two statements are given – one labelled **Assertion (A)** and the other labelled **Reason (R)**. Select the correct answer to these questions from the codes **(a)**, **(b)**, **(c)** and **(d)** as given below :

(A) Both Assertion (A) and Reason (R) are true and (R) is the correct explanation of (A).

(B) Both Assertion (A) and Reason (R) are true and (R) is NOT the correct explanation of (A).

(C) Assertion (A) is true and Reason (R) is false.

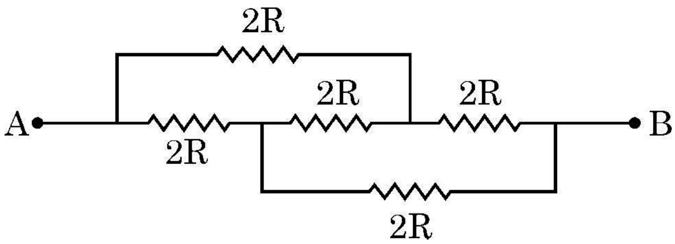
(D) Assertion (A) is false and Reason (R) is also false.

16. **Assertion (A)** : The resistance of an intrinsic semiconductor decreases with increase in its temperature. **1**

Reason (R) : The number of conduction electrons as well as hole increase in an intrinsic semiconductor with rise in its temperature.

17. **Assertion (A)** : The equivalent resistance between points A and B in the given network is 2R. **1**

Reason (R) : All the resistors are connected in parallel



18. **Assertion (A)** : The deflecting torque acting on a current carrying loop is zero when its plane is perpendicular to the direction of magnetic field. **1**

Reason (R) : The deflecting torque acting on a loop of magnetic moment $\vec{m}$ in a magnetic field $\vec{B}$ is given by the dot product of $\vec{m}$ and $\vec{B}$.

SECTION – B

19. Draw a graph showing the variation of potential energy of a pair of nucleons as a function of their separation. Indicate the region in which the nuclear force is (a) attractive and (b) repulsive. **2**

20. (a) How will the De Broglie wavelength associated with an electron be affected when the (i) velocity of the electron decreases ? and (ii) accelerating potential is increased ? Justify your answer. **2**

OR

(b) How would the stopping potential for a given photosensitive surface change if (i) the frequency of the incident radiation were increased ? and (ii) the intensity of incident radiation were decreased ? Justify your answer. **2**

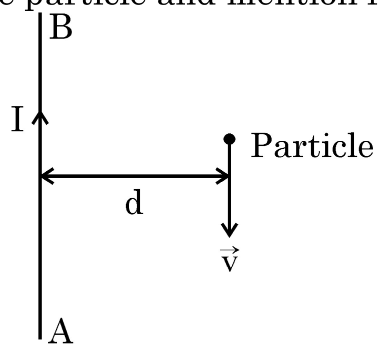
21. Identify the electromagnetic wave whose wavelengths range is from about
(a) 10^{-12} m to about 10^{-8} m.
(b) 10^{-3} m to about 10^{-1} m. **2**
Write one use of each.

22. Depict the orientation of an electric dipole in (a) stable and (b) unstable equilibrium in an external uniform electric field.
Write the potential energy of the dipole in each case. **2**

23. (a) Write the expression for the Lorentz force on a particle of charge q moving with a velocity $\vec{v}$ in a magnetic field $\vec{B}$. When is the magnitude of this force maximum ? Show that no work is done by this force on the particle during its motion from a point $\vec{r}_1$ to point $\vec{r}_2$. **2**

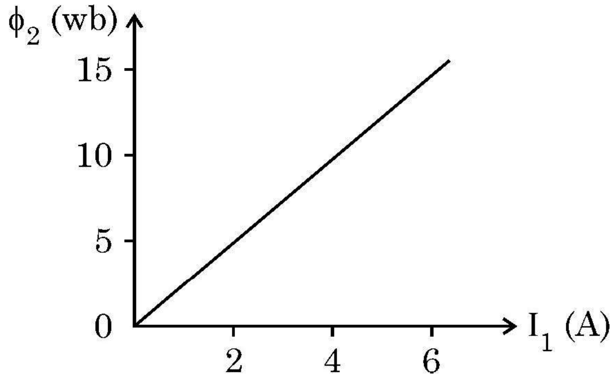
OR

(b) A long straight wire AB carries a current I. A particle (mass m and charge q) moves with a velocity $\vec{v}$, parallel to the wire, at a distance d from it as shown in the figure. Obtain the expression for the force experienced by the particle and mention its directions. **2**



24. The potential difference applied across a given conductor is doubled. How will this affect (i) the mobility of electrons and (ii) the current density in the conductor ? Justify your answers. **2**

25. Two coils C_1 and C_2 are placed close to each other. The magnetic flux ϕ_2 linked with the coil C_2 varies with the current I_1 flowing in coil C_1, as shown in the figure. Find **2**



(i) the mutual inductance of the arrangement, and

(ii) the rate of change of current $\left(\frac{dI_1}{dt}\right)$ that will induce an emf of 100 V in coil C_2.

SECTION – C

26. (a) A plane wave-front propagating in a medium of refractive index 'μ_1' is incident on a plane surface making an angle of incidence (i). It enters into a medium of refractive index μ_2 ($\mu_2 > \mu_1$).

Use Huygen's construction of secondary wavelets to trace the retracted wave-front. Hence verify Snell's law of refraction. **3**

OR

(b) Using Huygen's construction, show how a plane wave is reflected from a surface. Hence verify the law of reflection. **3**

27. An alternating voltage of 220 V is applied across a device X. A current of 0.22 A flows in the circuit and it lags behind the applied voltage in phase by $\pi/2$ radian. When the same voltage is applied across another device Y, the current in the circuit remains the same and it is in phase with the applied voltage. **3**

(i) Name the devices X and Y and,

(ii) Calculate the current flowing in the circuit when the same voltage is applied across the series combination of X and Y.

28. State the basic principle behind the working of an ac generator. Briefly describe its working and obtain the expression for the instantaneous value of emf induced. **3**

29. (a) Briefly describe how the current sensitivity of a moving coil galvanometer can be increased.

(b) A galvanometer shows full scale deflection for current I_g. A resistance R_1 is required to convert it into a voltmeter of range (0 – V) and a resistance R_2 to convert it into a voltmeter of range (0 – 2V). Find the resistance of the galvanometer. **3**

30. (a) (i) Differentiate between 'distance of closest approach' and 'impact parameter'.

(ii) Determine the distance of closest approach when an alpha particle of kinetic energy 3.95 MeV approaches a nucleus of Z = 79, stops and reverses its directions. **3**

OR

(b) (i) State three postulates of Bohr's theory of hydrogen atom.

(ii) Find the angular momentum of an electron revolving in the second orbit in Bohr's hydrogen atom. **3**

SECTION – D

31. (a) (i) Explain how free electrons in a metal at constant temperature attain an average velocity under the action of an electric field. Hence obtain an expression for it. **3**

(ii) Consider two conducting wires A and B of the same diameter but made of different materials joined in series across a battery. The number density of electrons in A is 1.5 times that in B. Find the ratio of drift velocity of electrons in wire A to that in wire B. **2**

OR

(b) (i) A cell emf of (E) and internal resistance (r) is connected across a variable load resistance (R). Draw plots showing the variation of terminal voltage V with (i) R and (ii) the current (I) in the load. **2**

(ii) Three cells, each of emf E but internal resistances 2r, 3r and 6r are connected in parallel across a resistor R.

Obtain expressions for (i) current flowing in the circuit, and (ii) the terminal potential difference across the equivalent cell. **3**

32. (a) Draw the circuit arrangement for studying V-I characteristics of a p-n junction diode in (i) forward biasing and (ii) reverse biasing. Draw the typical V-I characteristics of a silicon diode. Describe briefly the following terms : (i) minority carrier injection in forward biasing and (ii) breakdown voltage in reverse biasing. **5**

OR

(b) Name two important processes involved in the formation of a p-n junction diode. With the help of a circuit diagram, explain the working of junction diode as a full wave rectifier. Draw its input and output waveforms. State the characteristic property of a junction diode that makes it suitable for rectification. **5**

33. (a) (i) Draw a ray diagram to show the working of a compound microscope. Obtain the expression for the total magnification for the final image to be formed at the near point. **3**

(ii) In a compound microscope an object is placed at a distance of 1.5 cm from the objective of focal length 1.25 cm. If the eye-piece has a focal length of 5 cm and the final image is formed at the near point, find the magnifying power of the microscope. **2**

OR

(b) (i) Draw a ray diagram for the formation of image of an object by an astronomical telescope, in normal adjustment. Obtain the expression for its magnifying power.

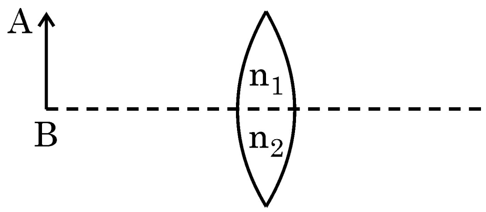
(ii) The magnifying power of an astronomical telescope in normal adjustment is 2.9 and the objective and the eyepiece are separated by a distance of 150 cm. Find the focal lengths of the two lenses. **5**

SECTION – E

Note : Questions number **34** and **35** are Case Study based questions. Read the following paragraph and answer the questions.

34. A lens is a transparent optical medium bounded by two surfaces; at least one of which should be spherical. Considering image formation by a single spherical surface successively at the two surfaces of a lens, lens maker's formula is obtained. It is useful to design lenses of desired focal length using surfaces of suitable radii of curvature. This formula helps us obtain a relation between u, v and f for a lens. Lenses form images of objects and they are used in a number of optical devices, for example microscopes and telescopes. **4**

(i) An object AB is kept in front of a composite convex lens, as shown in figure. Will the lens produce one image ? If not, explain.



(ii) A real image of an object formed by a convex lens is observed on a screen. If the screen is removed, will the image still be formed ? Explain.

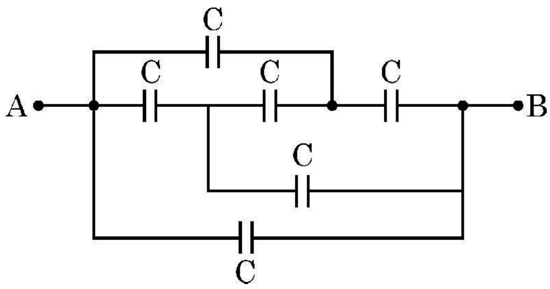
(iii) A double convex lens is made of glass of refractive index 1.55 with both faces of the same radius of curvature. Find the radius of curvature required if focal length is 20 cm.

OR

(iii) Two convex lenses A and B of focal lengths 15 cm and 10 cm respectively are placed coaxially 'd' distance apart. A point object is kept at a distance of 30 cm in front of lens A. Find the value of 'd' so that the rays emerging from lens B are parallel to its principal axis.

35. A capacitor is a system of two conductors separated by an insulator. The two conductors have equal and opposite charges with a potential difference between them. The capacitance of a capacitor depends on the geometrical configuration (shape, size and separation) of the system and also on the nature of the insulator separating the two conductors. They are used to store charges. Like resistors, capacitors can be arranged in series or parallel or a combination of both to obtain desired value of capacitance. **4**

(i) Find the equivalent capacitance between points A and B in the given diagram.

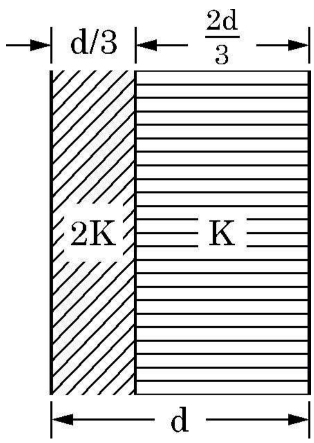


(ii) A dielectric slab is inserted between the plates of a parallel plate capacitor. The electric field between the plates decreases. Explain.

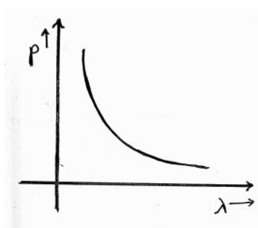
(iii) A capacitor A of capacitance C, having charge Q is connected across another uncharged capacitor B of capacitance 2C. Find an expression for (a) the potential difference across the combination and (b) the charge lost by capacitor A.

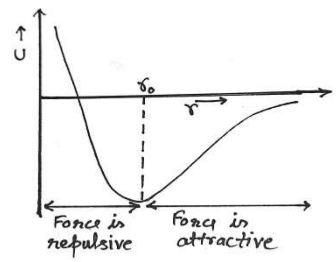
OR

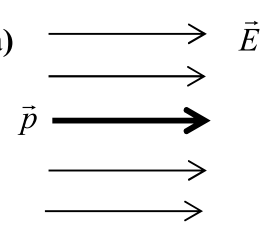
(iii) Two slabs of dielectric constants 2K and K fill the space between the plates of a parallel plate capacitor of plate area A and plate separation d as shown in figure. Find an expression for capacitance of the system.

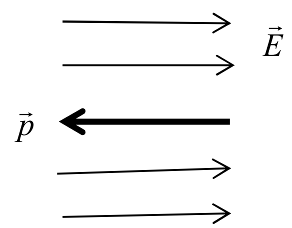


55/5/1

MARKING SCHEME: PHYSICS(042)			
Code:55/5/1			
Q No.	**VALUE POINTS/EXPECTED ANSWERS**	**Marks**	**Total Marks**
	SECTION - A		
1	(A) 4μC	1	**1**
2	No option is correct. **[Award one mark to each student]**	1	**1**
3	(A) Copper	1	**1**
4	(D) 1. 0 V	1	**1**
5	(A) Gamma rays	1	**1**
6	(C) (i) remains constant, but (ii) increases	1	**1**
7	(B) hc/λ	1	**1**
8	(D) 1	1	**1**
9	(D) Diffusion current remains almost constant but drift current increases till both currents become equal.	1	**1**
10	(A) I	1	**1**
11	(D)  	1	**1**
12	(C) Two of them connected in series and the combination in parallel to the third	1	**1**
13	(A) If the frequency of the source is increased, the impedance of the circuit first decreases and then increases.	1	**1**
14	(B) Maximum in the forward direction and zero in the backward direction.	1	**1**
15	(A) n^2	1	**1**
16	(A) Both Assertion (A) and reason (R) are true and (R) is correct explanation of (A) **Note:** **In Hindi version none of the answer is correct, Therefore award one mark to the student who opted Hindi medium to write the answer.**	1	**1**
17	(C) Assertion (A) is true and Reason (R) is false.	1	**1**
18	(C) Assertion (A) is true and Reason (R) is false.	1	**1**

	SECTION-B		
19	Graph between potential energy and separation between the nucleons **(1)** For indicating region of graph (a) For attractive nuclear force **(½)** (b) For repulsive nuclear force **(½)**  Repulsive nuclear force for r < r_0 Attractive force for r> r_0 (**Note-** If a student draws a graph without indicating the region of attractive and repulsive force, award 1 mark only.)	**1** **½** **½**	**2**
20	(a) (i) Effect of velocity of electron on de- Broglie wavelength (½) Justification (½) (ii) Effect of accelerating potential on de- Broglie wavelength (½) Justification (½) (i) λ= h/mv With decrease in velocity, de- Broglie wavelength increases (ii) $\lambda = \frac{h}{\sqrt{2meV}}$ With increase in accelerating potential, de- Broglie wavelength decreases **OR** (b) (i) Effect of frequency of incident radiation on stopping potential (½) Justification (½) (ii) Effect of intensity of incident radiation on stopping potential (½) Justification (½)	**½** **½** **½** **½**	

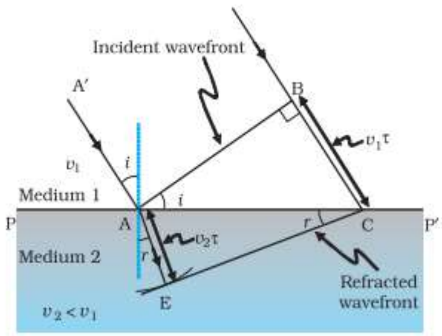
	(i) With increase in frequency stopping potential will increase. $V_0 = \frac{h}{e}\nu - \frac{\phi_0}{e}$ (ii) Stopping potential remains same. Energy of photoelectron ejected is independent of intensity of radiation	½ ½ ½ ½	 2
21	(a) Identification of electromagnetic wave (½) One use of the wave (½) (b) Identification of electromagnetic wave (½) One use of the wave (½) (a) X-rays Use: used as diagnostic tool in medicine. (Any one) Treatment for certain forms of cancer. To study crystal structure (Or any other one suitable use) **Alternatively** Gamma rays Use: used in medicine to destroy the cancer cell. (b) Microwaves Use: In radar system for aircraft navigation (Or any other one suitable use)	 ½ ½ ½ ½	 2
22	(a) For depiction of electric dipole in stable equilibrium. (½) Potential energy in stable equilibrium (½) (b) For depiction of electric dipole in unstable equilibrium. (½) Potential energy in unstable equilibrium (½) **(a)**  $\theta = 0^0$ U= - pE	 ½ ½	

	(b)  $\theta = 180^0$ U = pE **Note** – Award ½ mark , if a student mentions the value of θ as 0º and 180º without drawing the diagram.	½ ½	2
23	(a) Expression for Lorentz force (½) Condition for maximum magnitude of force (½) Showing no work done in moving the charge from point $\vec{r}_1$ *to* $\vec{r}_2$ (1) $\vec{F}_m = q\left(\vec{v} \times \vec{B}\right)$ $F_m = q\,v\,B\sin\theta \quad (\because \vec{v} \perp \vec{B})$ Force is maximum for $\theta = 90^0$ As magnetic force always acts in a direction perpendicular to the velocity vector, hence no work is done by this force on the particle during motion. **Alternatively** $W = \vec{F}.(\vec{r_2} - \vec{r_1})$ $= F\left\|\vec{r_2} - \vec{r_1}\right\|\cos 90^\circ$ $= 0$ OR (b) Obtaining the expression for force experienced (1 ½) Direction (½) The magnetic field produced by current carrying conductor AB $B = \frac{\mu_0 I}{2\pi d}$, directed into the plane of paper. Force experienced by charged particle $\vec{F}_m = q\left(\vec{v} \times \vec{B}\right)$	½ ½ 1 ½ ½	2

	$\therefore \vec{v} \perp \vec{B}$ $F_m = q\,vB\sin 90^0$ $F_m = q\,v \times \frac{\mu_0 I}{2\pi d}$ Force is repulsive/acts towards right / away from the conductor.	 ½ ½	
24	(i) Effect of potential difference on mobility of electron (½) Justification (½) (i) Effect of potential difference on current density (½) Justification (½) (i) No effect $\mu = \frac{v_d\, l}{V} = \frac{l}{enAR}$ = Constant **Alternatively:** $\mu = \frac{v_d}{E} = \frac{e\tau}{m} = Constant$ (ii) As J α V , current density gets doubled $J = \frac{I}{A} = \frac{V}{RA}$	 ½ ½ ½ ½	 2
25	(i) Finding mutual inductance from graph (1) (ii) Finding $\frac{dI_1}{dt}$ (1) (i) $\phi_2 = MI_1$ Slope of the graph , M = $\frac{\phi_2}{I_1}$ M = 2.5 H (ii) $\lvert\in_2\rvert = M\frac{dI_1}{dt}$ $\frac{dI_1}{dt} = \frac{\lvert\in_2\rvert}{M} = \frac{100}{2.5} = 40\,As^{-1}$	 ½ ½ ½ ½	 2
	SECTION-C		

26 **(a)**

Tracing the refractive wavefront (1)
Verification of Snell's Law of refraction (2)



1

AB is incident wavefront, incident at an angle i . let τ be the time taken by wavefront to travel distance BC.

$BC = v_1 \tau$ where v_1 is speed of wave in medium 1

To determine shape of refracted wavefront, we draw a sphere of radius $v_2\tau$, where v_2 is speed of wave in medium 2. ½

CE represents a tangent drawn from point C on sphere, CE is the refracted wavefront. ½

$$\sin i = \frac{BC}{AC} = \frac{v_1\tau}{AC} \text{ and}$$

$$\sin r = \frac{AE}{AC} = \frac{v_2\tau}{AC}$$ ½

Where i and r are the angles of incidence and refraction, respectively.

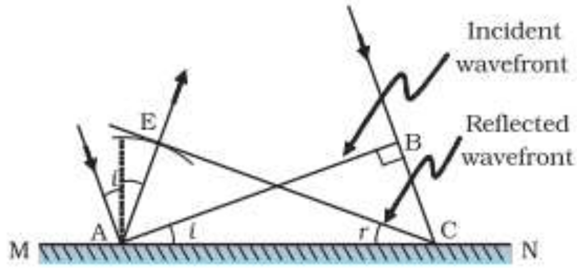
$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{\mu_2}{\mu_1}$$

$$\mu_1 \sin i = \mu_2 \sin r$$ ½

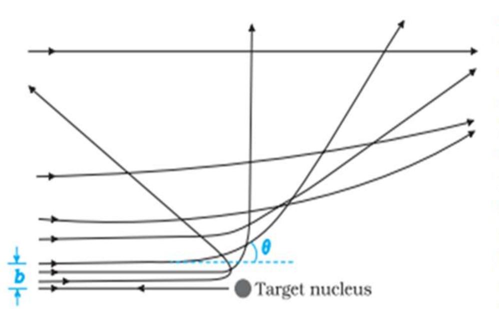
This is the Snell's law of refraction.

OR

Diagram showing the reflection of plane wave (1)
Verification of Law of reflection (2)

	 Consider a plane wave AB incident at an angle i on a reflecting surface MN. If v is the speed of the wave in the medium and if τ represents the time taken by the wavefront to advance from the point B to C then the distance BC= v τ In order to construct the reflected wavefront, draw a sphere of radius vτ from the point A. Let CE represent the tangent plane, drawn from the point C to this sphere. In ΔAEC and ΔABC AE = BC = v τ $\angle CEA = \angle ABC$ (90° *each*) AC is common side $\Delta AEC \cong \Delta AEC$ $\because \angle i = \angle r$ This is the law of reflection.	1 ½ ½ ½ ½	3
27	(i) Naming the devices X and Y (½ +½) (ii) Calculation of current (2) (i) X is inductor Y is resistor (ii) $X_L = \frac{220}{0.22} = 1000\Omega$ $R = \frac{220}{0.22} = 1000\Omega$ $I_{rms} = \frac{V_{rms}}{\sqrt{X_L^2 + R^2}}$	½ ½ ½ ½ ½	

	$I_{rms} = \frac{220}{\sqrt{2} \times 1000} = \frac{0.22}{\sqrt{2}} = 0.11 \times \sqrt{2}\, A$ $I_{rms} = 0.16A$	½	3
28	Principle of ac generator (1) Working (1) Obtaining expression for induced e m f (1) **Principle:** Whenever magnetic flux linked through a coil changes an emf is induced. **Alternatively:** ac generator is based on the phenomenon of electromagnetic induction. **Working:** The coil (armature) is mechanically rotated in the uniform magnetic field by some external means. The rotation of the coil causes the magnetic flux through it to change. So an emf is induced in the coil. **Expression for induced emf** Flux linked with the coil at any instant of time is- $\phi_B = BA\cos\omega t$ $\in = -N\frac{d\phi_B}{dt}$ $\in = -NBA\frac{d}{dt}(\cos\omega t)$ Thus, instantaneous value of emf is $\in = NBA\omega\sin\omega t$	1 1 ½ ½	3
29	(a) Methods to increase current sensitivity of moving coil galvanometer (1) (b) Calculation of resistance of galvanometer (2) (a) Current sensitivity of moving coil galvanometer can be increased by (1) increasing number of turns in the coil $(I_s \,\alpha\, N)$ (2) increasing magnetic field strength $(I_s \,\alpha\, B)$ (3) using a material having lesser value of torsional constant $\left(I_s \,\alpha\, \frac{1}{k}\right)$		

	(4) increasing area of cross-section of the coil (**Note-** Any one of the above) (b) $R = \frac{V}{I_g} - G$ For range $(0-V)$ $R_1 = \frac{V}{I_g} - G --------(1)$ For range (0-2V) $R_2 = \frac{2V}{I_g} - G --------(2)$ On solving equations (1) and (2) $G = R_2 - 2R_1$	1 ½ ½ ½ ½	3
30	(a) i. Differentiation between distance of closest approach and impact parameter (2) ii. Calculation of distance of closest approach (1) (i) **Distance of closest approach**: It is the minimum distance of α-particle from the centre of nucleus at which its total kinetic energy gets converted into electrostatic potential energy. **Alternatively**: Distance of closest approach $r_o = \frac{1}{4\pi \in_o} \frac{2Ze^2}{E_K}$ **Impact parameter**: Perpendicular distance of the initial velocity vector of the α- particle from the centre of the nucleus. **Alternatively:** 	 1 1	

	(ii) $r_o = \frac{1}{4\pi \in_o}\frac{2Ze^2}{E_K}$ $r_o = \frac{9\times10^9\times2\times79\times(1.6\times10^{-19})^2}{3.95\times1.6\times10^{-13}}$ $= 57.6\times10^{-15} m$ **OR** (b) i. Bohr's three postulates (1½) ii. Calculation of angular momentum (1½) (i) (1) An electron in an atom revolves in certain stable orbit without the emission of radiant energy. (2) The electron revolves around the nucleus only in those orbits for which the angular momentum is integral multiple of $\frac{h}{2\pi}$ where h is the Planck's constant. (3) When an electron makes a transition from one of its specified non-radiating orbits to another of lower energy orbit a photon is emitted having energy equal to the energy difference between the initial and final states. (ii) $\text{Angular momentum} = \frac{nh}{2\pi}$ For n=2 $\text{Angular momentum} = \frac{2h}{2\pi}$ $= \frac{6.63\times10^{-34}}{\pi}$ $= 2.1\times10^{-34}\ kg\ m^2 s^{-1}$	½ ½ ½ ½ ½ ½ ½ ½	 3
	SECTION-D		
31	(a) (i) Explanation (1) Obtaining expression for average velocity (2) (ii) Finding ratio of drift velocities (2)		

(a) (i) Under the effect of external field, an electron experiences a force

$\vec{F} = -e\vec{E}$ between collisions.

Due to this force the electron is accelerated and attains a velocity. This velocity is different for different electrons, which averaged over all electrons gives average drift velocity. This drift velocity is constant for a given temperature. **1**

Expression of average velocity:

Under the action of an electric field electrons get accelerated with

$$a = -\frac{eE}{m}$$ ½

Velocity of an electron at any instant of time is

$$\vec{V}_i = \vec{v}_i - \frac{e\vec{E}}{m}t_i$$ ½

Average velocity of the electrons at time 't' is the drift velocity

$$\vec{v}_d = (\vec{V}_i)_{average}$$

$$(\vec{V}_i)_{average} = (\vec{v}_i)_{average} - \frac{e\vec{E}}{m}(t_i)_{average}$$ ½

But $(\vec{v}_i)_{average} = 0$ due to randomness

$$\vec{v}_d = 0 - \frac{e\vec{E}}{m}\tau$$ ½

$$\vec{v}_d = -\frac{e\vec{E}}{m}\tau$$

(ii) $v_d = \frac{I}{enA} = \left(\frac{4I}{e\pi D^2}\right) \times \frac{1}{n}$ ½

$v_d \propto \frac{1}{n}$ for same diameter and current ½

$n_A = 1.5 n_B$ (Given)

$\frac{v_{dA}}{v_{dB}} = \frac{n_B}{n_A} = \frac{2}{3}$ **1**

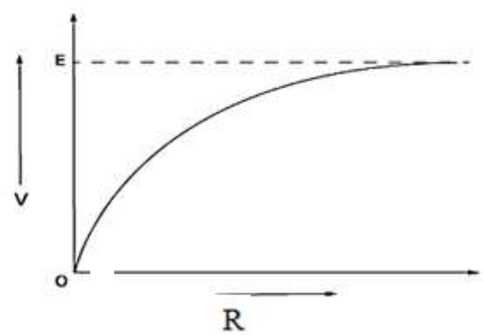
OR

(b)

(i)
i Plot showing variation of V with R (1)
ii Plot showing variation of V with I (1)
(ii)
(i) Obtaining expression for current flowing through circuit $(1\frac{1}{2})$
(ii) Obtaining expression for terminal potential difference across the equivalent cell. $(1\frac{1}{2})$

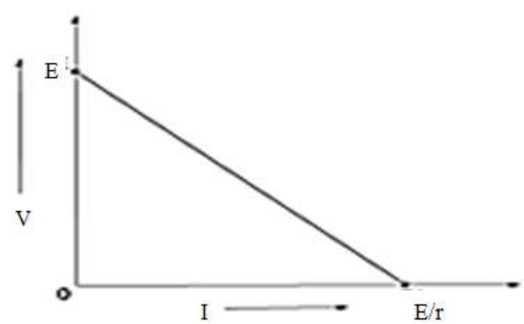
(b) (i)

i.



1

ii.



1

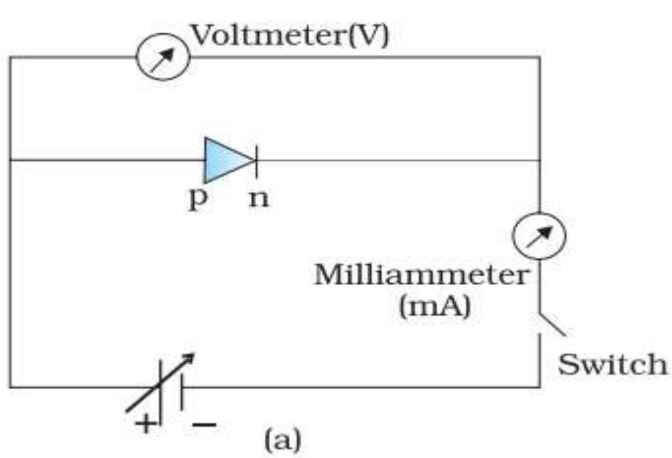
(ii)

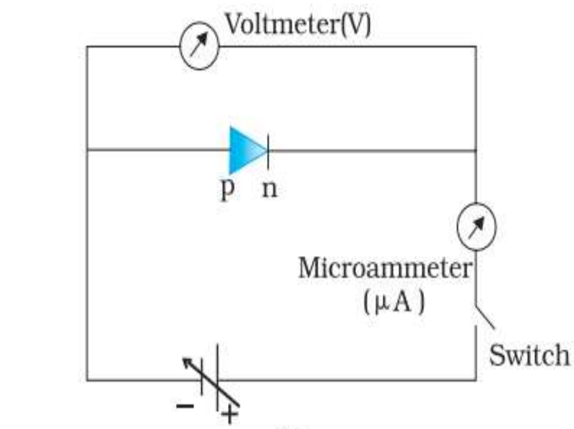
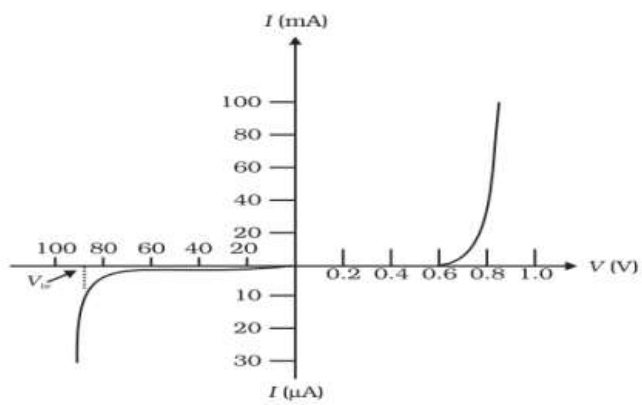
$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}$$

$$\frac{1}{r_{eq}} = \frac{1}{2r} + \frac{1}{3r} + \frac{1}{6r}$$

$$r_{eq} = r$$ ½

Given cells are of equal emf (E) and connected in parallel, so

	$\frac{E_{eq}}{r_{eq}} = \frac{E}{2r} + \frac{E}{3r} + \frac{E}{6r}$ $E_{eq} = E$ Current flowing $I = \frac{E_{eq}}{R + r_{eq}}$ $I = \frac{E}{R+r}$ The terminal potential difference $V = E_{eq} - Ir_{eq}$ $V = E - \frac{E}{(R+r)} \times r$ $V = \frac{ER}{R+r}$	½ ½ ½ ½ ½	5
32	(a) Circut arrangement for V-I characteristics of p-n junction in (i) forward bias (1) (ii) reverse bias (1) V-I characteristics (1) Explanation of (i) Minority carrier injection in forward bias (1) (ii) Breakdown Voltage in reverse bias (1) (i) 	1	

	 (b)	**1**	
	 (c)	1	
	(**Note:** Please do not deduct marks for not showing values.) **Minority carrier injection**: Under forward bias electrons from n-side cross the depletion region and reach p-side. Similarly, holes from p-side cross the junction and reach the n-side.	1	
	Breakdown voltage: It is the voltage under reverse bias for which reverse current increases sharply.	1	

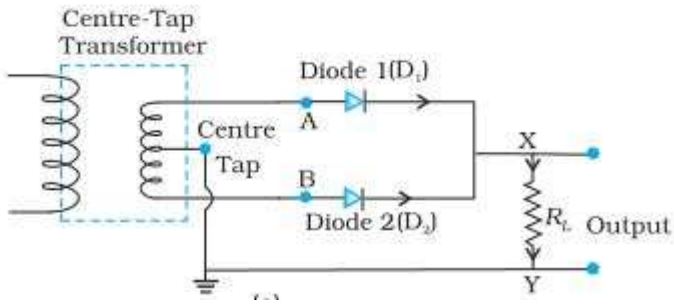
OR

(b)

Naming two important processes	(½ + ½)
Circuit diagram	(1)
Working of junction diode as a full wave rectifier	(1)
Input & output waveforms	(1)
Characteristics / Property	(1)

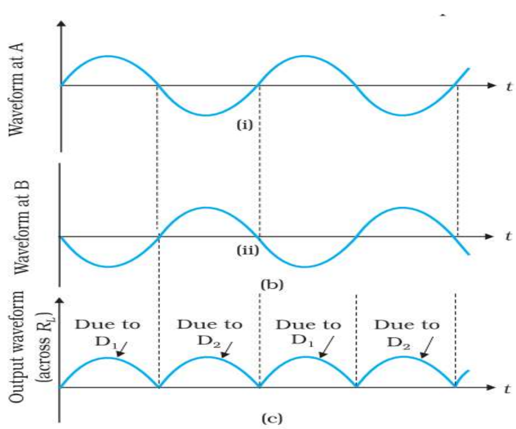
(a) Diffusion ½

Drift ½



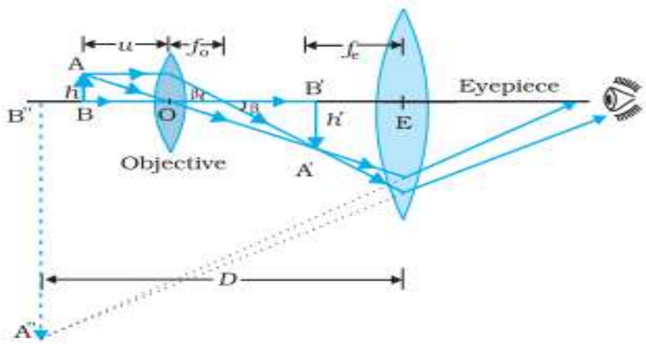
1

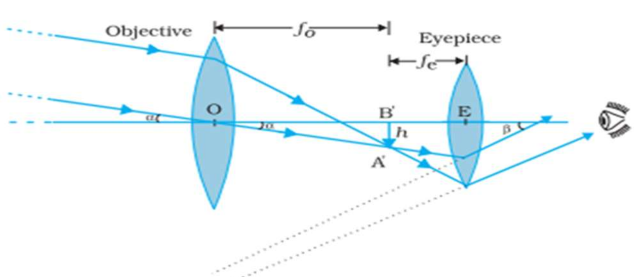
Suppose the input voltage to A with respect to the centre-tap at any instant is positive. At that instant, voltage at B being out of phase will be negative. So, diode D_1 gets forward biased and conducts (while D_2 being reverse biased is not conducting). Hence, during this positive half cycle we get an output current (and a output voltage across the load resistor R_L). In the course of ac cycle when the voltage at A becomes negative with respect to centre tap, the voltage at B would be positive. In this part of the cycle diode D_1 would not conduct but diode D_2 would, giving an output current and output voltage (across R_L) during the negative half cycle of the input ac. 1



½

½

	Property Junction diode allows current to pass only when it is forward biased.	1	**5**
33	(a) (i) Ray diagram of compound microscope. (1½) Expression for total magnification (1½) (ii) Finding the magnifying power of microscope (2)  	1½	
	(Note: Give full credit of the diagram, if a student draws diagram for normal adjustment. Deduct ½ mark for not showing the direction of propagation of light.) Linear magnification due to the objective is $\tan\beta = \left(\frac{h}{f_0}\right) = \left(\frac{h'}{L}\right)$ $m_0 = \frac{h'}{h} = \frac{L}{f_0}$	½	
	Here L is the distance between the second focal point of the objective and the first focal point of the eyepiece. Linear magnification due to eyepiece is $m_e = \left(1 + \frac{D}{f_e}\right)$	½	
	Thus, the total magnification is, $m = m_0 \times m_e$ $m = \frac{L}{f_0}\left(1 + \frac{D}{f_e}\right)$ **Note:** Full credit of the derivation should be given if a student derives $m = \frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right)$	½	

	(ii) Given: $u_0 = -1.5\,cm$ $f_0 = 1.25\,cm$ $f_e = 5\,cm$ $D = 25\,cm$ $\frac{1}{f_0} = \frac{1}{v_0} - \frac{1}{u_0}$ $\frac{1}{v_0} = \frac{1}{1.25} - \frac{1}{1.5} = \frac{2}{15}$		
	$v_0 = \frac{15}{2}\,cm$	½	
	$\lvert m_0 \rvert = \frac{v_0}{u_0} = \frac{15}{2} \times \frac{1}{1.5} = 5$	½	
	$\lvert m_e \rvert = \left(1 + \frac{D}{f_e}\right)$ $\lvert m_e \rvert = 1 + \frac{25}{5} = 6$	½	
	$m = m_0 \times m_e = 5 \times 6 = 30$	½	
	OR (i) Ray diagram for image formation by astronomical telescope in normal adjustment. (1½) Expression for magnifying power (1½) (ii) Formula (½+½) Calculation of focal length of both lenses (½+½)		
	(i)  	1½	

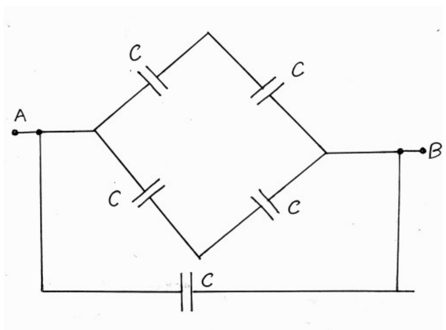
	Magnifying power (m) $m \approx \frac{\beta}{\alpha}$ $\beta = \frac{h}{f_e}$ $\alpha = \frac{h}{f_0}$ $m = \frac{f_0}{f_e}$ (ii) $m = 2.9$, $d = 150\,cm$ (Given) $m = \frac{f_o}{f_e} = \frac{29}{10}$ $f_0 + f_e = 150$ $f_e = 38.5\,cm$ $f_o = 150 - 38.5 = 111.5\,cm$	½ ½ ½ ½ ½ ½ ½	 **5**
	SECTION E		
34	i) Answer and explanation (½ + ½) ii) Answer and explanation (½ + ½) iii) For finding radius of curvature (2) **OR** Finding the separation between lenses (2) (i) No, The lens is made up of two materials of different refractive indices. It has two focal lengths. (ii) Yes Rays are still intersecting/ converging at the location of image. (iii) $\frac{1}{f} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$ $R_1 = +R$, $R_2 = -R$	 ½ ½ ½ ½ ½ ½	

	$\frac{1}{f}=(n-1)\left[\frac{2}{R}\right]$	½	
	$R=2(n-1)f$		
	R= 2 (1.55-1) x 20=22 cm	½	
	OR		
	For lens A (f =15 cm)		
	u = -30 cm		
	$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$	½	
	$\frac{1}{v_1}=\frac{1}{15}-\frac{1}{30}=\frac{1}{30}$		
	$v_1 = 30\ cm$	½	
	For lens B		
	For rays to go parallel to principal axis out of lens B the image formed by lens A must lie at the focus of B So d= 30+10=40 cm	1	
	Alternatively: (Object is kept at 2f so image will also be formed at 2f on the other side of the lens i.e. at 30 cm. Now the final image is to be formed at infinity so the image formed must lie at the focus of the second lens (B). Thus separation is 30 +10 =40 cm)		**4**

35

(i) Calculation of equivalent capacitance	(1)
(ii) Explanation of electric field reduction	(1)
(iii) Finding the potential difference across the combination	(1)
Finding the charge lost by capacitor A	(1)
OR	
Finding the capacitance of system	(2)

(i)



½

$$C_{net} = C + C$$
$$= 2C$$

½

(**Note:** Give full credit to a student if 2C written directly)

(ii) Within the dielectric slab, induced electric field due to polarization, Decreases the electric field. 1

Alternatively: $\mathbf{E} = \mathbf{E_0} - \mathbf{E}_p$

Alternatively: $\mathbf{E} = \dfrac{\mathbf{E_0}}{K}$

(iii)

(a) $$V' = \frac{Q_{Total}}{C_{eqi}} = \frac{Q}{3C}$$ ½

	$V' = \frac{Q}{3C} = \frac{V}{3}$ (b) $Q_A' = C \times \frac{V}{3} = \frac{Q}{3}$ $Q_A = CV = Q$ Charge lost by capacitor A is $\Delta Q = Q - \frac{Q}{3} = \frac{2Q}{3}$ OR Capacitance of left portion, $C_1 = \frac{6K \in_0 A}{d}$ Capacitance of right portion, $C_2 = \frac{3K \in_0 A}{2d}$ As the capacitors are in series $\frac{1}{C_{eqi}} = \frac{1}{C_1} + \frac{1}{C_2}$ $\frac{1}{C_{eqi}} = \frac{d}{6K \in_O A} + \frac{2d}{3K \in_O A} = \frac{5d}{6KA \in_O}$ $C_{eqi} = \frac{6KA \in_O}{5d}$	½ ½ ½ ½ ½ ½ ½	 4

General Instructions :

Read the following instructions very carefully and strictly follow them :

(i) *This question paper contains* **35** *questions.* **All** *questions are* **compulsory**.

(ii) *This question paper is divided into* **five** *Sections –* **A, B, C, D** *and* **E**.

(iii) *In* **Section A** *– Questions no.* **1** *to* **18** *are Multiple Choice (MCQ) type questions, carrying* **1** *mark each.*

(iv) *In* **Section B** *– Questions no.* **19** *to* **25** *are Very Short Answer (VSA) type questions, carrying* **2** *marks each.*

(v) *In* **Section C** *– Questions no.* **26** *to* **30** *are Short Answer (SA) type questions, carrying* **3** *marks each.*

(vi) *In* **Section D** *– Questions no.* **31** *to* **33** *are Long Answer (LA) type questions carrying* **5** *marks each.*

(vii) *In* **Section E** *– Questions no.* **34** *and* **35** *are case-based questions carrying* **4** *marks each.*

(viii) *There is no overall choice. However, an internal choice has been provided in 2 questions in Section B, 2 questions in Section C, 3 questions in Section D and 2 questions in Section E.*

(ix) *Use of calculators is* **not** *allowed.*

Use the following values of physical constants, if required :

$c = 3 \times 10^8$ m/s

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8{\cdot}854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

Mass of electron (m_e) = $9{\cdot}1 \times 10^{-31}$ kg

Mass of neutron = $1{\cdot}675 \times 10^{-27}$ kg

Mass of proton = $1{\cdot}673 \times 10^{-27}$ kg

Avogadro's number = $6{\cdot}023 \times 10^{23}$ per gram mole

Boltzmann constant = $1{\cdot}38 \times 10^{-23}$ JK^{-1}

SECTION A

1. A small object lies at the bottom of a vessel filled with water (refractive index 4/3) up to a height H. When viewed from a point above the surface of water, the object appears raised by n percent of H. The value of n is :

(a) 15 (b) 20

(c) 25 (d) 33

2. An electron with velocity $\vec{v} = (v_x \hat{i} + v_y \hat{j})$ moves through a magnetic field $\vec{B} = (B_x \hat{i} - B_y \hat{j})$. The force $\vec{F}$ on the electron is : (e is the magnitude of its charge)

(a) $-e(v_x B_y - v_y B_x)\hat{k}$ (b) $e(v_x B_y - v_y B_x)\hat{k}$

(c) $-e(v_x B_y + v_y B_x)\hat{k}$ (d) $e(v_x B_y + v_y B_x)\hat{k}$

3. A bar magnet is cut into two equal halves parallel to its magnetic axis. The physical quantity that remains unchanged is :

(a) pole strength (b) magnitude of magnetisation

(c) moment of inertia (d) magnetic moment

4. In a series LC circuit connected to an ac source, with the increase in the frequency of the source, the net reactance :

(a) increases linearly

(b) decreases linearly

(c) first increases to become maximum and then decreases to zero

(d) first decreases to become zero and then increases

5. Which of the following physical quantities remain the same for X-ray, red light and radio waves when travelling through a medium ?

(a) Wavelength (b) Speed

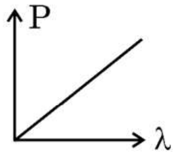
(c) Frequency (d) Momentum

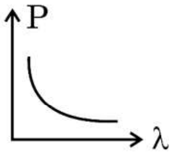
6. In Young's double-slit experiment, the intensity on the screen is I_0 at a point where path difference is λ. The intensity at the point where path difference is $\frac{\lambda}{4}$ is :

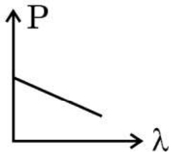
(a) $\frac{I_0}{4}$ (b) $\frac{I_0}{2}$

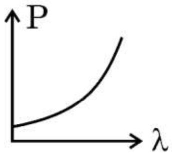
(c) I_0 (d) zero

7. Which of the following figures represents the variation of a particle's momentum with the de Broglie wavelength associated with it ?

(a) 

(b) 

(c) 

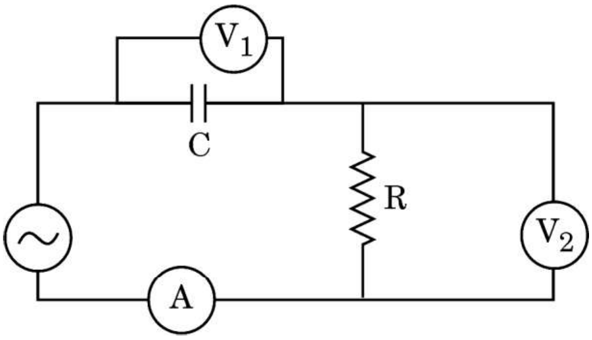
(d) 

8. In the nuclear reaction ${}_{7}N^{14} + {}_{2}He^{4} \longrightarrow X + {}_{1}H^{1}$, X represents :

(a) ${}_{7}O^{16}$ (b) ${}_{8}N^{17}$

(c) ${}_{8}O^{17}$ (d) ${}_{7}N^{16}$

9. The given figure shows a capacitor C and a resistor R connected in series to an ac source. V_1 and V_2 are voltmeters and A is an ammeter.



Which of the following statements is correct ?

(a) Current in the circuit lags in phase with voltage shown in V_2 .

(b) The voltage shown in V_1 is ahead in phase with voltage shown in V_2.

(c) The current in the circuit and the voltage shown in V_1 are always in phase.

(d) The voltage shown in V_1 lags behind in phase with the voltage shown in V_2 .

10. Light of frequency $1{\cdot}5\ \nu_0$ is incident on a photosensitive material of threshold frequency ν_0. If the frequency of the incident radiation is kept constant and intensity is increased, the photo current will :

(a) increase

(b) decrease

(c) not change

(d) first decrease and then become zero

11. The impact parameter for an alpha particle approaching a target nucleus is maximum when the scattering angle (θ) is :

(a) $0°$ (b) $90°$

(c) $180°$ (d) $45°$

12. Two nuclei have their mass numbers in the ratio of 1 : 27. What is the ratio of their nuclear densities ?

(a) 1 : 27 (b) 1 : 1

(c) 1 : 9 (d) 1 : 3

13. A plane wave is incident on a concave mirror of radius of curvature R. The reflected wave is a spherical wave of radius :

(a) $\frac{R}{4}$ (b) $\frac{R}{2}$

(c) R (d) 2R

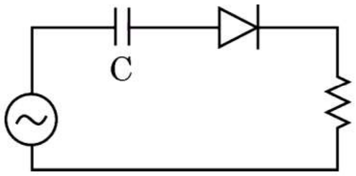
14. A planar loop is rotated in a magnetic field about an axis perpendicular to the field. The polarity of induced emf changes once in each :

(a) 1 revolution (b) $\left(\frac{1}{2}\right)$ revolution

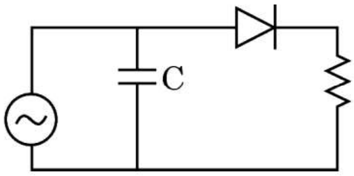
(c) $\left(\frac{1}{4}\right)$ revolution (d) $\left(\frac{3}{4}\right)$ revolution

15. In which of the following diagrams is the capacitor 'C' connected correctly to provide smooth output of a half-wave rectifier ?

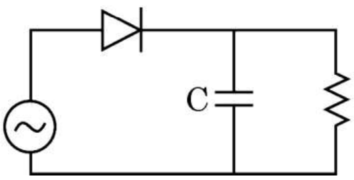
(a)



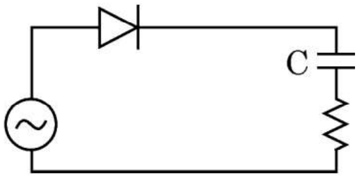
(b)



(c)



(d)



*Questions number **16** to **18** are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (a), (b), (c) and (d) as given below.*

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is ***not*** the correct explanation of the Assertion (A).

(c) Assertion (A) is true, but Reason (R) is false.

(d) Assertion (A) is false and Reason (R) is also false.

16. *Assertion (A) :* The temperature coefficient of resistance is positive for metals and negative for semi-conductors.

Reason (R) : The charge carriers in metals are negatively charged whereas in semiconductors they are positively charged.

17. *Assertion (A) :* A planar loop of irregular shape carrying current is subjected to a magnetic field acting perpendicular to the plane of the loop. If the wire is flexible, the loop takes a circular shape.

Reason (R) : The force acting on each point of a current carrying loop, in a magnetic field perpendicular to its plane, is radially outward.

18. *Assertion (A) :* Silicon is preferred over germanium for making semiconductor devices.

Reason (R) : The energy gap for germanium is more than the energy gap for silicon.

SECTION B

19. (a) The electric field of an electromagnetic wave passing through vacuum is represented as $E_x = E_0 \sin (kz - \omega t)$. Identify the parameter which is related to the (i) wavelength, and (ii) the frequency of the wave in the above equation.

(b) Write two properties of a medium that determine the velocity of light in that medium. *2*

20. Two identical bars, one of a paramagnetic material and another of a diamagnetic material are kept in a uniform magnetic field. Show diagrammatically the modifications in the pattern of magnetic field in each case. How are the two materials affected by increase in temperature ? *2*

21. Light of wavelength 3500 Å is incident on two metals A and B. Which of them will yield photoelectrons, if their work functions are 4·2 eV and 1·9 eV respectively ? Make the necessary calculations to justify your answer. *2*

22. The inward and the outward electric flux through a Gaussian surface are 2ϕ and ϕ respectively.

(a) What is the net charge enclosed by the surface ?

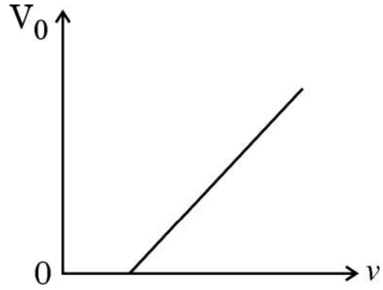
(b) If the net outward flux through the surface were zero, can it be concluded that there were no charges inside the surface ? Justify your answer. *2*

23. (a) When is more power delivered to a light bulb — just after it is turned on and the glow of the filament is increasing or after the glow becomes steady ? Why ? *2*

OR

(b) A battery is connected first across the series combination and then across the parallel combination, of three resistances R, 2R and 3R. In which of the three resistances will power dissipated be maximum in the two cases ? Justify your answer. *2*

24. The figure shows the variation of stopping potential V_0 with frequencies of incident monochromatic beam for a metal. Such a graph was first obtained by R.A. Millikan in 1916 for sodium.



Explain how, using Einstein's photoelectric equation and the graph, you can obtain the value of (i) Planck's constant, and (ii) work function of the metal, given the value of charge on electron. *2*

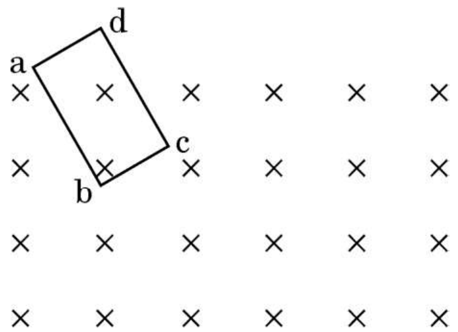
25. (a) A uniform electric field E of 500 N/C is directed along +x axis. O, B and A are three points in the field having x and y coordinates (in cm) (0, 0), (4, 0) and (0, 3) respectively. Calculate the potential difference between the points (i) O and A, and (ii) O and B. *2*

OR

(b) Three point charges $1\ \mu C$, $-1\ \mu C$ and $2\ \mu C$ are kept at the vertices A, B and C respectively of an equilateral triangle of side 1 m. A_1, B_1 and C_1 are the midpoints of the sides AB, BC and CA respectively. Calculate the net amount of work done in displacing the charge from A to A_1, from B to B_1 and from C to C_1. *2*

SECTION C

26. (a) State Lenz's law. Determine the direction of the induced current when a rectangular conducting loop abcd in xy-plane is moved into a region of magnetic field which is directed along z-axis. *3*



OR

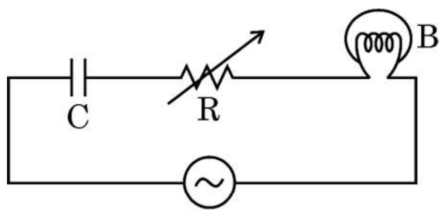
(b) Two identical circular loops, one of copper and the other of aluminium are rotated about their diameters with the same angular speed in a magnetic field directed perpendicular to their axes of rotation. Compare (i) the emf induced, and (ii) the current in the two loops. Justify your answers. *3*

27. (a) It is not advisable to use a galvanometer as such to measure current directly. Why ?

(b) Why should the value of resistance connected in parallel to a galvanometer be low ?

(c) Is the reading shown by an ammeter in a circuit less than or more than the actual value of current flowing in the circuit ? Why ? *3*

28. The figure shows a capacitor C, a variable resistor R and a bulb connected in series to the ac source of frequency (ν). The bulb glows with some brightness.



How will the glow of the bulb be affected, if the

(a) separation between the plates of the capacitor is doubled, keeping resistance R and frequency (ν) the same ?

(b) resistance R is decreased keeping the value of capacitance C and frequency (ν) same ?

(c) frequency of ac source is decreased for the same value of C and R ? Justify your answer in each case. *3*

29. (a) (i) In which case is diffraction effect more dominant — slit formed by 2 blades or slit formed by two fingers ?

(ii) Yellow light (λ = 6000 Å) illuminates a single slit of width 1×10^{-4} m. Calculate (i) the distance between two dark lines on either side of central maximum, in the diffraction pattern observed on a screen kept 1·5 m away from the slit, and (ii) the angular spread of the first minimum. *3*

OR

(b) (i) What will be the colour of the central bright fringe in Young's double slit experiment if the monochromatic source is replaced by a source of white light ? Give reason for your answer.

(ii) In Young's double slit experiment, the slits are separated by 0·3 mm and the screen is placed 1·5 m away from the slits. The distance between the central bright fringe and the sixth bright fringe is found to be 1·8 cm. Find the wavelength of light used in the experiment. *3*

30. (a) (i) An electron in a hydrogen atom jumps from second excited state to the first excited state. Name the spectral series in the spectrum of hydrogen atom to which the emitted radiation belongs.

(ii) Find the ratio of the wavelengths of the "most energetic spectral" lines in the Balmer series to that in Paschen series of Hydrogen spectrum. *3*

OR

(b) (i) An α-particle having kinetic energy K approaches a nucleus of atomic number Z. It gets close to the nucleus and then approaches a distance (d) and reverses its direction. Obtain an expression for the distance of closest approach (d) in terms of kinetic energy of the α-particle.

(ii) A proton and an alpha particle approach a target nucleus in head-on position, with equal velocities. Find the ratio of their distances of closest approach to the target nucleus. *3*

SECTION D

31. (a) (i) Draw a labelled ray diagram of an astronomical telescope to show the image formation of a distant object by it in normal adjustment. What are the main considerations required in selecting the objective and eyepiece lenses so that the telescope has large magnifying power and high resolution ?

(ii) A biconvex lens of focal length 20 cm is immersed in water, whose refractive index is $\frac{4}{3}$. Find the change, if any, in the nature and the focal length of the lens. Refractive index of the material of convex lens is $\frac{3}{2}$. *5*

OR

(b) (i) Draw a ray diagram showing refraction of light through a prism of angle A and obtain the relation between μ, A and the angle of minimum deviation δ_m.

(ii) An equiconvex lens of radius of curvature R and made of glass of refractive index μ is cut into two identical plano-convex lenses. Find the focal length of the plano-convex lenses. *5*

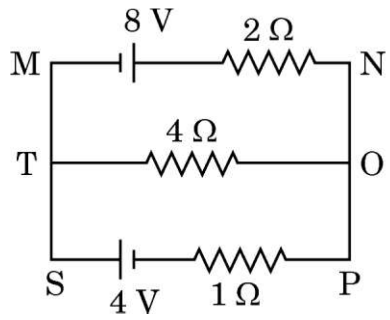
32. (a) (i) Derive the relation between the current and the drift velocity of free electrons in a conductor. Briefly explain the variation of resistance of a conductor with rise in temperature.

(ii) An ammeter, together with an unknown resistance in series is connected across two identical batteries, each of emf 1·5 V, connected (i) in series, and (ii) in parallel. If the current recorded in the two cases be $\left(\frac{1}{2}\right)$ A and $\left(\frac{1}{3}\right)$ A respectively, calculate the internal resistance of each battery. *5*

OR

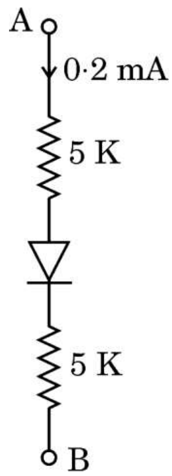
(b) (i) State Kirchhoff's rules. Use them to obtain the condition of balance for a Wheatstone Bridge.

(ii) Use Kirchhoff's rule to determine the currents flowing through the branches MN, TO and SP in the circuit shown in the figure. *5*



33. (a) (i) Draw the circuit diagram used to study I – V characteristics of a p-n junction diode in conducting mode. Mark on the graph the threshold voltage of the diode. Explain the significance of this voltage.

(ii) In the circuit shown in the figure, the forward voltage drop across the diode is 0·3 V. Find the voltage difference between A and B. *5*



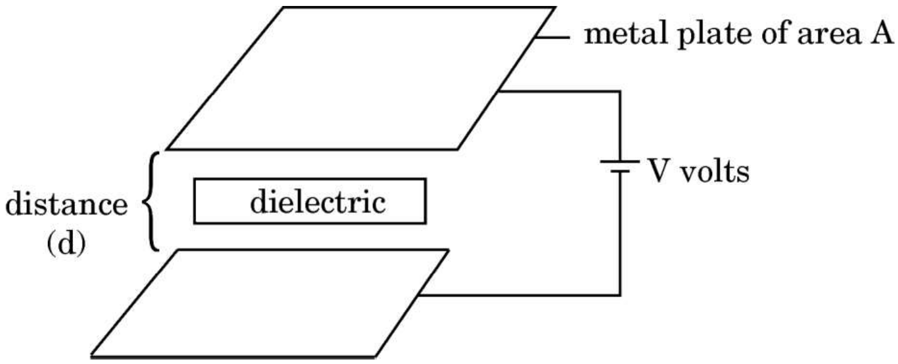
OR

(b) (i) Briefly describe the classification of solids into metals, insulators and semi-conductors on the basis of energy level diagrams.

(ii) In a silicon diode, the current increases from 10 mA to 20 mA when the voltage changes from 0·6 V to 0·7 V. Calculate the dynamic resistance of the diode. *5*

SECTION E

34.



A parallel plate capacitor is an arrangement of two identical metal plates kept parallel, a small distance apart. The capacitance of a capacitor depends on the size and separation of the two plates and also on the dielectric constant of the medium between the plates. Like resistors, capacitors can also be arranged in series or parallel or a combination of both. By virtue of electric field between the plates, charged capacitors store energy.

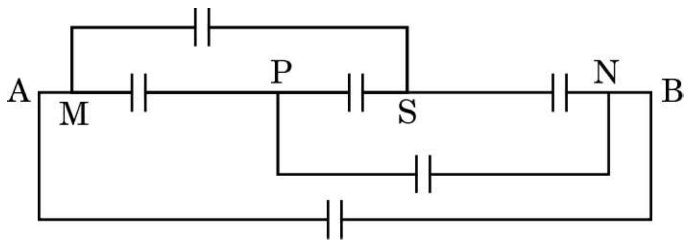
(a) The capacitance of a parallel plate capacitor increases from 10 μF to 80 μF on introducing a dielectric medium between the plates. Find the dielectric constant of the medium. *1*

(b) n capacitors, each of capacitance C, are connected in series. Find the equivalent capacitance of the combination. *1*

(c) A capacitor is charged to a potential (V) by connecting it to a battery. After some time, the battery is disconnected and a dielectric is introduced between the plates. How will the potential difference between the plates, and the energy stored in it be affected ? Justify your answer. *2*

OR

(c) Find the equivalent capacitance between points A and B, if capacitance of each capacitor is C. *2*



35. A prism is a solid transparent medium bounded by three rectangular faces with a triangular base and a top. A ray of light incident at angle i on one face of a prism suffers two refractions on passing through a prism. Hence it deviates through a certain angle δ from its original path. The angle of deviation becomes minimum ($\delta = \delta_m$) for a certain value of angle i. In such a condition, the refracted ray inside the prism becomes parallel to its base. An expression for refractive index μ of the material of the prism can be obtained in terms of angle A and angle δ_m.

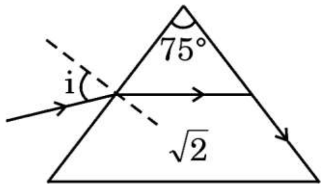
(a) Show in a figure the variation of angle δ with angle of incidence i. *1*

(b) Show that for a prism of small angle A, the refractive index μ of its material can be written as $\mu = 1 + \frac{\delta_m}{A}$. *1*

(c) A ray of light passes through an equilateral prism such that both the angle of incidence and the angle of emergence are equal to the angle of prism A. Find the refractive index of the material of the prism, in terms of A. *2*

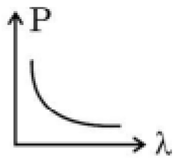
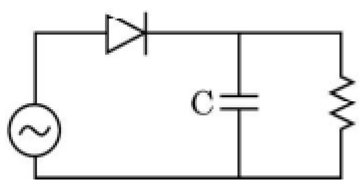
OR

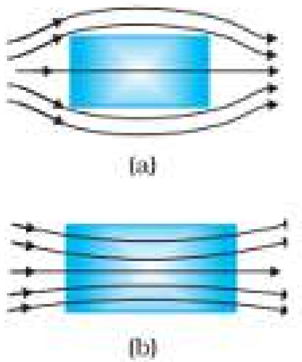
(c) A ray of light passes through a prism of angle 75°, as shown in the figure. The refractive index of the material of the prism, with respect to its surrounding is $\sqrt{2}$. Find the angle of incidence i. *2*



MARKING SCHEME: PHYSICS(042)

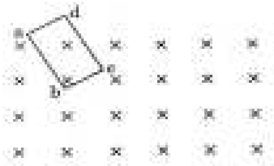
Code:

Q.No.	VALUE POINTS/EXPECTED ANSWERS	Marks	Total Marks
1.	(c) 25	1	1
2.	(d) $e(v_x B_y + v_y B_x)\hat{k}$	1	1
3.	(b) magnitude of magnetization	1	1
4.	(d) first decreases to become zero and then increases	1	1
5.	(b) speed	1	1
6.	(b) $\frac{I_0}{2}$	1	1
7.	(b) 	1	1
8.	(c) $_8O^{17}$	1	1
9.	(d) The voltage shown in V_1 lags behind in phase with the voltage shown in V_2 .	1	1
10.	(a) increase	1	1
11.	(a) 0^o	1	1
12.	(b) 1:1	1	1
13.	(b) $\frac{R}{2}$	1	1
14.	(b) ($\frac{1}{2}$) revolution	1	1
15.	(c) 	1	1
16.	(c)Assertion (A) is true, but Reason (R) is false.	1	1
17.	(a)Both Assertion (A) and Reason ® are true, but Reason (R) is the correct explanation of the Assertion (A)	1	1
18.	(c) Assertion (A) is true, but Reason (R) is false.	1	1
	SECTION B		
19.	(a) Identification of parameters ½ + ½ (b) Two properties of medium ½ + ½	½	

	(a) Parameter relating wavelength is ‘k’($= \frac{2\pi}{\lambda}$) Parameter relating frequency is ’ ω ’ (= $2\pi\nu$) (b) 1. Electric properties of the medium 2. Magnetic properties of the medium Alternatively: i. Permittivity (ε) of the medium ii. Permeability (μ) of the medium	½ ½ ½	2
20.	Showing the modifications in the pattern of magnetic field ½ + ½ Effect of increase in temperature ½ + ½  No effect in case of diamagnetic materials. Magnetization/ magnetic susceptibility decrease in case of paramagnetic materials.	½ + ½ ½ ½	2
21.	Calculation of energy of incident light in ‘eV’ 1 Conclusion with justification ½ + ½ $E = \frac{\lambda c}{\lambda}$ $= \frac{6.63\times10^{-34}\times3\times10^{8}}{3500\times10^{-10}\times1.6\times10^{-19}} eV$ E = 3.55 eV Metal B Since energy of incident light is more than the work function of metal ‘B’. (Note: Give full credit of one mark if student writes ‘Metal B’ only.)	½ ½ ½ ½	2

22.	(a) Calculation of net charge 1 (b) Conclusion ½ Justification ½ (a) Net outward flux $= -2\Phi + \Phi$ $= -\Phi$ Charge enclosed $= -\Phi\, \varepsilon_o$ (b) No There may be charges (positive and negative) and net charge is zero.	½ ½ ½ ½	2
23.	(a) For Answer 1 Reason 1 (a) Power delivered just after it is turned on, will be more because resistance of the bulb is low. After some time temperature of the bulb increases and resistance also increases and therefore power $(\frac{V^2}{R})$ becomes low. OR For series Answer ½ Justification ½ For parallel Answer ½ Justification ½ For series Power dissipated will be maximum for 3R. Because current is same and power is proportional to resistance. For parallel Power dissipated will be maximum for R. Because voltage is same and power is inversely proportional to resistance.	1 1 ½ ½ ½ ½	2
24.	Relating Einstein equation to the graph 1 (i) Finding value of Planck's constant from slope of the graph ½ (ii)Finding value of work function from intercept of the graph ½ According to Einstein's equation $h\nu = \Phi_o + eV_o$ $eV_o = h\nu - \Phi_o$ $V_o = \frac{h}{e}\nu - \frac{\Phi_o}{e}$	½ ½	

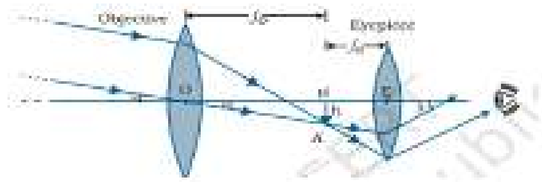
	This is equation of straight line as shown in figure, where slope is $\frac{h}{e}$. So from the value of slope from the graph and value of charge on electron value of Planck's constant can be calculated. Extrapolating the graph we get y - intercept $\frac{\Phi_o}{e}$. From this we can find work function given value of e.	½ ½	2
25.	(i) Calculation of V_{OA} ½ + ½ (ii) Calculation of V_{OB} ½ + ½ (a) (i) $V_{OA} = E(x_2 - x_1)$ $V_{OA} = 500 \times 0 = 0$ volt (ii) $V_{OB} = -E(x_2 - x_1)$ $V_{OB} = -500 \times (4 \times 10^{-2})$ $= -20$ V OR Calculating of initial potential energy 1 Calculation of final potential energy ½ Calculation of net work done ½ Initial electrostatic potential energy of the system $U_i = \frac{k}{r}[1\times(-1)+(-1)\times 2+(1)\times(2)]\times 10^{-12}$ $= \frac{9\times 10^9}{1}[-1-2+2]\times 10^{-12}$ $= -9\times 10^{-3} J$ Now $A_1B_1 = B_1C_1 = A_1C_1 = \frac{1}{2}$ m Final electrostatic potential energy of the system $U_f = \frac{-9\times 10^{-9}}{1/2} = -18\times 10^{-3}$ J Amount of work done W= U_f - U_i W= $-18\times 10^{-3} + 9\times 10^{-3} = -9\times 10^{-3} J$	 ½ ½ ½ ½ 1 ½ ½	2
	SECTION-C		
26.	(a) Statement of lenz's law 2 Finding direction of induced e.m.f 1 **OR** (b) (i) Answer and Justification ½ +1 (ii) Answer and justification ½ +1		

	(a) Lenz's law " the polarity of induced e.m.f is such that it tends to produce a current which opposes the change in magnetic flux that produced it"  Direction of induced current is abcd/anticlockwise OR (b) (i)Same e.m.f induced in both cases because they are identical and moving with same angular speed in same magnetic field. (ii) Induced current is more in copper loops, as its resistance is lesser than that of aluminum.	2 1 1½ 1½	3
27.	(a) Explanation 1 (b) Explanation 1 (c) Answer ½ Explanation ½ (a) It will not measure accurate value of current because its high resistance will affect the current in the circuit. (b) To reduce the galvanometer resistance a small resistance is connected in parallel. (c) It is less than the actual value of current because it has some resistance	1 1 1	3
28.	(a) Answer ½ Justification ½ (b) Answer ½ Justification ½ (c) Answer ½ Justification ½ (a) Glow of bulb will reduce. As capacitance reduces to half the net impedance of the circuit will increase and I decreases. (b) Glow will enhance as R is decreased, Z decreases and I increases (c) Glow of bulb will reduce When frequency is decreased, impedance increases which decreases current in the circuit.	½ ½ ½ ½ ½ ½	

	(Note: If a student attempt using relevant formulas and conclude correctly give full credit)		3
29.	(a) (i) Answer 1 (ii) i. Calculation of distance 1 ii. calculation of angular spread 1		
	(i) slit formed by two blades	1	
	(ii) (i) separation between two dark lines		
	$= \dfrac{2\lambda D}{d}$	½	
	$= \dfrac{2 \times 6000 \times 10^{-10} \times 1.5}{1 \times 10^{-4}} = 18 \times 10^{-3} m$	½	
	(ii) $\phi = \dfrac{\lambda}{a}$	½	
	$= \dfrac{6000 \times 10^{-10}}{1 \times 10^{-4}}$		
	$= 6 \times 10^{-3}$ rad	½	
	OR		
	(b) (i) Answer ½ Justification ½ (ii) Formula ½ Calculation 1 Answer ½		
	(b)		
	(i) White.	½	
	The interference pattern due to different component colors of white light overlap (incoherently). The central bright fringes for different colors are at the same position. Therefore the central fringe is white.	½	
	(ii) $\lambda_n = \dfrac{n\lambda D}{d}$	½	
	$\lambda = \dfrac{\lambda_n d}{nD}$	1	
	$\lambda = \dfrac{1.8 \times 10^{-2} \times 0.3 \times 10^{-3}}{6 \times 1.5}$		
	$\lambda = 6000 A^o$	½	3
30.	(a) (i) Name of spectral series ½ (ii) Calculation of λ_B ½ + ½ Calculation of λ_p ½ + ½ Calculation of ratio ½		

	(a) (i) Balmer series (ii) $\frac{1}{\lambda_B} = R[\frac{1}{2^2} - \frac{1}{\infty}]$ $\frac{1}{\lambda_B} = \frac{R}{4}$ $\frac{1}{\lambda_p} = R[\frac{1}{3^2} - \frac{1}{\infty}]$ $\frac{1}{\lambda p} = \frac{R}{9}$ $\frac{\lambda_B}{\lambda p} = \frac{4}{9}$	½ ½ ½ ½ ½ ½	
	OR (b) (i) Obtaining expression for distance of closest approach 1½ (ii) Finding the ratio of closest approaches 1½ (i) At the distance of closest approach. $K = \frac{(Ze)2e}{4\pi\varepsilon_o d}$ $d = \frac{2Ze^2}{4\pi\varepsilon_o K}$ $d = \frac{2(Ze)q}{\frac{1}{2}mv^2 \times 4\pi\varepsilon_o}$ $d = \frac{(Ze)q}{mv^2\pi\varepsilon_o}$ $d \alpha \frac{q}{m}$ $\frac{d_p}{d_\alpha} = \frac{e}{2e} \times \frac{4m}{m} = \frac{2}{1}$	½ 1 ½ ½ ½	3
	SECTION-D		
31.	(a) (i) Labelled Ray Diagram of astronomical telescope 1 Considerations for large magnifying power ½ Considerations for high resolution ½ (ii) Calculation for new focal length 2 Charge in focal length ½ Nature of new lens ½		

(a) (i)



1

½

For large magnifying power

$f_o > f_e$ ½

For high resolution

Aperture of objective should be large ½

(ii) $\frac{1}{f_a} = (n_g - 1)[\frac{1}{R_1} - \frac{1}{R_2}]$ ½

$\frac{1}{f_a} = (\frac{n_g}{n_w} - 1)[\frac{1}{R_1} - \frac{1}{R_2}]$

$\frac{f_w}{f_a} = \frac{(n_g - 1)}{(\frac{n_g}{n_w} - 1)}$

$\frac{f_w}{20} = \frac{(\frac{3}{2} - 1)}{(\frac{3}{2} \times \frac{3}{4} - 1)} = \frac{1/2}{1/8} = 4$ ½

f_w= 80 cm ½

Changes in focal length $\Delta f = 80 - 60$ ½

= 20 cm ½

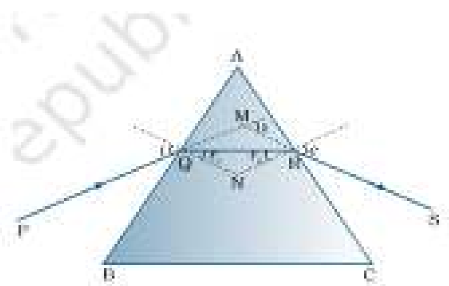
Nature of the lense is converging because f_w is positive

OR

(b)

(i) Ray diagram	1
Obtaining the relation between μ, A and δ m	2
(ii) Finding the focal length of plano-convex lens	2

(i)



1

From the figure

$\angle A + \angle QNR = 180^o$

From $\triangle QNR$

$r_1 + r_2 + \angle QNR = 180^o$

comparing the above equations

$r_1 + r_2 = A$ ------- (1) ½

$\delta = (i - r_1) + (e - r_2)$

$\delta = i + e - A$ ------- (2) ½

At the minimum derivation D_m

$\delta = D_m$, i=e and $r_1 = r_2$ ½

From equation (1)

2r= A

$r = \frac{A}{2}$

From equation (2)

$D_m = 2i - A$

$i = \frac{A + D_m}{2}$

The refractive index of the prism is

$$n_{21} = \frac{\sin i}{\sin r} = \frac{\sin[\frac{(A+D_m)}{2}]}{\sin[A/2]}$$ ½

(ii) ½

$$\frac{1}{f} = (n-1)[\frac{1}{R_1} - \frac{1}{R_2}]$$

$$\frac{1}{f_1} = (n-1)[\frac{2}{R}]$$ ½

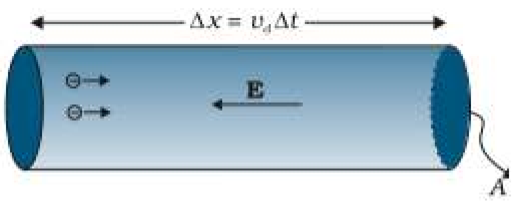
$$\frac{1}{f_2} = (n-1)[\frac{1}{R}]$$ ½

$f_2 = 2 f_1$ ½ 5

32.

(a) (i) Derivation of relation between I and v_d	2
Explanation	1
(ii) Calculating internal resistance of each battery	2

(a) (i)



½

Total charge transported across the area A in time Δt is

$\Delta Q = -neAv_d \Delta t$ ------(1) ½

Also the amount of charge crossing area 'A' in time Δt is

$\Delta Q = I \Delta t$ ------(2) ½

Comparing equation (1) and (2)

$I = neAv_d$ ½

With increase in temperature, average speed of electrons increases resulting in more frequent collisions

Hence relaxation time τ decreases

As $R = \frac{ml}{ne^2\tau A}$

Resistance increases. 1

(ii) For series $I = \frac{E}{R+r}$

$\frac{1}{2} = \frac{3}{R+2r}$

$R + 2r = 6$ --------(1) ½

For parallel $\frac{1}{3} = \frac{1.5}{R+\frac{r}{2}}$

$2R + r = 9$ ----------(2) ½

After solving $r = 1\,\Omega$ 1

OR

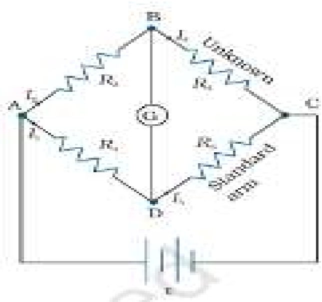
(b)

(i) Statement of Kirchhoff two rules	½ + ½
Obtaining the balanced condition	2
(ii) Finding current in branches MN, T0 and SP	2

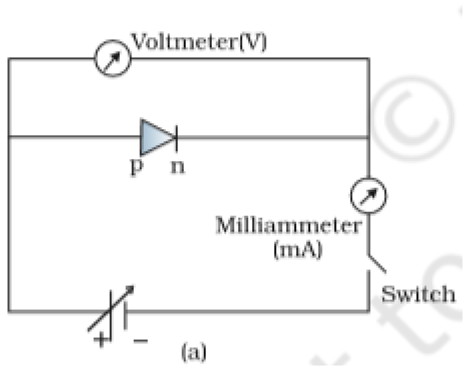
(i) Kirchhoff's junction rule - at any junction, the sum of the current entering the junction is equal to the sum of currents leaving the junction. ½

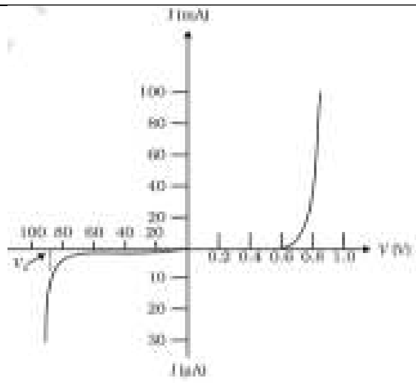
Kirchhoff second rule:

The algebraic sum of changes in potential around any closed loop involving resistors and cells in the loop is zero. ½



½

	In balanced fridge Ig=0, Hence $I_1= I_3$ and $I_2= I_4$ Using Kirchhoff's loop rule for closed loops ADBA and CBDC $- I_1R_1 +0+ I_1R_1 =0$ (Ig=0) -----(1)	½	
	In the second loop $I_3 = I_1$, $I_4 = I_2$ $I_2R_4 +0- I_1R_3 = 0$ -----(2) From equation (1) and (2) $\frac{I_1}{I_2} = \frac{R_2}{R_1} and \frac{I_1}{I_2} = \frac{R_4}{R_3}$	½	
	$\frac{R_2}{R_1} = \frac{R_4}{R_3}$ This is the condition for balanced Wheatstone bridge	½	
	(ii) In loop MNOTM $2 I + 4 I_1 =8$ ------(1)	½	
	Loop OPSTO $-I + 5 I_1 = - 4$ ------(2)	½	
	On solving Current in MN, I = 4A Current in TO, I_1 = 0A Current in SP, $I-I_1$ =4A	1	5
33.	(a) (i)Circuit diagram 1 I-V characteristics 1 Moving of threshold voltage ½ Significance of threshold voltage ½ (ii) Finding voltage difference between A and B 2  	1	



1

½

Beyond threshold voltage in forward bias diode current increases significantly even for very small increases in diode bias voltage.

½

2

(ii) $V_A - 5\times10^3 \times 0.2\times10^{-3} - 0.3 - 5\times10^3 \times 0.2\times10^{-3} - V_B = 0$

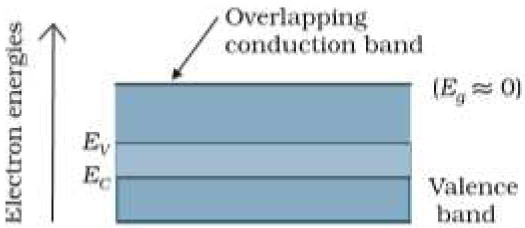
$V_A - V_B$ =2.3 volt

OR

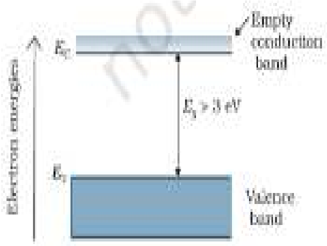
(b)

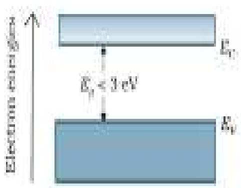
(i) Energy bond diagrams	1 ½
Description	1 ½
(ii) Calculation of dynamic resistance	2

(i)



½





½+ ½

½ + ½+ ½

For Eg> 3eV material is insulate

For Eg < 3eV material is semiconductor

For Eg=0 or overlapping of conduction and valence band material is conductor.

½ + ½

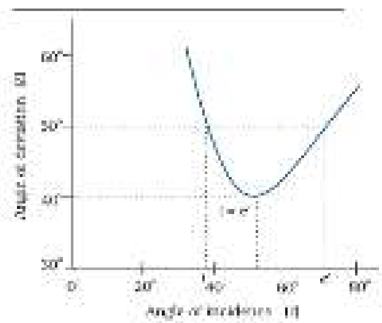
(ii) $r_d = \frac{\Delta V}{\Delta I} = \frac{0.7-0.6}{(20-10)\times10^{-3}}$

1

$r_d = 10\ \Omega$

5

	SECTION-E		
34.	(a) Finding dielectric constant — 1 (b) Finding equivalent capacitance — 1 (c) Effect on potential difference and justification — ½ + ½ Effect on energy stored and justification — ½ + ½ **OR** Calculation of effective capacitance — 2		
	(a) $K = \frac{C}{C_0}$	½	
	$K = \frac{80\mu F}{10\mu F} = 8$	½	
	(b) $\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots\ldots\ldots + \frac{1}{C_n}$	½	
	$\frac{1}{C_S} = \frac{n}{C}$		
	$C_S = \frac{C}{n}$	½	
	(c) Charge is constant $Q_1 = Q_2$ $C_2 = KC_1$ $C_1 V_1 = K C_1 V_2$	½	
	$V_2 = \frac{V_1}{K}$ Potential diff decreases by a factor (1/K)	½	
	$U_2 = \frac{1}{2}\frac{Q^2}{C_2}$	½	
	$= \frac{1}{2}\frac{Q^2}{kC_1} = \frac{1}{k}\left(\frac{Q^2}{2C_2}\right)$	½	
	$U_2 = \frac{U_1}{K}$	½	
	Energy reduces by a factor of 1/K.		
	OR		
	For calculating effective capacitance = 2 C.	2	4

35.	(a) Variation of δ with i — 1 (b) Derivation of equation for small angle prism — 1 (c) Calculation of μ in terms of A — 2 OR Calculation of angle of incident (i) — 2		
	(a) 	1	
	(b) $\mu=\dfrac{\sin\left(\dfrac{A+\delta_m}{2}\right)}{\sin A/2}$	½	
	For small angle $\mu=\dfrac{\dfrac{A+\delta_m}{2}}{A/2}$ $\mu=\dfrac{A+\delta_m}{A}$ $\mu=1+\dfrac{\delta_m}{A}$	½	
	(c) $i+e=A$	½	
	$r=\dfrac{A}{2}$	½	
	$\mu=\dfrac{\sin i}{\sin r}$ $\mu=\dfrac{\sin A}{\sin A/2}$	½	
		½	
	$\mu=\dfrac{2\sin(A/2)\cos(A/2)}{\sin(A/2)}=2\cos(A/2)$	½	
	OR $\dfrac{\sin i}{\sin r}=\sqrt{2}$	½	

	$\frac{\sin r_2}{\sin 90^0} = \frac{1}{\sqrt{2}}$ $\sin r_2 = \frac{1}{\sqrt{2}}$ $r_2 = 45^0$ $r_1 + r_2 = A$ $r_1 + 45^0 = 75^0$ $r_1 = 30^0$ $\frac{\sin i}{\sin r_1} = \sqrt{2}$ $\frac{\sin i}{\sin 30^0} = \sqrt{2}$ $\sin i = \sqrt{2} \times \frac{1}{2}$ $\sin i = \frac{1}{\sqrt{2}}$ $i = 45^0$	½ ½ ½	4

General Instructions :

Read the following instructions carefully and follow them :

(i) *This question paper contains **33** questions. **All** questions are **compulsory**.*

(ii) *This question paper is divided into **five** sections – **Sections A, B, C, D** and **E**.*

(iii) *In **Section A** – Questions no. **1** to **16** are Multiple Choice type questions. Each question carries **1** mark.*

(iv) *In **Section B** – Questions no. **17** to **21** are Very Short Answer type questions. Each question carries **2** marks.*

(v) *In **Section C** – Questions no. **22** to **28** are Short Answer type questions. Each question carries **3** marks.*

(vi) *In **Section D** – Questions no. **29** and **30** are case study-based questions. Each question carries **4** marks.*

(vii) *In **Section E** – Questions no. **31** to **33** are Long Answer type questions. Each question carries **5** marks.*

(viii) *There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.*

(ix) *Kindly note that there is a separate question paper for Visually Impaired candidates.*

(x) *Use of calculators is **not** allowed.*

You may use the following values of physical constants wherever necessary :

$c = 3 \times 10^8$ m/s

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8{\cdot}854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

Mass of electron (m_e) = $9{\cdot}1 \times 10^{-31}$ kg

Mass of neutron = $1{\cdot}675 \times 10^{-27}$ kg

Mass of proton = $1{\cdot}673 \times 10^{-27}$ kg

Avogadro's number = $6{\cdot}023 \times 10^{23}$ per gram mole

Boltzmann constant = $1{\cdot}38 \times 10^{-23}$ JK^{-1}

SECTION A

1. A thin plastic rod is bent into a circular ring of radius R. It is uniformly charged with charge density λ. The magnitude of the electric field at its centre is :

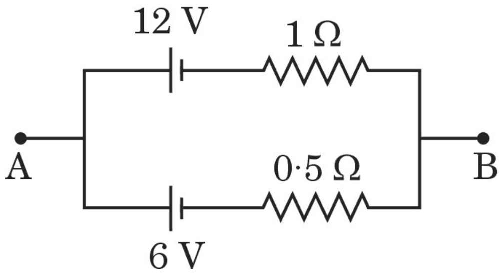
(A) $\frac{\lambda}{2\varepsilon_0 R}$ (B) Zero (C) $\frac{\lambda}{4\pi\varepsilon_0 R}$ (D) $\frac{\lambda}{4\varepsilon_0 R}$

2. Ten capacitors, each of capacitance 1 μF, are connected in parallel to a source of 100 V. The total energy stored in the system is equal to :

(A) 10^{-2} J (B) 10^{-3} J

(C) $0{\cdot}5 \times 10^{-3}$ J (D) $5{\cdot}0 \times 10^{-2}$ J

3. Consider the circuit shown in the figure. The potential difference between points A and B is :



(A) 6 V (B) 8 V (C) 9 V (D) 12 V

4. A loop carrying a current I clockwise is placed in x – y plane, in a uniform magnetic field directed along z-axis. The tendency of the loop will be to :

(A) move along x-axis (B) move along y-axis

(C) shrink (D) expand

5. A 10 cm long wire lies along y-axis. It carries a current of 1·0 A in positive y-direction. A magnetic field $\vec{B} = (5 \text{ mT})\hat{j} - (8 \text{ mT})\hat{k}$ exists in the region. The force on the wire is :

(A) $(0{\cdot}8 \text{ mN})\hat{i}$ (B) $-(0{\cdot}8 \text{ mN})\hat{i}$

(C) $(80 \text{ mN})\hat{i}$ (D) $-(80 \text{ mN})\hat{i}$

6. A galvanometer of resistance G Ω is converted into an ammeter of range 0 to I A. If the current through the galvanometer is 0·1% of I A, the resistance of the ammeter is :

(A) $\frac{G}{999}\ \Omega$ (B) $\frac{G}{1000}\ \Omega$ (C) $\frac{G}{1001}\ \Omega$ (D) $\frac{G}{100 \cdot 1}\ \Omega$

7. The reactance of a capacitor of capacitance C connected to an ac source of frequency ω is 'X'. If the capacitance of the capacitor is doubled and the frequency of the source is tripled, the reactance will become :

(A) $\frac{X}{6}$ (B) 6X (C) $\frac{2}{3}X$ (D) $\frac{3}{2}X$

8. In the four regions, I, II, III and IV, the electric fields are described as :

Region I : $E_x = E_0 \sin (kz - \omega t)$

Region II : $E_x = E_0$

Region III : $E_x = E_0 \sin kz$

Region IV : $E_x = E_0 \cos kz$

The displacement current will exist in the region :

(A) I (B) IV (C) II (D) III

9. The transition of electron that gives rise to the formation of the second spectral line of the Balmer series in the spectrum of hydrogen atom corresponds to :

(A) $n_f = 2$ and $n_i = 3$ (B) $n_f = 3$ and $n_i = 4$

(C) $n_f = 2$ and $n_i = 4$ (D) $n_f = 2$ and $n_i = \infty$

10. Ge is doped with As. Due to doping,

(A) the structure of Ge lattice is distorted.

(B) the number of conduction electrons increases.

(C) the number of holes increases.

(D) the number of conduction electrons decreases.

11. Two beams, A and B whose photon energies are 3·3 eV and 11·3 eV respectively, illuminate a metallic surface (work function 2·3 eV) successively. The ratio of maximum speed of electrons emitted due to beam A to that due to beam B is :

(A) 3 (B) 9 (C) $\frac{1}{3}$ (D) $\frac{1}{9}$

12. The waves associated with a moving electron and a moving proton have the same wavelength λ. It implies that they have the same :

(A) momentum (B) angular momentum

(C) speed (D) energy

*Questions number **13** to **16** are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below.*

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is ***not*** the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false and Reason (R) is also false.

13. *Assertion (A) :* In photoelectric effect, the kinetic energy of the emitted photoelectrons increases with increase in the intensity of the incident light.

Reason (R) : Photoelectric current depends on the wavelength of the incident light.

14. *Assertion (A) :* The mutual inductance between two coils is maximum when the coils are wound on each other.

Reason (R) : The flux linkage between two coils is maximum when they are wound on each other.

15. *Assertion (A) :* Two long parallel wires, freely suspended and connected in series to a battery, move apart.

Reason (R) : Two wires carrying current in opposite directions repel each other.

16. *Assertion (A) :* Plane and convex mirrors cannot produce real images under any circumstance.

Reason (R) : A virtual image cannot serve as an object to produce a real image.

SECTION B

17. Find the temperature at which the resistance of a wire made of silver will be twice its resistance at 20°C. Take 20°C as the reference temperature and temperature coefficient of resistance of silver at 20°C = $4{\cdot}0 \times 10^{-3}$ K^{-1}. *2*

18. (a) Monochromatic light of frequency $5{\cdot}0 \times 10^{14}$ Hz passes from air into a medium of refractive index 1·5. Find the wavelength of the light (i) reflected, and (ii) refracted at the interface of the two media. *2*

OR

(b) A plano-convex lens of focal length 16 cm is made of a material of refractive index 1·4. Calculate the radius of the curved surface of the lens. *2*

19. An object is placed 30 cm in front of a concave mirror of radius of curvature 40 cm. Find the (i) position of the image formed and (ii) magnification of the image. *2*

20. Consider a neutron (mass m) of kinetic energy E and a photon of the same energy. Let λ_n and λ_p be the de Broglie wavelength of neutron and the wavelength of photon respectively. Obtain an expression for $\frac{\lambda_n}{\lambda_p}$. *2*

21. Plot a graph showing the variation of current with voltage for the material GaAs. On the graph, mark the region where : *2*

(a) resistance is negative, and

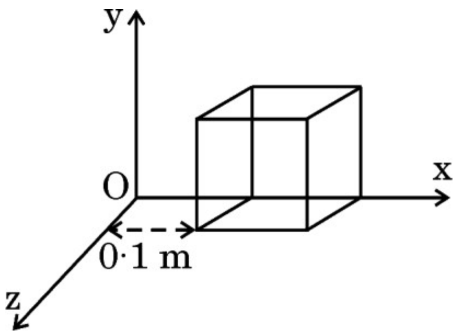
(b) Ohm's law is obeyed.

SECTION C

22. A cube of side 0·1 m is placed, as shown in the figure, in a region where electric field $\vec{E} = 500\, x\, \hat{i}$ exists. Here x is in meters and E in NC^{-1}. Calculate : *3*

(a) the flux passing through the cube, and

(b) the charge within the cube.



23. (a) Define 'current density'. Is it a scalar or a vector ? An electric field $\vec{E}$ is maintained in a metallic conductor. If n be the number of electrons (mass m, charge – e) per unit volume in the conductor and τ its relaxation time, show that the current density $\vec{j} = \alpha \vec{E}$, where $\alpha = \left(\frac{ne^2}{m}\right)\tau$. *3*

OR

(b) What is a Wheatstone bridge ? Obtain the necessary conditions under which the Wheatstone bridge is balanced. *3*

24. A proton with kinetic energy $1 \cdot 3384 \times 10^{-14}$ J moving horizontally from north to south, enters a uniform magnetic field B of 2·0 mT directed eastward. Calculate : *3*

(a) the speed of the proton

(b) the magnitude of acceleration of the proton

(c) the radius of the path traced by the proton

[Take (q/m) for proton = $1 \cdot 0 \times 10^{8}$ C/kg]

25. An inductor, a capacitor and a resistor are connected in series with an ac source $v = v_m \sin \omega t$. Derive an expression for the average power dissipated in the circuit. Also obtain the expression for the resonant frequency of the circuit. *3*

26. (a) "The wavelength of the electromagnetic wave is often correlated with the characteristic size of the system that radiates." Give two examples to justify this statement.

(b) (i) Long distance radio broadcasts use short-wave bands. Why ?

(ii) Optical and radio telescopes are built on the ground, but X-ray astronomy is possible only from satellites orbiting the Earth. Why ? *3*

27. Write the drawbacks of Rutherford's atomic model. How did Bohr remove them ? Show that different orbits in Bohr's atom are not equally spaced. *3*

28. (a) State any two properties of a nucleus.

(b) Why is the density of a nucleus much more than that of an atom ?

(c) Show that the density of the nuclear matter is the same for all nuclei. *3*

SECTION D

*Questions number **29** and **30** are case study-based questions. Read the following paragraphs and answer the questions that follow.*

29. A lens is a transparent medium bounded by two surfaces, with one or both surfaces being spherical. The focal length of a lens is determined by the radii of curvature of its two surfaces and the refractive index of its medium with respect to that of the surrounding medium. The power of a lens is reciprocal of its focal length. If a number of lenses are kept in contact, the power of the combination is the algebraic sum of the powers of the individual lenses.

(i) A double-convex lens, with each face having same radius of curvature R, is made of glass of refractive index n. Its power is : *1*

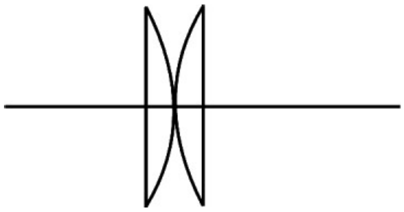
(A) $\frac{2(n-1)}{R}$ (B) $\frac{(2n-1)}{R}$

(C) $\frac{(n-1)}{2R}$ (D) $\frac{(2n-1)}{2R}$

(ii) A double-convex lens of power P, with each face having same radius of curvature, is cut into two equal parts perpendicular to its principal axis. The power of one part of the lens will be : *1*

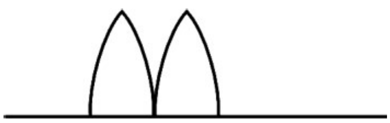
(A) 2P (B) P (C) 4P (D) $\frac{P}{2}$

(iii) The above two parts are kept in contact with each other as shown in the figure. The power of the combination will be : *1*



(A) $\frac{P}{2}$ (B) P (C) 2P (D) $\frac{P}{4}$

(iv) (a) A double-convex lens of power P, with each face having same radius of curvature, is cut along its principal axis. The two parts are arranged as shown in the figure. The power of the combination will be : *1*



(A) Zero (B) P

(C) 2P (D) $\frac{P}{2}$

OR

(b) Two convex lenses of focal lengths 60 cm and 20 cm are held coaxially in contact with each other. The power of the combination is : *1*

(A) 6·6 D (B) 15 D

(C) $\frac{1}{15}$ D (D) $\frac{1}{80}$ D

30. Junction Diode as a Rectifier :

The process of conversion of an ac voltage into a dc voltage is called rectification and the device which performs this conversion is called a rectifier. The characteristics of a p-n junction diode reveal that when a p-n junction diode is forward biased, it offers a low resistance and when it is reverse biased, it offers a high resistance. Hence, a p-n junction diode conducts only when it is forward biased. This property of a p-n junction diode makes it suitable for its use as a rectifier.

Thus, when an ac voltage is applied across a p-n junction, it conducts only during those alternate half cycles for which it is forward biased. A rectifier which rectifies only half cycle of an ac voltage is called a half-wave rectifier and one that rectifies both the half cycles is known as a full-wave rectifier.

(i) The root mean square value of an alternating voltage applied to a full-wave rectifier is $\frac{V_0}{\sqrt{2}}$. Then the root mean square value of the rectified output voltage is : *1*

(A) $\frac{V_0}{\sqrt{2}}$ (B) $\frac{V_0^2}{\sqrt{2}}$

(C) $\frac{2V_0}{\sqrt{2}}$ (D) $\frac{V_0}{2\sqrt{2}}$

(ii) In a full-wave rectifier, the current in each of the diodes flows for : *1*

(A) Complete cycle of the input signal

(B) Half cycle of the input signal

(C) Less than half cycle of the input signal

(D) Only for the positive half cycle of the input signal

(iii) In a full-wave rectifier : *1*

(A) Both diodes are forward biased at the same time.

(B) Both diodes are reverse biased at the same time.

(C) One is forward biased and the other is reverse biased at the same time.

(D) Both are forward biased in the first half of the cycle and reverse biased in the second half of the cycle.

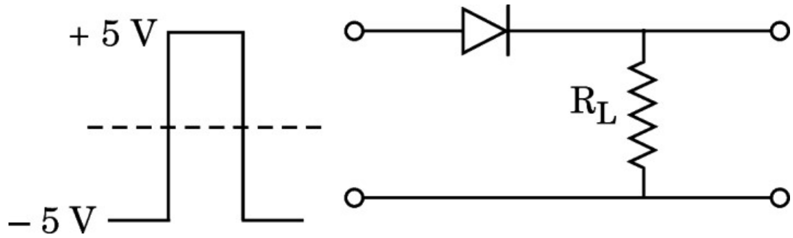
(iv) (a) An alternating voltage of frequency of 50 Hz is applied to a half-wave rectifier. Then the ripple frequency of the output will be : *1*

(A) 100 Hz (B) 50 Hz

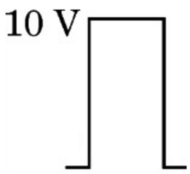
(C) 25 Hz (D) 150 Hz

OR

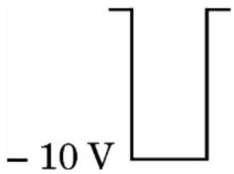
(b) A signal, as shown in the figure, is applied to a p-n junction diode. Identify the output across resistance R_L : *1*



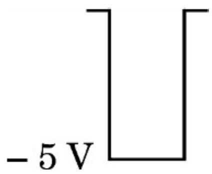
(A)



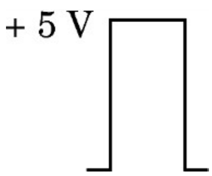
(B)



(C)



(D)



SECTION E

31. (a) (i) Derive an expression for potential energy of an electric dipole $\vec{p}$ in an external uniform electric field $\vec{E}$. When is the potential energy of the dipole (1) maximum, and (2) minimum ?

(ii) An electric dipole consists of point charges – 1·0 pC and + 1·0 pC located at (0, 0) and (3 mm, 4 mm) respectively in x – y plane. An electric field $\vec{E} = \left(\frac{1000 \text{ V}}{\text{m}}\right)\hat{i}$ is switched on in the region. Find the torque $\vec{\tau}$ acting on the dipole. *5*

OR

(b) (i) An electric dipole (dipole moment $\vec{p} = p\hat{i}$), consisting of charges – q and q, separated by distance 2a, is placed along the x-axis, with its centre at the origin. Show that the potential V, due to this dipole, at a point x, (x >> a) is equal to $\frac{1}{4\pi\varepsilon_0} \cdot \frac{\vec{p} \cdot \hat{i}}{x^2}$.

(ii) Two isolated metallic spheres S_1 and S_2 of radii 1 cm and 3 cm respectively are charged such that both have the same charge density $\left(\frac{2}{\pi} \times 10^{-9}\right) \text{C/m}^2$. They are placed far away from each other and connected by a thin wire. Calculate the new charge on sphere S_1. *5*

32. (a) (i) A resistor and a capacitor are connected in series to an ac source $v = v_m \sin \omega t$. Derive an expression for the impedance of the circuit.

(ii) When does an inductor act as a conductor in a circuit ? Give reason for it.

(iii) An electric lamp is designed to operate at 110 V dc and 11 A current. If the lamp is operated on 220 V, 50 Hz ac source with a coil in series, then find the inductance of the coil. *5*

OR

(b) (i) Draw a labelled diagram of a step-up transformer and describe its working principle. Explain any three causes for energy losses in a real transformer.

(ii) A step-up transformer converts a low voltage into high voltage. Does it violate the principle of conservation of energy ? Explain.

(iii) A step-up transformer has 200 and 3000 turns in its primary and secondary coils respectively. The input voltage given to the primary coil is 90 V. Calculate :

(1) The output voltage across the secondary coil

(2) The current in the primary coil if the current in the secondary coil is 2·0 A. *5*

33. (a) (i) A ray of light passes through a triangular prism. Show graphically, how the angle of deviation varies with the angle of incidence ? Hence define the angle of minimum deviation.

(ii) A ray of light is incident normally on a refracting face of a prism of prism angle A and suffers a deviation of angle δ. Prove that the refractive index n of the material of the prism is given by $n = \frac{\sin(A + \delta)}{\sin A}$.

(iii) The refractive index of the material of a prism is $\sqrt{2}$. If the refracting angle of the prism is 60°, find the

(1) Angle of minimum deviation, and

(2) Angle of incidence. *5*

OR

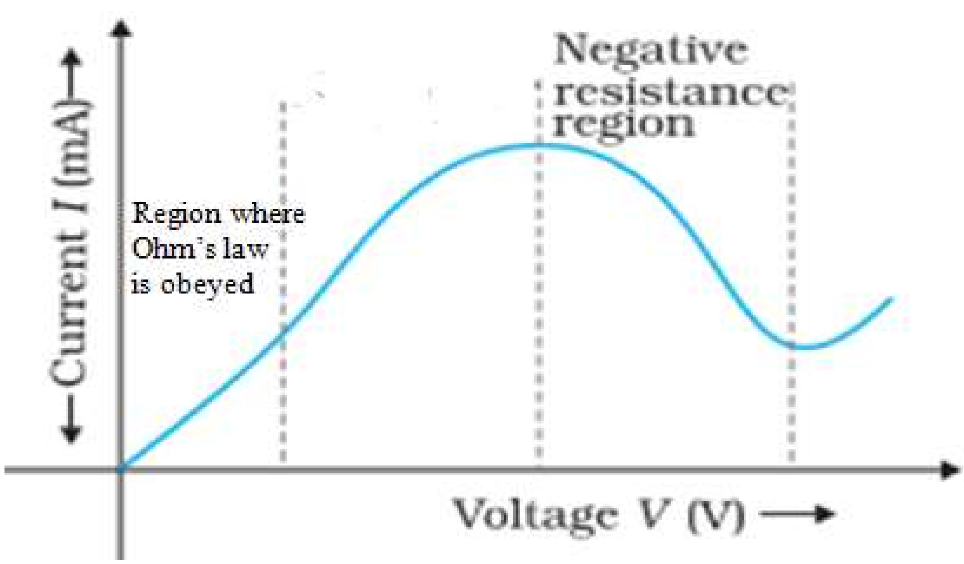
(b) (i) State Huygens' principle. A plane wave is incident at an angle i on a reflecting surface. Construct the corresponding reflected wavefront. Using this diagram, prove that the angle of reflection is equal to the angle of incidence.

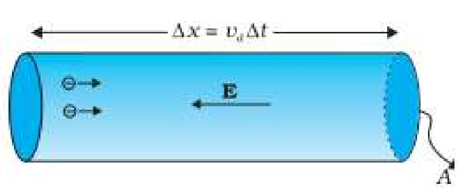
(ii) What are the coherent sources of light ? Can two independent sodium lamps act like coherent sources ? Explain.

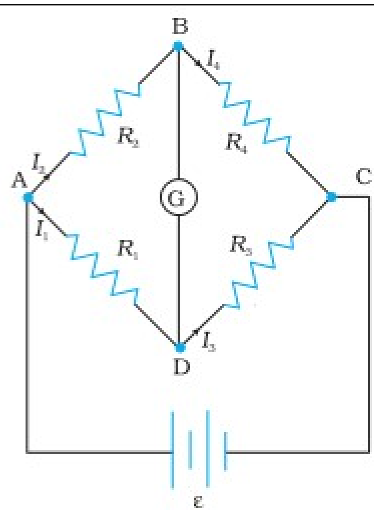
(iii) A beam of light consisting of a known wavelength 520 nm and an unknown wavelength λ, used in Young's double slit experiment produces two interference patterns such that the fourth bright fringe of unknown wavelength coincides with the fifth bright fringe of known wavelength. Find the value of λ. *5*

MARKING SCHEME : PHYSICS (042)			
CODE :55/1/1			
Q.NO.	**VALUE POINT/EXPECTED ANSWERS**	**MARKS**	**TOTAL MARKS**
	Section A		
1.	(B) Zero	1	1
2.	(D) 5.0×10^{-2} J	1	1
3.	(B) 8V	1	1
4.	(C) Shrink	1	1
5.	(B) $(-0.8\text{ mN})\,\hat{i}$	1	1
6.	(B) $\frac{G}{1000}\Omega$	1	1
7.	(A) $\frac{X}{6}$	1	1
8.	(A) I	1	1
9.	(C) $n_f = 2$ and $n_i = 4$	1	1
10.	(B) the number of conduction electrons increases	1	1
11.	(C) $\frac{1}{3}$	1	1
12.	(A) momentum	1	1
13.	(D) Assertion (A) is false and reason (R) is also false.	1	1
14.	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A)	1	1
15.	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A)	1	1
16.	(D) Assertion (A) is false and reason (R) is also false.	1	1
	Section B		
17.	Finding the temperature 2 $R = R_\circ\left[1+\alpha\left(T-T_\circ\right)\right]$ $R = 2R_\circ$ [Given] $2R_\circ = R_\circ\left[1+\alpha\left(T-T_\circ\right)\right]$ On solving $T = T_\circ + 250$ $T = 270°C$ or 543 K	½ ½ 1	2

18.	(a) Finding the wavelength of (i) Reflected Light 1 (ii) Refracted Light 1		
	(i) $v = \upsilon \lambda$ $3\times10^{8} = 5\times10^{14} \times \lambda$ $\lambda = 600$ nm or 6×10^{-7}m	1	
	(ii) $\lambda_{medium} = \dfrac{\lambda_{air}}{\mu}$ $\lambda_{medium} = \dfrac{600\,nm}{1.5}$ $= 400$ nm or 4×10^{-7}m	1	
	OR		
	(b) Calculating the radius of the curved surface 2		
	$\dfrac{1}{f} = (\mu - 1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$ $\dfrac{1}{16} = (1.4 - 1)\left(\dfrac{1}{R} - \dfrac{1}{\infty}\right)$	1	
	$\dfrac{1}{16} = 0.4 \times \dfrac{1}{R}$ R $= 16 \times 0.4$ R $= 6.4$ cm	1	2
19.	Finding the (i) position of the image formed 1 (ii) magnification of the image 1		
	(i) $\dfrac{1}{v} + \dfrac{1}{u} = \dfrac{1}{f}$ $\dfrac{1}{v} + \dfrac{1}{-30} = \dfrac{1}{-20}$	½	
	On solving v = - 60 cm	½	

	(ii) $m = -\frac{v}{u}$ $= -\left(\frac{-60}{-30}\right)$ $= -2$	½ ½	2
20.	Obtaining an expression for λ_n / λ_p 2 $E = \frac{hc}{\lambda p} \Rightarrow \lambda p = \frac{hc}{E}$ $\lambda n = \frac{h}{p} = \frac{h}{\sqrt{(2mE)}}$ $\frac{\lambda n}{\lambda p} = \frac{h}{\sqrt{(2mE)}} \times \frac{E}{hc}$ $\frac{\lambda n}{\lambda p} = \sqrt{\left(\frac{E}{2mc^2}\right)}$	½ ½ ½ ½	2
21.	Plotting the graph 1 Marking the region where: (a) resistance is negative ½ (b) Ohm's law is obeyed ½  	1+ ½ + ½	2

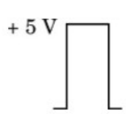
	SECTION C		
22.	Calculating (a) the flux passing through the cube 2 (b) the charge within the cube 1		
	a) $\varphi_L = \overrightarrow{E_L} \cdot \vec{A} = -[500 \times 0.1] \times [(0.1)^2] = -0.5$ N m^2 C$^{-1$	½	
	$\varphi_R = \overrightarrow{E_R} \cdot \vec{A} = [500 \times 0.2] \times [(0.1)^2] = 1$ N m^2 C^{-1}	½	
	Net flux = $\varphi_L + \varphi_R = 0.5$ N m^2 C^{-1}	1	
	b) flux, $\varphi = \frac{q}{\varepsilon_o}$	½	
	charge, $q = \varphi \times \varepsilon_o$ $= 0.5\ \varepsilon_o$ $= 4.4 \times 10^{-12}$ C	½	3
23.	a) • Defining current density ½ • Whether scalar or vector ½ • Showing $\vec{j} = \alpha\ \vec{E}$ 2		
	Current density is the amount of charge flowing per second per unit area normal to the flow. Alternatively: $j = \frac{I}{A}$	½	
	It is a vector quantity.	½	
			
	The amount of charge crossing the area A in time Δt is I Δt, where I is the magnitude of the current. Hence, $I\,\Delta t = ne\,A\,\lvert v_d\rvert\,\Delta t$	½	

	$I\,\Delta t = \frac{e^2 A}{m}\tau\, n\, \Delta t\, \lvert E\rvert$	½	
	$I = \lvert j\rvert A$	½	
	$\lvert j\rvert = \frac{ne^2}{m}\tau\ \lvert E\rvert$	½	
	$\vec{j} = \alpha\ \vec{E}$		
	OR		
	b) Defining Wheatstone bridge 1 Obtaining balancing conditions 2		
		1	
	Alternatively: If the figure is explained in words full credit to be given.		
	For loop ADBA: $-I_1 R_1 + I_2 R_2 + I_g G = 0$ (1)	½	
	For loop CBDC: $I_4 R_4 - I_3 R_3 - I_g G = 0$ (2)	½	
	For balanced wheatstone bridge, $I_g = 0$ And by applying Kirchoff's junction rule to junction D and B,	½	
	$I_1 = I_3$ & $I_2 = I_4$		
	From eqn (1) and (2)		

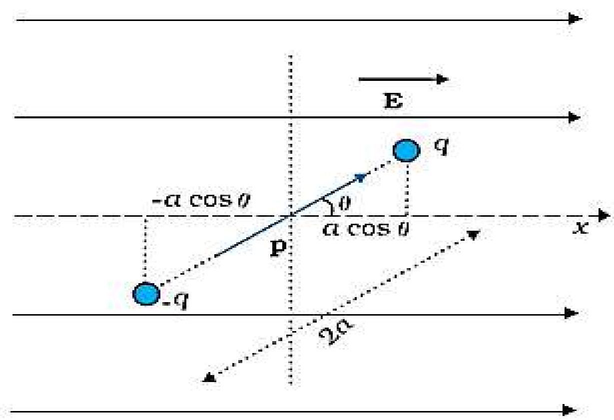
	$\frac{I_1}{I_2} = \frac{R_2}{R_1}$ and $\frac{I_1}{I_2} = \frac{R_4}{R_3}$ $\Rightarrow \frac{R_2}{R_1} = \frac{R_4}{R_3}$	½	3
24.	Calculating a) the speed of the proton 1 b) the magnitude of the acceleration of the proton 1 c) the radius of the path traced by the proton 1 a) $v = \sqrt{\left(\frac{2 \text{ x K.E.}}{m}\right)}$ $= 4 \text{ x } 10^6$ m/s b) acceleration = qvB / m $= 8 \text{ x } 10^{11}$ m/s^2 c) r = mv / Bq = 20 m	½ ½ ½ ½ ½ ½	3
25.	Deriving an expression for the average power dissipated in series LCR circuit 2 Obtaining expression for the resonant frequency 1 $v = v_m \sin\omega t$ $i = i_m \sin(\omega t+\varphi)$ Power, $P = v\, i = (v_m \sin\omega t) \times [i_m \sin(\omega t+\varphi)]$ $= \frac{v_m i_m}{2} [\cos\varphi - \cos(2\omega t+\varphi)]$ (1) The average power over a cycle is given by the average of the two terms in RHS of eqn (1). It is only the 2nd term which is time dependent. It's average is zero. Therefore, $P = \frac{v_m i_m}{2} \cos\varphi$	½ ½ ½	

	$P = V\, I \cos\varphi$ OR $P = I^2 Z \cos\varphi$ At resonance, $X_C = X_L$ $$\frac{1}{\omega C} = \omega L$$ $$\omega = \frac{1}{\sqrt{(LC)}}$$ $$\Rightarrow \quad \upsilon = \frac{1}{2\pi\sqrt{(LC)}}$$	½ ½ ½	3
26.	a) Two examples 1 b) (i) Reason for use of short waves bands 1 (ii) Reason for x-ray astronomy from satellites 1 a) (Any Two) • Gamma radiation having wavelength of 10^{-14} m to 10^{-15} m, typically originate from an atomic nucleus. • X-rays are emitted from heavy atoms. • Radio waves are produced by accelerating electrons in a circuit. A transmitting antenna can most efficiently radiate waves having a wavelength of about the same size as the antenna. b) (i) Ionosphere reflects waves in these bands (ii) Atmosphere absorbs x-rays, while visible and radio waves can penetrate it Note: Full credit to be given for part (b) for mere attempt.	½ + ½ 1 1	3
27.	• Drawbacks of Rutherford's atomic model 1 • Bohr's explanation 1 • Showing different orbits are not equally spaced 1 Drawbacks: i) According to classical electromagnetic theory, an accelerating charged particle emits radiation in the form of electromagnetic waves. The energy of an accelerating electron should therefore, continuously decrease. The electron would spiral inward and eventually fall into the nucleus. Thus, such		

	an atom cannot be stable. ii) As the electrons spiral inwards, their angular velocities and hence their frequencies would change continuously. Thus, they would emit a continuous spectrum, in contradiction to the line spectrum actually observed. Bohr postulated stable orbits in which electrons do not radiate energy Alternatively: Bohr's postulates (Any ONE of the three) (i) An electron in an atom could revolve in certain stable orbits without the emission of radiant energy. (ii) The electron revolves around the nucleus only in those orbits for which the angular momentum is some integral multiple of $h/2\pi$ (iii) An electron might make a transition from one of its specified non-radiating orbits to another of lower energy. When it does so, a photon is emitted having energy equal to the energy difference between the initial and final states. The radius of the n^{th} orbit is found as $r_n = \left(\frac{n^2}{m}\right)\left(\frac{h}{2\pi}\right)^2 \frac{4\pi\varepsilon_0}{e^2}$ $r_n \propto n^2$ Alternatively: Difference in radius of consecutive orbits is $r_{n+1} - r_n = k\,[(n+1)^2 - n^2)]$ $= k\,(2n + 1)$ which depends on n, and is not a constant	1 1 1	3
28.	a) Stating two properties of a nucleus 1 b) Why density of a nucleus is much more than that of an atom 1 c) Showing that density of nuclear matter is same for all nuclei 1 a) (Any TWO) (i) The nucleus is positively charged (ii) The nucleus consists of protons and neutrons (iii) The nuclear density is independent of mass number (iv) The radius of the nucleus, $R = R_o A^{1/3}$ b) Atoms have large amount of empty spaces. Mass is concentrated in nucleus.	½ + ½ 1	

	c) Density = Mass / Volume $= \frac{m\,A}{\frac{4}{3}\pi R^3} = \frac{m\,A}{\frac{4}{3}\pi R_o^3\,A}$ $= \frac{m}{\frac{4}{3}\pi R_o^3}$ So, density is independent of mass number	1	3
	SECTION D		
29.	(i) (A) $\frac{2(n-1)}{R}$ (ii) (D) P/2 (iii) (B) P (iv) a) (C) 2P OR b) (A) 6.6 D	1 1 1 1	4
30.	(i) (A) $\frac{Vo}{\sqrt{2}}$ (ii) (B) half cycle of the input signal (iii) (C) One is forward biased and the other is reverse biased at the same time (iv) a) (B) 50 Hz OR b) (D) 	1 1 1 1	4

<table>
<tr><td></td><td><u>Section E</u></td><td></td><td></td></tr>
<tr><td>31.</td><td>(a)
(i)
• Deriving the expression for potential energy 2
• Maximum & Minimum value of potential energy (½ + ½)
(ii) Finding the torque. 2

(i)

The amount of work done in rotating the dipole from θ = θ_0 to θ = θ_1 by the external torque
$W = \int_{\theta_0}^{\theta_1} \tau_{ext} d\theta$
$= \int_{\theta_0}^{\theta_1} pE \sin\theta \; d\theta$
$W = pE(\cos\theta_0 - \cos\theta_1)$
For $\theta_0 = \frac{\pi}{2}$ and $\theta_1 = \theta$
$= pE(\cos\frac{\pi}{2} - \cos\theta)$
$U(\theta) = -pE \cos\theta$
$= - \vec{p}.\vec{E}$</td><td>½
½
½
½</td><td></td></tr>
<tr><td></td><td>(1) Potential energy is maximum when:
$\vec{p}$ is antiparallel to $\vec{E}$
Alternatively:
$\theta = 180°$ or π radians</td><td>½</td><td></td></tr>
</table>

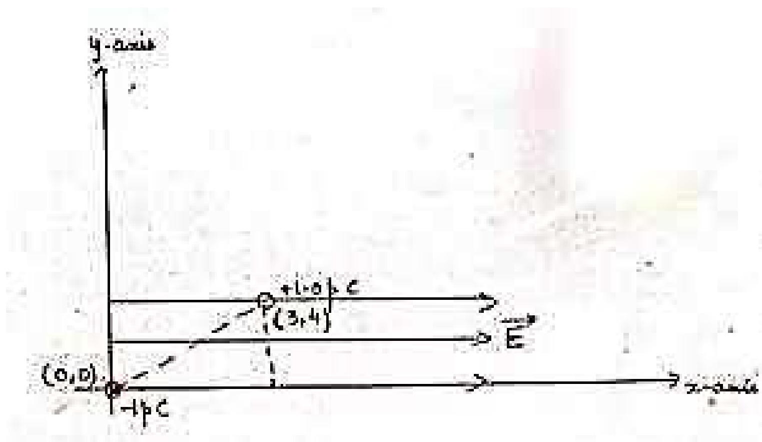
(2) Potential energy is minimum when:

$\vec{p}$ is along to $\vec{E}$ ½

Alternatively:

$\theta = 0°$

(ii)



$\tau = pE\sin\theta$ ½

$= (2aq)E\sin\theta$ ½

$= (5\times10^{-3}\times1\times10^{-12})10^{3}\times\frac{4}{5}$ ½

$= 4\times10^{-12}\ Nm$

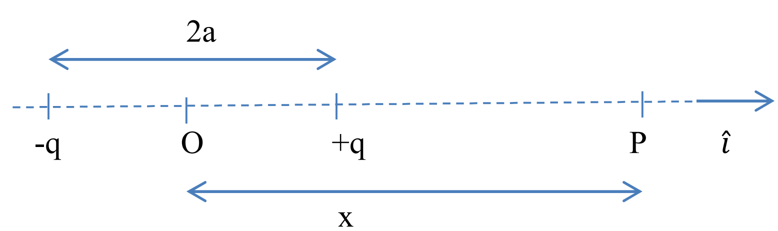
Direction is along –ve Z direction. ½

OR

(b)

(i) Deriving expression for potential	2 ½
(ii) New charge on Sphere S_1	2 ½

(i)



½

$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$ ½

$V = V_{+q} - V_{-q}$

$$V=\frac{1}{4\pi\varepsilon_0}\left[\frac{q}{(x-a)}-\frac{q}{(x+a)}\right]$$ ½

$$=\frac{q}{4\pi\varepsilon_0}\left[\frac{x+a-x+a}{(x^2-a^2)}\right]$$

$$V=\frac{q}{4\pi\varepsilon_0}\frac{2a}{(x^2-a^2)}=\frac{p}{4\pi\varepsilon_0(x^2-a^2)}$$

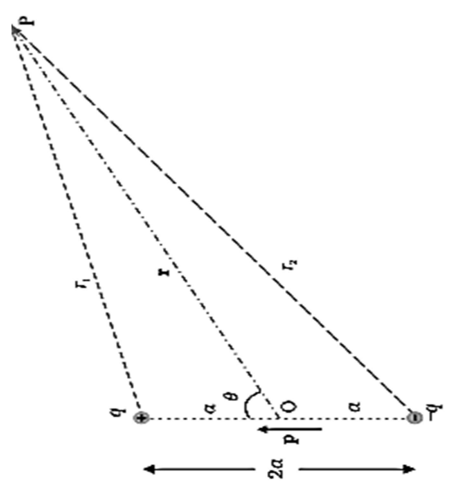
As p is along x-axis, so

$$V=\frac{1}{4\pi\varepsilon_0}\frac{\vec{p}.\hat{i}}{(x^2-a^2)}$$ ½

If x>>a

$$V=\frac{1}{4\pi\varepsilon_0}\frac{\vec{p}.\hat{i}}{x^2}$$ ½

Alternatively:



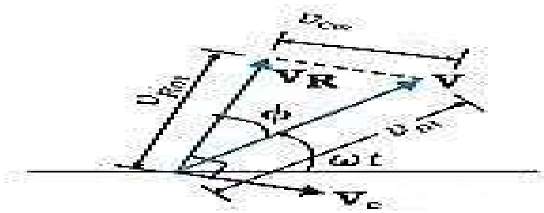
$$V=\frac{1}{4\pi\varepsilon_0}\left(\frac{q}{r_1}-\frac{q}{r_2}\right)$$ ----- (i) ½

	By geometry $r_1^2 = r^2 + a^2 - 2ar\,cos\theta$ $r_2^2 = r^2 + a^2 + 2ar\,cos\theta$ $r_1^2 = r^2\left(1 - \frac{2acos\theta}{r} + \frac{a^2}{r^2}\right)$ $\cong r^2\left(1 - \frac{2a\cos\theta}{r}\right)$ Similarly, $r_2^2 \cong r^2\left(1 + \frac{2a\cos\theta}{r}\right)$ Using binomial theorem & retaining terms upto the first order in $\frac{a}{r}$; we obtain $\frac{1}{r_1} \cong \frac{1}{r}\left(1 - \frac{2a\cos\theta}{r}\right)^{-\frac{1}{2}} \cong \frac{1}{r}\left(1 + \frac{a}{r}\cos\theta\right)$ ----- (ii) $\frac{1}{r_2} \cong \frac{1}{r}\left(1 - \frac{2a\cos\theta}{r}\right)^{-\frac{1}{2}} \cong \frac{1}{r}\left(1 - \frac{a}{r}\cos\theta\right)$ ----- (iii) Using equations (i) ,(ii) & (iii) & p = 2qa $V = \frac{q}{4\pi\varepsilon_0}\frac{2a\cos\theta}{r^2} = \frac{p\cos\theta}{4\pi\varepsilon_0 r^2}$ $\mathrm{p}\cos\theta = \vec{p}.\,\hat{r}$ As $\vec{r}$ is along the x – axis. $\Rightarrow \vec{p}.\hat{r} = \vec{p}.\hat{i}$ $\Rightarrow V = \frac{1}{4\pi\varepsilon_0}\frac{\vec{p}.\hat{i}}{x^2}$	½ ½ ½ ½	

	(ii) Charge on sphere S_1 : Q_1 = surface charge density × surface Area $= \left(\frac{2}{\pi}\times 10^{-9}\right)\times 4\pi(1\times 10^{-2})^2$ $= 8\times 10^{-13}\,C$	½	
	Charge on sphere S_2 : Q_2 = surface charge density × surface Area $= \left(\frac{2}{\pi}\times 10^{-9}\right)\times 4\pi(3\times 10^{-2})^2$ $= 72\times 10^{-13}\,C$	½	
	When connected by a thin wire they acquire a common potential V and the charge remains conserved. $Q_1 + Q_2 = Q_1' + Q_2'$ $= C_1V + C_2V$ $Q_1 + Q_2 = (C_1 + C_2)V$ $\text{Common potential}(V) = \frac{Q_1+Q_2}{C_1+C_2}$ $C_1 = 4\pi\varepsilon_0 r_1 = \frac{1}{9\times 10^9}\times 10^{-2} = \frac{1}{9}\times 10^{-11}F$ $C_2 = 4\pi\varepsilon_0 r_2 = \frac{1}{9\times 10^9}\times 3\times 10^{-2} = \frac{1}{3}\times 10^{-11}F$	½	
	$V = \frac{80\times 10^{-13}}{\left(\frac{1}{9}+\frac{1}{3}\right)\times 10^{-11}} = 1.8\,V$	½	
	$Q_1' = C_1V = \frac{1}{9}\times 10^{-11}\times 1.8$ $Q_1' = 2\times 10^{-12}\,C$	½	

	Alternatively: Charge on sphere S_1 : Q_1 = surface charge density × surface Area $= \left(\frac{2}{\pi}\times 10^{-9}\right)\times 4\pi(1\times 10^{-2})^2$ $= 8\times 10^{-13}\,C$ Charge on sphere S_2 : Q_2 = surface charge density × surface Area $= \left(\frac{2}{\pi}\times 10^{-9}\right)\times 4\pi(3\times 10^{-2})^2$ $= 72\times 10^{-13}\,C$ When connected by a thin wire they acquire a common potential V and the charge remains conserved. $Q_1 + Q_2 = Q_1' + Q_2'$ $\frac{Q_2'}{Q_1'} = \frac{r_2}{r_1}$ On solving, $Q_1' = 2\times 10^{-12}\,C$	 ½ ½ ½ ½ ½	 5
32.	(a) (i) Deriving expression for impedance — 2 (ii) Reason — 1 (iii) Inductance of coil — 2		

(i)



$V_C + V_R = V$ ½

$v_m^2 = v_{rm}^2 + v_{cm}^2$

$v_{rm} = i_m R$

$v_{cm} = i_m X_c$

$v_m^2 = (i_m R)^2 + (i_m X_c)^2$ ½

$= i_m^2 \left[R^2 + X_c^2\right]$

$\Rightarrow i_m = \dfrac{v_m}{\sqrt{R^2 + X_c^2}}$ ½

$\Rightarrow$ Impedance $Z = \sqrt{R^2 + X_c^2}$ ½

(ii) For direct current (dc), an inductor behaves as a conductor.

As $X_L = \omega L = 2\pi \nu L$

For dc $\nu = 0 \Rightarrow X_L = 0$ 1

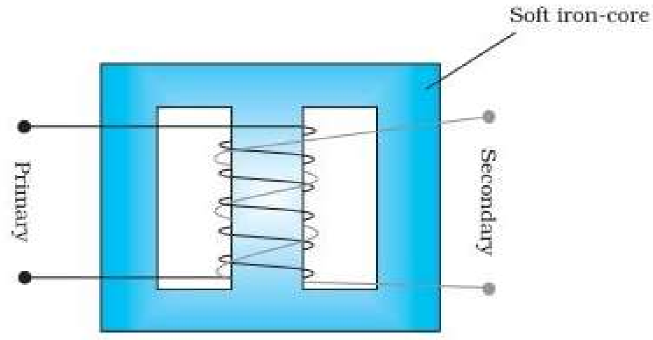
Alternatively: -

Induced emf (ε) = - $\dfrac{LdI}{dt}$

For dc; $dI = 0 \Rightarrow \varepsilon = 0$

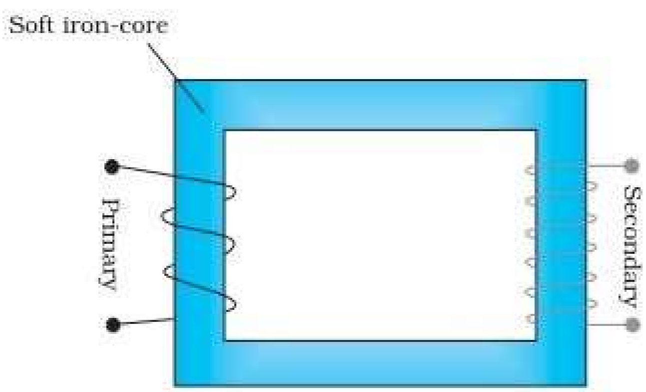
	(iii) R = $\frac{110}{11}$ = 10 Ω $i_{rms} = \frac{v_{rms}}{\sqrt{R^2 + X_L^2}} = \frac{220}{\sqrt{100 + X_L^2}}$ $11 = \frac{220}{\sqrt{100 + X_L^2}}$ $\sqrt{100 + X_L^2} = \frac{220}{11} = 20\Omega$ Squaring both sides: $\Rightarrow 100 + X_L^2 = 400$ $\Rightarrow X_L^2 = 300 \Rightarrow X_L = 10\sqrt{3}\,\Omega$ $X_L = 2\pi f L \Rightarrow 10\sqrt{3} = 2\pi \times 50 \times L$ L = $\frac{\sqrt{3}}{10\pi} H$ OR	½ ½ ½ ½	
	(b) (i) Labelled diagram of step – up transformer — 1 Describing working principle — ½ Three causes — 1 ½ (ii) Explanation — 1 (iii) (1) Output voltage across secondary coil — ½ (2) Current in primary coil — ½		

(i)



(a)

OR



(b) 1

The working principle of transformer is mutual induction.

When an alternating voltage is applied to the primary, the resulting current produces an alternating magnetic flux which links the secondary and induces an emf in it. ½

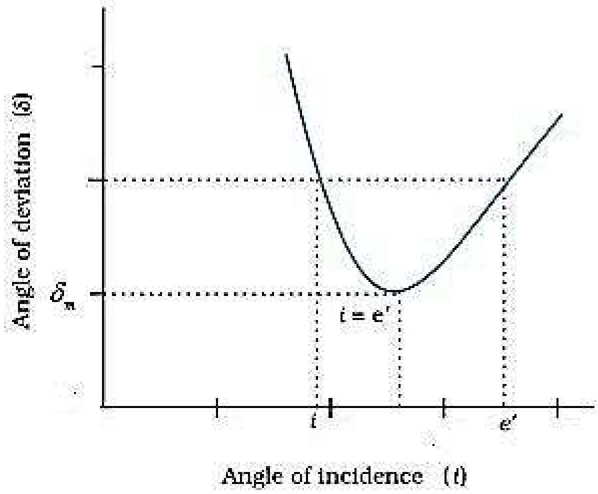
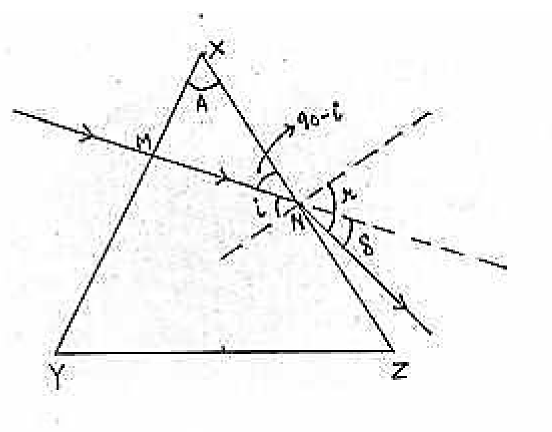
Causes of energy losses (Any three)

(a) Flux leakage

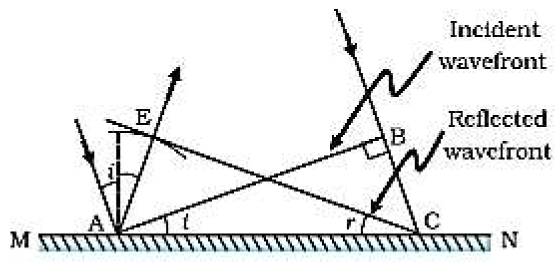
(b) Resistance of the windings

(c) Eddy currents

	(d) Hysteresis (ii) No Current changes correspondingly. So, the input power is equal to the output power. (iii) (1) $\frac{V_s}{V_P} = \frac{N_s}{N_P}$ $V_s = \frac{N_s}{N_P} \times V_P = \frac{3000}{200} \times 90$ $V_s = 1350\,V$ (2) $\frac{I_P}{I_s} = \frac{N_s}{N_P}$ $I_P = \frac{3000}{200} \times 2 = 30 \text{ A}$	½ + ½ + ½ ½ ½ ½ ½	5
33.	(a) (i) Graph showing variation of angle of deviation with angle of incidence 1 Defining angle of minimum deviation 1 (ii) Proof of refractive index $n = \frac{\sin(A+\delta)}{\sin A}$ 1 (iii) (1) Finding angle of minimum deviation 1 (2) Angle of Incidence 1		

	(i)		
		1	
	Minimum deviation angle is defined as the angle at which angle of incidence is equal to the angle of emergence.	1	
	Alternatively At minimum deviation refracted ray inside the prism becomes parallel to the base of the prism.		
	(ii)		
			
	At the face XZ :- $\mu \sin i = 1 \times \sin r$ ----- (1) r = i + δ [from diagram] ----- (2) In ΔXMN ; A+(90 –i) + 90 =180	½	

	$\Rightarrow A = i$ ----- (3) Putting eq. (3) & (2) in eq. (1) $\mu \sin A = \sin(A+\delta)$ $\mu = \dfrac{\sin(A+\delta)}{\sin A}$ (iii) (1) $\mu = \dfrac{\sin\left(\dfrac{A+\delta_m}{2}\right)}{\sin\dfrac{A}{2}}$ $\sqrt{2} = \dfrac{\sin\left(\dfrac{60+\delta_m}{2}\right)}{\sin 30°}$ $\Rightarrow \sin\left(\dfrac{60+\delta_m}{2}\right) = \dfrac{1}{\sqrt{2}} = \sin 45°$ $\dfrac{60+\delta_m}{2} = 45° \Rightarrow \delta_m = 30°$ (2) $i = \dfrac{A+\delta_m}{2}$ $\Rightarrow i = \dfrac{60+30}{2}$ $i = 45°$ OR	½ ½ ½ ½ ½	
	(b) (i) Statement of Huygens' Principle ½ Construction of reflected wave front ½ Proof of angle of reflection is equal to angle of incidence 1 (ii) Definition of coherent sources ½ Explanation 1 (iii) Finding the unknown wavelength 1 ½ (i) Each point of the wavefront is the source of a secondary disturbance and the wavelets emanating from these points spread out in all directions with the spread of the wave. Each point of the wavefront is the source of a		

	secondary disturbance and the wavelets emanating from these points spread out in all directions with the speed of the wave. These wavelets emanating from the wavefront are usually referred to as secondary wavelets and if we draw a common tangent to all these spheres, we obtain the new position of the wavefront at a later time.	½	
		½	
	ΔEAC is congruent to ΔBAC; so $\angle i = \angle r$	1	
	(ii) Two sources are said to be coherent if the phase difference between them does not change with time.	½	
	No, two independent sodium lamps cannot be coherent.	½	
	Two independent sodium lamps cannot be coherent as the phase between them does not remain constant with time.	½	
	(iii) $4\beta_2 = 5\beta_1$ $4 \times \frac{\lambda D}{d} = 5 \times \frac{\lambda_{known} D}{d}$	½	
	$\Rightarrow \lambda = \frac{5}{4} \times \lambda_{known}$ $= \frac{5}{4} \times 520$ $= 650$ nm	1	5

General Instructions :

Read the following instructions carefully and follow them :

(i) *This question paper contains **33** questions. **All** questions are **compulsory**.*

(ii) *This question paper is divided into **five** sections – **Sections A, B, C, D** and **E**.*

(iii) *In **Section A** – Questions no. **1** to **16** are Multiple Choice type questions. Each question carries **1** mark.*

(iv) *In **Section B** – Questions no. **17** to **21** are Very Short Answer type questions. Each question carries **2** marks.*

(v) *In **Section C** – Questions no. **22** to **28** are Short Answer type questions. Each question carries **3** marks.*

(vi) *In **Section D** – Questions no. **29** and **30** are case study based questions. Each question carries **4** marks.*

(vii) *In **Section E** – Questions no. **31** to **33** are Long Answer type questions. Each question carries **5** marks.*

(viii) *There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.*

(ix) *Kindly note that there is a separate question paper for Visually Impaired candidates.*

(x) *Use of calculators is **not** allowed.*

You may use the following values of physical constants wherever necessary :

$c = 3 \times 10^8$ m/s

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8{\cdot}854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

Mass of electron (m_e) = $9{\cdot}1 \times 10^{-31}$ kg

Mass of neutron = $1{\cdot}675 \times 10^{-27}$ kg

Mass of proton = $1{\cdot}673 \times 10^{-27}$ kg

Avogadro's number = $6{\cdot}023 \times 10^{23}$ per gram mole

Boltzmann constant = $1{\cdot}38 \times 10^{-23}$ JK^{-1}

SECTION A

1. Two charged particles P and Q, having the same charge but different masses m_P and m_Q, start from rest and travel equal distances in a uniform electric field $\vec{E}$ in time t_P and t_Q respectively. Neglecting the effect of gravity, the ratio $\left(\frac{t_P}{t_Q}\right)$ is :

(A) $\frac{m_P}{m_Q}$

(B) $\frac{m_Q}{m_P}$

(C) $\sqrt{\frac{m_P}{m_Q}}$

(D) $\sqrt{\frac{m_Q}{m_P}}$

2. Electrons drift with speed v_d in a conductor with potential difference V across its ends. If V is reduced to $\left(\frac{V}{2}\right)$, their drift speed will become :

(A) $\frac{v_d}{2}$

(B) v_d

(C) $2\ v_d$

(D) $4\ v_d$

3. A wire of length 4·4 m is bent round in the shape of a circular loop and carries a current of 1·0 A. The magnetic moment of the loop will be :

(A) 0·7 Am^2

(B) 1·54 Am^2

(C) 2·10 Am^2

(D) 3·5 Am^2

4. A circular coil of radius 10 cm is placed in a magnetic field $\vec{B} = (1{\cdot}0\ \hat{i} + 0{\cdot}5\ \hat{j})$ mT such that the outward unit vector normal to the surface of the coil is $(0{\cdot}6\ \hat{i} + 0{\cdot}8\ \hat{j})$. The magnetic flux linked with the coil is :

(A) 0·314 μWb (B) 3·14 μWb

(C) 31·4 μWb (D) 1·256 μWb

5. Which of the following quantity/quantities remains same in primary and secondary coils of an ideal transformer ?
Current, Voltage, Power, Magnetic flux

(A) Current only

(B) Voltage only

(C) Power only

(D) Magnetic flux and Power both

6. A resistor and an ideal inductor are connected in series to a $100\sqrt{2}$ V, 50 Hz ac source. When a voltmeter is connected across the resistor or the inductor, it shows the same reading. The reading of the voltmeter is :

(A) $100\sqrt{2}$ V (B) 100 V

(C) $50\sqrt{2}$ V (D) 50 V

7. Electromagnetic waves with wavelength 10 nm are called :

(A) Infrared waves (B) Ultraviolet rays

(C) Gamma rays (D) X-rays

8. The work function for a photosensitive surface is 3·315 eV. The cut-off wavelength for photoemission of electrons from this surface is :

(A) 150 nm (B) 200 nm

(C) 375 nm (D) 500 nm

9. Energy levels A, B and C of an atom correspond to increasing values of energy i.e. $E_A < E_B < E_C$. Let λ_1, λ_2 and λ_3 be the wavelengths of radiation corresponding to the transitions C to B, B to A and C to A, respectively. The correct relation between λ_1, λ_2 and λ_3 is :

(A) $\lambda_1^2 + \lambda_2^2 = \lambda_3^2$ (B) $\frac{1}{\lambda_1} + \frac{1}{\lambda_2} = \frac{1}{\lambda_3}$

(C) $\lambda_1 + \lambda_2 + \lambda_3 = 0$ (D) $\lambda_1 + \lambda_2 = \lambda_3$

10. An alpha particle approaches a gold nucleus in Geiger-Marsden experiment with kinetic energy K. It momentarily stops at a distance d from the nucleus and reverses its direction. Then d is proportional to :

(A) $\frac{1}{\sqrt{K}}$ (B) $\sqrt{K}$

(C) $\frac{1}{K}$ (D) K

11. An n-type semiconducting Si is obtained by doping intrinsic Si with :

(A) Al (B) B

(C) P (D) In

12. When a p-n junction diode is subjected to reverse biasing :

(A) the barrier height decreases and the depletion region widens.

(B) the barrier height increases and the depletion region widens.

(C) the barrier height decreases and the depletion region shrinks.

(D) the barrier height increases and the depletion region shrinks.

*Questions number **13** to **16** are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below.*

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is ***not*** the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false and Reason (R) is also false.

13. *Assertion (A) :* Photoelectric current increases with an increase in intensity of incident radiation, for a given frequency of incident radiation and the accelerating potential.

Reason (R) : Increase in the intensity of incident radiation results in an increase in the number of photoelectrons emitted per second and hence an increase in the photocurrent.

14. *Assertion (A) :* Lenz's law is a consequence of the law of conservation of energy.

Reason (R) : There is no power loss in an ideal inductor.

15. *Assertion (A) :* An electron and a proton enter with the same momentum $\vec{p}$ in a magnetic field $\vec{B}$ such that $\vec{p} \perp \vec{B}$. Then both describe a circular path of the same radius.

Reason (R) : The radius of the circular path described by the charged particle (charge q, mass m) moving in the magnetic field $\vec{B}$ is given by $r = \frac{mv}{qB}$.

16. *Assertion (A) :* The magnifying power of a compound microscope is negative.

Reason (R) : The final image formed is erect with respect to the object.

SECTION B

17. Define resistivity of a conductor. How does the resistivity of a conductor depend upon the following : *2*

(a) Number density of free electrons in the conductor (n)

(b) Their relaxation time (τ)

18. (a) Two waves, each of amplitude 'a' and frequency 'ω' emanating from two coherent sources of light superpose at a point. If the phase difference between the two waves is ϕ, obtain an expression for the resultant intensity at that point. *2*

OR

(b) What is the effect on the interference pattern in Young's double-slit experiment when (i) the source slit is moved closer to the plane of the slits, and (ii) the separation between the two slits is increased ? Justify your answers. *2*

19. A convex lens (n = 1·52) has a focal length of 15·0 cm in air. Find its focal length when it is immersed in liquid of refractive index 1·65. What will be the nature of the lens ? *2*

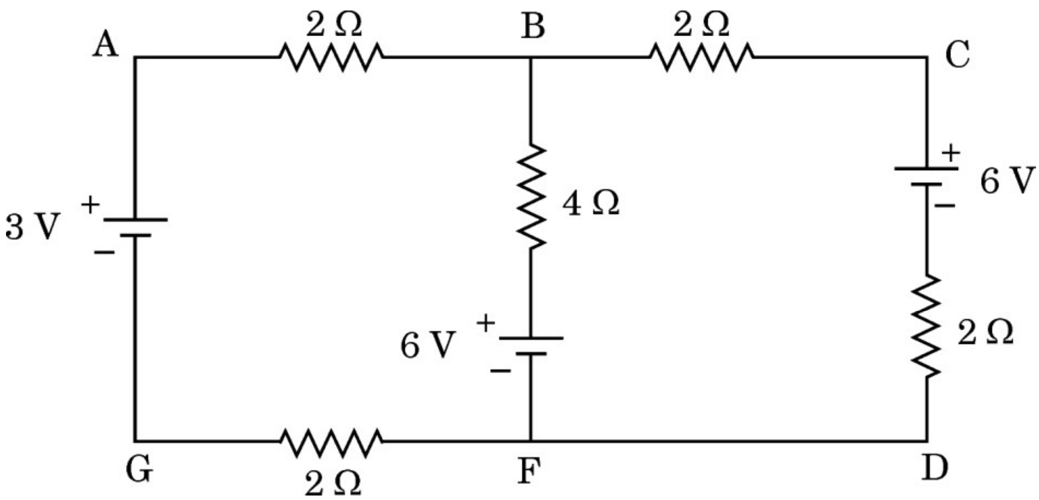
20. The carbon isotope ${}^{12}_{6}C$ has a nuclear mass of 12·000000 u. Calculate the binding energy of its nucleus.

Given m_p = 1·007825 u; m_n = 1·008665 u. *2*

21. How does the energy gap of an intrinsic semiconductor effectively change when doped with a (a) trivalent impurity, and (b) pentavalent impurity ? Justify your answer in each case. *2*

SECTION C

22. The figure shows a circuit with three ideal batteries. Find the magnitude and direction of currents in the branches AG, BF and CD. *3*



23. (a) On what factors does the speed of an electromagnetic wave in a medium depend ?

(b) How is an electromagnetic wave produced ?

(c) Sketch a schematic diagram depicting the electric and magnetic fields for an electromagnetic wave propagating along z-axis. *3*

24. A 100-turn coil of radius 1·6 cm and resistance 5·0 Ω is co-axial with a solenoid of 250 turns/cm and radius 1·8 cm. The solenoid current drops from 1·5 A to zero in 25 ms. Calculate the current induced in the coil in this duration. (Take $\pi^2 = 10$) *3*

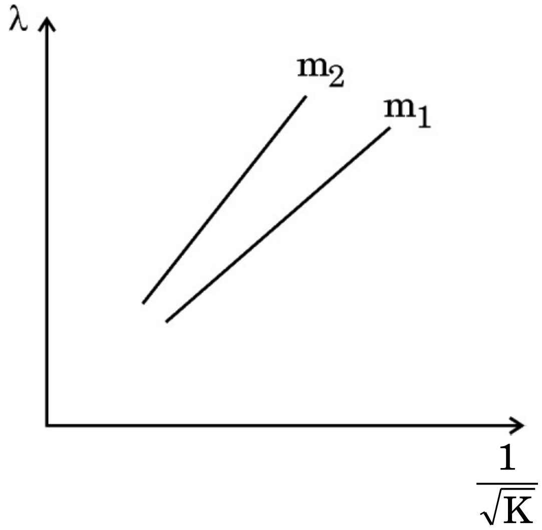
25. (a) Two long, straight, parallel conductors carry steady currents in opposite directions. Explain the nature of the force of interaction between them. Obtain an expression for the magnitude of the force between the two conductors. Hence define one ampere. *3*

OR

(b) Obtain an expression for the torque $\vec{\tau}$ acting on a current carrying loop in a uniform magnetic field $\vec{B}$. Draw the necessary diagram. *3*

26. Using Bohr's postulates, derive the expression for the radius of the n^{th} orbit of an electron in a hydrogen atom. Also find the numerical value of Bohr's radius a_0. *3*

27. de Broglie wavelength λ as a function of $\frac{1}{\sqrt{K}}$, for two particles of masses m_1 and m_2 are shown in the figure. Here, K is the energy of the moving particles.



(a) What does the slope of a line represent ?

(b) Which of the two particles is heavier ?

(c) Is this graph also valid for a photon ?

Justify your answer in each case. *3*

28. With the help of a circuit diagram, explain the working of a p-n junction diode as a full wave rectifier. Draw its input and output waveforms. *3*

SECTION D
Case Study Based Questions

*Questions number **29** and **30** are case study based questions. Read the following paragraphs and answer the questions that follow.*

29. When the terminals of a cell are connected to a conductor of resistance R, an electric current flows through the circuit. The electrolyte of the cell also offers some resistance in the path of the current, like the conductor. This resistance offered by the electrolyte is called internal resistance of the cell (r). It depends upon the nature of the electrolyte, the area of the electrodes immersed in the electrolyte and the temperature. Due to internal resistance, a part of the energy supplied by the cell is wasted in the form of heat.

When no current is drawn from the cell, the potential difference between the two electrodes in known as emf of the cell (ε). With a current drawn from the cell, the potential difference between the two electrodes is termed as terminal potential difference (V).

(i) Choose the ***incorrect*** statement : *1*

(A) The potential difference (V) between the two terminals of a cell in a closed circuit is always less than its emf (ε), during discharge of the cell.

(B) The internal resistance of a cell decreases with the decrease in temperature of the electrolyte.

(C) When current is drawn from the cell then $V = \varepsilon - Ir$.

(D) The graph between potential difference between the two terminals of the cell (V) and the current (I) through it is a straight line with a negative slope.

(ii) Two cells of emfs 2·0 V and 6·0 V and internal resistances 0·1 Ω and 0·4 Ω respectively, are connected in parallel. The equivalent emf of the combination will be : *1*

(A) 2·0 V (B) 2·8 V

(C) 6·0 V (D) 8·0 V

(iii) Dipped in the solution, the electrode exchanges charges with the electrolyte. The positive electrode develops a potential V_+ ($V_+ > 0$), and the negative electrode develops a potential $-(V_-)$ ($V_- \geq 0$), relative to the electrolyte adjacent to it. When no current is drawn from the cell then : *1*

(A) $\varepsilon = V_+ + V_- > 0$ (B) $\varepsilon = V_+ - V_- > 0$

(C) $\varepsilon = V_+ + V_- < 0$ (D) $\varepsilon = V_+ + V_- = 0$

(iv) (a) Five identical cells, each of emf 2 V and internal resistance 0·1 Ω are connected in parallel. This combination in turn is connected to an external resistor of 9·98 Ω. The current flowing through the resistor is : *1*

(A) 0·05 A (B) 0·1 A

(C) 0·15 A (D) 0·2 A

OR

(b) Potential difference across a cell in the open circuit is 6 V. It becomes 4 V when a current of 2 A is drawn from it. The internal resistance of the cell is : *1*

(A) 1·0 Ω (B) 1·5 Ω

(C) 2·0 Ω (D) 2·5 Ω

30. When a ray of light propagates from a denser medium to a rarer medium, it bends away from the normal. When the incident angle is increased, the refracted ray deviates more from the normal. For a particular angle of incidence in the denser medium, the refracted ray just grazes the interface of the two surfaces. This angle of incidence is called the critical angle for the pair of media involved.

(i) For a ray incident at the critical angle, the angle of reflection is : *1*

(A) 0° (B) < 90°

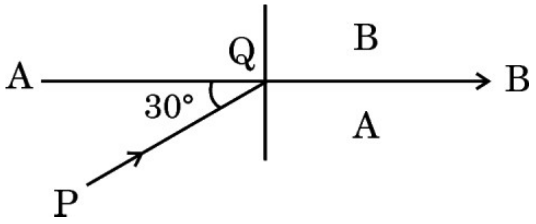
(C) > 90° (D) 90°

(ii) A ray of light of wavelength 600 nm is incident in water $\left(n = \frac{4}{3}\right)$ on the water-air interface at an angle less than the critical angle. The wavelength associated with the refracted ray is : *1*

(A) 400 nm (B) 450 nm

(C) 600 nm (D) 800 nm

(iii) (a) The interface AB between the two media A and B is shown in the figure. In the denser medium A, the incident ray PQ makes an angle of 30° with the horizontal. The refracted ray is parallel to the interface. The refractive index of medium B w.r.t. medium A is : *1*



(A) $\frac{\sqrt{3}}{2}$ (B) $\frac{\sqrt{5}}{2}$

(C) $\frac{4}{\sqrt{3}}$ (D) $\frac{2}{\sqrt{3}}$

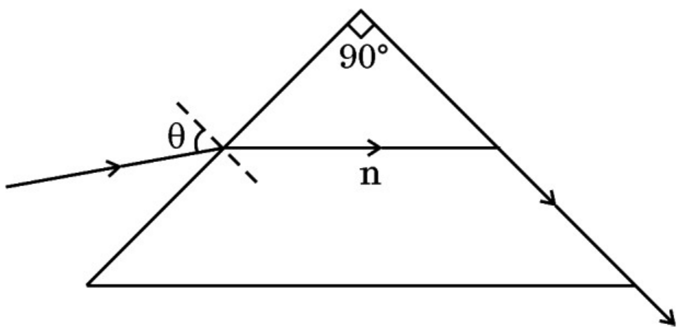
OR

(b) Two media A and B are separated by a plane boundary. The speed of light in medium A and B is 2×10^8 ms^{-1} and $2{\cdot}5 \times 10^8$ ms^{-1} respectively. The critical angle for a ray of light going from medium A to medium B is : *1*

(A) $\sin^{-1} \frac{1}{2}$ (B) $\sin^{-1} \frac{4}{5}$

(C) $\sin^{-1} \frac{3}{5}$ (D) $\sin^{-1} \frac{2}{5}$

(iv) The figure shows the path of a light ray through a triangular prism. In this phenomenon, the angle θ is given by : *1*



(A) $\sin^{-1} \sqrt{n^2 - 1}$ (B) $\sin^{-1} (n^2 - 1)$

(C) $\sin^{-1} \left[\frac{1}{\sqrt{n^2 - 1}}\right]$ (D) $\sin^{-1} \left[\frac{1}{(n^2 - 1)}\right]$

SECTION E

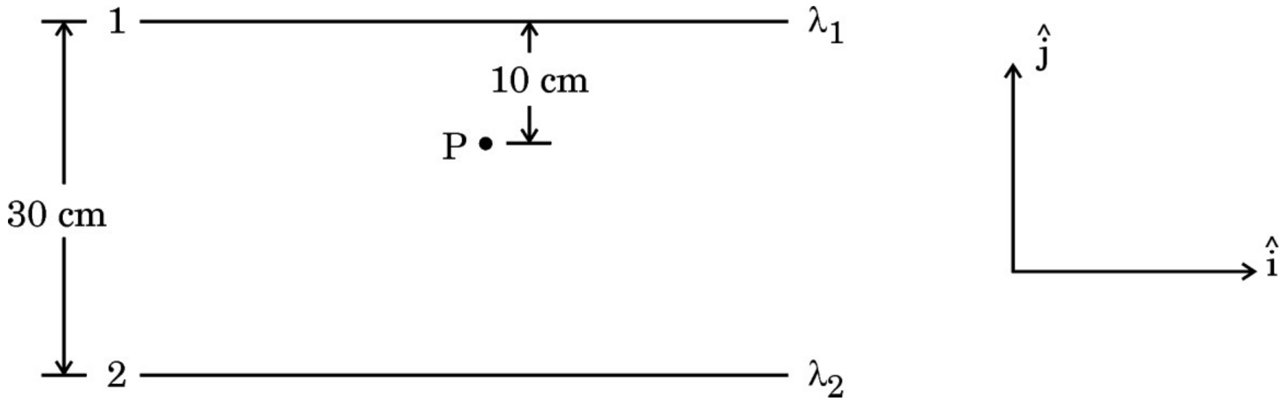
31. (a) (i) Obtain an expression for the electric potential due to a small dipole of dipole moment $\vec{p}$, at a point $\vec{r}$ from its centre, for much larger distances compared to the size of the dipole.

(ii) Three point charges q, 2q and nq are placed at the vertices of an equilateral triangle. If the potential energy of the system is zero, find the value of n. *5*

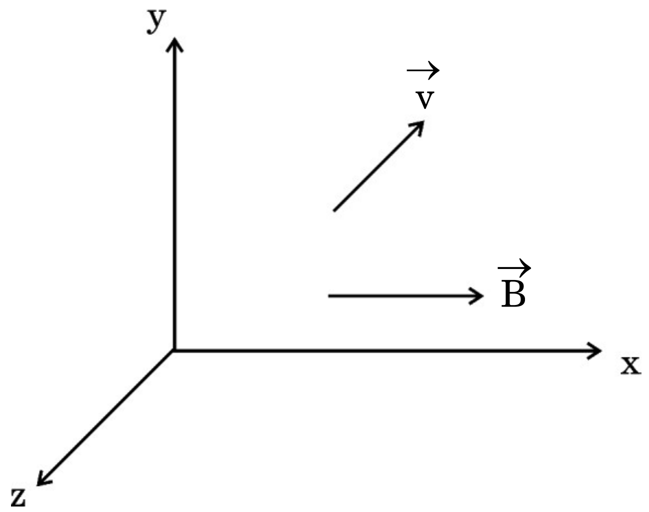
OR

(b) (i) State Gauss's Law in electrostatics. Apply this to obtain the electric field $\vec{E}$ at a point near a uniformly charged infinite plane sheet.

(ii) Two long straight wires 1 and 2 are kept as shown in the figure. The linear charge density of the two wires are $\lambda_1 = 10\ \mu C/m$ and $\lambda_2 = -20\ \mu C/m$. Find the net force $\vec{F}$ experienced by an electron held at point P. *5*



32. (a) (i) A particle of mass m and charge q is moving with a velocity $\vec{v}$ in a magnetic field $\vec{B}$ as shown in the figure. Show that it follows a helical path. Hence, obtain its frequency of revolution.



(ii) In a hydrogen atom, the electron moves in an orbit of radius $2\,\text{Å}$ making 8×10^{14} revolutions per second. Find the magnetic moment associated with the orbital motion of the electron. *5*

OR

(b) (i) What is current sensitivity of a galvanometer ? Show how the current sensitivity of a galvanometer may be increased. "Increasing the current sensitivity of a galvanometer may not necessarily increase its voltage sensitivity." Explain.

(ii) A moving coil galvanometer has a resistance 15 Ω and takes 20 mA to produce full scale deflection. How can this galvanometer be converted into a voltmeter of range 0 to 100 V ? *5*

33. (a) (i) Give any two differences between the interference pattern obtained in Young's double-slit experiment and a diffraction pattern due to a single slit.

(ii) Draw an intensity distribution graph in case of a double-slit interference pattern.

(iii) In Young's double-slit experiment using monochromatic light of wavelength λ, the intensity of light at a point on the screen, where path difference is λ, is K units. Find the intensity of light at a point on the screen where the path difference is $\frac{\lambda}{6}$. *5*

OR

(b) (i) Draw a labelled ray diagram of a compound microscope showing image formation at least distance of distinct vision. Derive an expression for its magnifying power.

(ii) A telescope consists of two lenses of focal length 100 cm and 5 cm. Find the magnifying power when the final image is formed at infinity. *5*

Marking Scheme
Strictly Confidential
(For Internal and Restricted use only)
Senior School Certificate Examination, 2024
SUBJECT- PHYSICS (CODE 55/2/1)

General Instructions: -

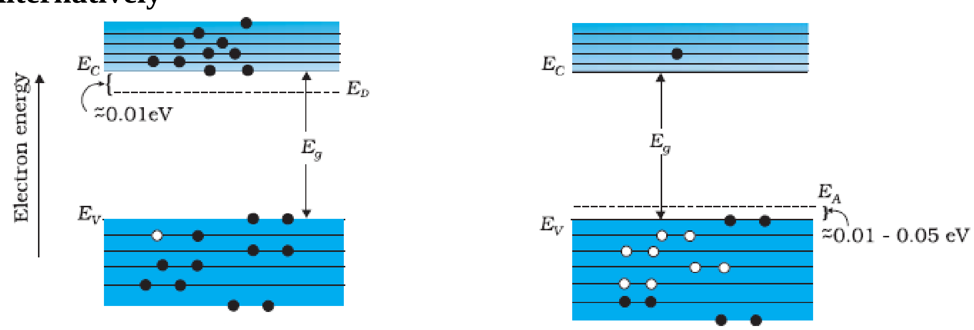
1	You are aware that evaluation is the most important process in the actual and correct assessment of the candidates. A small mistake in evaluation may lead to serious problems which may affect the future of the candidates, education system and teaching profession. To avoid mistakes, it is requested that before starting evaluation, you must read and understand the spot evaluation guidelines carefully.
2	**"Evaluation policy is a confidential policy as it is related to the confidentiality of the examinations conducted, Evaluation done and several other aspects. Its' leakage to public in any manner could lead to derailment of the examination system and affect the life and future of millions of candidates. Sharing this policy/document to anyone, publishing in any magazine and printing in News Paper/Website etc. may invite action under various rules of the Board and IPC."**
3	Evaluation is to be done as per instructions provided in the Marking Scheme. It should not be done according to one's own interpretation or any other consideration. Marking Scheme should be strictly adhered to and religiously followed. **However, while evaluating, answers which are based on latest information or knowledge and/or are innovative, they may be assessed for their correctness otherwise and due marks be awarded to them. In class-X, while evaluating two competency-based questions, please try to understand given answer and even if reply is not from marking scheme but correct competency is enumerated by the candidate, due marks should be awarded.**
4	The Marking scheme carries only suggested value points for the answers These are in the nature of Guidelines only and do not constitute the complete answer. The students can have their own expression and if the expression is correct, the due marks should be awarded accordingly.
5	The Head-Examiner must go through the first five answer books evaluated by each evaluator on the first day, to ensure that evaluation has been carried out as per the instructions given in the Marking Scheme. If there is any variation, the same should be zero after delibration and discussion. The remaining answer books meant for evaluation shall be given only after ensuring that there is no significant variation in the marking of individual evaluators.
6	Evaluators will mark (√) wherever answer is correct. For wrong answer CROSS 'X" be marked. Evaluators will not put right **(✓)** while evaluating which gives an impression that answer is correct and no marks are awarded. **This is most common mistake which evaluators are committing.**
7	If a question has parts, please award marks on the right-hand side for each part. Marks awarded for different parts of the question should then be totaled up and written in the left-hand margin and encircled. This may be followed strictly.
8	If a question does not have any parts, marks must be awarded in the left-hand margin and encircled. This may also be followed strictly.
9	If a student has attempted an extra question, answer of the question deserving more marks should be

	retained and the other answer scored out with a note **"Extra Question"**.
10	No marks to be deducted for the cumulative effect of an error. It should be penalized only once.
11	A full scale of marks 0 – 70 has to be used. Please do not hesitate to award full marks if the answer deserves it.
12	Every examiner has to necessarily do evaluation work for full working hours i.e., 8 hours every day and evaluate 20 answer books per day in main subjects and 25 answer books per day in other subjects (Details are given in Spot Guidelines).This is in view of the reduced syllabus and number of questions in question paper.
13	Ensure that you do not make the following common types of errors committed by the Examiner in the past:- ● Leaving answer or part thereof unassessed in an answer book. ● Giving more marks for an answer than assigned to it. ● Wrong totaling of marks awarded on an answer. ● Wrong transfer of marks from the inside pages of the answer book to the title page. ● Wrong question wise totaling on the title page. ● Wrong totaling of marks of the two columns on the title page. ● Wrong grand total. ● Marks in words and figures not tallying/not same. ● Wrong transfer of marks from the answer book to online award list. ● Answers marked as correct, but marks not awarded. (Ensure that the right tick mark is correctly and clearly indicated. It should merely be a line. Same is with the X for incorrect answer.) ● Half or a part of answer marked correct and the rest as wrong, but no marks awarded.
14	While evaluating the answer books if the answer is found to be totally incorrect, it should be marked as cross (X) and awarded zero (0)Marks.
15	Any unassessed portion, non-carrying over of marks to the title page, or totaling error detected by the candidate shall damage the prestige of all the personnel engaged in the evaluation work as also of the Board. Hence, in order to uphold the prestige of all concerned, it is again reiterated that the instructions be followed meticulously and judiciously.
16	The Examiners should acquaint themselves with the guidelines given in the "**Guidelines for Spot Evaluation**" before starting the actual evaluation.
17	Every Examiner shall also ensure that all the answers are evaluated, marks carried over to the title page, correctly totaled and written in figures and words.
18	The candidates are entitled to obtain photocopy of the Answer Book on request on payment of the prescribed processing fee. All Examiners/Additional Head Examiners/Head Examiners are once again reminded that they must ensure that evaluation is carried out strictly as per value points for each answer as given in the Marking Scheme.

MARKING SCHEME : PHYSICS (042)			
CODE :55/2/1			
Q.No	**VALUE POINTS/EXPECTED ANSWERS**	**MARKS**	**TOTAL MARKS**
SECTION –A			
1.	(C) $\sqrt{\frac{m_p}{m_Q}}$	1	1
2.	(A) $\frac{v_d}{2}$	1	1
3.	(B) $1.54Am^2$	1	1
4.	(C) 31.4μWb	1	1
5.	(D) Magnetic Flux and Power both	1	1
6.	(B) 100V	1	1
7.	(B) Ultraviolet rays	1	1
8.	(C) 375 nm	1	1
9.	(B) $\frac{1}{\lambda_1}+\frac{1}{\lambda_2}=\frac{1}{\lambda_3}$	1	1
10.	(C) $\frac{1}{K}$	1	1
11.	(C) P	1	1
12.	(B) The barrier height increases and the depletion region widens.	1	1
13.	(A) Both Assertion(A) and Reason (R) are true and Reason(R) is the correct explanation of the Assertion (A)	1	1
14.	(B) Both Assertion(A) and Reason (R) are true but Reason(R) is not the correct explanation of the Assertion (A)	1	1
15.	(A) Both Assertion(A) and Reason (R) are true and Reason(R) is the correct explanation of the Assertion (A)	1	1
16.	(C) Assertion(A) is true, but Reason (R) is false	1	1
SECTION -B			
17.	Defining resistivity 1 Dependence of resistivity on (a) Number density of free electron ½ (b) Relaxation time ½ Resistance offered by a material of unit length and having unit cross-sectional area is called resistivity. $\rho=\frac{m}{ne^2\tau}$ (a) $\rho\alpha\frac{1}{n}$ (b) $\rho\alpha\frac{1}{\tau}$	**1** **½** **½**	**2**

55/2/1

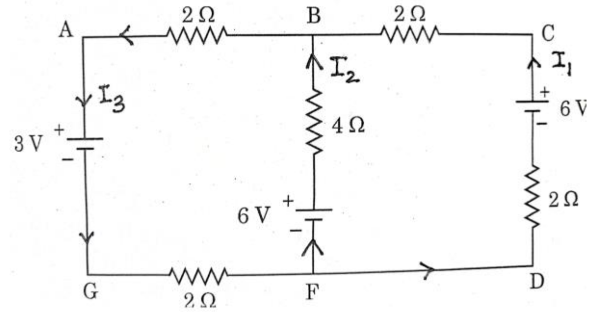
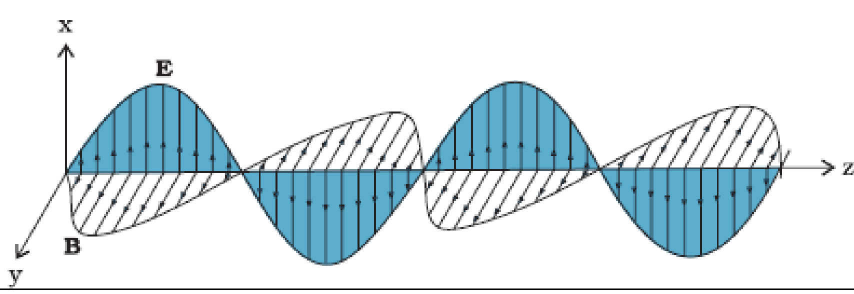
18.	**(a)** Obtaining expression for resultant intensity 2		
	$x_1 = a\cos\omega t$ $x_2 = a\cos(\omega t+\phi)$	½	
	$x = x_1 + x_2$ $= a(\cos\omega t + \cos(\omega t+\phi))$ $= a(2\cos(\omega t+\frac{\phi}{2})\cos\frac{\phi}{2})$ $= 2a\cos\frac{\phi}{2}\cos(\omega\,\mathrm{t}+\frac{\phi}{2})$	½	
	Intensity I = K (amplitude) ^{2} where K is a constant. $= K(2a\cos\frac{\phi}{2})^2$	½	
	$= 4I_0\cos^2\frac{\phi}{2}$	½	
	$I_o = Ka^2$ = intensity of each incident wave. **(Note : Award full credit of this part for all other alternative correct methods)** **OR**		
	(b) Effect and justification (i) Source slit moved closer to plane of slits 1 (ii) Separation between two slits 1		
	(i)Sharpness of interference pattern decreases $\frac{s}{S} < \frac{\lambda}{d}$	**1**	
	As S decreases, interference patterns produced by different parts of the source overlap and finally fringes disappear. **Alternatively** As the source slit is brought closer to the plane of the slits, the screen gets illuminated uniformly and fringes disappear. **Alternatively** Interference pattern is not formed. **(Note : Award full credit of this part if a student merely attempts this part.)**		
	(ii) $\beta = \frac{\lambda D}{d}$	½	
	As d increases, β decreases and fringes disappear.	½	**2**
19.	Finding focal length 1 ½ Nature of the lens ½		
	For convex lens in air $\frac{1}{f_a} = \left(\frac{n_g}{n_a} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$		

	For convex lens in liquid. $\frac{1}{f_l} = \left(\frac{n_g}{n_l}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ $\frac{f_l}{f_a} = \frac{\frac{1.52-1}{1}}{\frac{1.52-1.65}{1.65}}$ $= -6.6$ $f_l = -6.6\, f_a$ $= -99\text{cm}$ Nature of the lens: Diverging/ behaves like a concave lens.	½ ½ ½ ½	 2
20.	Calculation of binding energy 2 Binding Energy $= (Zm_p + (A-Z)m_n - M_N) \times 931.5$ MeV B. E.$= (6\times1.007825 + 6\times1.008665 - 12.000000)$ x 931.5 MeV = (0.09894) x 931.5 MeV B. E. = 92.16 MeV	 ½ ½ ½ ½	 2
21.	Effect on energy gap and justification (i) Trivalent impurity ½ + ½ (ii) Pentavalent impurity ½ + ½ (i) Decreases Justification: An acceptor energy level is formed just above the top of the valence band. (ii) Decreases Justification: A donor level is formed just below the bottom of conduction band. **Alternatively**  **(Note : Award the credit of justification if a student draws band diagram)**	 ½ ½ ½ ½	 2

SECTION C

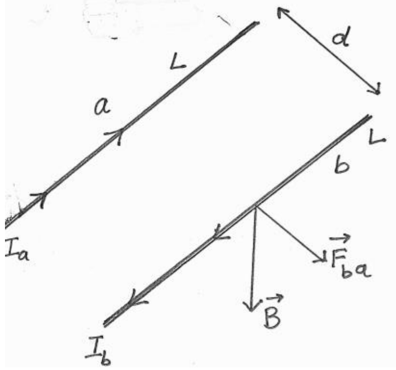
22.	Finding magnitude and direction of current in AG, BF and CD 1+1+1		

55/2/1

		½	
	By Kirchoff's Laws (at point B) $I_1 + I_2 = I_3$ ....(1) In the closed loop AGFBA $3 + 2I_3 - 6 + 4I_2 + 2I_3 = 0$	½	
	$I_2 + I_3 = \frac{3}{4}$ ....(2) From (i)	½	
	$2I_1 + I_2 = \frac{3}{4}$ ....(3) In closed loop BFDCB	½	
	$-4I_2 + 6 + 2I_1 - 6 + 2I_1 = 0$ $I_2 - I_1 = 0$ $I_2 = I_1$ ....(4) Putting in (3)	½	
	$I_1 = \frac{1}{4} A$ From (4) $I_2 = \frac{1}{4} A$ From (2) $I_3 = \frac{1}{2} A$	½	**3**
23.	(a) Factors affecting speed of Electromagnetic wave 1 (b) Production of Electromagnetic wave 1 (c) Sketch of Electromagnetic wave 1		
	(a) Speed of EM waves v = $\frac{1}{\sqrt{\mu\varepsilon}}$ Speed depends upon (i) Permittivity (ε) of medium (ii) Magnetic permeability (μ) of medium	½ + ½	
	(b) Accelerated charges or oscillating charges produce electromagnetic waves	**1**	
	(c) 	**1**	**3**

24.	Calculation of current induced in the coil 3		
	Induced emf $(\varepsilon) = \frac{-Nd\phi}{dt}$	½	
	$= \frac{-NAdB}{dt}$		
	$= -NA\frac{d}{dt}(\mu_0 nI)$		
	$= -N\mu_0 n(\pi r^2)\frac{dI}{dt}$		
	$\varepsilon = \frac{100\times4\pi\times10^{-7}\times250\times10^{2}\times\pi\times(1.6\times10^{-2})^2\times1.5}{25\times10^{-3}}$	**1**	
	=0.1536V	½	
	$I = \frac{\varepsilon}{R}$	½	
	= 0.03A	½	
	Alternatively		
	$\varepsilon = -M\frac{dI}{dt}$	½	
	$M = \mu_0 n_1 n_2 \pi r_1^2 l$ $= \mu_0 (n_1 l) n_2 \pi r_1^2$	½	
	$= 4\pi\times10^{-7}\times100\times250\times10^{2}\times\pi\times(1.6\times10^{-2})^2$		
	$= 2.56\times10^{-3}H$	½	
	$= -2.56\times10^{-3}\times\frac{(0-1.5)}{25\times10^{-3}}$		
	=0.1536V	½	
	$I = \frac{\varepsilon}{R} = \frac{0.1536}{5}$	½	
	= 0.03A	½	**3**
25.	**(a)** Explaining nature of force ½ Obtaining expression of force 1½ Defining one ampere 1		
	Nature of force is repulsive.	½	

55/2/1



½

Magnetic field due to current I_a at all points of conductor b

$B_{ab} = \dfrac{\mu_0 I_a}{2\pi d}$ directed downwards ½

Force experienced by conductor b on its segment of length *l*

$F_{ab} = I_b l B_{ab}$

$= \dfrac{\mu_0 I_a I_b}{2\pi d} l$ directed towards left ½

Similarly

Force experienced by conductor a on its segment of length *l*

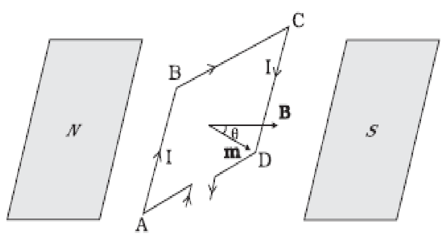
$F_{ba} = \dfrac{\mu_0 I_a I_b}{2\pi d} l$ directed towards right

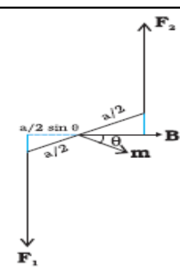
One ampere is that steady current which when maintained in each of two very long straight parallel conductors of negligible cross- section, placed one metre apart in vacuum produces a force of 2x10 $^{-7}$ N/m on each conductor. **1**

OR

(b)

Obtaining expression of torque	2
Drawing diagram	1





1

Forces on arm BC and DA are equal and opposite and act along the axis of the coil. Being collinear they cancel each other.

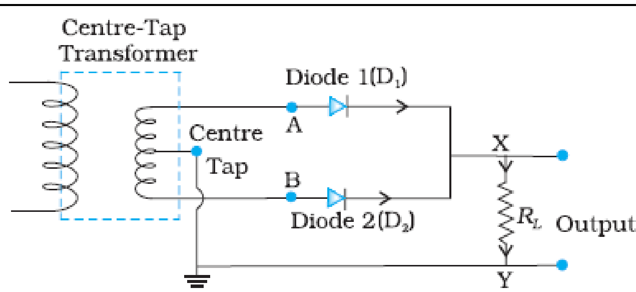
½

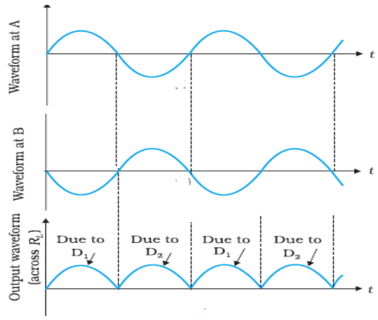
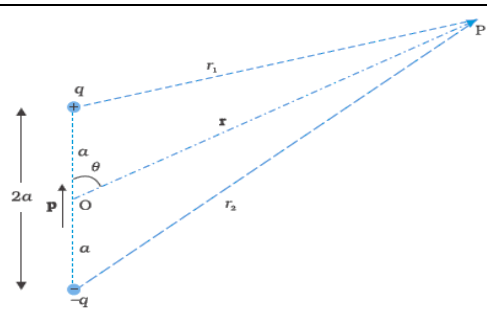
Forces on arms AB and CD are equal and opposite but not collinear. They form a couple.

$F_1 = F_2 = IbB$ ½

$\tau = F_1 \dfrac{a}{2}\sin\theta + F_2 \dfrac{a}{2}\sin\theta$ ½

$\tau = IabB\sin\theta$

	$\tau = IAB\sin\theta$ (where A = ab & m = IA) $\vec{\tau} = \vec{m}\times\vec{B}$	½	3
26.	Deriving expression for radius 2 Finding numerical value of a_o 1 From Bohr's second postulate $m v r = \frac{nh}{2\pi}$ ……(1) Also $\frac{m v^2}{r} = \frac{e^2}{4\pi\varepsilon_0 r^2}$ (z=1) $v = \frac{e}{\sqrt{4\pi\varepsilon_0 mr}}$ Substituting in (1) and simplifying $r = \frac{n^2h^2\varepsilon_0}{\pi me^2}$ For n = 1 r = a_o (Bohr's radius) $a_o = \frac{(6.63\times10^{-34})^2\times8.854\times10^{-12}}{3.14\times9.1\times10^{-31}\times(1.6\times10^{-19})^2}$ $= 5.29\text{x}10^{-11}$m = 0.53Å	½ ½ ½ ½ ½ ½	3
27.	(a) Interpretation of slope of line and justification ½ + ½ (b) Identification and justification ½ + ½ (c) Validation of graph and justification ½ + ½ (a) $\lambda = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2m}}\times\frac{1}{\sqrt{K}}$ $slope = \frac{h}{\sqrt{2m}}$ (b) $slope\ \alpha\ \frac{1}{\sqrt{m}}$ Slope of m_2 is more than that of m_1.Therefore, m_1 is heavier. (c) No Momentum (p) = $\sqrt{2mK}$ is not valid for a photon	½ ½ ½ ½ ½ ½	3
28.	Explaining working of full wave rectifier 2 Drawing input and output wave forms 1  When input voltage at A with respect to the centre tap at any instant is positive, at that instant voltage at B, being out of phase will be negative,	1 ½	

	during the positive half cycle diode D_1 gets forward biased and conducts while diode D_2 gets reverse biased and does not conduct. Hence during positive half cycle an output current and output voltage across R_L is obtained. During second half of the cycle when voltage at A becomes negative with respect to centre tap, the voltage at B would be positive hence D_1 would not conduct but D_2 would be giving an output current and output voltage. We get output voltage in both positive and negative half cycles.  	½ 1	3
29.	(i) (B) The internal resistance of a cell decreases with the decrease in temperature of the electrolyte. (ii) (B) 2.8 V (iii) (A) $\varepsilon = V_+ + V_- > 0$ (iv) (a) (D) 0.2A **OR** (b) (A) 1.0Ω	1 1 1 1	4
30.	(i) Since no option is correct, award 1 mark to all students. (ii) (D) 800 nm (iii) (a) (A) $\frac{\sqrt{3}}{2}$ **OR** (b) (B) $\sin^{-1}\left(\frac{4}{5}\right)$ (iv) (A) $\sin^{-1}\sqrt{n^2 - 1}$	1 1 1 1	4
31.	**(a)** (i) Obtaining expression for electric potential 3 (ii) Finding the value of n 2 (i)  Potential due to the dipole is the sum of potentials due to charges q and -q	½ ½	

$$V = \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{r_1} - \frac{q}{r_2}\right) \quad \text{------------------------------------(1)}$$

By geometry

½

$$r_1^2 = r^2 + a^2 - 2ar\cos\theta$$

$$r_2^2 = r^2 + a^2 + 2ar\cos\theta$$

For r >> a, retaining terms only up to first order in a/r

$$r_1^2 = r^2\left(1 - \frac{2a\cos\theta}{r} + \frac{a^2}{r^2}\right)$$

$$\cong r^2\left(1 - \frac{2a\cos\theta}{r}\right)$$

½

Similarly

$$r_2^2 \cong r^2\left(1 + \frac{2a\cos\theta}{r}\right)$$

Using the binomial theorem and retaining terms up to the first order in a/r

$$\frac{1}{r_1} \cong \frac{1}{r}\left(1 - \frac{2a\cos\theta}{r}\right)^{-1/2}$$

$$\cong \frac{1}{r}\left(1 + \frac{a\cos\theta}{r}\right) \quad \text{-------------------------------------(2)}$$

$$\frac{1}{r_2} \cong \frac{1}{r}\left(\frac{1 + 2a\cos\theta}{r}\right)^{-1/2} \quad \text{-------------------------------(3)}$$

½

$$\cong \frac{1}{r}\left(1 - \frac{a\cos\theta}{r}\right)$$

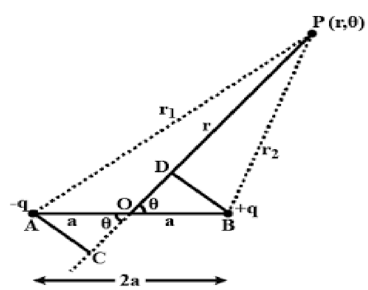
Using eqn. (1) (2), (3) and p = 2qa

$$V = \frac{q}{4\pi\varepsilon_0}\frac{2a\cos\theta}{r^2}$$

½

$$= \frac{p\cos\theta}{4\pi\varepsilon_0 r^2}$$

Alternatively –



½

$$r_2 = r + a\cos\theta$$

½

$$r_1 = r - a\cos\theta$$

$$V = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

½

$$V = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r - a\cos\theta} - \frac{1}{r + a\cos\theta}\right)$$

½

$$= \frac{q}{4\pi\varepsilon_0}\left(\frac{2a\cos\theta}{r^2 - a^2\cos^2\theta}\right)$$

½

$$= \frac{p}{4\pi\varepsilon_0 r^2}\left(\frac{\cos\theta}{1-\frac{a^2}{r^2}\cos^2\theta}\right)$$ ½

For r>>a, neglecting $\frac{a^2}{r^2}$

$$V= \frac{P\cos\theta}{4\pi\varepsilon_0 r^2}$$ ½

(ii) Consider the side of equilateral triangle as ‘a’

Potential energy $= U= \frac{kq_1q_2}{a}+\frac{kq_2q_3}{a}+\frac{kq_1q_3}{a}$ ½

According to question

$$U=\frac{k(q)(2q)}{a}+\frac{k(2q)(nq)}{a}+\frac{k(q)(n\,q)}{a}=0$$ ½

$$=\frac{2q^2}{a}+\frac{2nq^2}{a}+\frac{n\,q^2}{a}=0$$

$$2+2n+n=0$$ ½

$$3n=-2$$

$$n=-\frac{2}{3}$$

OR

(b)

(i) Statement of Gauss’s Law	1
Obtaining expression for electric field	2
(ii) Finding net force on electron	2

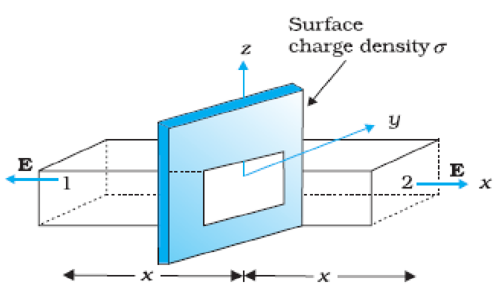
(i) Electric Flux through a closed surface is equal to $\frac{q}{\varepsilon_0}$, where q is the total charge enclosed by the surface. $\phi=\frac{q}{\varepsilon_0}$ **1**

Alternatively

The surface integral of electric field over a closed surface is $\frac{1}{\varepsilon_0}$ times the total charge enclosed by the surface.

$$\oint \vec{E}.d\vec{S}=\frac{q}{\varepsilon_0}$$

(Award ½ mark for writing the formula only.)

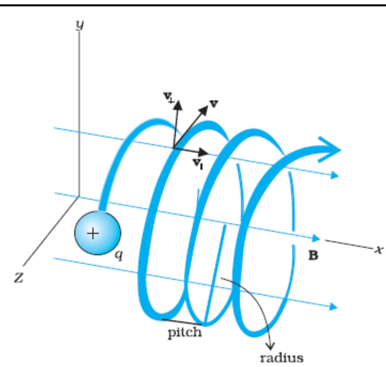


½

(Gaussian surface can be cylindrical also)

As seen from figure, only two faces 1 and 2 will contribute to the flux. ½

Flux $\vec{E}.d\vec{s}$ through both the surfaces is equal and add up.

	The charge enclosed by surface is σA, where σ is surface charge density		
	According to Gauss's theorem		
	$2EA = \sigma A / \varepsilon_0$	½	
	$E = \sigma / 2\varepsilon_0$		
	$\vec{E} = \dfrac{\sigma}{2\varepsilon_0}\hat{n}$ where $\hat{n}$ is unit vector directed normally out of the plane	½	
	(ii) $\vec{E} = \dfrac{\lambda}{2\pi\varepsilon_0 r}\hat{r}$		
	According to question		
	E_1 (at point P) $= \dfrac{\lambda_1}{2\pi\varepsilon_0 r_1}$		
	$\vec{E} = \dfrac{10\times10^{-6}}{2\pi\varepsilon_0(10\times10^{-2})}\ (-\hat{j})\ N/C$	½	
	E_2 (at point P) $= \dfrac{\lambda_2}{2\pi\varepsilon_0 r_2}$		
	$\vec{E} = \dfrac{20\times10^{-6}}{2\pi\varepsilon_0(20\times10^{-2})}\ (-\hat{j})\ N/C$	½	
	$E_{net} = \dfrac{10\times10^{-6}}{2\pi\varepsilon_0}\left(\dfrac{1}{0.1}+\dfrac{2}{0.2}\right)\ (-\hat{j})\ N/C$		
	$= 3.6\times10^{6}\ (-\hat{j})\ N/C$	½	
	$\vec{F}_{net} = q\times\vec{E}_{net}$		
	$\vec{F} = -1.6\times10^{-19}\times3.6\times10^{6}\ (-\hat{j})\ N$		
	$= 5.76\times10^{-13} N\ (\hat{j})$	½	5
32.	**(a)** (i) Showing helical path 1 ½ Obtaining frequency of revolution 1 ½ (ii) Finding magnetic moment of electron 2		
		½	
	$v_\perp = v\sin\theta$ is perpendicular to $\vec{B}$ and		
	$v_\parallel = v\cos\theta$ is parallel to $\vec{B}$		
	Due to $v_\perp$ the charge describes circular path and $v_\parallel$ pushes it in the direction of $\vec{B}$. Therefore under the combined effect of two components the charged particle describes helical path, as shown in the figure.	1	
	The centripetal force		

$$\frac{mv_\perp^{\ 2}}{r} = B\,qv_\perp$$ ½

$v_\perp = \dfrac{Bqr}{m}$ $\qquad (v_\perp = v\sin\theta)$ ½

Time period = $T = \dfrac{2\pi r}{v_\perp}$

$= \dfrac{2\pi m}{Bq}$

$frequency\, v = \dfrac{1}{T} = \dfrac{Bq}{2\pi m}$ ½

(ii) Magnetic moment $m = I\,A$

$I = \dfrac{e}{T} = ev$ ½

$= 1.6\times10^{-19}\times8\times10^{14}$

$= 1.28\times10^{-4}\,A$ ½

$M = 1.28\times10^{-4}\times3.14\times(2\times10^{-10})^2$ ½

$= 5.12\pi\times10^{-24}\,Am^2 = 1.6\times10^{-23}\,Am^2$ ½

OR

(b)

(i) Definition of current sensitivity	1
Showing dependence of current sensitivity & explanation	1+1
(ii) Calculation of resistance	2

(i) Deflection produced per unit current is called its current sensitivity.

$I_S = \dfrac{\theta}{I} = \dfrac{NBA}{K}$ **1**

Current sensitivity can be increased by
(a) increasing number of turns in coil
(b) increasing area of coil in magnetic field **1**
(c) decreasing K (Torsional Constant)
(any one)

$V_s = \dfrac{\theta}{V} = \dfrac{NBA}{KR}$

If current sensitivity is increased by increasing number of turns of the coil, the resistance of the galvanometer will also increase. Thus voltage sensitivity may not increase. **1**

(ii) $V = I_G(R+G)$

$R = \dfrac{V}{I_G} - G$ ½

$= \dfrac{100}{20\times10^{-3}} - 15$ ½

$= 5000 - 15$

$= 4985\Omega$ ½

By connecting 4985Ω in series with galvanometer it is converted to voltmeter of range (0-100V) ½ **5**

33.	**(a)**		

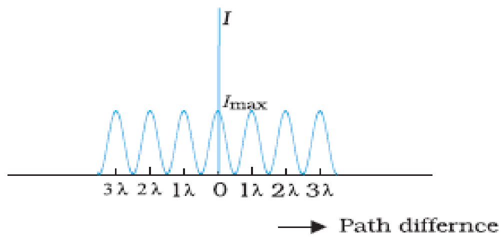
(i) Two differences between interference pattern and diffraction pattern	2
(ii) Intensity distribution graph	1
(iii) Finding intensity of light	2

(i)

	Interference	Diffraction
1	Bands are equally spaced	Bands are not equally spaced.
2	Intensity of bright bands is same.	Intensity of maxima decreases on either side of central maxima.
3	First maxima is at an angle λ / a	First minima is at an angle λ / a

1 + 1

(ii)



1

(iii) Path difference $(\Delta) = \lambda$

$$\phi = \frac{2\pi\Delta}{\lambda}$$

$$\phi = 2\pi$$

½

$$I = 4I_0 \cos^2 \frac{\phi}{2}$$

$$K = 4I_0 \cos^2 \pi \quad = 4I_0$$

½

$$\text{Path difference} = \frac{\lambda}{6}$$

$$\phi = \pi / 3$$

½

$$I = 4I_0 \cos^2 \frac{\pi}{6}$$

$$= 4I_0 \times \frac{3}{4}$$

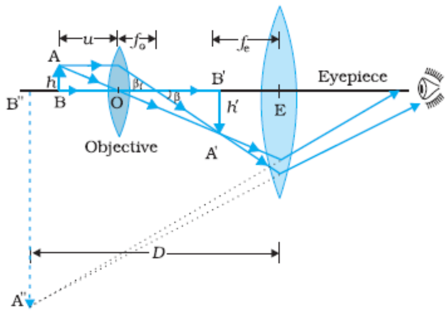
$$= \frac{3}{4}\text{K}$$

½

OR

(b)

(i) Drawing labeled ray diagram	1
Derivation of magnifying power	2
(iii) Finding magnifying power	2

	(i)		
	 	1	
	The magnification obtained by eye-piece lens $m_e = \left(1+\frac{D}{f_e}\right)$	½	
	The magnification obtained by objective lens $m_0 = \frac{v_0}{-u_0}$	½	
	Hence the total magnifying power is $m = m_0 \times m_e$	½	
	$= \frac{v_0}{-u_0}\left(1+\frac{D}{f_e}\right)$	½	
	$(ii)\, \mathrm{m} = \left\lvert\frac{f_0}{f_e}\right\rvert$	1	
	Identification of focal length of objective and eyepiece $f_0 = 100cm$ $f_e = 5cm$	½	
	$m = \left\lvert\frac{100}{5}\right\rvert = 20$	½	5

General Instructions :

Read the following instructions carefully and follow them :

(i) *This question paper contains **33** questions. **All** questions are **compulsory**.*

(ii) *This question paper is divided into **five** sections – **Sections A, B, C, D** and **E**.*

(iii) *In **Section A** – Questions no. **1** to **16** are Multiple Choice type questions. Each question carries **1** mark.*

(iv) *In **Section B** – Questions no. **17** to **21** are Very Short Answer type questions. Each question carries **2** marks.*

(v) *In **Section C** – Questions no. **22** to **28** are Short Answer type questions. Each question carries **3** marks.*

(vi) *In **Section D** – Questions no. **29** and **30** are case study based questions. Each question carries **4** marks.*

(vii) *In **Section E** – Questions no. **31** to **33** are Long Answer type questions. Each question carries **5** marks.*

(viii) *There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.*

(ix) *Kindly note that there is a separate question paper for Visually Impaired candidates.*

(x) *Use of calculators is **not** allowed.*

You may use the following values of physical constants wherever necessary :

$c = 3 \times 10^{8}$ m/s

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8{\cdot}854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^{9}$ N m^2 C^{-2}

Mass of electron (m_e) = $9{\cdot}1 \times 10^{-31}$ kg

Mass of neutron = $1{\cdot}675 \times 10^{-27}$ kg

Mass of proton = $1{\cdot}673 \times 10^{-27}$ kg

Avogadro's number = $6{\cdot}023 \times 10^{23}$ per gram mole

Boltzmann constant = $1{\cdot}38 \times 10^{-23}$ JK^{-1}

SECTION A

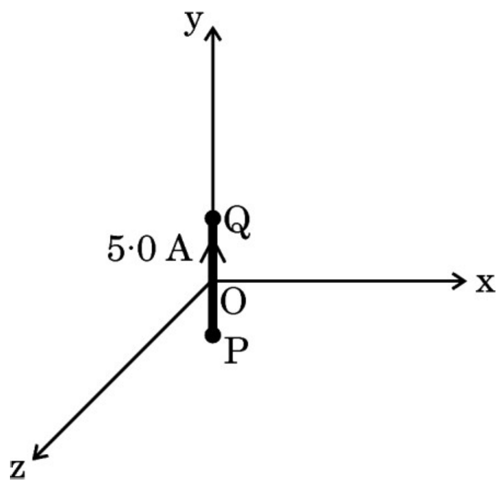
1. Consider a group of charges q_1, q_2, q_3 ... such that $\Sigma q \neq 0$. Then equipotentials at a large distance, due to this group are approximately :

(A) Plane
(B) Spherical surface
(C) Paraboloidal surface
(D) Ellipsoidal surface

2. A proton is taken from point P_1 to point P_2, both located in an electric field. The potentials at points P_1 and P_2 are – 5 V and + 5 V respectively. Assuming that kinetic energies of the proton at points P_1 and P_2 are zero, the work done on the proton is :

(A) $-1\cdot6 \times 10^{-18}$ J
(B) $1\cdot6 \times 10^{-18}$ J
(C) Zero
(D) $0\cdot8 \times 10^{-18}$ J

3. A 2·0 cm segment of wire, carrying 5·0 A current in positive y-direction lies along y-axis, as shown in the figure. The magnetic field at a point (3 m, 4 m, 0) due to this segment (part of a circuit) is :



(A) $(0\cdot12 \text{ nT})\ \hat{j}$
(B) $-(0\cdot10 \text{ nT})\ \hat{j}$
(C) $-(0\cdot24 \text{ nT})\ \hat{k}$
(D) $(0\cdot24 \text{ nT})\ \hat{k}$

4. A circular loop of wire, carrying a current 'I' is lying in xy-plane with its centre coinciding with the origin. It is subjected to a uniform magnetic field pointing along + z-axis. The loop will :

(A) move along x-axis
(B) move along – y-axis
(C) move along z-axis
(D) remain stationary

5. A current carrying circular loop of magnetic moment $\vec{M}$ is suspended in a vertical plane in an external magnetic field $\vec{B}$ such that its plane is normal to $\vec{B}$. The work done in rotating this loop by 45° about an axis perpendicular to $\vec{B}$ is closest to :

(A) $-0{\cdot}3$ MB (B) $0{\cdot}3$ MB

(C) $-1{\cdot}7$ MB (D) $1{\cdot}7$ MB

6. The current in a coil of 15 mH increases uniformly from zero to 4 A in 0·004 s. The emf induced in the coil will be :

(A) 22·5 V (B) 17·5 V

(C) 15·0 V (D) 12·5 V

7. Consider a solenoid of length l and area of cross-section A with fixed number of turns. The self-inductance of the solenoid will increase if :

(A) both l and A are increased

(B) l is decreased and A is increased

(C) l is increased and A is decreased

(D) both l and A are decreased

8. Which one of the following has the highest frequency ?

(A) Infrared rays (B) Gamma rays

(C) Radio waves (D) Microwaves

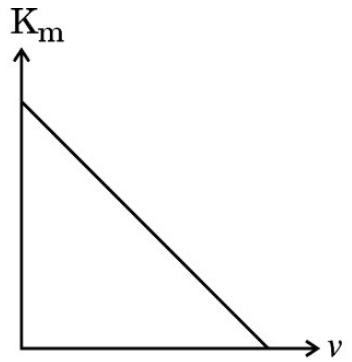
9. A proton and an alpha particle having equal velocities approach a target nucleus. They come momentarily to rest and then reverse their directions. The ratio of the distance of closest approach of the proton to that of the alpha particle will be :

(A) $\frac{1}{2}$ (B) 2

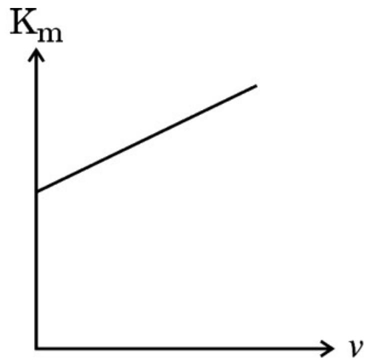
(C) $\frac{1}{4}$ (D) 4

10. Which one of the following is the correct graph between the maximum kinetic energy (K_m) of the emitted photoelectrons and the frequency of incident radiation (ν) for a given photosensitive surface ?

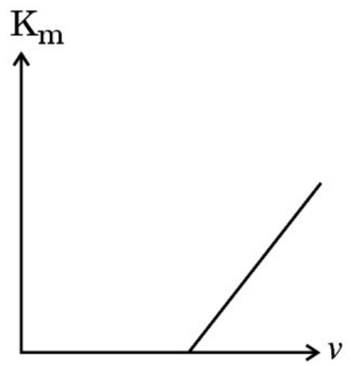
(A)



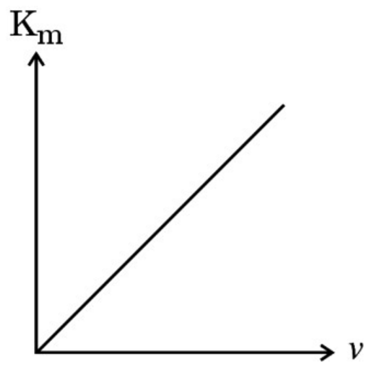
(B)



(C)



(D)



11. An electron makes a transition from n = 2 level to n = 1 level in the Bohr model of a hydrogen atom. Its period of revolution :

(A) increases by 87·5%

(B) decreases by 87·5%

(C) increases by 43·75%

(D) decreases by 43·75%

12. Si is doped with a pentavalent element. The energy required to set the additional electron free is about :

(A) 0·01 eV (B) 0·05 eV

(C) 0·72 eV (D) 1·1 eV

*Questions number **13** to **16** are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below.*

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is ***not*** the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false and Reason (R) is also false.

13. *Assertion (A) :* In a semiconductor, the electrons in the conduction band have lesser energy than those in the valence band.

Reason (R) : Donor energy level is just above the valence band in a semiconductor.

14. *Assertion (A) :* Photoelectric effect demonstrates the particle nature of light.

Reason (R) : Photoelectric current is proportional to frequency of incident radiation.

15. *Assertion (A) :* A proton and an electron enter a uniform magnetic field $\vec{B}$ with the same momentum $\vec{p}$ such that $\vec{p}$ is perpendicular to $\vec{B}$. They describe circular paths of the same radius.

Reason (R) : In a magnetic field, orbital radius r is equal to $\frac{p}{qB}$.

16. *Assertion (A) :* A convex lens, when immersed in a liquid, disappears.

Reason (R) : The refractive indices of material of the lens and the liquid are equal.

SECTION B

17. (a) What is meant by 'relaxation time' of free electrons in a conductor ? Show that the resistance of a conductor can be expressed by $R = \frac{m l}{ne^2 \tau A}$, where symbols have their usual meanings. *2*

OR

(b) Draw the circuit diagram of a Wheatstone bridge. Obtain the condition when no current flows through the galvanometer in it. *2*

18. The magnifying power of an astronomical telescope is 24. In normal adjustment, distance between its two lenses is 150 cm. Find the focal length of the objective lens. *2*

19. Explain the following : *2*

(a) For a simple microscope, the angular size of the object equals the angular size of the image. Yet it offers magnification.

(b) Both plane and convex mirrors produce virtual images of objects. Can they produce real images under some circumstances ?

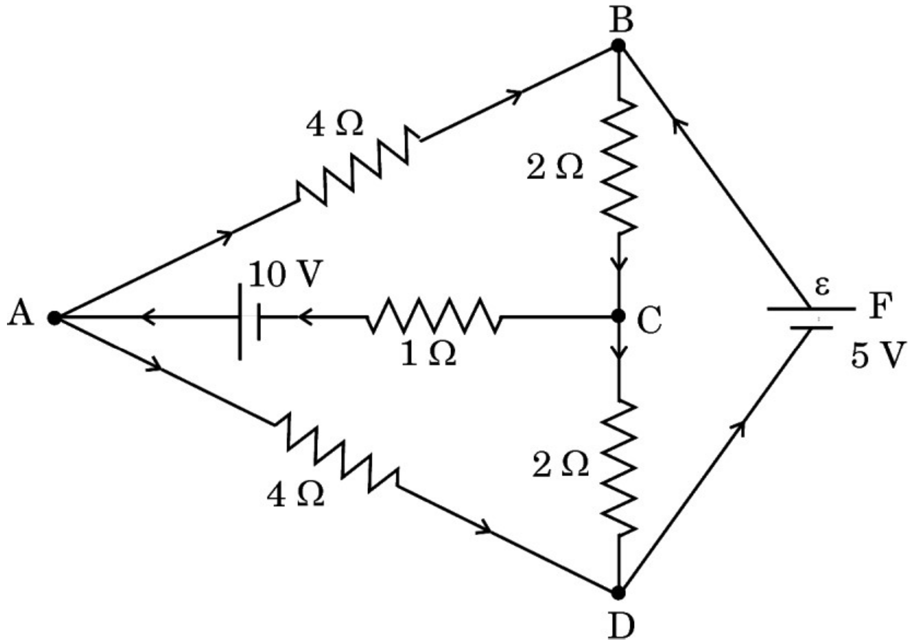
20. The minimum intensity of white light that our eyes can perceive is about $0{\cdot}1\ nWm^{-2}$. Calculate the number of photons of this light entering our pupil (area $0{\cdot}4\ cm^2$) per second. *2*

(Take average wavelength of white light = 500 nm and Planck's constant = $6{\cdot}6 \times 10^{-34}$ Js)

21. Suppose a pure Si crystal has 5×10^{28} atoms m^{-3}. It is doped by 1 ppm concentration of boron. Calculate the concentration of holes and electrons, given that $n_i = 1{\cdot}5 \times 10^{16}\ m^{-3}$. Is the doped crystal n-type or p-type ? *2*

SECTION C

22. Determine the current in branches AB, AC and BC of the network shown in figure. *3*



23. Two long straight parallel conductors carrying currents, exert a force on each other. Why ? Derive an expression for the force per unit length between two long straight parallel conductors carrying currents in opposite directions. Explain the nature of the force between these conductors. *3*

24. A sinusoidal voltage is applied to an electric circuit containing a circuit element 'X' in which the current leads the voltage by $\frac{\pi}{2}$.

(a) Identify the circuit element 'X' in the circuit.

(b) Write the formula for its reactance.

(c) Show graphically the variation of this reactance with frequency of ac voltage.

(d) Explain the behaviour of this element when it is used in (i) an ac circuit, and (ii) a dc circuit. *3*

25. The electric field in an electromagnetic wave in vacuum is given by :

$$\vec{E} = (6{\cdot}3\ \text{N/C})\ [\cos\ (1{\cdot}5\ \text{rad/m})\ y + (4{\cdot}5 \times 10^{8}\ \text{rad/s})\ t]\ \hat{i}$$

(a) Find the wavelength and frequency of the wave.

(b) What is the amplitude of the magnetic field of the wave ?

(c) Write an expression for the magnetic field of this wave. *3*

26. State Bohr's first and second postulates. Use them to derive an expression for the radius of the n^{th} orbit in a hydrogen atom. *3*

27. (a) Define atomic mass unit (u).

(b) Calculate the energy required to separate a deuteron into its constituent parts (a proton and a neutron). Given : *3*

$m(D) = 2{\cdot}014102$ u

$m_H = 1{\cdot}007825$ u

$m_n = 1{\cdot}008665$ u

28. (a) Draw the circuit diagrams for obtaining the V – I characteristics of a p-n junction diode. Explain briefly the salient features of the V – I characteristics in (i) forward biasing, and (ii) reverse biasing. *3*

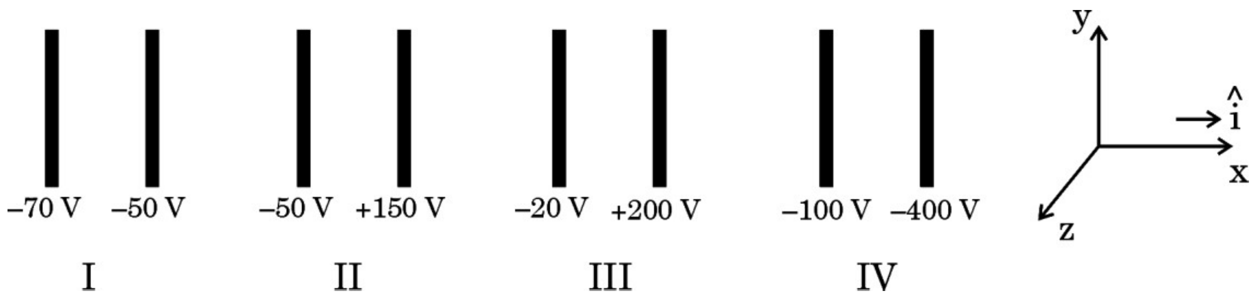
OR

(b) On the basis of energy band diagrams, distinguish between (i) an insulator, (ii) a semiconductor, and (iii) a conductor. *3*

SECTION D
Case Study Based Questions

*Questions number **29** and **30** are case study based questions. Read the following paragraphs and answer the questions that follow.*

29. The figure shows four pairs of parallel identical conducting plates, separated by the same distance 2·0 cm and arranged perpendicular to x-axis. The electric potential of each plate is mentioned. The electric field between a pair of plates is uniform and normal to the plates.



(i) For which pair of the plates is the electric field $\vec{E}$ along $\hat{i}$? *1*

(A) I (B) II
(C) III (D) IV

(ii) An electron is released midway between the plates of pair IV. It will : *1*

(A) move along $\hat{i}$ at constant speed

(B) move along $-\hat{i}$ at constant speed

(C) accelerate along $\hat{i}$

(D) accelerate along $-\hat{i}$

(iii) Let V_0 be the potential at the left plate of any set, taken to be at $x = 0$ m. Then potential V at any point ($0 \le x \le 2$ cm) between the plates of that set can be expressed as : *1*

(A) $V = V_0 + \alpha x$ (B) $V = V_0 + \alpha x^2$
(C) $V = V_0 + \alpha x^{1/2}$ (D) $V = V_0 + \alpha x^{3/2}$

where α is a constant, positive or negative.

(iv) (a) Let E_1, E_2, E_3 and E_4 be the magnitudes of the electric field between the pairs of plates, I, II, III and IV respectively. Then : *1*

(A) $E_1 > E_2 > E_3 > E_4$ (B) $E_3 > E_4 > E_1 > E_2$

(C) $E_4 > E_3 > E_2 > E_1$ (D) $E_2 > E_3 > E_4 > E_1$

OR

(b) An electron is projected from the right plate of set I directly towards its left plate. It just comes to rest at the plate. The speed with which it was projected is about :
(Take $(e/m) = 1{\cdot}76 \times 10^{11}$ C/kg) *1*

(A) $1{\cdot}3 \times 10^5$ m/s (B) $2{\cdot}6 \times 10^6$ m/s

(C) $6{\cdot}5 \times 10^5$ m/s (D) $5{\cdot}2 \times 10^7$ m/s

30. Diffraction and interference are closely related phenomena that occur together. Diffraction is the phenomenon of bending of light around the edges of the obstacle, while interference is the combination of waves that results in a new wave pattern. In order to get interference, there must be at least two waves that are diffracting. So while diffraction can occur without interference, interference cannot occur without diffraction.

Two slits of width 2 μm each in an opaque material are separated by a distance of 6 μm. Monochromatic light of wavelength 450 nm is incident normally on the slits. One finds a combined interference and diffraction pattern on the screen.

(i) The number of peaks of the interference fringes formed within the central peak of the envelope of the diffraction pattern will be : *1*

(A) 2 (B) 3

(C) 4 (D) 6

(ii) The number of peaks of the interference formed if the slit width is doubled while keeping the distance between the slits same will be : *1*

(A) 1 (B) 2

(C) 3 (D) 4

(iii) (a) If instead of 450 nm light, another light of wavelength 680 nm is used, number of peaks of the interference formed in the central peak of the envelope of the diffraction pattern will be : *1*

(A) 2 (B) 4

(C) 6 (D) 9

OR

(b) Consider the diffraction of light by a single slit described in this case study. The first minimum falls at an angle θ equal to : *1*

(A) $\sin^{-1}(0{\cdot}12)$ (B) $\sin^{-1}(0{\cdot}225)$

(C) $\sin^{-1}(0{\cdot}32)$ (D) $\sin^{-1}(0{\cdot}45)$

(iv) The number of bright fringes formed due to interference on 1 m of screen placed at $\frac{4}{3}$ m away from the slits is : *1*

(A) 2 (B) 3

(C) 6 (D) 10

SECTION E

31. (a) (i) Obtain the expression for the capacitance of a parallel plate capacitor with a dielectric medium between its plates.

(ii) A charge of 6 μC is given to a hollow metallic sphere of radius 0·2 m. Find the potential at (i) the surface and (ii) the centre of the sphere. *5*

OR

(b) (i) A charge + Q is placed on a thin conducting spherical shell of radius R. Use Gauss's theorem to derive an expression for the electric field at a point lying (i) inside and (ii) outside the shell.

(ii) Show that the electric field for same charge density (σ) is twice in case of a conducting plate or surface than in a nonconducting sheet. *5*

32. (a) (i) (1) What is meant by current sensitivity of a galvanometer ? Mention the factors on which it depends.

(2) A galvanometer of resistance G is converted into a voltmeter of range (0 – V) by using a resistance R. Find the resistance, in terms of R and G, required to convert it into a voltmeter of range $\left(0 - \frac{V}{2}\right)$.

(ii) The magnetic flux through a coil of resistance 5 Ω increases with time as :

$$\phi = (2{\cdot}0\ t^3 + 5{\cdot}0\ t^2 + 6{\cdot}0\ t)\ \text{mWb}$$

Find the magnitude of induced current through the coil at t = 2 s. *5*

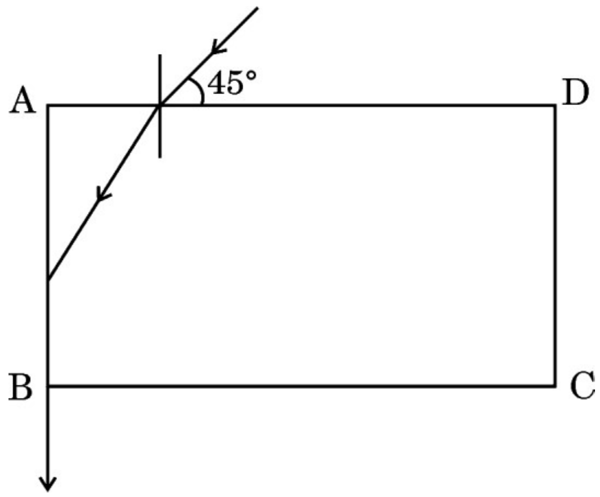
OR

(b) (i) A rectangular coil of N turns and area of cross-section A is rotated at a steady angular speed ω in a uniform magnetic field. Obtain an expression for the emf induced in the coil at any instant of time.

(ii) Two coplanar and concentric circular loops L_1 and L_2 are placed coaxially with their centres coinciding. The radii of L_1 and L_2 are 1 cm and 100 cm respectively. Calculate the mutual inductance of the loops. (Take $\pi^2 = 10$) *5*

33. (a) (i) Trace the path of a ray of light showing refraction through a triangular prism and hence obtain an expression for angle of deviation (δ) in terms of A, i and e, where symbols have their usual meanings. Draw a graph showing the variation of angle of deviation with the angle of incidence.

(ii) In the figure, a ray of light is incident on a transparent liquid contained in a thin glass box at an angle of 45° with its one face. The emergent ray passes along the face AB. Find the refractive index of the liquid. *5*



OR

(b) (i) The displacement of two light waves, each of amplitude 'a' and frequency ω, emanating from two coherent sources of light, are given by $y_1 = a \cos \omega t$ and $y_2 = a \cos (\omega t + \phi)$. ϕ is the phase difference between the two waves. These light waves superpose at a point. Obtain the expression for the resultant intensity at that point.

(ii) In Young's double slit experiment, find the ratio of intensities at two points on a screen when waves emanating from two slits reaching these points have path differences (i) $\frac{\lambda}{6}$ and (ii) $\frac{\lambda}{12}$. *5*

Marking Scheme
Strictly Confidential
(For Internal and Restricted use only)
Senior School Certificate Examination, 2024
SUBJECT PHYSICS (CODE 55/3/1)

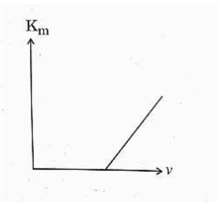
General Instructions: -

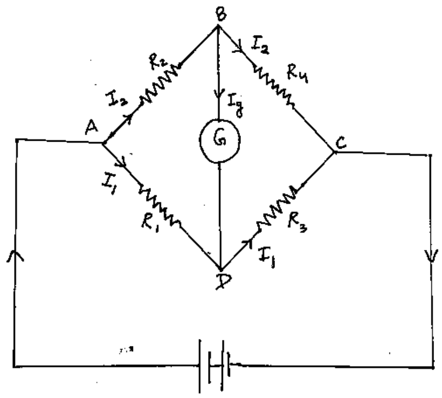
1	You are aware that evaluation is the most important process in the actual and correct assessment of the candidates. A small mistake in evaluation may lead to serious problems which may affect the future of the candidates, education system and teaching profession. To avoid mistakes, it is requested that before starting evaluation, you must read and understand the spot evaluation guidelines carefully.
2	**“Evaluation policy is a confidential policy as it is related to the confidentiality of the examinations conducted, Evaluation done and several other aspects. Its’ leakage to public in any manner could lead to derailment of the examination system and affect the life and future of millions of candidates. Sharing this policy/document to anyone, publishing in any magazine and printing in News Paper/Website etc may invite action under various rules of the Board and IPC.”**
3	Evaluation is to be done as per instructions provided in the Marking Scheme. It should not be done according to one’s own interpretation or any other consideration. Marking Scheme should be strictly adhered to and religiously followed. **However, while evaluating, answers which are based on latest information or knowledge and/or are innovative, they may be assessed for their correctness otherwise and due marks be awarded to them. In class-X, while evaluating two competency-based questions, please try to understand given answer and even if reply is not from marking scheme but correct competency is enumerated by the candidate, due marks should be awarded.**
4	The Marking scheme carries only suggested value points for the answers. These are in the nature of Guidelines only and do not constitute the complete answer. The students can have their own expression and if the expression is correct, the due marks should be awarded accordingly.
5	The Head-Examiner must go through the first five answer books evaluated by each evaluator on the first day, to ensure that evaluation has been carried out as per the instructions given in the Marking Scheme. If there is any variation, the same should be zero after delibration and discussion. The remaining answer books meant for evaluation shall be given only after ensuring that there is no significant variation in the marking of individual evaluators.
6	Evaluators will mark(√) wherever answer is correct. For wrong answer CROSS ‘X” be marked. Evaluators will not put right (✓)while evaluating which gives an impression that answer is correct and no marks are awarded. **This is most common mistake which evaluators are committing.**
7	If a question has parts, please award marks on the right-hand side for each part. Marks awarded for different parts of the question should then be totaled up and written in the left-hand margin and encircled. This may be followed strictly.
8	If a question does not have any parts, marks must be awarded in the left-hand margin and encircled. This may also be followed strictly.

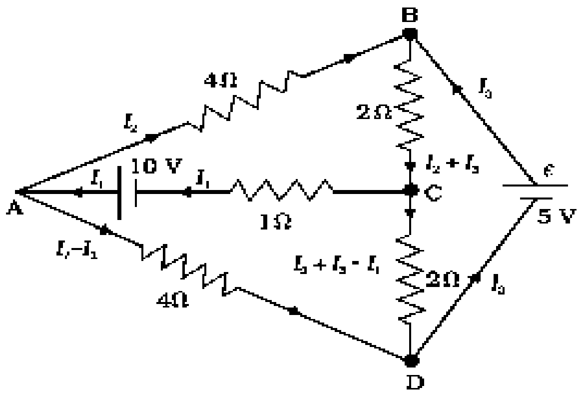
9	If a student has attempted an extra question, answer of the question deserving more marks should be retained and the other answer scored out with a note **"Extra Question"**.
10	No marks to be deducted for the cumulative effect of an error. It should be penalized only once.
11	A full scale of marks 0-70 has to be used. Please do not hesitate to award full marks if the answer deserves it.
12	Every examiner has to necessarily do evaluation work for full working hours i.e., 8 hours every day and evaluate 20 answer books per day in main subjects and 25 answer books per day in other subjects (Details are given in Spot Guidelines).This is in view of the reduced syllabus and number of questions in question paper.
13	Ensure that you do not make the following common types of errors committed by the Examiner in the past:- ● Leaving answer or part thereof unassessed in an answer book. ● Giving more marks for an answer than assigned to it. ● Wrong totaling of marks awarded on an answer. ● Wrong transfer of marks from the inside pages of the answer book to the title page. ● Wrong question wise totaling on the title page. ● Wrong totaling of marks of the two columns on the title page. ● Wrong grand total. ● Marks in words and figures not tallying/not same. ● Wrong transfer of marks from the answer book to online award list. ● Answers marked as correct, but marks not awarded. (Ensure that the right tick mark is correctly and clearly indicated. It should merely be a line. Same is with the X for incorrect answer.) ● Half or a part of answer marked correct and the rest as wrong, but no marks awarded.
14	While evaluating the answer books if the answer is found to be totally incorrect, it should be marked as cross (X) and awarded zero (0)Marks.
15	Any unassessed portion, non-carrying over of marks to the title page, or totaling error detected by the candidate shall damage the prestige of all the personnel engaged in the evaluation work as also of the Board. Hence, in order to uphold the prestige of all concerned, it is again reiterated that the instructions be followed meticulously and judiciously.
16	The Examiners should acquaint themselves with the guidelines given in the "**Guidelines for Spot Evaluation**" before starting the actual evaluation.
17	Every Examiner shall also ensure that all the answers are evaluated, marks carried over to the title page, correctly totaled and written in figures and words.
18	The candidates are entitled to obtain photocopy of the Answer Book on request on payment of the prescribed processing fee. All Examiners/Additional Head Examiners/Head Examiners are once again reminded that they must ensure that evaluation is carried out strictly as per value points for each answer as given in the Marking Scheme.

MARKING SCHEME : PHYSICS (042)

CODE :55/3/1

Q.NO.	**VALUE POINTS/ EXPECTED ANSWERS**	**MARKS**	**TOTAL MARKS**
	SECTION-A		
1.	(B) Spherical surface	**1**	**1**
2.	(B) 1.6×10^{-18} J	**1**	**1**
3.	(C) $-(0.24\ \text{nT})\ \hat{k}$	**1**	**1**
4.	(D) remain stationary	**1**	**1**
5.	(B) 0.3 MB	**1**	**1**
6.	(C) 15.0 V	**1**	**1**
7.	(B) l is decreased and A is increased	**1**	**1**
8.	(B) Gamma rays	**1**	**1**
9.	(B) 2	**1**	**1**
10.	(C) 	**1**	**1**
11.	(B) decreased by 87.5%	**1**	**1**
12.	(B) 0.05 eV	**1**	**1**
13.	(D) Assertion (A) is false and Reason (R) is also false.	**1**	**1**
14.	(C) Assertion (A) is true but Reason (R) is false.	**1**	**1**
15.	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion(A).	**1**	**1**
16.	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion(A).	**1**	**1**
	SECTION- B		
17.	**(a)** Meaning of relaxation time ½ Derivation of R 1 ½		
	Average time between two successive collisions of electron in presence of electric field	½	
	Drift velocity of an electron $\upsilon_d = \frac{eE}{m}\tau \quad ---(\text{i})$	½	
	Current flowing through a conductor of length *l* and area of cross section A $I = neA\upsilon_d \quad ---(\text{ii})$ $I = \frac{ne^2AE\tau}{m} = \frac{ne^2A\tau V}{ml}$	½	
	$R = \frac{V}{I} = \frac{ml}{ne^2\tau A}$	½	**2**
	OR		
	(b) Circuit diagram of Wheatstone bridge ½ Obtaining the condition when no current flows through galvanometer 1½		

	 By applying Kirchoff's loop rule to closed loops ADBA and CBDC $-I_1R_1 + 0 + I_2R_2 = 0$ -----(i) [$I_g = 0$] $I_2R_4 + 0 - I_1R_3 = 0$ -----(ii) From eq (i)- $\frac{I_1}{I_2} = \frac{R_2}{R_1}$ From eq (ii)- $\frac{I_1}{I_2} = \frac{R_4}{R_3}$ Hence, $\frac{R_2}{R_1} = \frac{R_4}{R_3}$	½ ½ ½ ½	2
18.	Finding the focal length of objective lens 2 Magnifying power = 24 , Distance between lenses =150 cm $\frac{f_o}{f_e} = 24$ $f_o + f_e = 150\,\text{cm}$ $f_e = 6\,\text{cm}$ $f_o = 144\,\text{cm}$	½ ½ ½ ½	2
19.	(a) Explanation of magnification 1 (b) Explanation 1 (a) Yes, it offers magnification. We can keep the small object much closer to the eye than 25 cm and hence have it subtend a large angle. (b) Yes, Rays converging to a point behind a plane or convex mirror are reflected to a point in front of the mirror on a screen	½ ½ ½ ½	2
20.	Calculation of number of photons per second 2 Total Energy gained per second from photon= IA $E = N\,h\nu$	½	

	$IA = N\times\frac{hc}{\lambda}$ $N=\frac{[IA]\lambda}{hc}$ $N=\frac{[0.1\times10^{-9}\times0.4\times10^{-4}]\times500\times10^{-9}}{6.6\times10^{-34}\times3\times10^{8}}$ $N=1.01\times10^{4}$	1 ½	2
21.	Calculation of concentration of holes & electrons 2 $n_e n_h = n_i^2$ $n_h \approx 5\times10^{22}/m^3$ $n_e=\frac{n_i^2}{n_h}$ $n_e=\frac{(1.5\times10^{16})^2}{5\times10^{22}}$ $n_e=4.5\times10^{9}/m^3$ $n_h > n_e$, it is a p- type crystal	½ ½ ½ ½	2
	SECTION- C		
22.	Determination of current in branches AB, AC, BC 1+1+1  For closed loop ADCA , $10-4(I_1-I_2)+2(I_2+I_3-I_1)-I_1=0$ $7I_1-6I_2-2I_3=10$ ------(i) For closed loop ABCA , $10-4I_2-2(I_2+I_3)-I_1=0$ $I_1+6I_2+2I_3=10$ ------(ii) For closed loop BCDED , $5-2(I_2+I_3)-2(I_2+I_3-I_1)=0$ $2I_1-4I_2-4I_3=-5$ -----(iii) Current in branch AB = $I_2=\frac{5}{8}A$ Current in branch AC = $I_1=2.5A$ Current in branch BC = $I_2+I_3=2.5A$	½ ½ ½ ½ ½ ½	3

55/3/1

<table>
<tr><td>23.</td><td>

Reason for exerting force on straight parallel conductors	½
Derivation for force per unit length	2
Explanation of nature of Force	½

</td><td></td><td></td></tr>
<tr><td></td><td>One conductor experiences a force due to magnetic field of the other conductor</td><td>½</td><td></td></tr>
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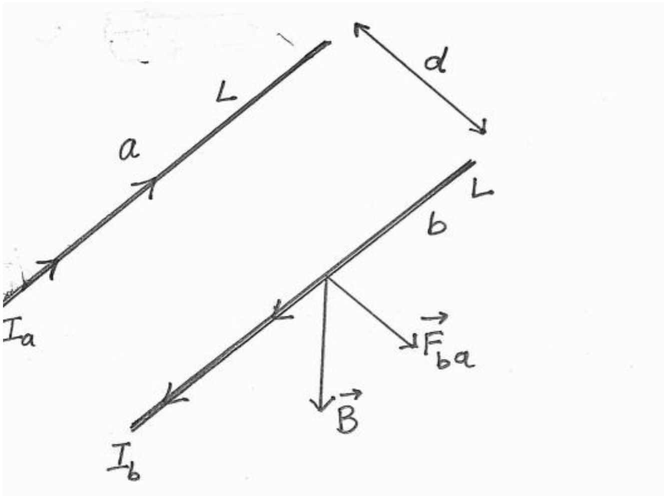


</td><td>½</td><td></td></tr>
<tr><td></td><td>Magnetic field produced by conductor 'a' at all points along the length of conductor 'b'

$$B_a = \frac{\mu_0 I_a}{2\pi d}$$</td><td>½</td><td></td></tr>
<tr><td></td><td>Force on conductor 'b' due to this magnetic field

$$F_{ba} = I_b L B_a$$

$$F_{ba} = \frac{\mu_0 I_a I_b L}{2\pi d}$$</td><td>½</td><td></td></tr>
<tr><td></td><td>

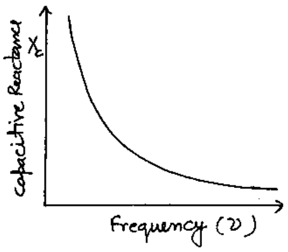
$$f_{ba} = \frac{F_{ba}}{L} = \frac{\mu_0 I_a I_b}{2\pi d}$$ directed away from a

$$f_{ab} = \frac{F_{ab}}{L} = \frac{\mu_0 I_a I_b}{2\pi d}$$ directed away from b</td><td>½</td><td></td></tr>
<tr><td></td><td>Repulsive, the forces acting on them are away from each other.</td><td>½</td><td>3</td></tr>
<tr><td>24.</td><td>

(a) Identifying the element X	½
(b) Writing the formula for reactance	½
(c) Showing variation of reactance with frequency	1
(d) Explanation of behavior of element with	
(i) an ac circuit	½
(ii) a dc circuit	½

</td><td></td><td></td></tr>
<tr><td></td><td>(a) Capacitor</td><td>½</td><td></td></tr>
<tr><td></td><td>(b) $X_c = \frac{1}{\omega c}$</td><td>½</td><td></td></tr>
</table>

(c)



1

(d) (i) For ac X_c is finite and therefore allows the ac to pass. ½

(ii) For dc X_c is infinite and therefore does not allow the dc to pass. ½ **3**

25.

(a) Finding the wavelength and frequency	1+1
(b) Finding the amplitude of magnetic field	½
(c) Writing expression for magnetic field	½

(a) $k = \dfrac{2\pi}{\lambda}$ ½

$\lambda = \dfrac{2\pi}{K} = \dfrac{4\pi}{3}\,\text{m} = 4.18\,\text{m}$ ½

$\omega = 2\pi\upsilon$

$\nu = \dfrac{\omega}{2\pi} = \dfrac{4.5\times10^{8}}{2\pi}\,\text{Hz}$ ½

$\nu = \dfrac{9}{4\pi}\times10^{8}\,\text{Hz}$ ½

$\nu = 7.16\times10^{-1}\ \text{Hz}$

(b) $B_0 = \dfrac{E_0}{c}$

$B_0 = \dfrac{6.3}{3\times10^{8}} = 2.1\times10^{-8}\,\text{T}$ ½

(c) $\vec{B} = 2.1\times10^{-8}[(\cos 1.5\,\text{rad/m})\,y + (4.5\times10^{8}\,\text{rad/s})\,t]\,\hat{k}\,\text{T}$ ½ **3**

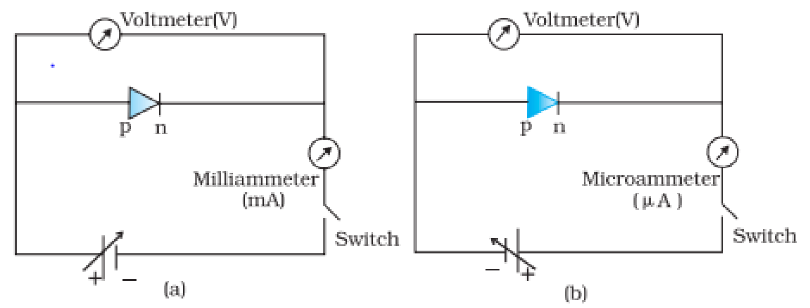
26.

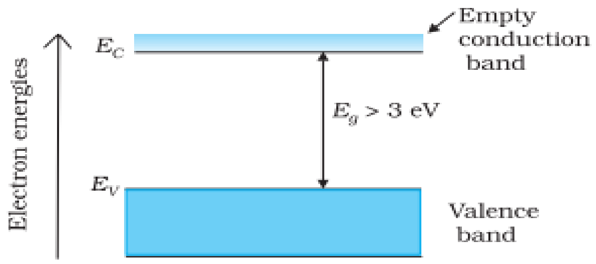
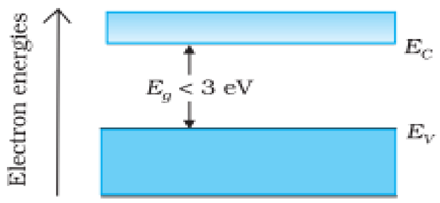
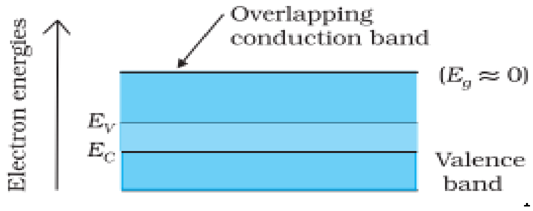
Statements of Bohr's first and second Postulates	½+½
Derivation of expression for radius of n^th orbit	2

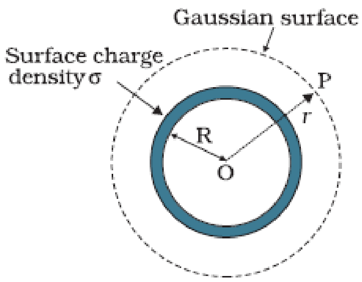
- **Bohr's first postulate**
  An electron in an atom revolves in certain stable orbits without the emission of radiant energy. ½
- **Bohr's second postulate**
  Electron revolves around the nucleus only in those orbits for which the angular momentum is integral multiple of $\dfrac{h}{2\pi}$. ½

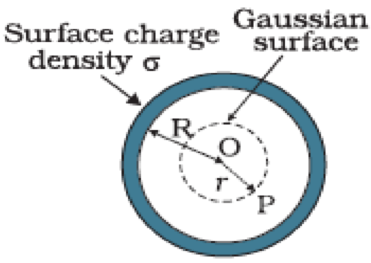
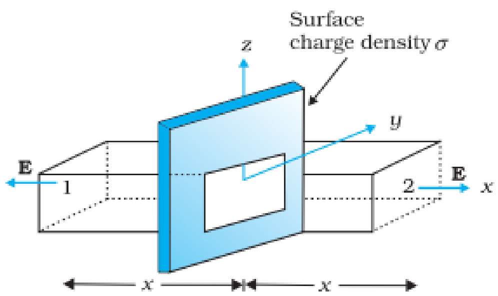
Electrostatic force between revolving electron and nucleus provides requisite centripetal force

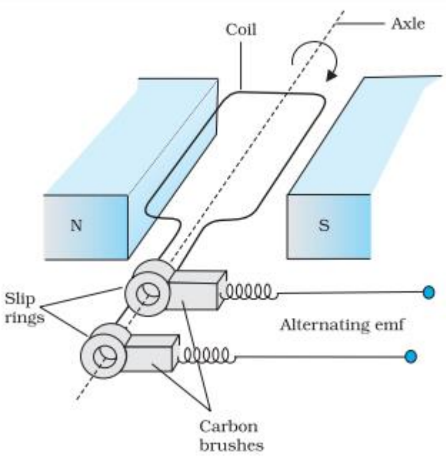
$$\frac{mv_n^2}{r_n} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r_n^2}$$ ½

	$v_n = \dfrac{e}{\sqrt{4\pi\varepsilon_0 m r_n}}$ ------(i) $m v_n r_n = \dfrac{nh}{2\pi}$ ------(ii) using equations (i) and (ii) $r_n = \left(\dfrac{n^2}{m}\right)\left(\dfrac{h}{2\pi}\right)^2 \dfrac{4\pi\varepsilon_0}{e^2}$	½ ½ ½	3
27.	(a) Definition of atomic mass unit (u) 1 (b) Calculation of energy required 2 (a) atomic mass unit (u) is defined as 1/12th of the mass of the carbon (^{12}C) atom. (b) $m\left({}_1H^2\right) \rightarrow m\left({}_1H^1\right) + m\left({}_0n^1\right)$ $Q = (m_R - m_P) \times 931.5\,MeV$ $= (2.014102 - 1.007825 - 1.008665) \times 931.5\,MeV$ $= -0.002388 \times 931.5\,MeV$ $= -2.224\,MeV$ Hence energy required is 2.224 MeV	**1** ½ ½ ½ ½	**3**
28.	**(a)** (a) Drawing the circuit diagram for V-I characteristics 1 Salient features of V-I characteristics in (i) Forward biasing 1 (ii) Reverse biasing 1  **[any one circuit diagram]** **Salient features** (i) **Forward biasing**- After threshold voltage or cut in voltage diode current increases significantly (exponentially), even for a small increase in the diode bias voltage. (ii) **Reverse biasing**- Current is very small (~μA) and almost remains constant and it increases rapidly after breakdown voltage. **OR**	**1** **1** **1**	

	(b) Energy band diagrams Difference between (i) an insulator (ii) a semiconductor (iii) a metal 1+1+1		
	(i) 	1	
	(ii) 	1	
	(iii) 	1	3
	SECTION- D		
29.	(i) (D) IV	1	
	(ii) (D) accelerate along $-\hat{i}$	1	
	(iii) (A) V= $V_0 + \alpha x$	1	
	(iv) (a) (C) $E_4 > E_3 > E_2 > E_1$ **OR** (b) (B) 2.6×10^6 m/s	1	4
30.	(i) (D) 6	1	
	(ii) (C) 3	1	
	(iii) (a) (C) 6 **OR** (b) $\sin^{-1}(0.225)$	1	
	(iv) (D) 10	1	4
	SECTION-E		
31.	**(a)** (i) Obtaining expression for the capacitance 3 (ii) Finding the electric potential 2 (i) at the surface (ii) at the centre (i) When a dielectric slab is inserted between the plates of capacitor, there is induced charge density σ_P which opposes the original charge density		

	(σ) on the plate of capacitance. Electric field with dielectric medium is $E = \frac{(\sigma - \sigma_P)}{\varepsilon_0}$ $V = E \times d = \frac{(\sigma - \sigma_P)}{\varepsilon_0} d$ $(\sigma - \sigma_P) = \frac{\sigma}{K}$ $V = \frac{\sigma d}{\varepsilon_0 K} = \frac{Qd}{A\varepsilon_0 K}$ $C = \frac{Q}{V} = \frac{K\varepsilon_0 A}{d}$ (ii) Electric potential due to a point charge $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$ (i) At the surface $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r} = \frac{9\times10^9\times6\times10^{-6}}{0.2}$ $V = 2.7 \times 10^5$ V (ii) Since electric field inside the hollow sphere is zero, hence V is same as that of the surface and remains constant throughout the volume. $V = 2.7 \times 10^5$ V **OR** **(b)** (i) Expression for electric field at a point lying (i) inside 1 (ii) outside 2 (ii) Explanation 2 **(i)** **Field inside the shell**  The Flux through the Gaussian surface is $= E \times 4\pi R^2$ In this case Gaussian surface encloses no charge. Hence $E \times 4\pi R^2 = 0$ E =0 **(Note: Award full credit of this part if a student writes directly E=0, mentioning as there is no charge enclosed by Gaussian surface)**	½ ½ ½ ½ ½ ½ ½ ½ ½ ½ ½ ½	

	(ii) <u>Field outside the shell</u>-		
		½	
	Electric flux through Gaussian surface $E \times 4\pi r^2 = \frac{(\sigma\, 4\pi R^2)}{\varepsilon_0}$	½	
	Charge enclosed by the Gaussian surface $E \times 4\pi r^2 = \frac{(\sigma\, 4\pi R^2)}{\varepsilon_0}$		
	Using Gauss's law: $\int \vec{E}.\vec{ds} = \frac{Q}{\varepsilon_0}$	½	
	$E \times 4\pi r^2 = \frac{(\sigma\, 4\pi R^2)}{\varepsilon_0}$ $E = \frac{\sigma}{\varepsilon_0}\frac{R^2}{r^2} = \frac{q}{4\pi\varepsilon_0 r^2}$	½	
	(ii) For conducting sheet, Electric field due to a conducting sheet $E_c = \frac{\sigma}{\varepsilon_0}$	½	
			
	For non-conducting sheet $E_{nc} = \frac{\sigma}{2\varepsilon_0}$	½	
	Since surface charge density is same.	½	
	$2E_{nc} = E_c$	½	5
32.	**(a)** (i)(1) Meaning of current sensitivity, mentioning factors 2 (2) Finding the required resistance 1½ (ii) Finding the induced current 1½		
	(i) (1). Current sensitivity of galvanometer is defined as the deflection per unit current.	**1**	
	Alternatively, $\frac{\phi}{I} = \frac{NBA}{K}$		
	Factors Number of turns in coil, Magnetic field intensity, Area of coil, Torsional Constant **(Any two)**	½+½	

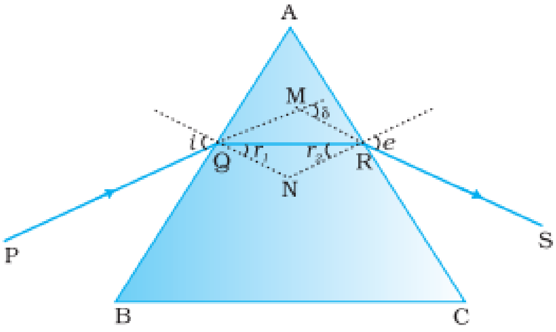
	(2) $R = \frac{V}{I} - G$ for (0-V) Range	½	
	$R_1 = \frac{V}{2I} - G$ for (0-$\frac{V}{2}$) Range	½	
	$\frac{V}{I} = R + G$		
	$R_1 = \left(\frac{R+G}{2}\right) - G$		
	$R_1 = \frac{R-G}{2}$	½	
	(ii) $\phi = (2.0t^3 + 5.0t^2 + 6.0t)$ mWb		
	$\lvert\varepsilon\rvert = \frac{d\phi}{dt} = 50 \times 10^{-3}$ V	½	
	I= $\frac{\lvert\varepsilon\rvert}{R}$	½	
	I= $\frac{50\times10^{-3}}{5}$ A=10 mA	½	
	OR		
	(b) (i) Obtaining the expression of emf induced — 3 (ii) Calculation of mutual inductance — 2		
		1	
	(i) The flux at any instant t is		
	$\phi = NBA\cos\theta$=NBA $\cos\omega t$	½	
	From Faraday's law $\boldsymbol{\varepsilon} = -\frac{d\phi_B}{dt}$	½	
	$= -NBA\frac{d}{dt}(\cos\omega t)$	½	
	$\boldsymbol{\varepsilon} = -NBA\,\omega\sin\omega t$	½	
	(ii) $M = \frac{\mu_0\pi r_1^2}{2r_2} = \frac{4\pi\times10^{-7}\times\pi r_1^2}{2r_2}$	½+½	
	$= \frac{2\times10\times10^{-7}\times(10^{-2})^2}{100\times10^{-7}}$	½	
	$= 2 \times 10^{-10}$ H	½	5

33.

(a)

(i) Tracing the path of ray	½
Obtaining an expression for angle of deviation	1½
Drawing Graph	1
(ii) Finding the refractive index	2

(i)



½

For quadrilateral AQNR,

$\angle A + \angle QNR = 180^o$ --- (i) ½

For triangle QNR

$r_1 + r_2 + \angle QNR = 180^o$ ---- (ii)

comparing equation (i) and (ii)

$r_1 + r_2 = A$ ------ (iii) ½

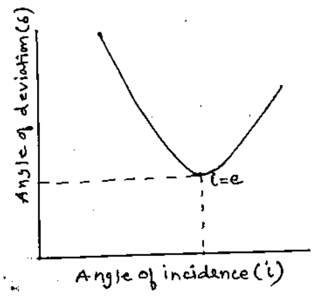
The angle of deviation

$\delta = (i - r_1) + (e - r_2)$ ------ (iv)

from equation (iii) and (iv)

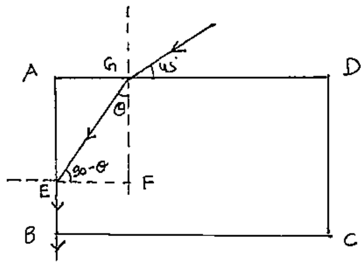
$\delta = i + e - A$ ½

Graph



1

(ii)



$$\frac{\sin 45^0}{\sin\theta} = \mu$$

$$\frac{1}{\sqrt{2}} = \mu \sin\theta$$ ½

For second surface,

$$\frac{\sin(90^0 - \theta)}{\sin 90^0} = \frac{1}{\mu}$$ ½

$\frac{1}{\sqrt{2}}\frac{\cos\theta}{\sin\theta} = 1$

$\tan\theta = \frac{1}{\sqrt{2}}$ ½

From the triangle GEF

$\sin\theta = \frac{1}{\sqrt{3}}$ ½

$\mu = \sqrt{\frac{3}{2}}$

OR

(b)

(i) Expression for resultant intensity	3
(ii) Ratio of intensities	2

(i) $y_1 = a\cos\omega t$

$y_2 = a\cos(\omega t + \phi)$

According to the principle of superposition

$y = y_1 + y_2$ ½

$y = a\cos\omega t + a\cos(\omega t + \phi)$

$y = a\cos\omega t + a\cos\omega t\cos\phi - a\sin\omega t\sin\phi$

$y = a\cos\omega t(1 + \cos\phi) - a\sin\phi\sin\omega t$ ½

Let,

$a(1 + \cos\phi) = A\cos\theta$ ------- (i)

$a\sin\phi = A\ \sin\theta$ --------(ii) ½

Squaring and adding equation (i) and (ii)

$A^2 = a^2(1+\cos\phi)^2 + a^2\sin^2\phi$

$= a^2(1 + \cos^2\phi + 2\cos\phi) + a^2\sin^2\phi$

$= 2a^2(1 + \cos\phi)$ ½

$= 4a^2\cos^2\phi/2$ ½

$I \alpha A^2$

$I = kA^2$

where k is constant ½

$I = 4ka^2\cos^2\phi/2$

[Award full credit for this part for any other alternative methods]

(ii) $\phi_1 = \frac{2\pi}{\lambda} \times \frac{\lambda}{6} = \pi/3$ ½

$I_1 = 4I_0\cos^2\phi/2$

$= 4I_0\cos^2(\pi/6)$

$I_1 = 3I_0$ ½

$\phi_2 = \frac{2\pi}{\lambda} \times \frac{\lambda}{12} = \pi/6$

$I_2 = 4I_0\cos^2(\pi/12)$ ½

$I_2 = 4I_0\cos^2 15^0$

$\frac{I_1}{I_2} = \frac{3}{4\cos^2 15^0}$ ½ **5**

General Instructions :

Read the following instructions very carefully and follow them :

(i) *This question paper contains **33** questions. **All questions are compulsory.***

(ii) *Question paper is divided into **FIVE** sections – Section **A, B, C, D** and **E**.*

(iii) ***Section A** – Question number **1** to **16** are Multiple Choice (MCQ) type questions. Each question carries **1** mark.*

(iv) ***Section B** – Question number **17** to **21** are Very Short Answer type questions. Each question carries **2** mark.*

(v) ***Section C** – Question number **22** to **28** are Short Answer type questions. Each question carries **3** mark.*

(vi) ***Section D :** Question number **29** and **30** are Case-Based questions. Each question carries **4** mark.*

(vii) ***Section E** – Question number **31** to **33** are Long Answer type questions. Each question carries **5** mark.*

(viii) *There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section–**A**.*

(ix) *Kindly note that there is a separate question paper for Visually Impaired candidates.*

(x) *Use of calculators is NOT allowed.*

You may use the following values of physical constants wherever necessary :

$c = 3 \times 10^{8}$ m/s

$h = 6.63 \times 10^{-34}$ Js

$e = 1.6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^{9}$ N m^2 C^{-2}

Mass of electron (m_e) = 9.1×10^{-31} kg

Mass of neutron = 1.675×10^{-27} kg

Mass of proton = 1.673×10^{-27} kg

Avogadro's number = 6.023×10^{23} per gram mole

Boltzmann constant = 1.38×10^{-23} JK^{-1}

SECTION – A $16 \times 1 = 16$

1. Two charges + q each are kept '2a' distance apart. A third charge – 2q is placed midway between them. The potential energy of the system is – 1

(A) $\frac{q^2}{8\pi\varepsilon_0 a}$ (B) $-\frac{6q^2}{8\pi\varepsilon_0 a}$

(C) $\frac{-7q^2}{8\pi\varepsilon_0 a}$ (D) $\frac{9q^2}{8\pi\varepsilon_0 a}$

2. Two identical small conducting balls B_1 and B_2 are given –7 pC and + 4 pC charges respectively. They are brought in contact with a third identical ball B_3 and then separated. If the final charge on each ball is –2 pC, the initial charge on B_3 was 1

(A) –2 pC (B) –3 pC

(C) –5 pC (D) –15 pC

3. The quantum nature of light explains the observations on photoelectric effect as – 1

(A) there is a minimum frequency of incident radiation below which no electrons are emitted.

(B) the maximum kinetic energy of photoelectrons depends only on the frequency of incident radiation.

(C) when the metal surface is illuminated, electrons are ejected from the surface after sometime.

(D) the photoelectric current is independent of the intensity of incident radiation.

4. The radius (r_n) of n^{th} orbit in Bohr model of hydrogen atom varies with n as 1

(A) $r_n \propto n$ (B) $r_n \propto \frac{1}{n}$

(C) $r_n \propto n^2$ (D) $r_n \propto \frac{1}{n^2}$

5. A straight wire is kept horizontally along east-west direction. If a steady current flows in wire from east to west, the magnetic field at a point above the wire will point towards **1**

(A) East (B) West

(C) North (D) South

6. The magnetic susceptibility for a diamagnetic material is **1**

(A) small and negative (B) small and positive

(C) large and negative (D) large and positive

7. A galvanometer of resistance 100 Ω is converted into an ammeter of range (0 – 1 A) using a resistance of 0.1 Ω. The ammeter will show full scale deflection for a current of about **1**

(A) 0.1 mA (B) 1 mA

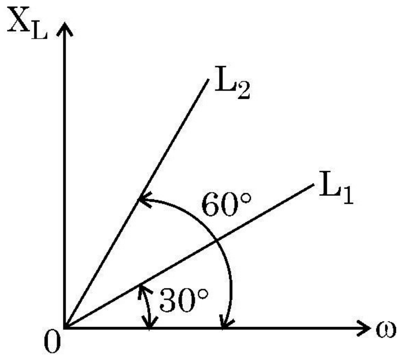
(C) 10 mA (D) 0.1 A

8. A circular loop A of radius R carries a current I. Another circular loop B of radius $r\left(=\frac{R}{20}\right)$ is placed concentrically in the plane of A. The magnetic flux linked with loop B is proportional to **1**

(A) R (B) $\sqrt{R}$

(C) $R^{\frac{3}{2}}$ (D) R^2

9. Figure shows the variation of inductive reactance X_L of two ideal inductors of inductance L_1 and L_2, with angular frequency ω. The value of $\frac{L_1}{L_2}$ is **1**



(A) $\sqrt{3}$ (B) $\frac{1}{\sqrt{3}}$

(C) 3 (D) $\frac{1}{3}$

10. The phase difference between electric field $\vec{E}$ and magnetic field $\vec{B}$ in an electromagnetic wave propagating along z-axis is – **1**

(A) zero (B) π

(C) $\frac{\pi}{2}$ (D) $\frac{\pi}{4}$

11. A coil of N turns is placed in a magnetic field $\vec{B}$ such that $\vec{B}$ is perpendicular to the plane of the coil. $\vec{B}$ changes with time as $B = B_0 \cos\left(\frac{2\pi}{T}t\right)$ where T is time period. The magnitude of emf induced in the coil will be maximum at **1**

(A) $t = \frac{nT}{8}$ (B) $t = \frac{nT}{4}$

(C) $t = \frac{nT}{2}$ (D) $t = nT$

Here, n = 1, 2, 3, 4, ...

12. In Balmer series of hydrogen atom, as the wavelength of spectral lines decreases, they appear **1**

(A) equally spaced and equally intense.
(B) further apart and stronger in intensity.
(C) closer together and stronger in intensity.
(D) closer together and weaker in intensity.

Note : For questions number **13** to **16**, two statements are given – one labelled **Assertion (A)** and the other labelled **Reason (R)**. Select the correct answer to these questions from the codes **(A)**, **(B)**, **(C)** and **(D)** as given below :

(A) If both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A).
(C) If Assertion (A) is true and Reason (R) is false.
(D) If both Assertion (A) and Reason (R) are false.

13. **Assertion (A) :** Electrons are ejected from the surface of zinc when it is irradiated by yellow light.

Reason (R) : Energy associated with a photon of yellow light is more than the work function of zinc. **1**

14. **Assertion (A) :** The temperature coefficient of resistance is positive for metals and negative for p-type semiconductors.

Reason (R) : The charge carriers in metals are negatively charged, whereas the majority charge carriers in p-type semiconductors are positively charged. **1**

15. **Assertion (A) :** When electrons drift in a conductor, it does not mean that all free electrons in the conductor are moving in the same direction.

Reason (R) : The drift velocity is superposed over large random velocities of electrons. **1**

16. **Assertion (A) :** In interference and diffraction of light, light energy reduces in one region producing a dark fringe. It increases in another region and produces a bright fringe.

Reason (R) : This happens because energy is not conserved in the phenomena of interference and diffraction. **1**

SECTION – B $\quad 5 \times 2 = 10$

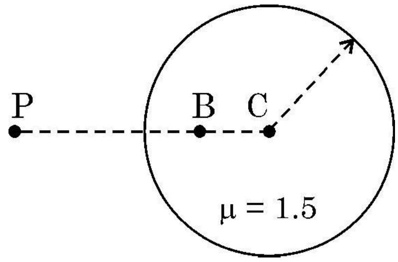
17. Draw the circuit diagram of a p-n junction diode in (i) forward biasing and (ii) reverse biasing. Also draw its I-V characteristics in the two cases. **2**

18. A proton and α-particle are accelerated through different potentials V_1 and V_2 respectively so that they have the same de Broglie wavelengths. Find $\frac{V_1}{V_2}$. **2**

19. A ray of light is incident normally on one face of an equilateral glass prism of refractive index μ. When the prism is completely immersed in a transparent medium, it is observed that the emergent ray just grazes the adjacent face. Find the refractive index of the medium. **2**

20. Two electric heaters have power ratings P_1 and P_2, at voltage V. They are connected in series to a dc source of voltage V. Find the power consumed by the combination. Will they consume the same power if connected in parallel across the same source ? **2**

21. (a) An air bubble is trapped at point B (CB = 20 cm) in a glass sphere of radius 40 cm and refractive index 1.5 as shown in figure. Find the nature and position of the image of the bubble as seen by an observer at point P. **2**



OR

(b) In normal adjustment, for a refracting telescope, the distance between objective and eye piece lens is 1.00 m. If the magnifying power of the telescope is 19, find the focal length of the objective and the eyepiece lens. **2**

SECTION – C $\quad 7 \times 3 = 21$

22. (a) Differentiate between nuclear fission and fusion. **3**

(b) The fission properties of $_{94}Pu^{239}$ are very similar to those of $_{92}U^{235}$. How much energy (in MeV), is released if all the atoms in 1 g of pure $_{94}Pu^{239}$ undergo fission ? The average energy released per fission is 180 MeV.

23. The electric field in a region is given by

$$\vec{E} = (10x + 4)\,\hat{i}$$

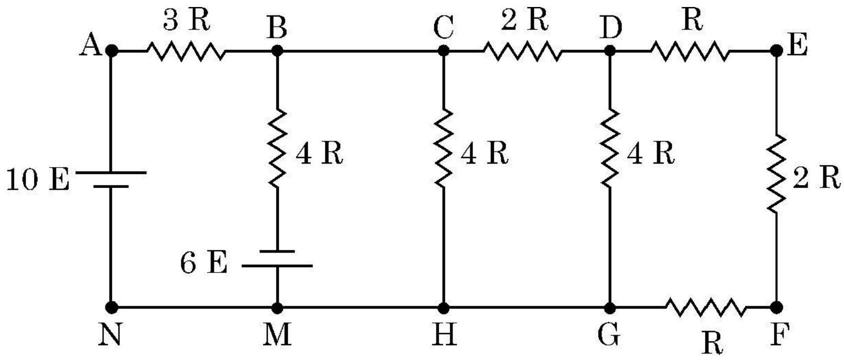
where x is in m and E is in N/C. Calculate the amount of work done in taking a unit charge from

(i) (5 m, 0) to (10 m, 0)

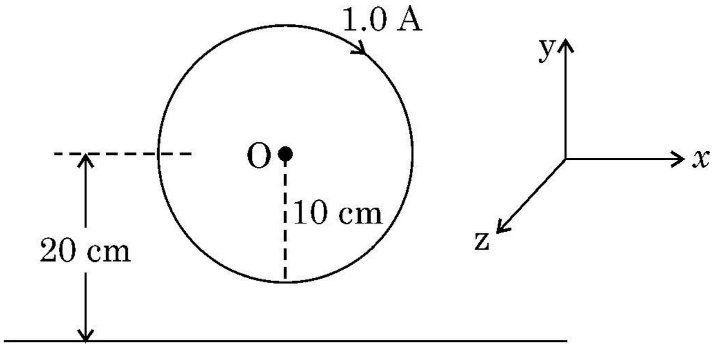
(ii) (5 m, 0) to (5 m, 10 m) **3**

24. Draw the graph showing variation of scattered particles detected (N) with the scattering angle (θ) in Geiger-Marsden experiment. Write two conclusions that you can draw from this graph. Obtain the expression for the distance of closest approach in this experiment. **3**

25. Find the current in branch BM in the network shown : **3**



26. A circular loop of radius 10 cm carrying current of 1.0 A lies in x-y plane. A long straight wire lies in the same plane parallel to x-axis at a distance of 20 cm as shown in figure.



Find the direction and value of current that has to be maintained in the wire so that the net magnetic field at O is zero. **3**

27. Name the electromagnetic waves with their wavelength range which are used for

(i) FM radio broadcast

(ii) detection of fracture in bones

(iii) treatment of muscular strain **3**

28. (a) (i) Define mutual inductance. Write its SI unit. **3**

(ii) Derive an expression for the mutual inductance of a system of two long coaxial solenoids of same length l, having turns N_1 and N_2 and of radii r_1 and r_2 ($> r_1$).

OR

(b) What are ferromagnetic materials ? Explain ferromagnetism with the help of suitable diagrams, using the concept of magnetic domain. **3**

SECTION – D $\quad 2 \times 4 = 8$

Note : Questions number **29** to **30** are Case Study based questions. Read the following paragraph and answer the questions that follow.

29. A pure semiconductor like Ge or Si, when doped with a small amount of suitable impurity, becomes an extrinsic semiconductor. In thermal equilibrium, the electron and hole concentration in it are related to the concentration of intrinsic charge carriers. A p-type or n-type semiconductor can be converted into a p-n junction by doping it with suitable impurity. Two processes, diffusion and drift take place during formation of a p-n junction. A semiconductor diode is basically a p-n junction with metallic contacts provided at the ends for the application of an external voltage. A p-n junction diode allows currents to pass only in one direction when it is forward biased. Due to this property, a diode is widely used to rectify alternating voltages, in half-wave or full wave configuration. **$4 \times 1 = 4$**

(i) When Ge is doped with pentavalent impurity, the energy required to free the weakly bound electron from the dopant is about

(A) 0.001 eV (B) 0.01 eV

(C) 0.72 eV (D) 1.1 eV

(ii) At a given temperature, the number of intrinsic charge carriers in a semiconductor is 2.0×10^{10} cm^{-3}. It is doped with pentavalent impurity atoms. As a result, the number of holes in it becomes 8×10^3 cm^{-3}. The number of electrons in the semiconductor is

(A) 2×10^{24} m^{-3} (B) 4×10^{23} m^{-3}

(C) 1×10^{22} m^{-3} (D) 5×10^{22} m^{-3}

(iii) (a) During the formation of a p-n junction –

(A) electrons diffuse from p-region into n-region and holes diffuse from n-region into p-region.

(B) both electrons and holes diffuse from n-region into p-region.

(C) electrons diffuse from n-region into p-region and holes diffuse from p-region into n-region.

(D) both electrons and holes diffuse from p-region into n-region.

OR

(iii) (b) Initially during the formation of a p-n junction –

(A) diffusion current is large and drift current is small.

(B) diffusion current is small and drift current is large.

(C) both the diffusion and the drift currents are large.

(D) both the diffusion and the drift currents are small.

(iv) An ac voltage $V = 0.5 \sin (100 \pi t)$ volt is applied, in turn, across a half-wave rectifier and a full-wave rectifier. The frequency of the output voltage across them respectively will be

(A) 25 Hz, 50 Hz (B) 25 Hz, 100 Hz

(C) 50 Hz, 50 Hz (D) 50 Hz, 100 Hz

30. A lens is a transparent optical medium bounded by two surfaces; at least one of which should be spherical. Applying the formula of image formation by a single spherical surface successively at the two surfaces of a thin lens, a formula known as lens maker's formula and hence the basic lens formula can be obtained. The focal length (or power) of a lens depends on the radii of its surfaces and the refractive index of its material with respect to the surrounding medium. The refractive index of a material depends on the wavelength of light used. Combination of lenses helps us to obtain diverging or converging lenses of desired power and magnification. **4 × 1 = 4**

(i) A thin converging lens of focal length 20 cm and a thin diverging lens of focal length 15 cm are placed coaxially in contact. The power of the combination is

(A) $\frac{-5}{6}$ D (B) $\frac{-5}{3}$ D

(C) $\frac{4}{3}$ D (D) $\frac{3}{2}$ D

(ii) The radii of curvature of two surfaces of a convex lens are R and 2R. If the focal length of this lens is $\left(\frac{4}{3}\right)$R, the refractive index of the material of the lens is :

(A) $\frac{5}{3}$ (B) $\frac{4}{3}$

(C) $\frac{3}{2}$ (D) $\frac{7}{5}$

(iii) The focal length of an equiconvex lens

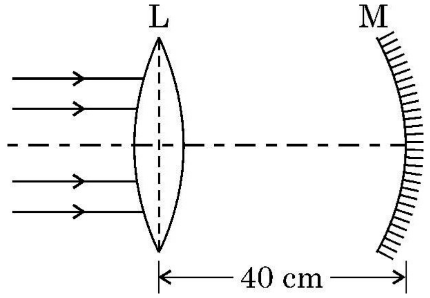
(A) increases when the lens is dipped in water.

(B) increases when the wavelength of incident light decreases.

(C) increases with decrease in radius of curvature of its surface.

(D) decreases when the lens is cut into two identical parts along its principal axis.

(iv) (a) A thin convex lens L of focal length 10 cm and a concave mirror M of focal length 15 cm are placed coaxially 40 cm apart as shown in figure. A beam of light coming parallel to the principal axis is incident on the lens. The final image will be formed at a distance of



(A) 10 cm, left of lens (B) 10 cm, right of lens

(C) 20 cm, left of lens (D) 20 cm, right of lens

OR

(b) A beam of light coming parallel to the principal axis of a convex lens L_1 of focal length 16 cm is incident on it. Another convex lens L_2 of focal length 12 cm is placed coaxially at a distance 40 cm from L_1. The nature and distance of the final image from L_2 will be

(A) real, 24 cm (B) virtual, 12 cm

(C) real, 32 cm (D) virtual, 18 cm

SECTION – E $3 \times 5 = 15$

31. (a) (i) Draw a ray diagram for the formation of the image of an object by a convex mirror. Hence, obtain the mirror equation.

(ii) Why are multi-component lenses used for both the objective and the eyepiece in optical instruments ?

(iii) The magnification of a small object produced by a compound microscope is 200. The focal length of the eyepiece is 2 cm and the final image is formed at infinity. Find the magnification produced by the objective. **5**

OR

(b) (i) Differentiate between a wavefront and a ray.

(ii) State Huygen's principle and verify laws of reflection using suitable diagram.

(iii) In Young's double slit experiment, the slits S_1 and S_2 are 3 mm apart and the screen is placed 1.0 m away from the slits. It is observed that the fourth bright fringe is at a distance of 5 mm from the second dark fringe. Find the wavelength of light used. **5**

32. (a) (i) A dielectric slab of dielectric constant 'K' and thickness 't' is inserted between plates of a parallel plate capacitor of plate separation d and plate area A. Obtain an expression for its capacitance.

(ii) Two capacitors of different capacitances are connected first (1) in series and then (2) in parallel across a dc source of 100 V. If the total energy stored in the combination in the two cases are 40 mJ and 250 mJ respectively, find the capacitance of the capacitors. **5**

OR

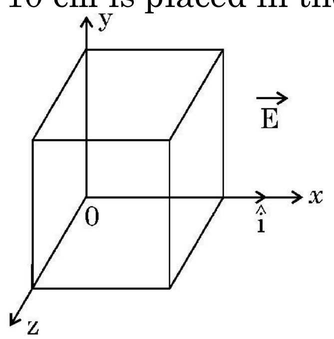
(b) (i) Using Gauss's law, show that the electric field $\vec{E}$ at a point due to a uniformly charged infinite plane sheet is given by $\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{n}$ where symbols have their usual meanings.

(ii) Electric field $\vec{E}$ in a region is given by

$\vec{E} = (5x^2 + 2)\hat{i}$

where E is in N/C and x is in meters.

A cube of side 10 cm is placed in the region as shown in figure.



Calculate (1) the electric flux through the cube, and (2) the net charge enclosed by the cube. **5**

33. (a) (i) Mention the factors on which the resonant frequency of a series LCR circuit depends. Plot a graph showing variation of impedance of a series LCR circuit with the frequency of the applied a.c. source.

(ii) With the help of a suitable diagram, explain the working of a step-up transformer.

(iii) Write two causes of energy loss in a real transformer. **5**

OR

(b) (i) With the help of a diagram, briefly explain the construction and working of ac generator.

(ii) An electron is revolving around a proton in an orbit of radius r with a speed v. Obtain expression for magnetic moment associated with the electron. **5**

2155/4/1

MARKING SCHEME : PHYSICS (042)

Code : 55/04/01

Q.NO	VALUE POINTS/EXPECTED ANSWERS	MARKS	TOTAL MARKS
	SECTION - A		
1	(C) $\frac{-7q^2}{8\pi\varepsilon_0 a}$	1	1
2	(B) -3 pC	1	1
3	(A) There is a minimum frequency of incident radiation below which no electrons are emitted.	1	1
4	(C) $r_n \,\alpha\, n^2$	1	1
5	(C) North	1	1
6	(A) Small and negative.	1	1
7	(B) 1mA	1	1
8	(A) R	1	1
9	(D) $\frac{1}{3}$	1	1
10	(A) Zero	1	1
11	No option is correct, award 1 mark.	1	1
12	(D) Closer together and weaker in intensity.	1	1
13	(D) Both Assertion (A) and Reason (R) are false.	1	1
14	(B) Both assertion (A) and Reason (R) are true and Reason (R)is not the correct explanation of Assertion(A).	1	1
15	(A) Both assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion(A).	1	1
16	(C) Assertion (A) is true and Reason (R) is false.	1	1

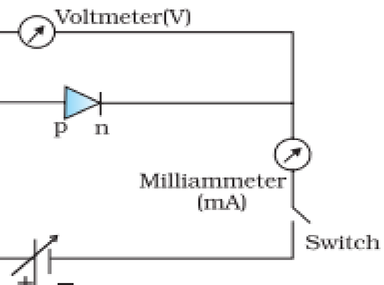
SECTION – B

17

Drawing of circuit diagram of p-n junction diode

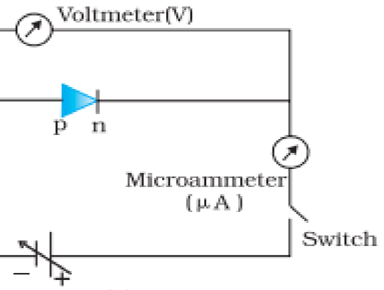
(i) Forward bias	½
(ii) Reverse bias	½
I-V charcteristics in forward and reverse bias	½ + ½

i)



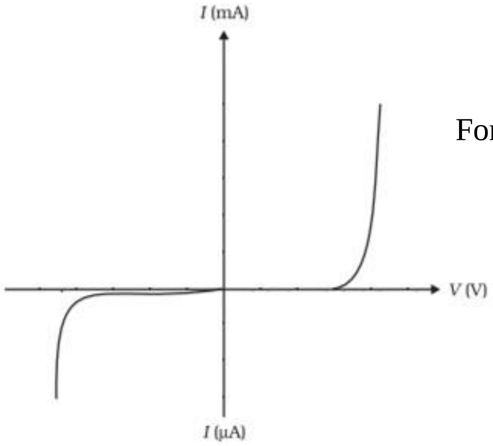
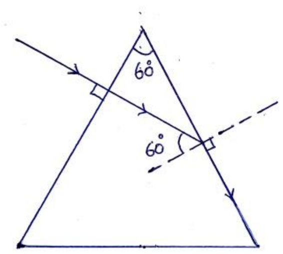
(a)

½



(b)

½

	I-V characteristics in forward and reverse bias  Forward bias Reverse bias	½ + ½	**2**
18	Finding $\frac{V_1}{V_2}$ 2 De Broglie wavelength of a proton $\lambda_p = \frac{h}{\sqrt{2m_p q_p V_1}} = \frac{h}{\sqrt{2meV_1}}$ De Broglie wavelength of an α particle $\lambda_\alpha = \frac{h}{\sqrt{2m_\alpha q_\alpha V_2}} = \frac{h}{\sqrt{2(4m)(2e)V_2}}$ $\lambda_p = \lambda_\alpha$ $\frac{h}{\sqrt{2meV_1}} = \frac{h}{\sqrt{16meV_2}}$ $\frac{V_1}{V_2} = 8$	½ ½ ½ ½	**2**
19	Finding refractive index of the medium 2  From snell's law, $\mu.\sin i = \mu_m.\sin r$ $\mu.\sin 60^0 = \mu_m.\sin 90^0$ $\mu_m = \mu.\frac{\sqrt{3}}{2}$	½ ½ ½ ½	**2**

	Alternatively $\mu = \frac{1}{\sin C}$ $\frac{\mu}{\mu_m} = \frac{1}{\sin 60^0}$ $\mu_m = \frac{\sqrt{3}}{2}\mu$	1 ½ ½	
20	Finding power consumed by two electric heaters in series combination 1 ½ Writing answer for parallel combination ½ $R_1 = \frac{V^2}{P_1}$ & $R_2 = \frac{V^2}{P_2}$ $R_{eq} = R_1 + R_2 = V^2\left(\frac{1}{P_1} + \frac{1}{P_2}\right)$ $P_{series} = \frac{V^2}{R_{eq}}$ $P_{series} = \frac{V^2}{V^2\left(\frac{1}{P_1} + \frac{1}{P_2}\right)}$ $\frac{1}{P_{series}} = \frac{1}{P_1} + \frac{1}{P_2}$ No	½ ½ ½ ½	2
21	(a) Finding nature and position of image 2 Using refraction formula at spherical surface from denser to rarer medium n_1 = refractive index of rarer medium n_2 = refractive index of denser medium $\frac{n_1}{v} - \frac{n_2}{u} = \frac{n_1 - n_2}{R}$ u = - 20 cm , R= - 40 cm , n_1 = 1 , n_2 = 1.5 $\frac{1}{v} - \frac{1.5}{(-20)} = \frac{1-1.5}{(-40)}$ v = -16 cm Nature of image is virtual. OR (b) Finding the focal lengths of the objective and eyepiece 2 Distance between objective and eyepiece fo + fe = 1.00 m = 100 cm Magnifying power $\lvert m \rvert = \frac{fo}{fe} = 19$	½ ½ ½ ½ ½ ½	2

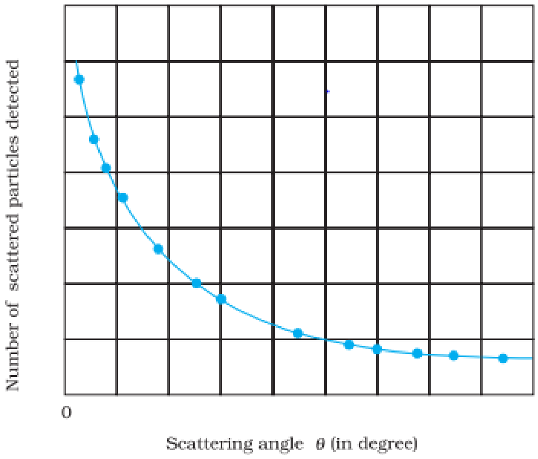
	On solving fo = 95 cm = 0.95 m fe = 5 cm = 0.05 m	 ½ ½	

SECTION - C

22	(a) Difference between nuclear fission and fusion (1) (b) Calculating energy released in fission (2) (a) In nuclear fission , a heavy nucleus splits into two or more lighter nuclei and energy is released. In nuclear fusion, lighter nuclei combine together a form a heavy nucleus and larger amount of energy is released. (b) Number of atoms in 1 g of ${}_{94}Pu^{239}$ $= \frac{6.023\times10^{23}}{239}$ $= 2.5\times10^{21}$ Energy released in fission of 1 g of ${}_{94}Pu^{239}$, $E = 180 MeV \times 2.5\times10^{21}$ $E = 4.5\times10^{23}$ MeV	 ½ ½ 1 1	 **3**
23	Calculating work done in taking a unit charge from (i) (5m , 0) to (10m , 0) 2 (ii) (5m , 0) to (5m , 10m) 1 (i) $\Delta V = -\int_{x_1}^{x_2} E\,dx$ $\Delta V = -\int_{5}^{10} (10x+4)dx = -\left[\frac{10x^2}{2}+4x\right]_5^{10}$ $= -395$ V $W = q\Delta V = -395\times1$ $= -395$ J (ii) $\Delta V = -\int_{x_1}^{x_2} E\,dx$ $\Delta V = -\int_{5}^{5} (10x+4)dx = 0$ $W = q.\Delta V = 0$ **<u>Alternatively</u>** If a student writes, displacement is perpendicular to electric field then $\Delta V = 0$ $W = q.\Delta V = 0$ Award full credit for part (ii)	 ½ ½ ½ ½ ½ ½ ½ ½	 **3**

24

Marking scheme	
Drawing graph showing variation of scattered particles detected(N) with scattering angle(θ)	1
Two conclusions	1
Obtaining expression for the distance of closest approach	1



1

Two conclusions

(i) Most of an atom is empty space. ½

(ii) Almost entire mass and entire positive charge is concentrated in a very small region called nucleus. ½

At distance of closest approach

$E_k = E_P$ ½

$$K = \frac{1}{4\pi\varepsilon_0}\frac{(Ze).(2e)}{d}$$

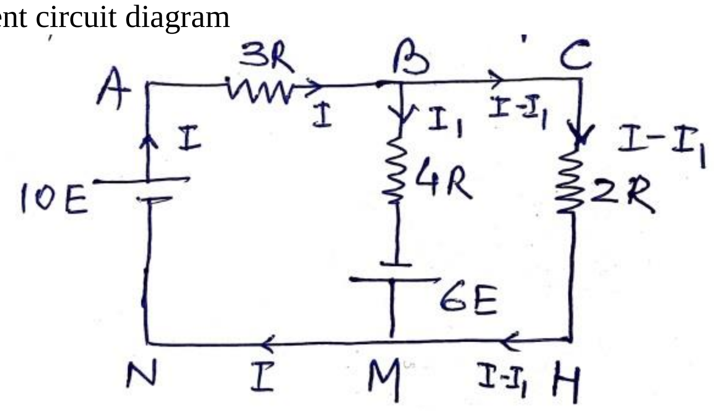
$$d = \frac{1}{4\pi\varepsilon_0}\frac{(2Ze^2)}{K}$$ ½ **3**

25

Marking scheme	
Finding the current in the branch BM in the network.	3

Finding equivalent resistance across CH , R_{CH} = 2R ½

Equivalent circuit diagram ½



In closed loop ABMNA

$-3IR - 4I_1R + 16E = 0$ ……………..……………………(1) ½

In closed loop BCHMB

$-2R(I-I_1) - 6E + 4I_1R = 0$ ……………………………..(2) ½

	On solving equations (1) and (2) $$I_1 = \frac{25E}{13R}$$	1	**3**
26	Finding value of current in a long straight wire 2 ½ Finding direction of current in a long straight wire ½ Magnetic field due to circular current loop at its centre O. $B_1 = \frac{\mu_0 I_1}{2r}$ $= \frac{\mu_0 \times 1}{2\times 0.1}$ $= 5\mu_0 \, T$ The magnetic field B_1 is perpendicular to plane of loop and directed inwards. Magnetic field due to long current carrying straight wire at O. $B_2 = \frac{\mu_0 I_2}{2\pi r}$ $B_2 = \frac{\mu_0 I_2}{2\pi\times 0.2}\ T$ For net magnetic field at O to be zero, B_1 should be equal and opposite to B_2. $5\mu_0 = \frac{\mu_0 I_2}{0.4\pi}$ $I_2 = 2\pi \ A$ $= 6.28 \ A$ Direction of current in the straight wire is along +ve x axis. **Alternatively** Net magnetic field at O is zero. $B_{loop} = B_{wire}$ $\frac{\mu_0 I_1}{2r_1} = \frac{\mu_0 I_2}{2\pi r_2}$ $\frac{\mu_0 \times 1}{2\times 0.1} = \frac{\mu_0 I_2}{2\pi\times 0.2}$ $I_2 = 2\pi \ A$ $= 6.28 \ A$ Direction of current is along + x-axis.	½ ½ ½ ½ ½ ½ ½ 1 ½ ½ ½	**3**
27	Naming the electromagnetic waves 1 ½ Writing range of electromagnetic waves 1 ½ Electromagnetic waves — wavelength range (i) Radio waves — > 0.1 m (ii) X- rays — $1 nm - 10^{-3}$ nm (iii) Infrared waves — $1 mm - 700 nm$	½ + ½ ½ + ½ ½ + ½	**3**

28 (a)

(i) Defining mutual inductance	½
SI unit of mutual inductance	½
(ii) Deriving expression for mutual inductance	2

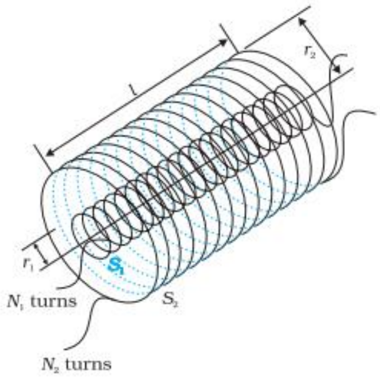
(i) Mutual inductance between two coils is defined as the magnetic flux associated with a coil when unit current flows through neighbouring coil. ½

<u>Alternatively</u>

Mutual inductance between two coils is defined as the magnitude of induced emf in a coil when the rate of change of current in neighbouring coil is unity.

SI unit of mutual inductance is henry(H). ½

(ii)



When current I_2 flows in outer solenoid, the resulting flux linkage with inner solenoid.

$$N_1\phi_1 = N_1B_2A_1$$ ½

$$N_1\phi_1 = N_1\left(\frac{\mu_0 N_2 I_2}{l}\right)\pi r_1^2$$

$$N_1\phi_1 = \frac{\mu_0 N_1 N_2 \pi r_1^2 I_2}{l} \qquad \text{.........................(1)}$$ ½

$$N_1\phi_1 = M_{12}I_2 \qquad \text{......................... (2)}$$ ½

From equations (1) and (2)

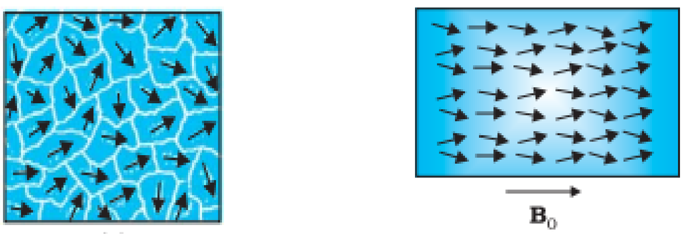
$$M_{12} = \frac{\mu_0 N_1 N_2 \pi r_1^2}{l}$$ ½ **3**

OR

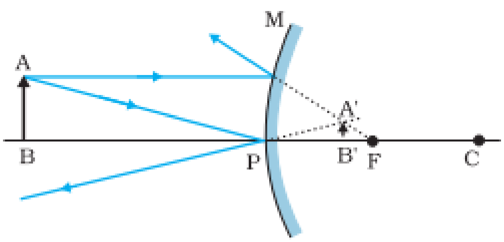
(b)

Defining ferromagnetic materials	1
Explanation of ferromagnetism with diagram	2

Ferromagnetic substances are those which get strongly magnetised when placed in an external magnetic field. 1



(a) (b) ½ + ½

	In absence of external magnetic field, domains are randomly oriented and it exhibits weak magnetisation. In the presence of external magnetic field domains orient themselves in the direction of magnetic field and it exhibits strong magnetisation.	½ ½	
SECTION - D			
29	(i) (B) 0.01 eV (ii) (D) 5×10^{22} m^{-3} (iii) (a) (C) Electrons diffuse from n-region into p-region and holes diffuse from p-region to n-region. OR (b) (A) Diffusion current is large and drift current is small. (iv) (D) 50 Hz , 100 Hz.	1 1 1 1	**4**
30	(i) (B) $\frac{-5}{3}D$ (ii) (C) $\frac{3}{2}$ (iii) (A) increases when a lens is dipped in water. (iv) (a) (B) 10 cm , right from lens. OR (b) (A) real , 24 cm	1 1 1 1	**4**
SECTION - E			
31	a) i) Drawing of ray diagram 1 Obtaining mirror equation 2 ii) Reason for using multi-component lenses 1 iii) Finding magnification produced by the objective 1 i)  For paraxial rays MP can be considered to be a straight line perpendicular to CP, Therefore right angled triangles $A'B'F$ and MPF are similar $\frac{B'A'}{PM} = \frac{B'F}{FP}$ Or $\frac{B'A'}{BA} = \frac{B'F}{FP}$ ($\because$ PM = AB) ----------------(1) Since $\angle$ APB = $\angle$ $A'PB'$, the right angled triangles $A'PB'$ and ABP are also similar	1 ½	

Therefore , $\frac{B'A'}{BA} = \frac{B'P}{BP}$ ------------------------------------ (2) ½

Comparing eq (1) and (2), we get

$$\frac{B'F}{FP} = \frac{B'P}{BP}$$

$$\frac{PF - PB'}{FP} = \frac{B'P}{BP}$$

Using sign convention

$PF = f, \; PB' = +v \quad , \; PB = -u$ ½

on solving $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ ½

ii) To improve image quality by minimizing various optical aberrations in lenses. 1

iii) Magnification produced by compound microscope

$$m = m_o \times m_e$$ ½

$$m_o = \frac{m}{m_e} = \frac{m}{\left|\frac{D}{fe}\right|}$$

$$m_o = \frac{200}{\frac{25}{2}} = 16$$ ½ **5**

OR

(b)

i) Difference between a wavefront and a ray	1
ii) Statement of Huygens' principle	1
Verification of the law of reflection	1 ½
iii) Finding wavelength of light	1 ½

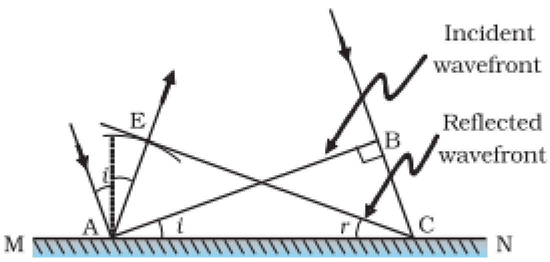
i) Wavefront is a surface of constant phase. ½

Alternatively Locus of points, which oscillate in phase

Ray - The straight line path along which light travels (or energy propagates). ½

Alternatively – Ray is normal to wave front.

ii) **Huygens' Principle** Each point of the wave front is the source of secondary disturbance and the wavelets emanating from the points spread out in all directions with speed of wave. The wavelets emanating from wave front are usually referred to as secondary wavelets. A common tangent to all these spheres gives the new position of the wave front at a later time. 1



1

Triangles EAC and BAC are congruent therefore $\angle i = \angle r$ ½

iii) Position of 4^{th} bright fringe

$$x_{4(bright)} = 4\frac{D\lambda}{d}$$ ½

Position of 2^{nd} dark fringe

$$x_{2(dark)} = \frac{3}{2}\frac{D\lambda}{d}$$ ½

$$x_{4(bright)} - x_{2(dark)} = 5mm$$

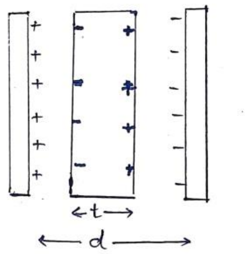
$$4\frac{D\lambda}{d} - \frac{3}{2}\frac{D\lambda}{d} = 5\times10^{-3}$$

$$\lambda = 6\times10^{-6}\ m$$ ½

32

(i) Obtaining expression for capacitance	3
(ii) Finding capacitance of capacitors	2

a) (i)



Electric field in air between plates

$$E_0 = \frac{\sigma}{\varepsilon_0}$$ ½

Electric field inside the dielectric

$$E = \frac{\sigma}{\varepsilon_0 K}$$ ½

Potential difference between the plates

$$V = E_0(d-t) + Et$$ ½

$$V = \frac{\sigma}{\varepsilon_0}\left[d-t+\frac{t}{K}\right]$$

$$V = \frac{q}{A\varepsilon_0}\left[d-t+\frac{t}{K}\right]$$ ½

Capacitance

$$C = \frac{q}{V}$$ ½

$$C = \frac{A\varepsilon_0}{d-t+\frac{t}{K}}$$

$$C = \frac{A\varepsilon_0}{d-t\left(1-\frac{1}{K}\right)}$$ ½

ii) Total energy stored in series combination

$$\frac{1}{2}\left(\frac{C_1C_2}{C_1+C_2}\right)V^2 = 40\times10^{-3}\ J \text{..............................(1)}$$ ½

Energy stored in parallel combination

$$\frac{1}{2}\left(C_1+C_2\right)V^2 = 250\times10^{-3}\ J \text{.......................................(2)}$$ ½

Substituting value of V=100 V in eq (1) and (2) , on solving

$$C_1 = 4\times10^{-5}\ F \text{ or } 40\,\mu F$$ ½

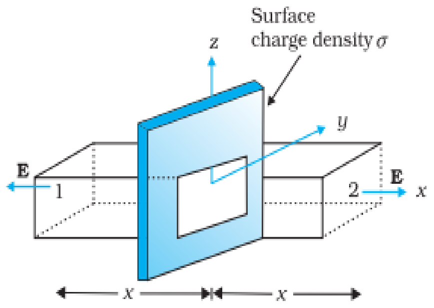
$$C_2 = 1\times10^{-5}\ F \text{ or } 10\,\mu F$$ ½ **5**

OR

b)

i) Showing electric field at a point due to a uniformly charged infinite plane sheet		3
ii) Calculating	(1) electric flux through the cube	1
	(2) charge enclosed by cube	1

(i)



1

$$\oint \vec{E}.d\vec{s} = \int_1 \vec{E}.d\vec{s} + \int_2 \vec{E}.d\vec{s}$$ ½

$$= 2EA$$

From Gauss's law

$$\oint \vec{E}.d\vec{s} = \frac{q}{\varepsilon_0}$$ ½

$$2EA = \frac{\sigma A}{\varepsilon_0}$$

$$E = \frac{\sigma}{2\varepsilon_0}$$ ½

Vectorially $\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{n}$ ½

Electric field is normally outward of the sheet.

(ii)

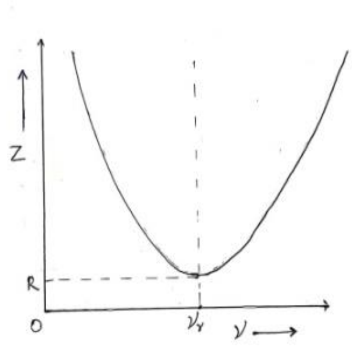
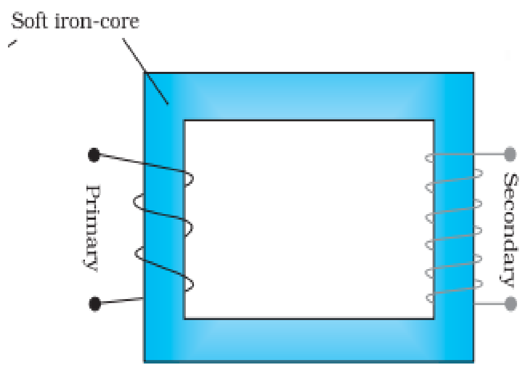
(1) Electric flux through the cube

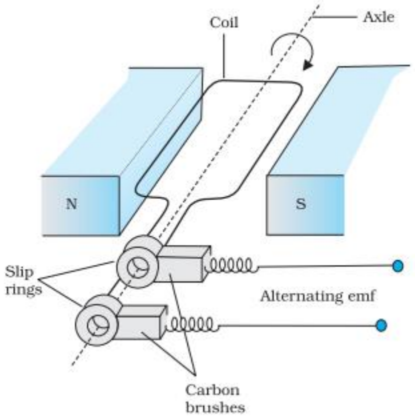
$$\phi = \phi_L + \phi_R$$ ½

$$\phi = \int \vec{E}_L.d\vec{s} + \int \vec{E}_R.d\vec{s}$$

$$= -2\times100\times10^{-4} + [5\times(10\times10^{-2})^2 + 2]\times100\times10^{-4}$$

$$\phi = 5\times10^{-4}\ \mathrm{Nm^2C^{-1}}$$ ½

	(2)		
	$\phi = \dfrac{q_{en}}{\varepsilon_0}$	½	
	$q_{en} = \phi.\varepsilon_0$ $= 5\times10^{-4}\times8.85\times10^{-12}$		
	$=4.43\times10^{-15}\text{C}$	½	
33	(a) (i) Factors on which the resonant frequency of a series LCR circuit depends 1 Plotting of graph 1 (ii) Diagram of a transformer 1 Working of a step-up transformer 1 (iii) Two causes of energy loss in a real transformer 1		
	(i) Inductance	½	
	Capacitance	½	
	Alternatively $\nu_0 = \dfrac{1}{2\pi\sqrt{LC}}$		
	(ii) 	1	
		1	
	Working - when an alternating voltage is applied to the primary, the resulting current produces an alternating magnetic flux which links the secondary and induces an emf in it.	1	
	(iii) Causes of energy loss (any two) (1) Flux leakage (2) Resistance of the windings (3) Hysteresis (4) Eddy currents	½ + ½	**5**
	OR		
	(b) (i) Diagram of ac generator 1 Brief explanation of construction and working of ac generator 2 (ii) Obtaining expression of magnetic moment associated with revolving electron 2		

	(i)  **Construction** – It consists of a coil placed in a magnetic field. The coil is mounted on a rotor shaft. The ends of the coil are connected to an external circuit by means of slip rings and brushes. **Alternatively** If a student draws only a labeled diagram of ac generator give 2 marks for construction and diagram. **Working** – The coil is rotated in the uniform magnetic field by some external means. The rotation of the coil causes the magnetic flux through it to change, so an emf is induced in the coil. **Alternatively** If a student derives $e = e_0 \sin \omega t$ give one mark for working. (ii) The equivalent current $I = \frac{q}{t} = \frac{e}{\frac{2\pi r}{v}} = \frac{ev}{2\pi r}$ Mangetic moment of revolving electron $m = IA$ $= \frac{ev}{2\pi r} \times \pi r^2$ $= \frac{1}{2} evr$	1 1 1 ½ ½ ½ ½	

General Instructions :

Read the following instructions carefully and follow them :

(i) *This question paper contains **33** questions. **All** questions are **compulsory**.*

(ii) *This question paper is divided into **five** sections – **Sections A, B, C, D** and **E**.*

(iii) *In **Section A** – Questions no. **1** to **16** are Multiple Choice type questions. Each question carries **1** mark.*

(iv) *In **Section B** – Questions no. **17** to **21** are Very Short Answer type questions. Each question carries **2** marks.*

(v) *In **Section C** – Questions no. **22** to **28** are Short Answer type questions. Each question carries **3** marks.*

(vi) *In **Section D** – Questions no. **29** and **30** are case study-based questions. Each question carries **4** marks.*

(vii) *In **Section E** – Questions no. **31** to **33** are Long Answer type questions. Each question carries **5** marks.*

(viii) *There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.*

(ix) *Kindly note that there is a separate question paper for Visually Impaired candidates.*

(x) *Use of calculators is **not** allowed.*

You may use the following values of physical constants wherever necessary :

$c = 3 \times 10^{8}$ m/s

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8{\cdot}854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^{9}$ N m^2 C^{-2}

Mass of electron (m_e) = $9{\cdot}1 \times 10^{-31}$ kg

Mass of neutron = $1{\cdot}675 \times 10^{-27}$ kg

Mass of proton = $1{\cdot}673 \times 10^{-27}$ kg

Avogadro's number = $6{\cdot}023 \times 10^{23}$ per gram mole

Boltzmann constant = $1{\cdot}38 \times 10^{-23}$ JK^{-1}

SECTION A

1. Two particles A and B of the same mass but having charges q and 4q respectively, are accelerated from rest through different potential differences V_A and V_B such that they attain same kinetic energies. The value of $\left(\frac{V_A}{V_B}\right)$ is :

   (A) $\frac{1}{4}$ (B) $\frac{1}{2}$ (C) 2 (D) 4

2. A coil of resistance 20 Ω and self-inductance 10 mH is connected to an ac source of frequency 1000/π Hz. The phase difference between current in the circuit and the source voltage is :

   (A) 30° (B) 60° (C) 75° (D) 45°

3. Isotones are nuclides having :

   (A) same number of neutrons but different number of protons

   (B) same number of protons but different number of neutrons

   (C) same number of protons and also same number of neutrons

   (D) different number of protons and also different number of neutrons

4. A bulb is rated (100 W, 110 V). It is operated by current of 1.0 A supplied by a step down transformer. If the input voltage and efficiency of the transformer are 220 V and 0.9 respectively, the input current drawn from the mains is :

   (A) $\frac{1}{2}$ A (B) $\frac{3}{8}$ A (C) $\frac{5}{9}$ A (D) $\frac{4}{7}$ A

5. Which of the following substances has relative magnetic permeability $\mu_r >> 1$?

   (A) Aluminium (B) Copper chloride

   (C) Nickel (D) Sodium chloride

6. Which of the following statements is correct for alpha particle scattering experiment ?

(A) For angle of scattering $\theta \approx 0$, the impact parameter is small.

(B) For angle of scattering $\theta \simeq \pi$, the impact parameter is large.

(C) The number of alpha particles undergoing head-on collision is small.

(D) The experiment provides an estimate of the upper limit to the size of target atom.

7. A straight wire of length 1.0 m is placed along x-axis, in a region with magnetic field $\vec{B} = (3\hat{i} + 2\hat{j})$ T. A current of 2.0 A flows in the wire along +x direction. The magnetic force acting on the wire is :

(A) 2.0 N, along z-axis
(B) 2.0 N, along –z-axis
(C) 4.0 N, along z-axis
(D) 4.0 N, along –z-axis

8. The electric field E associated with an electromagnetic wave is represented by

$$E_y = E_0 \sin (kx - \omega t)$$

Which of the following statements is correct ?

(A) The wave is propagating along +x-axis.

(B) The wave is propagating along +z-axis.

(C) The magnetic field $\vec{B}$ of the wave is acting along +y-axis.

(D) The magnetic field $\vec{B}$ of the wave is acting along –x-axis.

9. A point object is placed in air at a distance of 4R on the principal axis of a convex spherical surface of radius of curvature R separating two mediums, air and glass. As the object is moved towards the surface, the image formed is :

(A) always real

(B) always virtual

(C) first virtual and then real

(D) first real and then virtual

10. An electron makes a transition from orbit n = 2 to orbit n = 1, in Bohr's model of hydrogen atom. Consider change in magnitudes of its kinetic energy (K) and potential energy (U).

(A) K increases and U decreases (B) K decreases and U increases

(C) Both K and U decrease (D) Both K and U increase

11. Which of the following statements is ***not*** true for a p-n junction diode under reverse bias ?

(A) The current is almost independent of the applied voltage.

(B) Holes flow from p-side to n-side.

(C) Electric field in the depletion region increases.

(D) n-side of the junction is connected to +ve terminal and p-side to –ve terminal of the battery.

12. A parallel plate capacitor is charged by a battery. The battery is then disconnected and the plates of the charged capacitor are then moved farther apart. In the process :

(A) the charge on the capacitor increases.

(B) the potential difference across the plates decreases.

(C) the capacitance of the capacitor increases.

(D) the electrostatic energy stored in the capacitor increases.

*Questions number **13** to **16** are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below.*

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is ***not*** the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Both Assertion (A) and Reason (R) are false.

13. *Assertion (A) :* The current density ($\vec{J}$) at a point in a conducting wire is in the direction of electric field ($\vec{E}$) at that point.

Reason (R) : A conducting wire obeys Ohm's law.

14. *Assertion (A) :* The torque acting on a current carrying coil is maximum when it is suspended in a radial magnetic field.

Reason (R) : The torque tends to rotate the coil on its own axis.

15. *Assertion (A) :* Although the surfaces of a goggle lens are curved, it does not have any power.

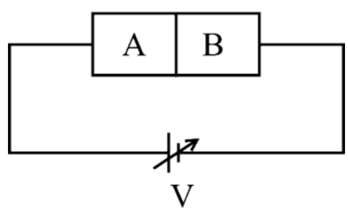
Reason (R) : In case of goggles, both the curved surfaces are curved on the same side and have equal radii of curvature.

16. *Assertion (A) :* Nuclear fission reactions are responsible for energy generation in the Sun.

Reason (R) : Light nuclei fuse together in the nuclear fission reactions.

SECTION B

17. Two halves of a silicon crystal (A and B) are doped with arsenic and boron respectively, forming a p-n junction in it. A battery is connected across it as shown in the figure.



(a) Will the junction be forward biased or reverse biased ? Give reason.

(b) Draw V-I graph for this arrangement. *2*

18. A long straight horizontal wire is carrying a current I. At an instant, an alpha particle at a distance r from it, is travelling with speed v parallel to the wire in a direction opposite to the current. Find the magnitude and direction of the force experienced by the particle at this instant. *2*

19. A point light source rests on the bottom of a bucket filled with a liquid of refractive index $\mu = 1.25$ up to height of 10 cm. Calculate :

(a) the critical angle for liquid-air interface

(b) radius of circular light patch formed on the surface by light emerging from the source. *2*

20. State Huygens principle. Using it draw a diagram showing the details of passage of a plane wave from a denser into a rarer medium. *2*

21. (a) A cell is connected across an external resistance 12 Ω and supplies 0.25 A current. When the external resistance is increased by 4 Ω, the current reduces to 0.2 A. Calculate (i) the emf, and (ii) the internal resistance, of the cell. *2*

OR

(b) Two point charges of 3 μC and 4 μC are kept in air at (0·3 m, 0) and (0, 0.3 m) in x-y plane. Find the magnitude and direction of the net electric field produced at the origin (0, 0). *2*

SECTION C

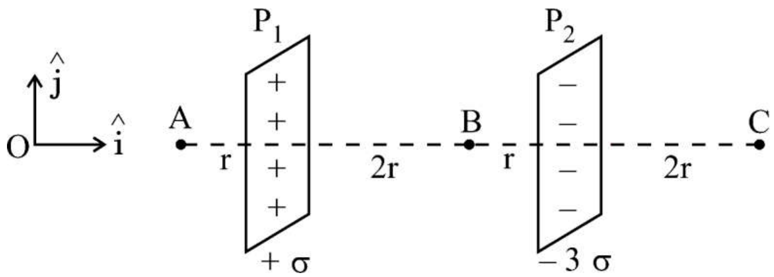
22. A small circular loop of area $\frac{6}{\pi}$ cm^2 is placed inside a long solenoid at its centre such that its axis makes an angle of 60° with the axis of the solenoid. The number of turns per cm is 10 in the solenoid. The current in the solenoid changes uniformly from 5 A to zero in 10 ms. Calculate the emf induced in the loop. *3*

23. Two point charges of 10 μC and 20 μC are located at points (– 4 cm, 0, 0) and (5 cm, 0, 0) respectively, in a region with electric field $E = \frac{A}{r^2}$, where $A = 2 \times 10^6$ NC^{-1} m^2 and $\vec{r}$ is the position vector of the point under consideration. Calculate the electrostatic potential energy of the system. *3*

24. (a) The radius of a conducting wire AB uniformly decreases from its one end A to another end B. It is connected across a battery. How will (i) electric field, (ii) current density, and (iii) mobility of electrons change from end A to end B ? Justify your answer in each case. *3*

OR

(b) Two large plane sheets P_1 and P_2 having charge densities $+\sigma$ and -3σ respectively are arranged parallel to each other as shown in the figure. Find the net electric field ($\vec{E}$) at points A, B and C. *3*



25. In photoelectric effect experiment, show the variation of

(a) photocurrent with collector plate potential for a given surface for different intensities of incident radiation. Do the curves meet at any point ? If so, why ?

(b) photocurrent with intensity of radiation incident on a surface keeping the frequency and plate potential fixed. *3*

26. Explain the following, giving proper reason : *3*

(a) During charging of a capacitor, displacement current exists in the capacitor. But there is no displacement current when it gets fully charged.

(b) The frequency of microwaves in ovens matches with the resonant frequency of water molecules.

(c) Infrared waves are also known as heat waves.

27. A galvanometer is converted into a voltmeter of range (0 – V) volt using a resistor of 9900 Ω. If a resistor of 4900 Ω is used, the range becomes half, i.e. $(0 - \frac{V}{2})$ volt. Calculate :

(a) resistance of the galvanometer

(b) resistance required to convert it into a voltmeter of range (0 – 2V) volt. *3*

28. (a) A ray of light is incident on a surface separating air from a denser medium A of refractive index μ_1. It is then made incident on the parallel surface of another medium B of refractive index μ_2 at the same angle of incidence. If the angle of refraction in the two media are 30° and 35° respectively, then in which one of the two media (A or B) will light travel faster and why ?

(b) The intensity of the two interfering waves in Young's double slit experiment is I_0 each. Find the intensity at a point on the screen where path difference between the interfering waves is (i) $\frac{\lambda}{2}$, and (ii) $\frac{\lambda}{3}$. *3*

SECTION D

*Questions number **29** and **30** are case study-based questions. Read the following paragraphs and answer the questions that follow.*

29. Dipoles, whether electric or magnetic, are characterised by their dipole moments, which are vector quantities. Two equal and opposite charges separated by a small distance constitute an electric dipole, while a current carrying loop behaves as a magnetic dipole. Electric dipoles create electric fields around them. Electric dipoles experience a torque when placed in an external electric field.

(i) Two identical electric dipoles, each consisting of charges $-q$ and $+q$ separated by distance d, are arranged in x-y plane such that their negative charges lie at the origin O and positive charges lie at points (d, 0) and (0, d) respectively. The net dipole moment of the system is : *1*

(A) $-q\,d\,(\hat{i}+\hat{j})$ (B) $q\,d\,(\hat{i}+\hat{j})$

(C) $q\,d\,(\hat{i}-\hat{j})$ (D) $q\,d\,(\hat{j}-\hat{i})$

(ii) E_1 and E_2 are magnitudes of electric field due to a dipole, consisting of charges $-q$ and $+q$ separated by distance 2a, at points r (>> a) (1) on its axis, and (2) on equatorial plane, respectively. Then $\left(\frac{E_1}{E_2}\right)$ is : *1*

(A) $\frac{1}{4}$ (B) $\frac{1}{2}$ (C) 2 (D) 4

(iii) An electric dipole of dipole moment 5.0×10^{-8} Cm is placed in a region where an electric field of magnitude 1.0×10^{3} N/C acts at a given instant. At that instant the electric field $\vec{E}$ is inclined at an angle of 30° to dipole moment $\vec{P}$. The magnitude of torque acting on the dipole, at that instant is : *1*

(A) 2.5×10^{-5} Nm (B) 5.0×10^{-5} Nm

(C) 1.0×10^{-4} Nm (D) 2.0×10^{-6} Nm

(iv) (a) An electron is revolving with speed v around the proton in a hydrogen atom, in a circular orbit of radius r. The magnitude of magnetic dipole moment of the electron is : *1*

(A) 4 evr (B) 2 evr

(C) $\frac{1}{2}$ evr (D) $\frac{1}{4}$ evr

OR

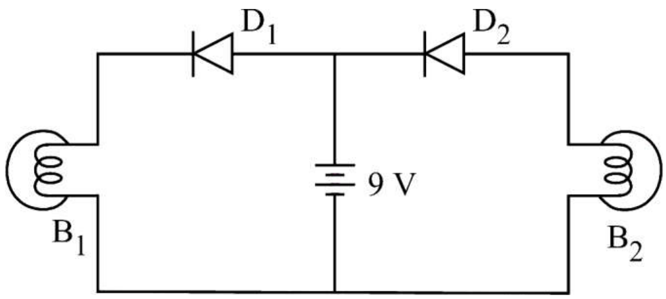
(b) A square loop of side 5.0 cm carries a current of 2.0 A. The magnitude of magnetic dipole moment associated with the loop is : *1*

(A) 1.0×10^{-3} Am^2 (B) 5.0×10^{-3} Am^2

(C) 1.0×10^{-2} Am^2 (D) 5.0×10^{-2} Am^2

30. The process of converting ac into dc is called rectification and the device used is called a rectifier. When ac signal is fed to a junction diode during positive half cycle, the diode is forward biased and current flows through it. During the negative half cycle, the diode is reverse biased and it does not conduct. Thus the ac signal is rectified. The p-n junction diodes can be used as half-wave and full-wave rectifiers.

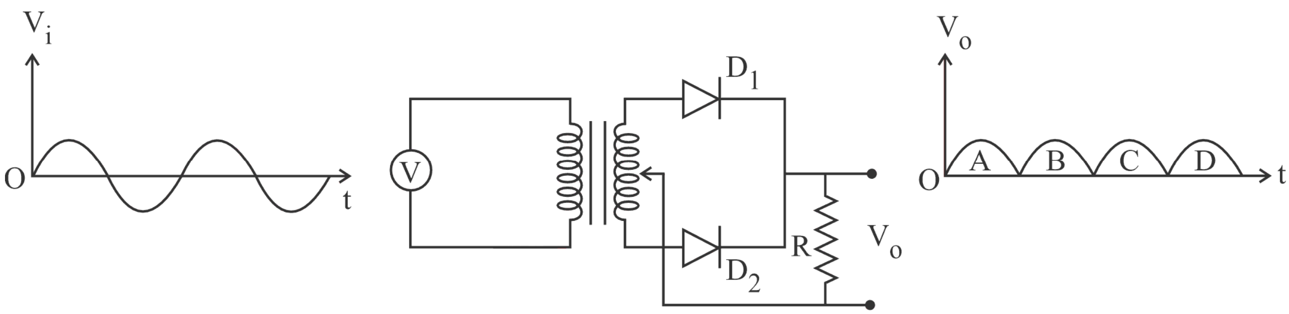
(i) Which bulb/bulbs will glow in the given circuit ? *1*



(A) B_1 only (B) B_2 only

(C) Both B_1 and B_2 (D) Neither B_1 nor B_2

(ii) (a) A full-wave rectifier circuit is shown in the figure. The contribution in output waveform from junction diode D_1 is : *1*



(A) A, D (B) A, C

(C) B, D (D) B, C

OR

(b) The output in a half-wave rectifier is : *1*

(A) unidirectional without ripple (B) steady and continuous

(C) unidirectional with ripple (D) steady but discontinuous

(iii) In a p-n junction diode, the majority charge carriers on p-side and on n-side are, respectively : *1*

(A) electrons, electrons (B) electrons, holes

(C) holes, holes (D) holes, electrons

(iv) If the frequency of the half-wave rectifier is 50 Hz, the frequency of full-wave rectifier is : *1*

(A) 25 Hz (B) 50 Hz

(C) 100 Hz (D) 200 Hz

SECTION E

31. (a) (i) What are matter waves ? A particle of mass m and charge q is accelerated from rest through a potential difference V. Obtain an expression for de Broglie wavelength associated with the particle.

(ii) Monochromatic light of frequency 5.0×10^{14} Hz is produced by a source of power output 3.315 mW. Calculate :

(1) energy of the photon in the beam

(2) number of photons emitted per second by the source *5*

OR

(b) (i) State Bohr's postulates and derive an expression for the energy of electron in n^{th} orbit in Bohr's model of hydrogen atom.

(ii) Calculate binding energy per nucleon (in MeV) of ${}^{12}_{6}C$. *5*

Given :

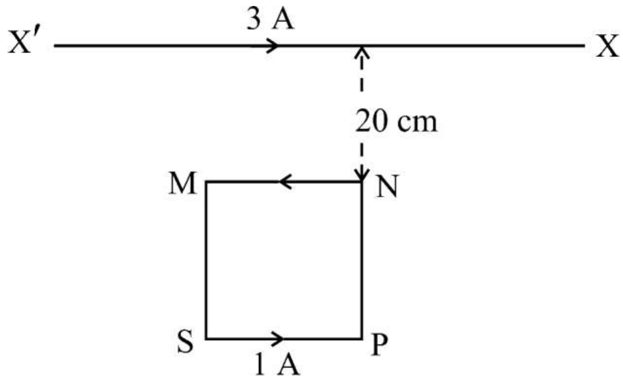
$$m\left({}^{12}_{6}C\right) = 12.000000 \text{ u}$$

$$m\left({}^{1}_{0}n\right) = 1.008665 \text{ u}$$

$$m\left({}^{1}_{1}H\right) = 1.007825 \text{ u}$$

32. (a) (i) With the help of a labelled diagram, explain the working of an ac generator. Obtain the expression for the emf induced at an instant 't'.

(ii) A long, straight horizontal wire $X'X$ is held stationary and carries a current of 3.0 A. A square loop MNPS of side 10 cm, carrying a current of 1.0 A is kept near the wire $X'X$ as shown in the figure. Find the magnitude and direction of the net magnetic force acting on the loop due to the wire. *5*



OR

(b) (i) State Faraday's law of electromagnetic induction and mention the utility of Lenz's law. Obtain an expression for self-inductance of a coil in terms of its geometry and permeability of the medium.

(ii) A resistance of 20 Ω, a capacitance of 80 μF and an inductor of 50 mH are connected in series. This combination is connected across a 220 V ac supply of variable frequency. When the frequency of supply equals the natural frequency of the circuit, calculate :

(1) angular frequency of supply

(2) impedance of the circuit *5*

33. (a) (i) What are the two main considerations for designing the objective and eyepiece lenses of an astronomical telescope ? Obtain the expression for magnifying power of the telescope when the final image is formed at infinity.

(ii) A ray of light is incident at an angle of 45° at one face of an equilateral triangular prism and passes symmetrically through the prism. Calculate :

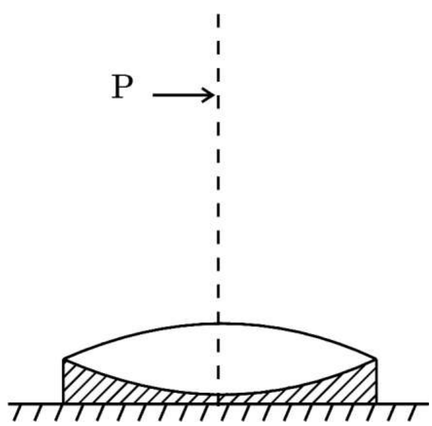
(1) the angle of deviation produced by the prism

(2) the refractive index of the material of the prism *5*

OR

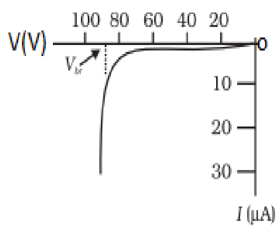
(b) (i) Describe a simple activity to observe diffraction pattern due to a single slit.

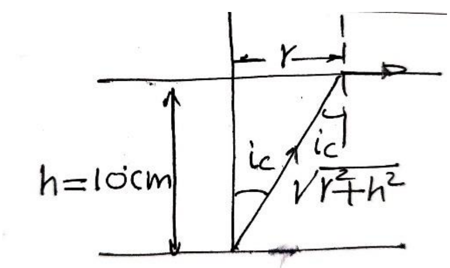
(ii) The figure below shows an equiconvex lens (of refractive index 1.50) in contact with a liquid layer on top of a plane mirror. A small needle with its tip on the principal axis is moved along the axis until its inverted image is found at the position of the needle. The distance of the needle from the lens is measured to be 45.0 cm. When the liquid is removed and the experiment is repeated, the new distance is 30.0 cm. Find the refractive index of the liquid. *5*

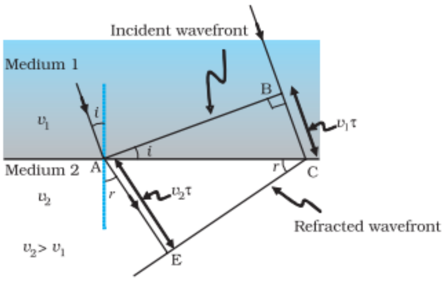
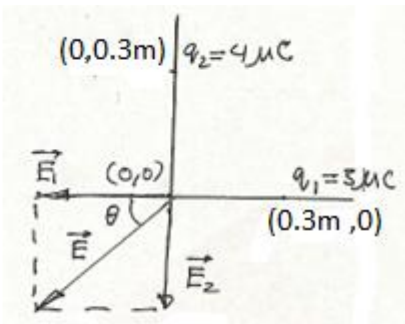


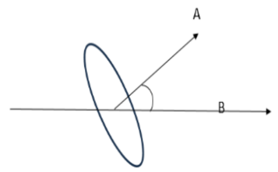
MARKING SCHEME: PHYSICS(042)

Code: 55/S/1

Q. No.	VALUE POINTS/EXPECTED ANSWERS	Marks	Total Marks
	SECTION A		
1.	(D) 4	1	1
2.	(D) 45^o	1	1
3.	(A) Same number of neutrons but different number of protons	1	1
4.	(C) $\frac{5}{9}A$	1	1
5.	(C) Nickel	1	1
6.	(C)The number of alpha particles undergoing head on collision is small	1	1
7.	(C) 4.0 N, along z-axis	1	1
8.	(A) The wave is propagating along +x-axis.	1	1
9.	(D) First real and then virtual	1	1
10.	(A) K increases and U decreases	1	1
11.	(B) Holes flow from p-side to n-side	1	1
12.	(D) The electrostatic energy stored in the capacitor increases	1	1
13.	(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).	1	1
14.	(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).	1	1
15.	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).	1	1
16.	(D) Both Assertion (A) and Reason (R) are false.	1	1
	SECTION – B		
17.	(a) Identifying the biasing ½ Reason ½ (b) V-I graph 1 (a) p-n junction is reverse biased. Crystal A is doped with arsenic which is pentavalent. Hence it is n-type. Crystal B is doped with boron which is trivalent. Hence it is p-type. (b)  Note : if the graph is drawn without values full credit will be given	½ ½ 1	2

18.	• Finding the magnitude of force 1½ • Identifying the direction of force ½		
	Magnetic field due to current carrying wire at distance r $B = \frac{\mu_o I}{2\pi r}$	½	
	Charge on alpha particle, q = 2e Force acting on a charged particle in motion in a uniform magnetic field. $\vec{F} = q(\vec{v} \times \vec{B})$	½	
	$\therefore$ F= $2ev\left(\frac{\mu_o I}{2\pi r}\right)$ $(\because \theta = 90^0)$		
	$F = \frac{\mu_o evI}{\pi r}$	½	
	Direction of the force on alpha particle is away from the wire.	½	2
19.	(a) Calculation of critical angle 1 (b) Calculation of radius of circular light patch 1		
	(a) $\sin i_c = \frac{1}{\mu}$	½	
	$\sin i_c = \frac{4}{5}$ $(\because \mu = 1.25 = \frac{5}{4})$ $i_c = \sin^{-1}(\frac{4}{5})$	½	
	$or\ i_c = 53^o$		
	(b) $\sin i_c = \frac{r}{\sqrt{r^2 + h^2}}$	½	
	$\frac{r^2}{r^2+h^2} = \left(\frac{4}{5}\right)^2$ $25r^2 = 16r^2 + 16h^2$ $9r^2 = 1600$ $r = \frac{40}{3} cm$  	½	2
20.	• Stating Huygens Principle 1 • Diagram 1		
	Huygens Principle : Each point of the wavefront is the source of a secondary disturbance and the wavelets emanating from these points spread out in all directions with the speed of the wave. These wavelets emanating from the wavefront are usually referred to as secondary wavelets and if we draw a common		

	tangent to all these spheres, we obtain the new position of the wavefront at a later time.	1	
		1	2
21. (a)	(i) Calculating e.m.f of cell 1 (ii) Calculating internal resistance of cell 1		
	$I = \dfrac{\varepsilon}{R+r}$		
	$0.25 = \dfrac{\varepsilon}{12+r}$ ------(1)	½	
	$0.2 = \dfrac{\varepsilon}{16+r}$ --------(2)	½	
	On solving eq (1) and eq (2)		
	$r = 4\Omega$	½	
	$\varepsilon = 4\,\mathrm{V}$	½	
	OR		
(b)	Finding the magnitude of electric field 1 ½ Finding the direction of electric field ½		
			
	$\vec{E}_1 = \dfrac{kq_1}{r_1^2}(-\hat{i}) = \dfrac{9\times10^9\times3\times10^{-6}}{(0.3)^2}(-\hat{i}) = 3\times10^5(-\hat{i})\,\mathrm{NC}^{-1}$	½	
	$\vec{E}_2 = \dfrac{kq_2}{r_2^2}(-\hat{j}) = \dfrac{9\times10^9\times4\times10^{-6}}{(0.3)^2}(-\hat{j}) = 4\times10^5(-\hat{j})\,\mathrm{NC}^{-1}$	½	
	$\vec{E} = \vec{E}_1 + \vec{E}_2$		
	$E = \sqrt{E_1^2 + E_2^2}$		
	$E = 5\times10^5\ \mathrm{NC}^{-1}$	½	
	$\tan\theta = \dfrac{4}{3}$		

	$\theta = \tan^{-1}\left(\frac{4}{3}\right)$ inclination with respect to the x-axis (in III quadrant).	½	2
	SECTION C		
22.	Calculation of e.m.f induced in the loop 3 E.m.f induced in the circular loop: axis  $\lvert\varepsilon\rvert = \frac{d\varphi}{dt}$ $= \frac{d}{dt}(BAcos\theta)$ $= \frac{d}{dt}(\mu_0 nIAcos\theta)$ $\lvert\varepsilon\rvert = \left(\mu_0 nAcos\theta.\frac{dI}{dt}\right)$ $\lvert\varepsilon\rvert = 4\pi\times10^{-7}\times1000\times\frac{6}{\pi}\times10^{-4}\times\cos60^0\times\frac{5}{10^{-2}}$ $=6\times10^{-5}$ V	½ 1 1 ½	 3
23.	Calculating electrostatic potential energy of the system 3 Electrostatic potential energy of the system : $U = \frac{kq_1q_2}{r_{12}} + q_1V_1 + q_2V_2$ $\frac{kq_1q_2}{r_{12}} = \frac{9\times10^9\times10\times10^{-6}\times20\times10^{-6}}{9\times10^{-2}} = 20\text{J}$ $q_1V_1 = q_1\frac{A}{r_1} = \frac{10\times10^{-6}\times2\times10^6}{4\times10^{-2}} = 500\text{J}$ $q_2V_2 = q_2\frac{A}{r_2} = \frac{20\times10^{-6}\times2\times10^6}{5\times10^{-2}} = 800\text{J}$ $\text{U} = (20+500+800)\,\text{J}$ $U = 1320\,\text{J}$	1 ½ ½ ½ ½	 3
24. (a)	(i) Variation of electric field and justification ½ + ½ (ii) Variation of current density and justification ½ + ½ (iii) Variation of mobility of electrons and justification ½ + ½ With the decrease in area of cross-section. (i) $E = \frac{I}{A}\rho$, electric field increases (ii) $j = \frac{I}{A}$, current density increases	 ½+½ ½+½	

(iii) $\mu_e = \frac{e\tau}{m}$, mobility remains same ½+½

OR

(b)

Finding the net electric field ($\vec{E}$) at points A,B & C 1+1+1

Electric field at A($\vec{E}_A$)

$$\vec{E}_A = \vec{E}_1 + \vec{E}_2$$

$$= \frac{\sigma}{2\varepsilon_0}(-\hat{\text{i}}) + \frac{3\sigma}{2\varepsilon_0}(\hat{\text{i}})$$ ½

$$\vec{E}_A = \frac{\sigma}{\varepsilon_0}(\hat{\text{i}})$$ ½

Electric field at B ($\vec{E}_B$)

$$\vec{E}_B = \vec{E}_1 + \vec{E}_2$$

$$= \frac{\sigma}{2\varepsilon_0}\hat{i} + \frac{3\sigma}{2\varepsilon_0}\hat{i}$$ ½

$$= \frac{2\sigma}{\varepsilon_0}\hat{i}$$ ½

Electric field at C ($\vec{E}_C$)

$$\vec{E}_c = \vec{E}_1 + \vec{E}_2$$

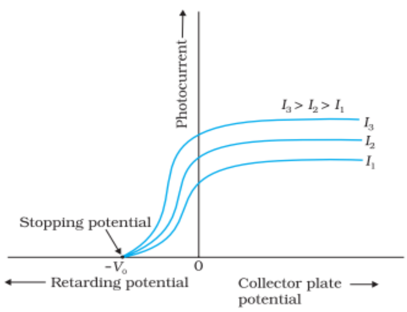
$$= \frac{\sigma}{2\varepsilon_0}\hat{i} + \frac{3\sigma}{2\varepsilon_0}(-\hat{i})$$ ½

$$= \frac{\sigma}{\varepsilon_0}(-\hat{i})$$ ½ 3

25.

(a) Showing the variations of photocurrent with collector plate potential 1
Explanation 1
(b) Showing the variation of photocurrent with intensity of incident radiation 1

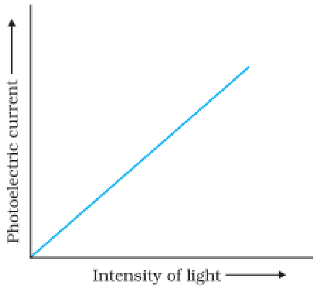
(a)



1

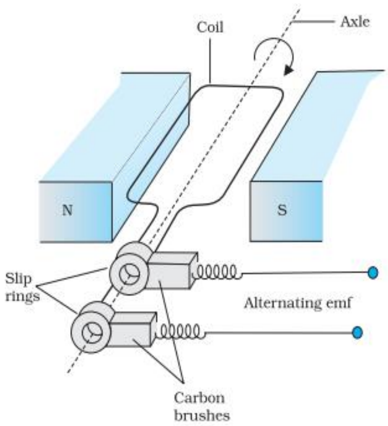
Yes, these curves meet at stopping potential ½

For any surface , as the energy of photons does not depend upon intensity of light, at the stopping potential current reduces to zero. ½

	(b)  	1	3
26.	Explanation of (a),(b) and (c) with reason 1+1+1 (a) $i_d = \varepsilon_0 \frac{d\varphi_E}{dt}$ Displacement current is due to changing electric flux. During charging of capacitor, there is change in electric flux. When fully charged electric field hence electric flux does not change. Hence no displacement current. (b) The frequency of the microwaves is selected to match the resonant frequency of water molecules so that energy from the waves is transferred efficiently to the kinetic energy of the molecules. (c) Infrared waves are also known as heat waves, because water molecules present in most materials readily absorbs infrared waves and their thermal motion increases and heat up.	1 1 1	3
27.	(a) Calculating galvanometer resistance 2 (b) Calculating resistance required for conversion of galvanometer into voltmeter 1 (a) $V = I_g(R+G)$ $V = I_g(9900+G)$ --------(1) $\frac{V}{2} = I_g(4900+G)$ --------(2) On Solving above eq (1) and eq (2) G= 100 Ω (b) $2V = I_g(R_1+G)$ --------(3) *From eq* (1) *and* (3) $R_1 = 19900\,\Omega$	½ ½ 1 ½ ½	3

28.	(a) Identifying the medium ½ Justification ½ (b) (i)Finding the intensity for path difference $=\frac{\lambda}{2}$ 1 (ii) Finding the intensity for path difference $=\frac{\lambda}{3}$ 1 (a) Light travels faster in medium 'B' $\mu_1 = \frac{\sin i}{\sin r_1}$ $\mu_2 = \frac{\sin i}{\sin r_2}$ $\therefore \frac{\mu_1}{\mu_2} = \frac{\sin r_2}{\sin r_1} = \frac{\sin 35^0}{\sin 30^0}$ $\Rightarrow \frac{\mu_1}{\mu_2} = \frac{v_2}{v_1} > 1$ $\therefore v_2 > v_1$ (b) $I = 4I_0 \cos^2 \frac{\phi}{2}$ (i) $\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{2} = \pi$ $I = 4I_0 (\cos \frac{\pi}{2})^2 = 0$ (ii) $\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{3} = \frac{2\pi}{3}$ $I = 4I_0 (\cos \frac{\pi}{3})^2$ $I = I_0$	½ ½ ½ ½ ½ ½	3
	SECTION - D		
29.	(i) (B) $qd(\hat{i}+\hat{j})$	1	
	(ii) (C) 2	1	
	(iii) (A) 2.5 x 10^{-5} Nm	1	
(a) (b)	(iv) (C) $\frac{1}{2} evr$ OR (B) $5.0 \times 10^{-3}\,Am^2$	1	4

30.	(i) (A) B_1 only	1	
(a) (b)	(ii) (B) A, C OR (C) unidirectional with ripple	1	
	(iii) (D) holes, electrons	1	
	(iv) (C) 100 Hz	1	4
31. (a)	(i) Defining matter waves 1 Obtaining expression for de- Broglie wavelength 2 (ii) (1) Calculating energy of photon 1 (2) Calculating number of photons per second 1		
	(i) Wave associated with a mass in motion is called matter wave.	1	
	Particle of mass m and charge q gains energy in the form of kinetic energy. $\frac{1}{2}m\text{v}^2 = qV$	½	
	$(m\text{v})^2 = 2qVm$ $m\text{v} = \sqrt{2mqV}$	½	
	Accordingly to de-Broglie relation $\lambda = \frac{h}{m\text{v}}$	½	
	$\lambda = \frac{h}{\sqrt{2mqV}}$	½	
	(ii) (1) $E = hv$	½	
	$= 6.63\times10^{-34}\times5\times10^{14}$ $= 3.315\times10^{-19}\text{ J}$	½	
	(2) $n = \frac{P}{E}$	½	
	$= \frac{3.315\times10^{-3}}{3.315\times10^{-19}} = 10^{16}\text{s}^{-1}$	½	
	OR		
(b)	(i)		
	(i) Bohr's postulates ½ x 3 Deriving expression for energy of electron in n^{th} orbit of hydrogen atom 2 (ii) Calculating Binding Energy per nucleon 1 ½		
	Bohr's Postulates (a) Bohr's first postulate was that an electron in an atom could revolve in certain stable orbits without the emission of radiant energy,	½	

	(b) Bohr's second postulate states that the electron revolves around the nucleus only in those orbits for which the angular momentum is some integral multiple of h/2 π where h is the Planck's constant. (c) Bohr's third postulate states that an electron might make a transition from one of its specified non-radiating orbits to another of lower energy. When it does so, a photon is emitted having energy equal to the energy difference between the initial and final states. **Derivation** Total energy of electron in the stationary state of hydrogen atoms is $E = -\frac{e^2}{8\pi\varepsilon_0 r_n}$ -------------------(1) Where r_n is radius of n^{th} orbit $r_n = \frac{n^2h^2\varepsilon_0}{\pi me^2}$ ---------------------(2) Substituting eq (2) in eq (1) $E_n = -\frac{me^4}{8n^2{\varepsilon_0}^2h^2}$ (ii) Mass defect, $\Delta m = \left[6\,m({}_0^1n) + 6\,m({}_1^1H)\right] - m({}_6^{12}C)$ $\Delta m = (6\times 1.008665 + 6\times 1.007825) - 12.000000$ $\Delta m = 0.09894\,\text{u}$ $B.E. = \Delta m \times 931.5\,\text{MeV}$ $= 92.16\text{MeV}$ Binding energy per nucleon, $E_{bn} = \frac{E_b}{A}$ $= \frac{92.16}{12}$ =7.68MeV	½ ½ ½ ½ 1 ½ ½ ½	5
32. (a)	(i) Labelled diagram of ac generator 1 Working of ac generator 1 Obtaining expression for e.m.f 1 (ii) Finding magnitude of force and direction 2  	1	

	Working of ac generator When coil is rotated in a uniform magnetic field with a constant angular speed ω, magnetic flux through it changes. As a result, an e.m.f is induced in the coil.	1	
	Flux linked with the coil at any instant 't' is $\varphi_B = BA\cos\omega t$	½	
	$\varepsilon = -N\dfrac{d\varphi_B}{dt}$ $\varepsilon = NBA\omega\sin\omega t$	½	
	(ii) $F = \dfrac{\mu_0 I_1 I_2 l}{2\pi r}$ force on arm MN of the loop $F_1 = \dfrac{4\pi\times10^{-7}\times3\times1\times10\times10^{-2}}{2\pi\times20\times10^{-2}}$ $F_1 = 3\times10^{-7}$ N	½	
	Force is directed away from the wire Force on arm SP of the loop $F_2 = \dfrac{4\pi\times10^{-7}\times3\times1\times10\times10^{-2}}{2\pi\times30\times10^{-2}}$ $F_2 = 2\times10^{-7}$ N	½	
	Force is directed towards the wire Net force on the loop	½	
	$F = F_1 - F_2 = 10^{-7}$ N Net force on the loop is away from the wire.	½	
	OR		
(b)	(i) Statement of Faraday's law of electromagnetic induction ½ Utility of Lenz's law ½ Obtaining expression for self inductance 2 (ii) (1) calculating angular frequency 1 (2) calculating impedance of the circuit 1		
	(i) The magnitude of induced e.m.f in a circuit is equal to the time rate of change of magnetic flux through the circuit	½	
	Utility of Lenz's law It give polarity of the induced e.m.f .	½	
	Expression for self inductance Consider a long solenoid of cross-sectional area A and length l, having n turns per unit length. If I is the current flowing in the solenoid, magnetic field inside the solenoids is $B = \mu_0 nI$	½	
	Total magnetic flux linked with the solenoid is $N\varphi_B = (nl)(\mu_0 nI)(A)$ $N\varphi_B = \mu_0 n^2 AlI$	½	

Self inductance

$$L = \frac{N\varphi_B}{I}$$

$$L = \mu_0 n^2 Al$$ ½

If solenoid is filled with a material of relative permeability μ_r, then

$$L = \mu_r \mu_0 n^2 Al$$ ½

(ii) (1) Resonant angular frequency is

$$\omega_0 = \frac{1}{\sqrt{LC}}$$ ½

$$\omega_0 = \frac{1}{\sqrt{50\times10^{-3}\times80\times10^{-6}}} = 500\ \text{rad}\,\text{s}^{-1}$$ ½

(2) When frequency of supply is equal to natural frequency of the circuit

$$Z = R$$ ½

$$Z = 20\ \Omega$$ ½ 5

33. (a)

(i) Two main considerations for designing objective and eye piece	1
Obtaining expression for magnifying power of telescope	2
(ii) Calculating	
(1) Angle of deviation	1
(2) Refractive index	1

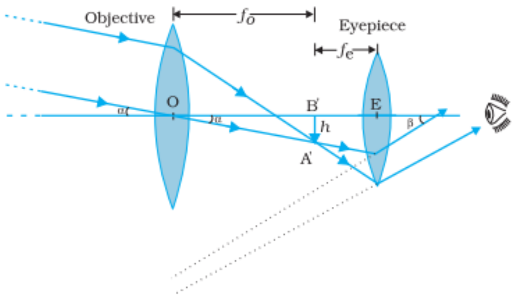
Two main considerations

Objective should have ½

1. Larger diameter
2. Larger focal length

Eye piece should have

1. Smaller diameter
2. Smaller focal length ½



1

Magnifying power of telescope

Magnifying power is the ratio of the angle β subtended at the eye by the final images to the angle α which the object subtends at the lens or eye

$$m \approx \frac{\beta}{\alpha} \approx \frac{h}{f_e}\cdot\frac{f_0}{h} = \frac{f_0}{f_e}$$ 1

(ii) i+e = D+A

$$at\ \ D = D_m\ ,\ i = e$$

$$2i = D_m + A$$

$$2 \times 45 = D_m + 60^0$$

$$D_m = 30^0$$ 1

$$\mu = \frac{\sin\left(\frac{A+D_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$\mu = \frac{\sin\left(\frac{60^0+30^0}{2}\right)}{\sin\left(\frac{60^0}{2}\right)}$$

$$= \sqrt{2}$$ 1

OR

(i) Describing activity to observe diffraction pattern due to a single slit	2
(ii) Finding refractive index of the liquid	3

(b) **(i)** We hold two razor blades in such a way that their edges are parallel and with a narrow slit in between. Keep the slit parallel to the filament of electric bulb, right in front of the eye.
A diffraction is seen with its bright and dark bands. 2

(ii) $$\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$ ½

Focal length of convex lens, $f_1 = 30\,\text{cm}$

$$\frac{1}{30} = (1.5-1)\left[\frac{1}{R} - \frac{1}{(-R)}\right]$$

$$R = 30\,\text{cm}$$ ½

focal length of combination, f = 45 cm
focal length of plane concave lens of liquid.

$$\frac{1}{f_2} = \frac{1}{f} - \frac{1}{f_1}$$ ½

$$\frac{1}{f_2} = \frac{1}{45} - \frac{1}{30}$$

$$f_2 = -90\,\text{cm}$$ ½

Using lens maker's formula

$$\frac{1}{-90} = \left(\mu_l - 1\right)\left[\frac{1}{-30} - \frac{1}{\infty}\right]$$ ½

$$\mu_l = \frac{4}{3}$$ ½

5

~

General Instructions :

Read the following instructions very carefully and follow them :

(i) *This question paper contains **33** questions. **All** questions are **compulsory**.*

(ii) *Question paper is divided into **FIVE** sections – Sections **A, B, C, D** and **E**.*

(iii) *In **Section A :** Question numbers **1** to **16** are Multiple Choice (MCQ) type questions. Each question carries **1** mark.*

(iv) *In **Section B :** Question numbers **17** to **21** are Very Short Answer (VSA) type questions. Each question carries **2** marks.*

(v) *In **Section C :** Question numbers **22** to **28** are Short Answer (SA) type questions. Each question carries **3** marks.*

(vi) *In **Section D :** Question numbers **29** & **30** are Case Study-Based questions. Each question carries **4** marks.*

(vii) *In **Section E :** Question numbers **31** to **33** are Long Answer (LA) type questions. Each question carries **5** marks.*

(viii) *There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.*

(ix) *Kindly note that there is a separate question paper for Visually Impaired candidates.*

(x) *Use of calculators is NOT allowed.*

You may use the following values of physical constants wherever necessary :

$c = 3 \times 10^8$ m/s

$h = 6.63 \times 10^{-34}$ Js

$e = 1.6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

Mass of electron (m_e) = 9.1×10^{-31} kg.

Mass of neutron = 1.675×10^{-27} kg.

Mass of proton = 1.673×10^{-27} kg.

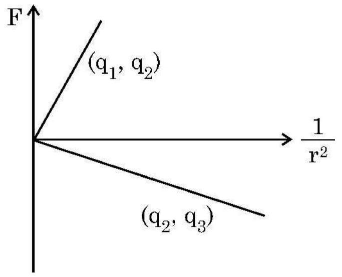
Avogadro's number = 6.023×10^{23} per gram mole

Boltzmann's constant = 1.38×10^{-23} JK^{-1}

~

SECTION – A

1. Figure shows variation of Coulomb force (F) acting between two point charges with $\frac{1}{r^2}$, r being the separation between the two charges (q_1, q_2) and (q_2, q_3). If q_2 is positive and least in magnitude, then the magnitudes of q_1, q_2 and q_3 are such that **1**



(A) $q_2 < q_3 < q_1$ (B) $q_3 < q_1 < q_2$

(C) $q_1 < q_2 < q_3$ (D) $q_2 < q_1 < q_3$

2. Two wires P and Q are made of the same material. The wire Q has twice the diameter and half the length as that of wire P. If the resistance of wire P is R, the resistance of the wire Q will be **1**

(A) R (B) $\frac{R}{2}$

(C) $\frac{R}{8}$ (D) 2R

3. A 1 cm segment of a wire lying along x-axis carries current of 0.5 A along +x direction. A magnetic field $\vec{B} = (0.4 \text{ mT})\,\hat{j} + (0.6 \text{ mT})\,\hat{k}$ is switched on, in the region. The force acting on the segment is **1**

(A) $(2\hat{j} + 3\hat{k})$ mN (B) $(-3\hat{j} + 2\hat{k})$ μN

(C) $(6\hat{j} + 4\hat{k})$ mN (D) $(-4\hat{j} + 6\hat{k})$ μN

4. A coil has 100 turns, each of area 0.05 m^2 and total resistance 1.5 Ω. It is inserted at an instant in a magnetic field of 90 mT, with its axis parallel to the field. The charge induced in the coil at that instant is : **1**

(A) 3.0 mC (B) 0.30 C

(C) 0.45 C (D) 1.5 C

5. You are required to design an air-filled solenoid of inductance 0.016 H having a length 0.81 m and radius 0.02 m. The number of turns in the solenoid should be **1**

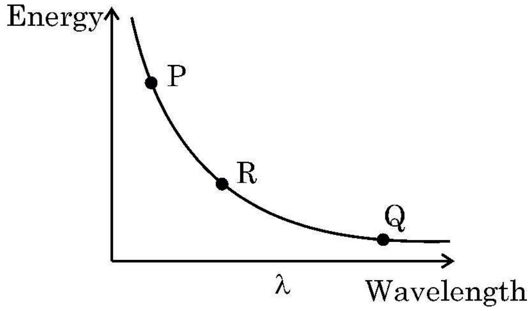
(A) 2592 (B) 2866

(C) 2976 (D) 3140

6. A voltage $\nu = \nu_0 \sin \omega t$ applied to a circuit drives a current $i = i_0 \sin(\omega t + \phi)$ in the circuit. The average power consumed in the circuit over a cycle is **1**

(A) Zero
(B) $i_0 \nu_0 \cos \phi$
(C) $\frac{i_0 \nu_0}{2}$
(D) $\frac{i_0 \nu_0}{2} \cos \phi$

7. The given diagram exhibits the relationship between the wavelength of the electromagnetic waves and the energy of photon associated with them. The three points P, Q and R marked on the diagram may correspond respectively to : **1**



(A) X-rays, microwaves, UV radiation
(B) X-rays, UV radiation, microwaves
(C) UV radiation, microwaves, X-rays
(D) Microwaves, UV radiation, X-rays

8. A beaker is filled with water (refractive index $\frac{4}{3}$) upto a height H. A coin is placed at its bottom. The depth of the coin, when viewed along the near normal direction, will be **1**

(A) $\frac{H}{4}$
(B) $\frac{3H}{4}$
(C) H
(D) $\frac{4H}{3}$

9. The stopping potential V_0 measured in a photoelectric experiment for a metal surface is plotted against frequency ν of the incident radiation. Let m be the slope of the straight line so obtained. Then the value of charge of an electron is given by (h is the Planck's constant.) **1**

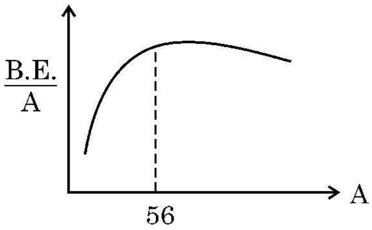
(A) mh
(B) $\frac{m}{h}$
(C) $\frac{h}{m}$
(D) $\frac{1}{mh}$

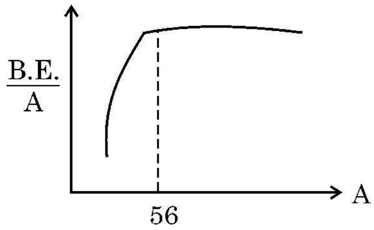
10. Let λ_e, λ_p and λ_d be the wavelengths associated with an electron, a proton and a deuteron, all moving with the same speed. Then the correct relation between them is **1**

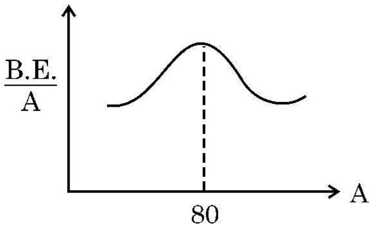
(A) $\lambda_d > \lambda_p > \lambda_e$ (B) $\lambda_e > \lambda_p > \lambda_d$

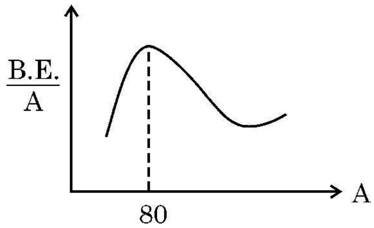
(C) $\lambda_p > \lambda_e > \lambda_d$ (D) $\lambda_e = \lambda_p = \lambda_d$

11. Which of the following figures correctly represent the shape of curve of binding energy per nucleon as a function of mass number ? **1**

(A)


(B)


(C)


(D)


12. When a p-n junction diode is forward biased **1**
 (A) the barrier height and the depletion layer width both increase.
 (B) the barrier height increases and the depletion layer width decreases.
 (C) the barrier height and the depletion layer width both decrease.
 (D) the barrier height decreases and the depletion layer width increases.

Note : Question numbers **13** to **16** are Assertion (A) and Reason (R) type questions. Two statements are given – one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below :

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).
(C) Assertion (A) is true, but Reason (R) is false.
(D) Assertion (A) is false and Reason (R) is also false.

13. **Assertion (A) :** It is difficult to move a magnet into a coil of large number of turns when the circuit of the coil is closed. **1**

 Reason (R) : The direction of induced current in a coil with its circuit closed, due to motion of a magnet, is such that it opposes the cause.

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14. **Assertion (A)** : The deflection in a galvanometer is directly proportional to the current passing through it. **1**

Reason (R) : The coil of a galvanometer is suspended in a uniform radial magnetic field.

15. **Assertion (A)** : We cannot form a p-n junction diode by taking a slab of a p-type semiconductor and physically joining it to another slab of a n-type semiconductor. **1**

Reason (R) : In a p-type semiconductor $\eta_e >> \eta_h$ while in a n-type semiconductor $\eta_h >> \eta_e$.

16. **Assertion (A)** : The potential energy of an electron revolving in any stationary orbit in a hydrogen atom is positive. **1**

Reason (R) : The total energy of a charged particle is always positive.

SECTION – B

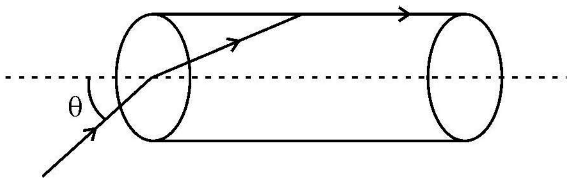
17. A battery of emf E and internal resistance r is connected to a rheostat. When a current of 2A is dawn from the battery, the potential difference across the rheostat is $5V$. The potential difference becomes $4V$ when a current of 4A is drawn from the battery. Calculate the value of E and r. **2**

18. (a) In a diffraction experiment, the slit is illuminated by light of wavelength 600 nm. The first minimum of the pattern falls at $\theta = 30^\circ$. Calculate the width of the slit. **2**

OR

(b) In a Young's double-slit experiment, two light waves, each of intensity I_o, interfere at a point, having a path difference $\frac{\lambda}{8}$ on the screen. Find the intensity at this point.

19. A transparent solid cylindrical rod (refractive index $\frac{2}{\sqrt{3}}$) is kept in air. A ray of light incident on its face travels along the surface of the rod, as shown in figure. Calculate the angle θ. **2**



20. Prove that, in Bohr model of hydrogen atom, the time period of revolution of an electron in n^{th} orbit is proportional to n^3. **2**

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21. A p-type Si semiconductor is made by doping an average of one dopant atom per 5×10^7 silicon atoms. If the number density of silicon atoms in the specimen is 5×10^{28} atoms m^{-3}, find the number of holes created per cubic centimetre in the specimen due to doping. Also give one example of such dopants. **2**

SECTION – C

22. (a) Two batteries of emf's 3V & 6V and internal resistances 0.2 Ω & 0.4 Ω are connected in parallel. This combination is connected to a 4 Ω resistor. Find : **3**
    (i) the equivalent emf of the combination
    (ii) the equivalent internal resistance of the combination
    (iii) the current drawn from the combination

OR

(b) (i) A conductor of length l is connected across an ideal cell of emf E. Keeping the cell connected, the length of the conductor is increased to $2l$ by gradually stretching it. If R and R′ are initial and final values of resistance and v_d and v_d' are initial and final values of drift velocity, find the relation between (i) R′ and R and (ii) v_d' and v_d.
    (ii) When electrons drift in a conductor from lower to higher potential, does it mean that all the 'free electrons' of the conductor are moving in the same direction ?

23. Using Biot-Savart law, derive expression for the magnetic field ($\vec{B}$) due to a circular current carrying loop at a point on its axis and hence at its centre. **3**

24. (a) Show that the energy required to build up the current I in a coil of inductance L is $\frac{1}{2} LI^2$. **3**
    (b) Considering the case of magnetic field produced by air-filled current carrying solenoid, show that the magnetic energy density of a magnetic field B is $\frac{B^2}{2\mu_0}$.

25. (a) A parallel plate capacitor is charged by an ac source. Show that the sum of conduction current (I_c) and the displacement current (I_d) has the same value at all points of the circuit. **3**
    (b) In case (a) above, is Kirchhoff's first rule (junction rule) valid at each plate of the capacitor ? Explain.

~

26. Answer the following giving reason : **3**
   (a) All the photo electrons do not eject with the same kinetic energy when monochromatic light is incident on a metal surface.
   (b) The saturation current in case (a) is different for different intensity.
   (c) If one goes on increasing the wavelength of light incident on a metal surface, keeping its intensity constant, emission of photo electrons stop at a certain wavelength for this metal.

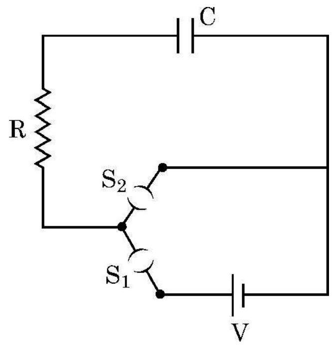
27. (a) Define 'Mass defect' and 'Binding energy' of a nucleus. Describe 'Fission process' on the basis of binding energy per nucleon. **3**
   (b) A deuteron contains a proton and a neutron and has a mass of 2.013553 u. Calculate the mass defect for it in u and its energy equivalence in MeV. (m_p = 1.007277 u, m_n = 1.008665 u, 1u = 931.5 MeV/c^2)

28. (a) Draw circuit arrangement for studying V-I characteristics of a p-n junction diode. **3**
   (b) Show the shape of the characteristics of a diode.
   (c) Mention two information that you can get from these characteristics.

SECTION – D

Question numbers **29** and **30** are case study based questions. Read the following paragraphs and answer the questions that follow.

29. A circuit consisting of a capacitor C, a resistor of resistance R and an ideal battery of emf V, as shown in figure is known as RC series circuit. $4 \times \mathbf{1} = \mathbf{4}$



As soon as the circuit is completed by closing key S_1 (keeping S_2 open) charges begin to flow between the capacitor plates and the battery terminals. The charge on the capacitor increases and consequently the potential difference V_c (= q/C) across the capacitor also increases with time. When this potential difference equals the potential difference across the battery, the capacitor is fully charged (Q = VC). During this process of charging, the charge q on the capacitor changes with time t as $q = Q[1 - e^{-t/RC}]$

The charging current can be obtained by differentiating it and using $\frac{d}{dx}(e^{mx}) = me^{mx}$.

Consider the case when R = 20 kΩ, C = 500 μF and V = 10 V.

~

(i) The final charge on the capacitor, when key S_1 is closed and S_2 is open, is

(A) 5 μC (B) 5 mC

(C) 25 mC (D) 0.1 C

(ii) For sufficient time the key S_1 is closed and S_2 is open. Now key S_2 is closed and S_1 is open. What is the final charge on the capacitor ?

(A) Zero (B) 5 mC

(C) 2.5 mC (D) 5 μC

(iii) The dimensional formula for RC is

(A) $[M\, L^2\, T^{-3}\, A^{-2}]$ (B) $[M^0\, L^0\, T^{-1}\, A^0]$

(C) $[M^{-1}\, L^{-2}\, T^4\, A^2]$ (D) $[M^0\, L^0\, T\, A^0]$

(iv) The key S_1 is closed and S_2 is open. The value of current in the resistor after 5 seconds, is

(A) $\frac{1}{2\sqrt{e}}$ mA (B) $\sqrt{e}$ mA

(C) $\frac{1}{\sqrt{e}}$ mA (D) $\frac{1}{2e}$ mA

OR

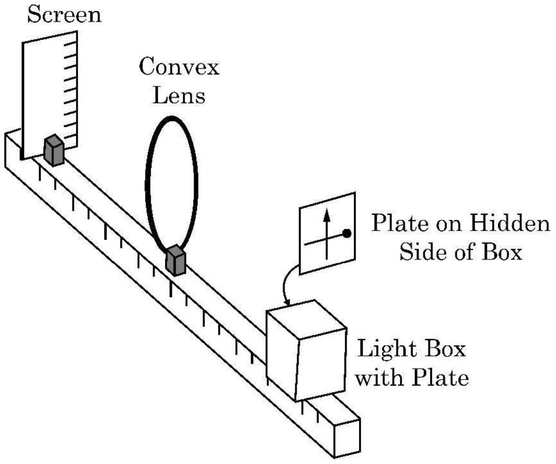
(iv) The key S_1 is closed and S_2 is open. The initial value of charging current in the resistor, is

(A) 5 mA (B) 0.5 mA

(C) 2 mA (D) 1 mA

30. A thin lens is a transparent optical medium bounded by two surfaces, at least one of which should be spherical. Applying the formula for image formation by a single spherical surface successively at the two surfaces of a lens, one can obtain the 'lens maker formula' and then the 'lens formula'. A lens has two foci – called 'first focal point' and 'second focal point' of the lens, one on each side. **4 × 1 = 4**

(i)



Consider the arrangement shown in figure. A black vertical arrow and a horizontal thick line with a ball are painted on a glass plate. It serves as the object. When the plate is illuminated, its real image is formed on the screen.

Which of the following correctly represents the image formed on the screen ?

(A) (B) (C) (D)

(ii) Which of the following statements is incorrect ?

(A) For a convex mirror magnification is always negative.

(B) For all virtual images formed by a mirror magnification is positive.

(C) For a concave lens magnification is always positive.

(D) For real and inverted images, magnification is always negative.

(iii) A convex lens of focal length 'f' is cut into two equal parts perpendicular to the principal axis. The focal length of each part will be :

(A) f (B) 2 f

(C) $\frac{f}{2}$ (D) $\frac{f}{4}$

OR

(iii) If an object in case (i) above is 20 cm from the lens and the screen is 50 cm away from the object, the focal length of the lens used is

(A) 10 cm (B) 12 cm

(C) 16 cm (D) 20 cm

(iv) The distance of an object from first focal point of a biconvex lens is X_1 and distance of the image from second focal point is X_2. The focal length of the lens is

(A) $X_1 X_2$ (B) $\sqrt{X_1 + X_2}$

(C) $\sqrt{X_1 X_2}$ (D) $\sqrt{\frac{X_2}{X_1}}$

~

SECTION – E

31. (a) (i) Two point charges 5 μC and –1 μC are placed at points (–3 cm, 0, 0) and (3 cm, 0, 0) respectively. An external electric field $\vec{E} = \frac{A}{r^2}\hat{r}$ where $A = 3 \times 10^5$ Vm is switched on in the region. Calculate the change in electrostatic energy of the system due to the electric field. **5**

(ii) A system of two conductors is placed in air and they have net charge of +80μC and –80μC which causes a potential difference of 16 V between them.

(1) Find the capacitance of the system.

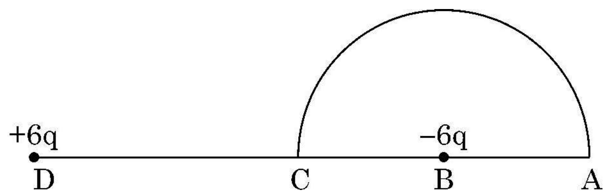
(2) If the air between the capacitor is replaced by a dielectric medium of dielectric constant 3, what will be the potential difference between the two conductors ?

(3) If the charges on two conductors are changed to +160 μC and –160 μC, will the capacitance of the system change ? Give reason for your answer.

OR

(b) (i) Consider three metal spherical shells A, B and C, each of radius R. Each shell is having a concentric metal ball of radius R/10. The spherical shells A, B and C are given charges +6q, –4q, and 14q respectively. Their inner metal balls are also given charges –2q, +8q and –10q respectively. Compare the magnitude of the electric fields due to shells A, B and C at a distance 3R from their centres.

(ii) A charge –6 μC is placed at the centre B of a semicircle of radius 5 cm, as shown in the figure. An equal and opposite charge is placed at point D at a distance of 10 cm from B. A charge +5 μC is moved from point 'C' to point 'A' along the circumference. Calculate the work done on the charge.



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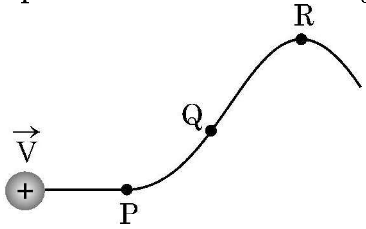
32. (a) (i) A proton moving with velocity $\vec{V}$ in a non-uniform magnetic field traces a path as shown in the figure. **5**



The path followed by the proton is always in the plane of the paper. What is the direction of the magnetic field in the region near points P, Q and R ? What can you say about relative magnitude of magnetic fields at these points ?

(ii) A current carrying circular loop of area A produces a magnetic field B at its centre. Show that the magnetic moment of the loop is $\frac{2\,BA}{\mu_0}\sqrt{\frac{A}{\pi}}$.

OR

(b) (i) Derive an expression for the torque acting on a rectangular current loop suspended in a uniform magnetic field.

(ii) A charged particle is moving in a circular path with velocity $\vec{V}$ in a uniform magnetic field $\vec{B}$. It is made to pass through a sheet of lead and as a consequence, it looses one half of its kinetic energy without change in its direction. How will (1) the radius of its path (2) its time period of revolution change ?

33. (a) (i) (1) What are coherent sources ? Why are they necessary for observing a sustained interference pattern ? **5**

(2) Lights from two independent sources are not coherent. Explain.

(ii) Two slits 0.1 mm apart are arranged 1.20 m from a screen. Light of wavelength 600 nm from a distant source is incident on the slits.

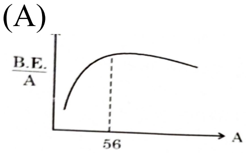
(1) How far apart will adjacent bright interference fringes be on the screen ?

(2) Find the angular width (in degree) of the first bright fringe.

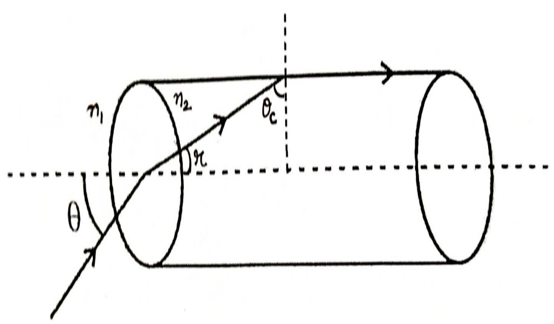
OR

(b) (i) Define a wavefront. An incident plane wave falls on a convex lens and gets refracted through it. Draw a diagram to show the incident and refracted wavefront.

(ii) A beam of light coming from a distant source is refracted by a spherical glass ball (refractive index 1.5) of radius 15 cm. Draw the ray diagram and obtain the position of the final image formed.

MARKING SCHEME: PHYSICS(042)			
Code: 55/1/1			
Q.No	**VALUE POINTS/EXPECTED ANSWERS**	**Marks**	**Total Marks**
	SECTION A		
1	(A) $q_2 < q_3 < q_1$	1	1
2	(C) $\frac{R}{8}$	1	1
3	(B) $\left(-3\hat{j}+2\hat{k}\right)\mu N$	1	1
4	(B) 0.30 C	1	1
5	(B) 2866	1	1
6	(D) $\frac{i_0 v_0}{2}\cos\phi$	1	1
7	(A) X- rays , Micro waves , UV radiation	1	1
8	(B) $\frac{3H}{4}$	1	1
9	(C) $\frac{h}{m}$	1	1
10	(B) $\lambda_e > \lambda_p > \lambda_d$	1	1
11	(A) 	1	1
12	(C) The barrier height and the depletion layer width both decrease.	1	1
13	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion(A).	1	1
14	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion(A).	1	1
15	(C) Assertion (A) is true but Reason (R) is false.	1	1
16	(D) Assertion (A) is false and Reason (R) is also false.	1	1
	SECTION - B		
17	Calculating the value of E 1 Calculating the value of r 1 $E = V + Ir$ In first case E = 5 + 2r In second case E = 4 + 4r After solving	 ½ ½	

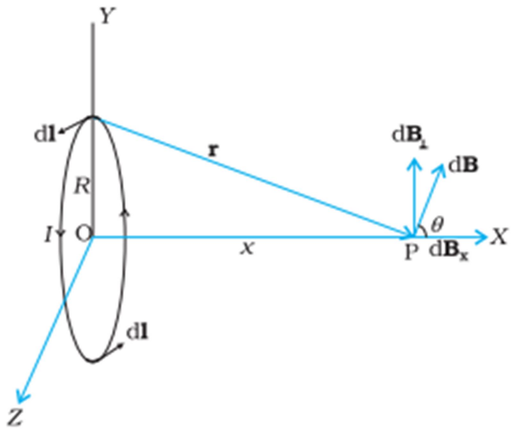
	E= 6 V r = 0.5 Ω	½ ½	2
18	(a) $\boxed{\text{Calculating the width of the slit} \quad 2}$ Condition for Minima a sinθ = nλ For First Minima n=1 $a \sin 30^\circ = 600 \times 10^{-9}$ m $a \times \frac{1}{2} = 600 \times 10^{-9}$ m $a = 1200 \times 10^{-9}$ m $= 1.2 \times 10^{-6}$ m OR (b) $\boxed{\text{Finding the Intensity} \quad 2}$ Phase difference = $\frac{2\pi}{\lambda} \times$ path difference $\Delta\phi = \frac{2\pi}{\lambda}\Delta x$ $\because \Delta x = \frac{\lambda}{8}\ (given)$ $\Delta\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{8}$ $\Delta\phi = \frac{\pi}{4}$ $I = I_\circ + I_\circ + 2\sqrt{I_\circ I_\circ}\cos\frac{\pi}{4}$ $= 2I_\circ + 2I_\circ \times \frac{1}{\sqrt{2}}$ $I = 2I_\circ\left(1 + \frac{1}{\sqrt{2}}\right)$ $= I_\circ(2 + \sqrt{2})$ $I = 3.414\, I_\circ$ **Alternatively** Phase difference = $\frac{2\pi}{\lambda} \times$ path difference	 1 ½ ½ ½ ½ ½ ½ ½	

	$\Delta\phi = \frac{2\pi}{\lambda}\Delta x$ $\because \Delta x = \frac{\lambda}{8}\ (given)$ $\Delta\phi = \frac{2\pi}{\lambda}\times\frac{\lambda}{8}$ $\Delta\phi = \frac{\pi}{4}$ $I = 4I_{\circ}\cos^2\left(\frac{\phi}{2}\right)$ $I = 4I_{\circ}\cos^2\left(\frac{\pi}{8}\right)$	½ ½ ½	2
19	Calculating angle θ 2  For critical Angle $\frac{n_2}{n_1} = \frac{1}{\sin\theta_c}$ $n_1=1 \quad n_2=\frac{2}{\sqrt{3}}$ (given) $\frac{2}{\sqrt{3}} = \frac{1}{\sin\theta_c}$ $\sin\theta_c = \frac{\sqrt{3}}{2}$ $\theta_c = 60^\circ$ $r = 90 - \theta_c$ $= 30^\circ$ From Snell's law at air rod interface $n_1 \sin i = n_2 \sin r$	½ ½ ½	

	$n_2 = \frac{\sin\theta}{\sin r}$ $\frac{2}{\sqrt{3}} = \frac{\sin\theta}{\sin 30^0}$ $\frac{2}{\sqrt{3}} \times \frac{1}{2} = \sin\theta$ $\frac{1}{\sqrt{3}} = \sin\theta$ $\theta = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$	½	2
20	Proving Time period of Revolution ,T α n^3 2 $T=\frac{2\pi r}{v}$ ---------- (1) From Bohr's quantization condition $mvr=\frac{nh}{2\pi}$ $v=\frac{nh}{2\pi mr}$ ---------- (2) From (1) and (2) $T=\frac{2\pi r}{\left(nh/2\pi mr\right)}$ $T=\frac{2\pi r(2\pi mr)}{nh}$ $T=\frac{4\pi^2 mr^2}{nh}$ From $r=\frac{n^2h^2}{4\pi^2 mke^2}$ $T=\frac{4\pi^2 m}{nh}\left(\frac{n^2h^2}{4\pi^2 mke^2}\right)^2$ $T=\frac{n^3h^3}{4\pi^2 mk^2e^4}$ $\Rightarrow T\,\alpha\, n^3$ **Alternatively ---**	½ ½ ½ ½	

	$T=\frac{2\pi r}{v}$ $\because r \,\alpha\, n^2$ and $v \alpha \frac{1}{n}$ $\therefore T \,\alpha\, n^3$	½ ½ ½ ½	2
21	Finding the number of holes 1 One example 1 1 dopant atom for 5×10^7 Si atoms and number density of Si atoms = $5\times10^{28}\ \frac{\text{atoms}}{m^3}$ (*given*) No. of holes created per m^3 = $\frac{5\times10^{28}}{5\times10^7}=10^{21}$ Number of holes created per cubic centimeter $=\frac{10^{21}}{10^6}=10^{15}$ Any one example of dopant - Aluminium / Indium / Gallium	 1 1	2
	SECTION - C		
22	(a) Finding (i) Equivalent emf of combination 1 (ii) Equivalent internal resistance of combination 1 (iii) Current drawn from combination 1 (i) Because $E_{eq}=\frac{E_1r_2+E_2r_1}{r_1+r_2}$ $E_{eq}=\frac{3\times0.4+6\times0.2}{0.6}$ = 4 V (ii) $r_{eq}=\frac{r_1r_2}{r_1+r_2}$ $r_{eq}=\frac{0.2\times0.4}{0.2+0.4}=0.133\Omega$ (iii) $I=\frac{E}{R+r_{eq}}$ $I=\frac{4}{4+0.13}=\frac{4}{4.13}A$ $I=0.9A$	 ½ ½ ½ ½ ½ ½	

	OR		
	(b) (i) Finding the relation (i) between R' and R 1 (ii) between v_d' and v_d 1 (ii) To identify whether all free electrons are moving in the same direction. 1		
	(i) $l' = 2l$ $Al = A'l'$ = volume of the wire $Al = A'(2l)$ $\frac{A}{2} = A'$		
	R = $\frac{\rho l}{A}$	½	
	$R' = \frac{\rho l'}{A'}$ $R' = \frac{\rho(2l)}{A/2}$		
	$\frac{R'}{R} = 4$	½	
	Alternatively		
	$R' = n^2 R$	½	
	n= 2 $R' = 4R$	½	
	(ii) $v_d = \frac{eE}{m}\tau$	½	
	$v_d = \frac{eV}{ml}\tau$ $v_d' = \frac{eV}{ml'}\tau$		
	$\frac{v_d'}{v_d} = \frac{l}{l'} = \frac{1}{2}$	½	
	(ii) No	1	3
23	Derivation for Magnetic field on the axis 2 ½ Magnetic field at the centre ½		



½

From Biot Savart' s Law

$$|d\vec{B}| = \frac{\mu_\circ}{4\pi}\frac{I|d\vec{l}\times\vec{r}|}{r^3}$$ ½

Now $r^2 = x^2 + R^2$

Because $|d\vec{l}\times\vec{r}| = rdl$

$$\therefore dB = \frac{\mu_\circ}{4\pi}\frac{idl}{(x^2+R^2)}$$ ½

$d\vec{B}$ has two components.

All the components perpendicular to x- axis are summed over and we obtain a null result.

Only x- components contribute. The net contribution along x- direction

$$dB_x = dB\cos\theta$$ ½

$$\cos\theta = \frac{R}{\left(R^2+x^2\right)^{\frac{1}{2}}}$$

Thus :

$$dB_x = \frac{\mu_\circ i}{4\pi}dl\frac{R}{\left(R^2+x^2\right)^{\frac{3}{2}}}$$

Summing dB_x over the entire loop

$$\oint dl = 2\pi R$$

$$\vec{B} = B_x\hat{i} = \frac{\mu_\circ iR^2}{2(x^2+R^2)^{\frac{3}{2}}}\hat{i}$$ ½

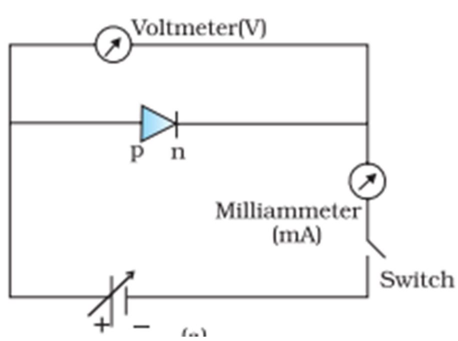
Magnetic field at the centre of the loop-

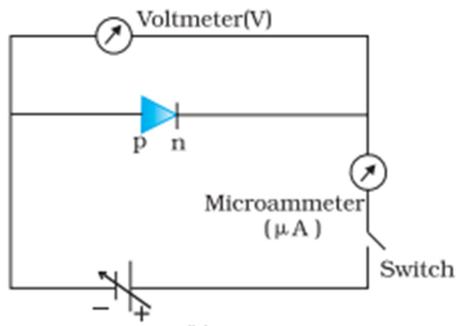
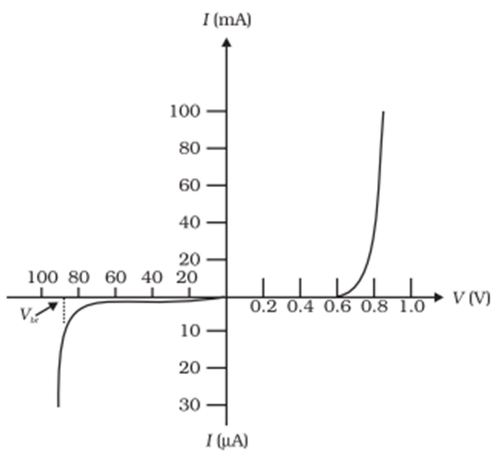
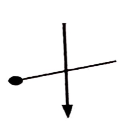
Here x= 0

$$\therefore \vec{B} = \frac{\mu_\circ i}{2R}\hat{i}$$ ½ 3

24	a) Deriving the expression for energy stored in an inductor. 1 ½ b) Deriving the energy density of magnetic field. 1 ½		
	a) Induced emf in an inductor $|\varepsilon| = L\dfrac{dI}{dt}$	½	
	Rate of work done at any instant $\dfrac{dW}{dt} = |\varepsilon| I$	½	
	Total Amount of work done in establishing current I $W = \int dW = \int_0^I LIdI$ Energy required to build up current I is $W = \frac{1}{2} L I^2$	½	
	b) The Magnetic Energy is $W = U_B = \frac{1}{2} LI^2$ $= \frac{1}{2} L\left(\dfrac{B}{n\mu_0}\right)^2$ as $B = n\mu_0 I$	½	
	Using $L = \mu_0 n^2 A l$ $U_B = \dfrac{1}{2}\left(\mu_0 n^2 A l\right)\left(\dfrac{B^2}{\mu_0^2 n^2}\right)$	½	
	Energy density $= \dfrac{U_B}{\text{volume}}$ $\dfrac{U_B}{\text{volume}} = \dfrac{1}{2} \times \mu_0 n^2 A l \times \dfrac{B^2}{\mu_0^2 n^2} \times \dfrac{1}{Al}$ $= \dfrac{1}{2}\dfrac{B^2}{\mu_0}$	½	3
25	a) Showing that ($I_c + I_d$) has the same value. 2 b) Explanation of Kirchhoff's first rule at each plate of capacitor. 1		
	a) $\because$ Total current $I = I_c + I_d$ outside the capacitor $I_d = 0$	½	
	$\therefore I = I_c$ Inside the capacitor $I_c = 0$	½	

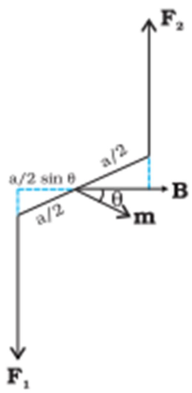
	$\therefore\ I = I_d = \varepsilon_0 \dfrac{d\phi_E}{dt}$ $= \varepsilon_0 \dfrac{d}{dt}[EA]$ $= \varepsilon_0 \dfrac{d}{dt}\left[\dfrac{\sigma}{\varepsilon_0} A\right]$ $= \dfrac{\varepsilon_0}{\varepsilon_0} A \dfrac{d}{dt}\left[\dfrac{Q}{A}\right]$ $I = \dfrac{dQ}{dt} = I_c$ **Alternatively** $\because$ Total current $I = I_c + I_d$ outside the capacitor $I_d = 0$ $\therefore I = I_c$ Inside the capacitor $I_c = 0$ $I = I_d = \varepsilon_0 \dfrac{d\phi_E}{dt}$ $= \varepsilon_0 \dfrac{d}{dt}\left[\dfrac{Q}{\varepsilon_0}\right]$ $I = \dfrac{dQ}{dt} = I_c$ hence $I_c + I_d$ has the same value at all points of the circuit. b) Yes Current entering the capacitor is (I_c) and between the plates capacitor is (I_d) $I_c = I_d$ which validates Kirchhoff's junction rule.	½ ½ ½ ½ ½ ½ 1	3
26	Reason for a) All photoelectrons not having same Kinetic Energy. 1 b) Having different saturation current for different intensity. 1 c) Stopping of emission of photoelectrons at a certain wavelength. 1 a) When monochromatic light is incident on a metal surface then more/less tightly bound electrons will emerge with less/more kinetic energy. So all the photoelectrons do not eject with same kinetic energy. b) Maximum number of photoelectrons ejected per second (saturation current) is directly proportional to the Intensity of incident radiation Hence saturation current is different for different intensities.	1 1	

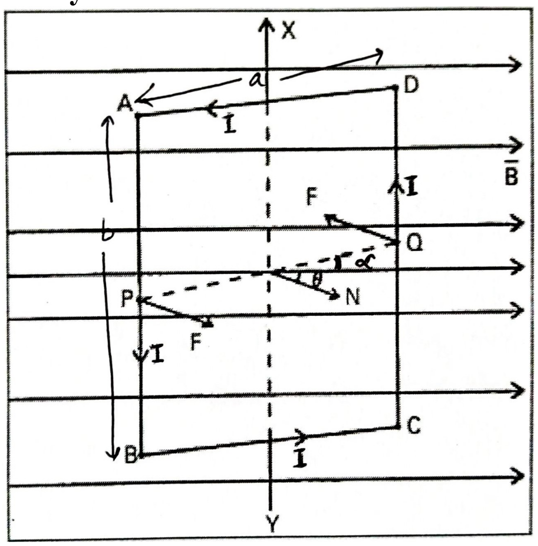
	c) when λ increases , ν decreases and energy of incident photon ($h\nu$) also decreases. When $\lambda > \lambda_0$, $\nu < \nu_0$ (threshold frequency) , no photoelectron is ejected. Emission of photoelectrons stop at $\lambda > \lambda_0$.	1	3
27	a) Defining Mass Defect ½ Defining Binding Energy ½ Describing Fission Process ½ b) Calculation of Mass Defect 1 Calculation of Energy ½ a) Difference in the mass of the nucleus and its constituents is defined as mass defect. Binding Energy is the energy required to separate the nucleons from the nucleus. In Fission process a heavy nucleus splits into lighter nuclei and energy is released. As a result the Binding Energy per nucleon increases. b) $\Delta m = (m_p + m_n) - m_d$ $\Delta m = (1.007277 + 1.008665) - 2.013553$ $\Delta m = 0.002389$ u Energy released = $\Delta m \times c^2$ Energy released = 0.002389×931.5 $= 2.2253$ MeV ≈ 2.22 MeV	½ ½ ½ ½ ½ ½	3
28	a) Circuit Arrangement for studying V–I characteristics. 1 b) Showing the shape of characteristic curves. 1 c) Two informations from the characteristics ½ + ½ a)  Circuit diagram for forward characteristics	½	

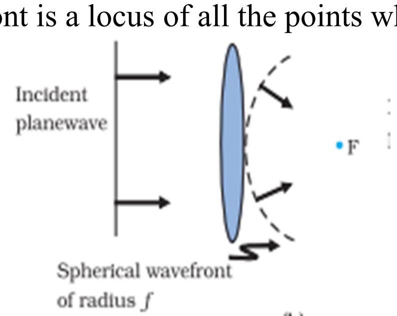
	 Circuit diagram for Reverse characteristics b)  Note : Please do not deduct marks for not writing values. c) Any two informations Knee voltage / reverse saturation current / Breakdown voltage / very low resistance in forward biasing / very high resistance in Reverse biasing.	½ 1 ½ + ½	3
	SECTION - D		
29	i) (B) 5mC ii) (A) zero iii) (D) [$M^0L^0TA^0$] iv) (A) $\frac{1}{2\sqrt{e}} mA$ **Note: 1 mark for this part may be given to all the students who have attempted other parts of the question.** OR (B) 0.5 mA	1 1 1 1	4
30	i) (C)  ii) (A) For a convex mirror magnification is always negative iii) (B) 2f	1 1 1	

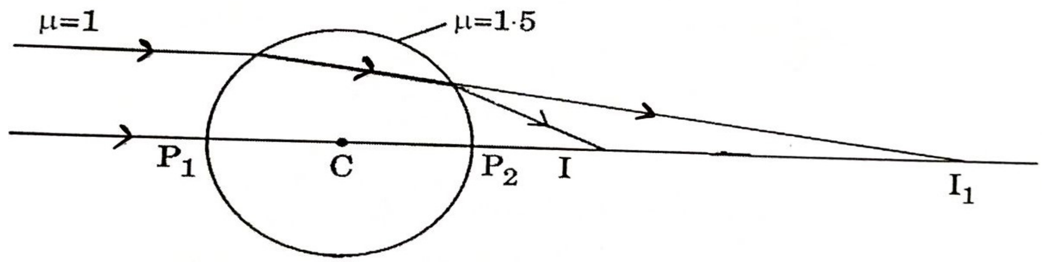
	OR (B) 12 cm iv) (C) $\sqrt{X_1 X_2}$	1	4
	SECTION - E		
31	a) i) Calculating the change in electrostatic energy of the system 2 ii) (1) Finding the capacitance. 1 (2) Finding the potential difference. 1 (3) Answering and Reason ½ + ½		
	(i) $\vec{E} = \frac{3\times10^5}{r^2}\hat{r}$ (Given) $dV = -\vec{E}.\mathrm{d}\vec{r}$ $V = 3 \times 10^5 / r$ Electrostatic energy of the system in the absence of the field $U_i = \frac{Kq_1q_2}{r_{12}}$	½	
	Electrostatic energy in the presence of the field $U_f = \frac{Kq_1q_2}{r_{12}} + q_1V(\vec{r}_1) + q_2V(\vec{r}_2)$ $\Delta U = U_f - U_i = q_1V(\vec{r}_1) + q_2V(\vec{r}_2)$	½	
	$\Delta U = \frac{5\times10^{-6}\times3\times10^5}{3\times10^{-2}} - \frac{1\times10^{-6}\times3\times10^5}{3\times10^{-2}}$	½	
	$= 40\ \mathrm{J}$	½	
	ii) 1) $C = \frac{Q}{V} = \frac{80}{16} = 5\mu F$	1	
	2) $C' = KC$ $= 3\times5\mu F = 15\ \mu F$	½	
	$V' = \frac{Q}{C'} = \frac{80\mu C}{15\mu F} = 5.33V$	½	
	3) No,	½	
	The capacitance of the system depends on its geometry.	½	
	OR b) i) Comparing the magnitude of the Electric fields 2 ii) Calculating the work done on the charge 3		
	Total charge for A = Total charge for B = Total charge for C = +4q	1	
	As , $E = \frac{kQ}{r^2}$		

	Since Q = 4q and r = 3R $E = \frac{k(4q)}{9R^2} = \frac{4kq}{9R^2}$ $\therefore E_A = E_B = E_c$ ii) $V_c = \left[\frac{k\times 6\times 10^{-6}}{5\times 10^{-2}} - \frac{k\times 6\times 10^{-6}}{5\times 10^{-2}}\right]$ $= 0$ $V_A = \left[\frac{k\times 6\times 10^{-6}}{15\times 10^{-2}} - \frac{k\times 6\times 10^{-6}}{5\times 10^{-2}}\right]$ $= \frac{k\times 6\times 10^{-6}}{10^{-2}}\left[\frac{1-3}{15}\right]$ $= -\frac{9\times 10^{9}\times 6\times 10^{-6}\times 2}{15\times 10^{-2}}$ $= -7.2\times 10^{5}$ V $W = q\left[V_A - V_c\right]$ $= 5\times 10^{-6}\left[-7.2\times 10^{5} - 0\right]$ W = - 3.6 J	½ ½ 1 ½ ½ ½ ½	5
32	a) i) Finding the direction of magnetic field near points P,Q and R ½ + ½ + ½ Conclusion about the relative magnitude of magnetic field. ½ + ½ + ½ ii) Showing the given expression of magnetic moment. 2 i) <u>Near point P</u> Magnetic field is acting into the plane of the paper as Force is acting upwards. <u>Near point Q</u> Magnetic field is into the plane of paper as force is acting upwards. <u>Near point R</u> Magnetic field is acting out of the plane of the paper as $\vec{F}$ is acting downwards. <u>Relative Magnitude of the Magnetic field.</u> As B $\alpha \frac{1}{r}$ Therefore, Near point P, magnitude of B is small. Near point Q, B is relatively smaller than point P. Near point R, B is relatively larger than point P. ($B_Q < B_P < B_R$) ii) Let r be the radius of the circular coil and I is the current in the coil then	½ ½ ½ ½ ½ ½	

	$B = \frac{\mu_0 I}{2r}$ or $I = \frac{2Br}{\mu_0}$	½	
	$A = \pi r^2$ $\quad$ $r = \sqrt{\frac{A}{\pi}}$	½	
	$M = IA$	½	
	$= \frac{2Br}{\mu_0} A$		
	$= \frac{2BA}{\mu_0}\sqrt{\frac{A}{\pi}}$	½	
	OR		
	b) i) Deriving the expression for the torque. 3 ii) 1) Finding the change in radius. 1 2) Finding the change in time period of Revolution. 1		
	i) 	½	
	$\vec{F}_1$ *and* $\vec{F}_2$ are the forces acting on two arms of the rectangular coil having sides a and b.		
	$\lvert\vec{F}_1\rvert = \lvert\vec{F}_2\rvert = I\,b\,B$ $\quad$ (b = length of the arm)	1	
	Forces constitute a couple. The magnitude of Torque on the loop is –		
	$\tau = F_1 \frac{a}{2}\sin\theta + F_2 \frac{a}{2}\sin\theta$	½	
	$= I\,a\,\,b\,B\sin\theta$	½	
	$= IA\,B\sin\theta$	½	
	$\vec{\tau} = I\vec{A} \times \vec{B}$		

	Alternatively 	½	
	If the plane of the current carrying coil marks an angle ∝ with the magnetic field $\vec{F}_{DA} = -\vec{F}_{Bc}$ (cancel each other) .	½	
	Force on the arm DC is into the plane of the paper $\lvert F_{DC} \rvert = IbB$.	½	
	Force on the arm AB is out of the plane of the paper. $\lvert F_{AB} \rvert = IbB$	½	
	Both of them form a couple and Torque acting on the coil is τ=either force ×perpendicular distance between the two forces. $\tau = IbB \times a\cos\alpha$ $= IabB\cos\alpha$ $\tau = IAB\cos\alpha$	½	
	Let $\hat{n}$ =outward drawn normal to the plane of the coil. $\theta + \alpha = 90^0$ $\alpha = 90^0 - \theta$ $\tau = IAB\cos(90-\theta)$ $= IAB\sin\theta$ $\vec{\tau} = I\vec{A} \times \vec{B}$	½	
	ii) 1) $\mathrm{r} = \frac{\mathrm{mv}}{\mathrm{qB}} = \frac{\sqrt{2\mathrm{mK}}}{\mathrm{qB}}$	½	
	$\mathrm{r} \;\; \alpha \; \sqrt{\mathrm{K}}$ $\frac{\mathrm{r}'}{\mathrm{r}} = \frac{\sqrt{\mathrm{K}/2}}{\sqrt{\mathrm{K}}} = \frac{1}{\sqrt{2}}$ $\mathrm{r}' = \frac{\mathrm{r}}{\sqrt{2}}$	½	

	2) $T=\dfrac{2\pi m}{qB}$ Time period does not depend on Kinetic Energy $\therefore$ Time period will not change.	½ ½	5
33	a) i) 1) Definition of coherent sources. 1 Necessity of coherent sources for sustained interference pattern 1 2) Explanation 1 ii) 1) Finding distance between adjacent bright fringes. 1 2) Finding angular width 1 i) 1) If the phase difference between the displacement produced by each of the wave from two sources does not change with time then two sources are said to be coherent. **Alternatively** Two sources are said to be coherent if they emit light continuously of same frequency / wavelength and having zero or constant phase difference. Coherent sources are required to get constant phase difference. 2) Two independent sources will never be coherent because phase difference between them will not be constant. ii) 1) Distance between adjacent bright fringe = fringe width $\beta=\dfrac{\lambda D}{d}$ $=\dfrac{600\times10^{-9}\times1.2}{0.1\times10^{-3}}=7.2\,\text{mm}$ 2) $\theta=\dfrac{\lambda}{d}$ $=\dfrac{600\times10^{-9}}{0.1\times10^{-3}}=6\times10^{-3}$ rad= 0.34° Give full marks if the student writes the answer in radians only. OR b) i) Definition of wave front. 1 Drawing the incident and refracted wave front ½ + ½ ii) Drawing the ray diagram 1 Obtaining the position of final image 2 i) A wavefront is a locus of all the points which oscillate in phase. 	1 1 1 ½ ½ ½ ½ 1 ½ + ½	

	ii)  	1	
	From I[st] surface , Refraction is from rarer to denser medium and object is at ∞ $n_1 = 1$, $n_2 = 1.5$, R = 15 cm , u= ∞ $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$	½	
	$\frac{1.5}{v} - \frac{1}{\infty} = \frac{1.5-1}{15}$	½	
	v= 45 cm From 2[nd] surface , Refraction is from denser to rarer medium and object is at 15 cm $n_1 = 1$, $n_2 = 1.5$, R = -15 cm , u= 15cm $\frac{n_1}{v} - \frac{n_2}{u} = \frac{n_1 - n_2}{R}$	½	
	$\frac{1}{v} - \frac{1.5}{15} = \frac{1-1.5}{-15}$ v= 7.5 cm	½	5

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General Instructions :

Read the following instructions very carefully and follow them :

(i) *This question paper contains **33** questions. **All** questions are* **compulsory**.

(ii) *This question paper is divided into **five** sections – Sections **A, B, C, D** and **E**.*

(iii) *In* **Section A :** *Question numbers **1** to **16** are Multiple Choice type questions. Each question carries **1** mark.*

(iv) *In* **Section B :** *Question numbers **17** to **21** are Very Short Answer type questions. Each question carries **2** marks.*

(v) *In* **Section C :** *Question numbers **22** to **28** are Short Answer type questions. Each question carries **3** marks.*

(vi) *In* **Section D :** *Question numbers **29** & **30** are case study-based questions. Each question carries **4** marks.*

(vii) *In* **Section E :** *Question numbers **31** to **33** are Long Answer type questions. Each question carries **5** marks.*

(viii) *There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section **A**.*

(ix) *Kindly note that there is a separate question paper for Visually Impaired candidates.*

(x) *Use of calculators is* **not** *allowed.*

You may use the following values of physical constants wherever necessary :

$c = 3 \times 10^{8}$ m/s

$h = 6.63 \times 10^{-34}$ Js

$e = 1.6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^{9}$ N m^2 C^{-2}

Mass of electron (m_e) = 9.1×10^{-31} kg.

Mass of neutron = 1.675×10^{-27} kg.

Mass of proton = 1.673×10^{-27} kg.

Avogadro's number = 6.023×10^{23} per gram mole

Boltzman's constant = 1.38×10^{-23} JK^{-1}

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SECTION – A

1. Two charges –q each are placed at the vertices A and B of an equilateral triangle ABC. If M is the mid-point of AB, the net electric field at C will point along **1**

(A) CA (B) CB
(C) MC (D) CM

2. A student has three resistors, each of resistance R. To obtain a resistance of $\frac{2}{3}$R, she should connect **1**

(A) all the three resistors in series.
(B) all the three resistors in parallel.
(C) two resistors in series and then this combination in parallel with the third resistor.
(D) two resistors in parallel and then this combination in series with the third resistor.

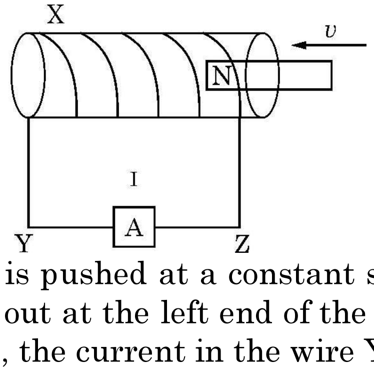
3. A 1 cm straight segment of a conductor carrying 1 A current in x direction lies symmetrically at origin of Cartesian coordinate system. The magnetic field due to this segment at point (1m, 1m, 0) is **1**

(A) $1.0 \times 10^{-9}\,\hat{k}$ T (B) $-1.0 \times 10^{-9}\,\hat{k}$ T
(C) $\frac{5.0}{\sqrt{2}} \times 10^{-10}\,\hat{k}$ T (D) $-\frac{5.0}{\sqrt{2}} \times 10^{-10}\,\hat{k}$ T

4. The magnetic field due to a small magnetic dipole of dipole moment 'M' at a distance 'r' from the centre along the axis of the dipole is given by **1**

(A) $\frac{\mu_0}{4\pi} \times \frac{2M}{r^3}$ (B) $\frac{\mu_0}{4\pi} \times \frac{M}{r^3}$
(C) $\frac{\mu_0}{4\pi} \times \frac{M}{2r^3}$ (D) $\frac{\mu_0}{4\pi} \times \frac{2M}{r^2}$

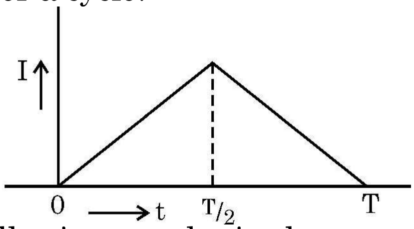
5. In the figure X is a coil wound over a hollow wooden pipe. **1**



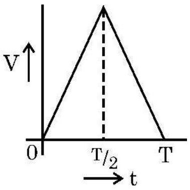
A permanent magnet is pushed at a constant speed v from the right into the pipe and it comes out at the left end of the pipe. During the entry and the exit of the magnet, the current in the wire YZ will be from

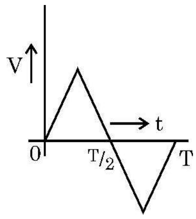
(A) Y to Z and then Y to Z (B) Z to Y and then Y to Z
(C) Y to Z and then Z to Y (D) Z to Y and then Z to Y

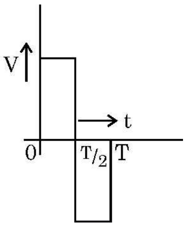
6. The alternating current I in an inductor is observed to vary with time t as shown in the graph for a cycle. **1**

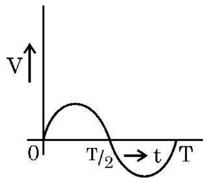


Which one of the following graphs is the correct representation of wave form of voltage V with time t ?

(A)


(B)


(C)


(D)


7. A transformer is connected to a 200 V ac source. The transformer supplies 3000 V to a device. If the number of turns in the primary coil is 450, then the number of turns in its secondary coil is – **1**

(A) 30 (B) 450

(C) 4500 (D) 6750

8. Which one of the following statements is correct ?

Electric field due to static charges is **1**

(A) conservative and field lines do not form closed loops.

(B) conservative and field lines form closed loops.

(C) non-conservative and field lines do not form closed loops.

(D) non-conservative and field lines form closed loops.

9. A tub is filled with a transparent liquid to a height of 30.0 cm. The apparent depth of a coin lying at the bottom of the tub is found to be 16.0 cm. The speed of light in the liquid will be **1**

(A) 1.6×10^8 m s^{-1} (B) 2.0×10^8 m s^{-1}

(C) 3.0×10^8 m s^{-1} (D) 2.5×10^8 m s^{-1}

10. Atomic spectral emission lines of hydrogen atom are incident on a zinc surface. The lines which can emit photoelectrons from the surface are members of **1**

(A) Balmer series

(B) Paschen series

(C) Lyman series

(D) Neither Balmer, nor Paschen nor Lyman series

~

11. The energy of an electron in a hydrogen atom in ground state is –13.6 eV. Its energy in an orbit corresponding to quantum number n is –0.544 eV. The value of n is **1**

(A) 2 (B) 3
(C) 4 (D) 5

12. When the resistance measured between p and n ends of a p-n junction diode is high, it can act as a/an – **1**

(A) resistor (B) inductor
(C) capacitor (D) switch

For Questions **13** to **16**, two statements are given – one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below :

(A) If both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) If both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
(C) If Assertion (A) is true but Reason (R) is false.
(D) If both Assertion (A) and Reason (R) are false.

13. **Assertion (A)** : In a semiconductor diode the thickness of depletion layer is not fixed. **1**

Reason (R) : Thickness of depletion layer in a semiconductor device depends upon many factors such as biasing of the semiconductor.

14. **Assertion (A)** : In Bohr model of hydrogen atom, the angular momentum of an electron in n^{th} orbit is proportional to the square root of its orbit radius r_n. **1**

Reason (R) : According to Bohr model, electron can jump to its nearest orbits only.

15. **Assertion (A)** : Out of Infrared and radio waves, the radio waves show more diffraction effect. **1**

Reason (R) : Radio waves have greater frequency than infrared waves.

16. **Assertion (A)** : In an ideal step-down transformer, the electrical energy is not lost. **1**

Reason (R) : In a step-down transformer, voltage decreases but the current increases.

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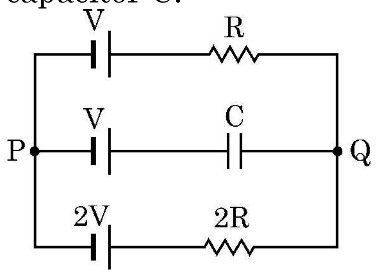
SECTION – B

17. (a) Two wires of the same material and the same radius have their lengths in the ratio 2 : 3. They are connected in parallel to a battery which supplies a current of 15 A. Find the current through the wires. **2**

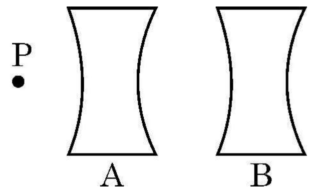
OR

(b) In the circuit three ideal cells of e.m.f. V, V and 2V are connected to a resistor of resistance R, a capacitor of capacitance C and another resistor of resistance 2R as shown in figure. In the steady state find (i) the potential difference between P and Q and (ii) potential difference across capacitor C.



18. In a double-slit experiment, 6^{th} dark fringe is observed at a certain point of the screen. A transparent sheet of thickness t and refractive index n is now introduced in the path of one of the two interfering waves to increase its phase by 2π (n – 1) t/λ. The pattern is shifted and 8^{th} bright fringe is observed at the same point. Find the relation for thickness t in terms of n and λ. **2**

19. Two concave lenses A and B, each of focal length 8.0 cm are arranged coaxially 16 cm apart as shown in figure. An object P is placed at a distance of 4.0 cm from A. Find the position and nature of the final image formed. **2**



20. A light of wavelength 400 nm is incident on metal surface whose work function is 3.0×10^{-19} J. Calculate the speed of the fastest photoelectrons emitted. **2**

21. The threshold voltage of a silicon diode is 0.7 V. It is operated at this point by connecting the diode in series with a battery of V volt and a resistor of 1000 Ω. Find the value of V when the current drawn is 15 mA. **2**

SECTION – C

22. (a) A cell of e.m.f. E and internal resistance r is connected with a variable external resistance R and a voltmeter showing potential drop *V* across R. Obtain the relationship between *V*, E, R and r. **3**

(b) Draw the shape of the graph showing the variation of terminal voltage V of the cell as a function of current I drawn from it. How one can determine the e.m.f. of the cell and its internal resistance from this graph ?

23. (a) In a region of a uniform electric field $\vec{E}$, a negatively charged particle is moving with a constant velocity $\vec{v} = -v_0 \hat{i}$ near a long straight conductor coinciding with XX$'$ axis and carrying current I towards –X axis. The particle remains at a distance d from the conductor. **3**

(i) Draw diagram showing direction of electric and magnetic fields.

(ii) What are the various forces acting on the charged particle ?

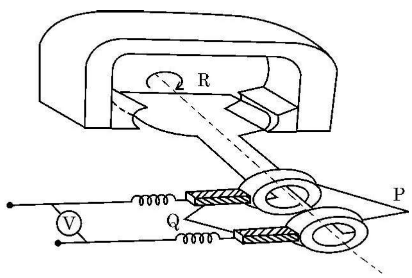
(iii) Find the value of v_0 in terms of E, d and I.

OR

(b) Two infinitely long conductors kept along XX$'$ and YY$'$ axes are carrying current I_1 and I_2 along –X axis and –Y axis respectively. Find the magnitude and direction of the net magnetic field produced at point P(X, Y).

24. (a) State Lenz's law. **3**

(b) In the given figure :



(i) Identify the machine.

(ii) Name the parts P and Q and R of the machine.

(iii) Give the polarities of the magnetic poles.

(iv) Write the two ways of increasing the output voltage.

25. (a) The electric field $\vec{E}$ of an electromagnetic wave propagating in north direction is oscillating in up and down direction. Describe the direction of magnetic field $\vec{B}$ of the wave. **3**

(b) Are the wave length of radio waves and microwaves longer or shorter than those detectable by human eyes ?

(c) Write main use of each of the following in human life :

(i) Infrared waves (ii) Gamma rays

26. (a) When a parallel beam of light enters water surface obliquely at some angle, what is the effect on the width of the beam ? **3**

(b) With the help of a ray diagram, show that a straw appears bent when it is partly dipped in water and explain it.

(c) Explain the transmission of optical signal through an optical fibre by a diagram.

27. (a) Show the variation of binding energy per nucleon with mass number. Write the significance of the binding energy curve. **3**

(b) Two nuclei with lower binding energy per nucleon form a nuclei with more binding energy per nucleon.

(i) What type of nuclear reaction is it ?

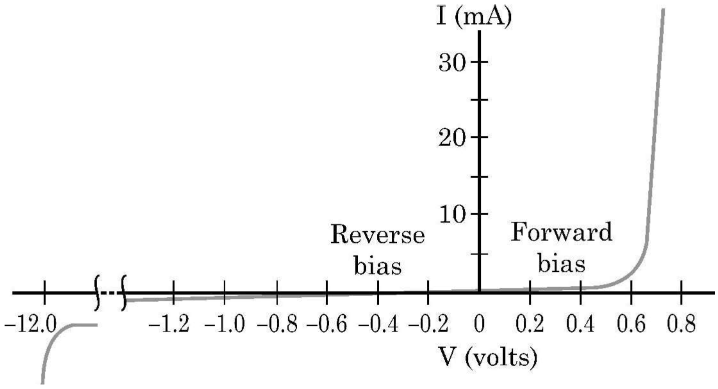
(ii) Whether the total mass of nuclei increases, decreases or remains unchanged ?

(iii) Does the process require energy or produce energy ?

28. (a) What are majority and minority charge carriers in an extrinsic semiconductor ? **3**

(b) A p-n junction is forward biased. Describe the movement of the charge carriers which produce current in it.

(c) The graph shows the variation of current with voltage for a p-n junction diode.



Estimate the dynamic resistance of diode at V = –0.6 volt.

SECTION – D

Question numbers **29** and **30** are case study based questions. Read the following paragraphs and answer the questions that follow.

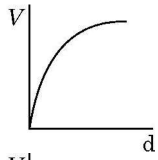
29. A parallel plate capacitor has two parallel plates which are separated by an insulating medium like air, mica, etc. When the plates are connected to the terminals of a battery, they get equal and opposite charges and an electric field is set up in between them. This electric field between the two plates depends upon the potential difference applied, the separation of the plates and nature of the medium between the plates. **4 × 1 = 4**

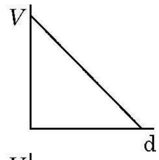
(i) The electric field between the plates of a parallel plate capacitor is E. Now the separation between the plates is doubled and simultaneously the applied potential difference between the plates is reduced to half of its initial value. The new value of the electric field between the plates will be :

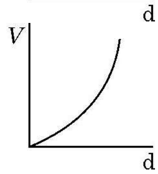
(A) E (B) 2E

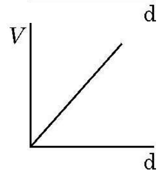
(C) $\frac{E}{4}$ (D) $\frac{E}{2}$

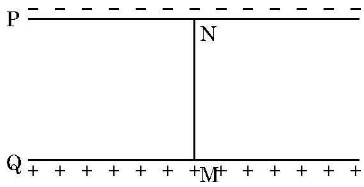
(ii) A constant electric field is to be maintained between the two plates of a capacitor whose separation d changes with time. Which of the graphs correctly depict the potential difference (V) to be applied between the plates as a function of separation between the plates (d) to maintain the constant electric field ?

(A) 

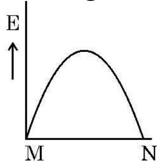
(B) 

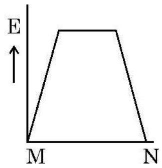
(C) 

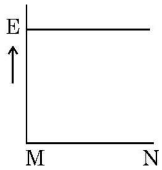
(D) 

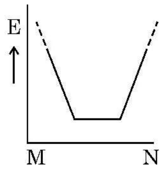
(iii) 

In the above figure P, Q are the two parallel plates of a capacitor. Plate Q is at positive potential with respect to plate P. MN is an imaginary line drawn perpendicular to the plates. Which of the graphs shows correctly the variations of the magnitude of electric field strength E along the line MN ?

(A) 

(B) 

(C) 

(D) 

(iv) Three parallel plates are placed above each other with equal displacement $\vec{d}$ between neighbouring plates. The electric field between the first pair of the plates is $\vec{E}_1$ and the electric field between the second pair of the plates is $\vec{E}_2$. The potential difference between the third and the first plate is –

(A) $(\vec{E}_1 + \vec{E}_2) \cdot \vec{d}$ (B) $(\vec{E}_1 - \vec{E}_2) \cdot \vec{d}$

(C) $(\vec{E}_2 - \vec{E}_1) \cdot \vec{d}$ (D) $\dfrac{d(E_1 + E_2)}{2}$

OR

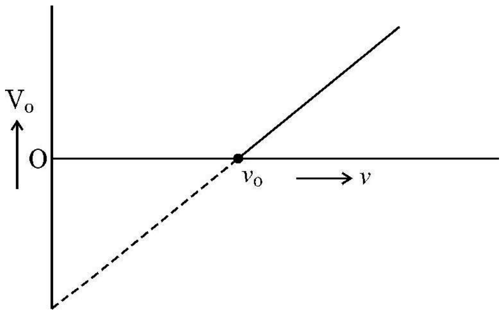
~

(iv) A material of dielectric constant K is filled in a parallel plate capacitor of capacitance C. The new value of its capacitance becomes

(A) C (B) $\frac{C}{K}$

(C) CK (D) $C\left(1+\frac{1}{K}\right)$

30. When a photon of suitable frequency is incident on a metal surface, photoelectron is emitted from it. If the frequency is below a threshold frequency (v_o) for the surface, no photoelectron is emitted. For a photon of frequency $v(v > v_o)$, the kinetic energy of the emitted photoelectrons is $h(v - v_o)$. The photocurrent can be stopped by applying a potential V_o called 'stopping potential' on the anode. Thus maximum kinetic energy of photoelectrons $K_m = eV_o = h(v - v_o)$. The experimental graph between V_o and v for a metal is shown in figure. This is a straight line of slope m. **4 × 1 = 4**



(i) The straight line graphs obtained for two metals
- (A) coincide each other.
- (B) are parallel to each other.
- (C) are not parallel to each other and cross at a point on v-axis.
- (D) are not parallel to each other and do not cross at a point on v-axis.

(ii) The value of Planck's constant for this metal is

(A) $\frac{e}{m}$ (B) $\frac{1}{me}$

(C) me (D) $\frac{m}{e}$

(iii) The intercepts on v-axis and V_o-axis of the graph are respectively :

(A) $v_o, \frac{hv_o}{e}$ (B) v_o, hv_o

(C) $\frac{hv_o}{e}, v_o$ (D) hv_o, v_o

OR

(iii) When the wavelength of a photon is doubled, how many times its wave number and frequency become, respectively ?

(A) $2, \frac{1}{2}$ (B) $\frac{1}{2}, \frac{1}{2}$

(C) $\frac{1}{2}, 2$ (D) 2, 2

(iv) The momentum of a photon is 5.0×10^{-29} kg. m/s. Ignoring relativistic effects (if any), the wavelength of the photon is

(A) 1.33 μm (B) 3.3 μm

(C) 16.6 μm (D) 13.3 μm

SECTION – E

31. (a) (i) A small conducting sphere A of radius r charged to a potential V, is enclosed by a spherical conducting shell B of radius R. If A and B are connected by a thin wire, calculate the final potential on sphere A and shell B. **5**

(ii) Write two characteristics of equipotential surfaces. A uniform electric field of 50 NC^{-1} is set up in a region along $+x$ axis. If the potential at the origin (0, 0) is 220 V, find the potential at a point (4m, 3m).

OR

(b) (i) What is difference between an open surface and a closed surface ? Draw elementary surface vector $d\vec{S}$ for a spherical surface S.

(ii) Define electric flux through a surface. Give the significance of a Gaussian surface. A charge outside a Gaussian surface does not contribute to total electric flux through the surface. Why ?

(iii) A small spherical shell S_1 has point charges $q_1 = -3$ μC, $q_2 = -2$ μC and $q_3 = 9$ μC inside it. This shell is enclosed by another big spherical shell S_2. A point charge Q is placed in between the two surfaces S_1 and S_2. If the electric flux through the surface S_2 is four times the flux through surface S_1, find charge Q.

32. (a) (i) What is the source of force acting on a current-carrying conductor placed in a magnetic field ? Obtain the expression for force acting between two long straight parallel conductors carrying steady currents and hence define 'ampere'. **5**

~

(ii) A point charge q is moving with velocity $\vec{v}$ in a uniform magnetic field $\vec{B}$. Find the work done by the magnetic force on the charge.

(iii) Explain the necessary conditions in which the trajectory of a charged particle is helical in a uniform magnetic field.

OR

(b) (i) A current carrying loop can be considered as a magnetic dipole placed along its axis. Explain.

(ii) Obtain the relation for magnetic dipole moment $\vec{M}$ of current carrying coil. Give the direction of $\vec{M}$.

(iii) A current carrying coil is placed in an external uniform magnetic field. The coil is free to turn in the magnetic field. What is the net force acting on the coil ? Obtain the orientation of the coil in stable equilibrium. Show that in this orientation the flux of the total field (field produced by the loop + external field) through the coil is maximum.

33. (a) (i) A thin pencil of length (f/4) is placed coinciding with the principal axis of a mirror of focal length f. The image of the pencil is real and enlarged, just touches the pencil. Calculate the magnification produced by the mirror. **5**

(ii) A ray of light is incident on a refracting face AB of a prism ABC at an angle of 45°. The ray emerges from face AC and the angle of deviation is 15°. The angle of prism is 30°. Show that the emergent ray is normal to the face AC from which it emerges out. Find the refraction index of the material of the prism.

OR

(b) (i) Light consisting of two wavelengths 600 nm and 480 nm is used to obtain interference fringes in a double slit experiment. The screen is placed 1.0 m away from slits which are 1.0 nm apart.

(1) Calculate the distance of the third bright fringe on the screen from the central maximum for wavelength 600 nm.

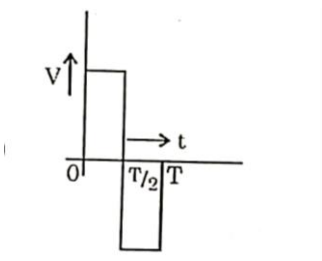
(2) Find the least distance from the central maximum where the bright fringes due to both the wavelengths coincide.

(ii) (1) Draw the variation of intensity with angle of diffraction in single slit diffraction pattern. Write the expression for value of angle corresponding to zero intensity locations.

(2) In what way diffraction of light waves differs from diffraction of sound waves ?

Marking Scheme **Strictly Confidential** **(For Internal and Restricted use only)** **Senior School Certificate Examination, 2025** **SUBJECT NAME PHYSICS (PAPER CODE 55/2/1)**	
General Instructions: -	
1	You are aware that evaluation is the most important process in the actual and correct assessment of the candidates. A small mistake in evaluation may lead to serious problems which may affect the future of the candidates, education system and teaching profession. To avoid mistakes, it is requested that before starting evaluation, you must read and understand the spot evaluation guidelines carefully.
2	**"Evaluation policy is a confidential policy as it is related to the confidentiality of the examinations conducted, Evaluation done and several other aspects. Its' leakage to public in any manner could lead to derailment of the examination system and affect the life and future of millions of candidates. Sharing this policy/document to anyone, publishing in any magazine and printing in News Paper/Website etc. may invite action under various rules of the Board and IPC."**
3	Evaluation is to be done as per instructions provided in the Marking Scheme. It should not be done according to one's own interpretation or any other consideration. Marking Scheme should be strictly adhered to and religiously followed. **However, while evaluating, answers which are based on latest information or knowledge and/or are innovative, they may be assessed for their correctness otherwise and due marks be awarded to them. In Class-X, while evaluating two competency-based questions, please try to understand given answer and even if reply is not from marking scheme but correct competency is enumerated by the candidate, due marks should be awarded.**
4	The Marking scheme carries only suggested value points for the answers These are in the nature of Guidelines only and do not constitute the complete answer. The students can have their own expression and if the expression is correct, the due marks should be awarded accordingly.
5	The Head-Examiner must go through the first five answer books evaluated by each evaluator on the first day, to ensure that evaluation has been carried out as per the instructions given in the Marking Scheme. If there is any variation, the same should be zero after deliberation and discussion. The remaining answer books meant for evaluation shall be given only after ensuring that there is no significant variation in the marking of individual evaluators.
6	Evaluators will mark (√) wherever answer is correct. For wrong answer CROSS 'X" be marked. Evaluators will not put right **(✓)** while evaluating which gives an impression that answer is correct and no marks are awarded. **This is most common mistake which evaluators are committing.**
7	If a question has parts, please award marks on the right-hand side for each part. Marks awarded for different parts of the question should then be totaled up and written in the left-hand margin and encircled. This may be followed strictly.
8	If a question does not have any parts, marks must be awarded in the left-hand margin and encircled. This may also be followed strictly.
9	If a student has attempted an extra question, answer of the question deserving more marks should be retained and the other answer scored out with a note **"Extra Question"**.

10	No marks to be deducted for the cumulative effect of an error. It should be penalized only once.
11	A full scale of marks 70 (example 0 to 80/70/60/50/40/30 marks as given in Question Paper) has to be used. Please do not hesitate to award full marks if the answer deserves it.
12	Every examiner has to necessarily do evaluation work for full working hours i.e., 8 hours every day and evaluate 20 answer books per day in main subjects and 25 answer books per day in other subjects (Details are given in Spot Guidelines).This is in view of the reduced syllabus and number of questions in question paper.
13	Ensure that you do not make the following common types of errors committed by the Examiner in the past: - ● Leaving answer or part thereof unassessed in an answer book. ● Giving more marks for an answer than assigned to it. ● Wrong totaling of marks awarded on an answer. ● Wrong transfer of marks from the inside pages of the answer book to the title page. ● Wrong question wise totaling on the title page. ● Wrong totaling of marks of the two columns on the title page. ● Wrong grand total. ● Marks in words and figures not tallying/not same. ● Wrong transfer of marks from the answer book to online award list. ● Answers marked as correct, but marks not awarded. (Ensure that the right tick mark is correctly and clearly indicated. It should merely be a line. Same is with the X for incorrect answer.) ● Half or a part of answer marked correct and the rest as wrong, but no marks awarded.
14	While evaluating the answer books if the answer is found to be totally incorrect, it should be marked as cross (X) and awarded zero (0)Marks.
15	Any un assessed portion, non-carrying over of marks to the title page, or totaling error detected by the candidate shall damage the prestige of all the personnel engaged in the evaluation work as also of the Board. Hence, in order to uphold the prestige of all concerned, it is again reiterated that the instructions be followed meticulously and judiciously.
16	The Examiners should acquaint themselves with the guidelines given in the "**Guidelines for spot Evaluation**" before starting the actual evaluation.
17	Every Examiner shall also ensure that all the answers are evaluated, marks carried over to the title page, correctly totaled and written in figures and words.
18	The candidates are entitled to obtain photocopy of the Answer Book on request on payment of the prescribed processing fee. All Examiners/Additional Head Examiners/Head Examiners are once again reminded that they must ensure that evaluation is carried out strictly as per value points for each answer as given in the Marking Scheme.

MARKING SCHEME: PHYSICS(042)			
Code: 55/2/1			
Q.No.	**VALUE POINTS/EXPECTED ANSWERS**	**Marks**	**Total Marks**
	SECTION A		
1.	(D) CM	1	1
2.	(C) two resistors in series and then this combination in parallel with the third resistor.	1	1
3.	(C) $\frac{5.0}{\sqrt{2}} x10^{-10}\,\hat{k}$ T	1	1
4.	(A) $\frac{\mu_0}{4\pi} x \frac{2M}{r^3}$	1	1
5.	(B) Z to Y and then Y to Z	1	1
6.	(C) 	1	1
7.	(D) 6750	1	1
8.	(A) conservative and field lines do not form closed loops	1	1
9.	(A) 1.6 x 10^8 ms^{-1}	1	1
10.	(C) Lyman series	1	1
11.	(D) 5	1	1
12.	(A) resistor / (C) capacitor	1	1
13.	(A) If both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).	1	1
14.	(C) If Assertion (A) is true and Reason (R) is false.	1	1
15.	(C) If Assertion (A) is true and Reason (R) is false.	1	1
16.	(B) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A).	1	1

	SECTION B		
17.	(a) Finding current 2 $R_1 = \frac{\rho l_1}{A}$; $R_2 = \frac{\rho l_2}{A}$ $\frac{l_1}{l_2} = \frac{2}{3} \Rightarrow \frac{R_1}{R_2} = \frac{2}{3}$ $I \alpha \frac{1}{R}$ $\Rightarrow \frac{I_1}{I_2} = \frac{3}{2}$ $\Rightarrow I_1 = \frac{3}{5} \times 15 = 9A$ $\Rightarrow I_2 = \frac{2}{5} \times 15 = 6A$	½ ½ ½ ½	
	OR (b) Finding the potential difference (i) between P and Q 1 (ii) across capacitor C 1 In steady state, $2V - V = i(2R+R)$ $i = \frac{V}{3R}$ (i) $V_P - V_Q = -V - iR$ $= -V - \frac{V}{3}$ $V_P - V_Q = -\frac{4V}{3}$ (ii) $V_P - V_Q = -V + V_C$ $-\frac{4V}{3} = -V + V_C$ $V_C = -\frac{V}{3}$	1 1	2

18.	Finding the relation 2		
	Phase difference for 6th dark fringe = 11π	½	
	Phase difference for 8th bright fringe = 16π	½	
	$\Delta\phi + \phi_6 = \phi_8$	½	
	$2\pi(\text{n-1})\frac{t}{\lambda} + 11\pi = 16\pi$		
	$t = \frac{5\lambda}{2(\text{n-1})}$	½	
	Alternatively: -		
	Path difference for 6th dark fringe (x_6) = $\frac{11\lambda}{2}$	½	
	Path difference for 8th bright fringe(x_8) = 8λ	½	
	Increase in path difference after introducing the sheet (Δx)		
	$= \frac{\lambda}{2\pi} \text{ x } 2\pi(\text{n-1})\frac{t}{\lambda} = (\text{n-1})t$		
	$\therefore x_6 + \Delta x = x_8$	½	
	$\frac{11\lambda}{2} + (n-1)\,t = 8\lambda$		
	On solving:-		
	$t = \frac{5\lambda}{2(n-1)}$	½	
			2

<table>
<tr><td>19.</td><td>

Finding the position and nature of the final image 1½ + ½

For the first lens: -

$\frac{1}{v_1} - \frac{1}{u_1} = \frac{1}{f_1}$

$\frac{1}{v_1} + \frac{1}{4} = -\frac{1}{8}$

$v_1 = -\frac{8}{3}cm$

For the second lens: -

$u_2 = -16 - \frac{8}{3} = -\frac{56}{3}cm$

$\frac{1}{v_2} - \left(-\frac{3}{56}\right) = -\frac{1}{8}$

$v_2 = -5.6cm$

Image is virtual.

</td><td>

½

½

½

½

</td><td>2</td></tr>
<tr><td>20.</td><td>

Calculating Speed 2

$h\nu = \phi_o + K_{max}$

$\frac{hc}{\lambda} = \phi_0 + \frac{1}{2}mv^2_{max}$

$\frac{6.63x10^{-34}x\ 3x10^8}{4x10^{-7}} = 3x10^{-19} + \frac{1}{2}mv^2_{max}$

$\frac{19.89}{4}x10^{-19} = 3x10^{-19} + \frac{1}{2}mv^2_{max}$

$\frac{4x10^{-19}}{9x10^{-31}} = v^2_{max}$

$v_{max} = \frac{2}{3}x10^6 m/s$

</td><td>

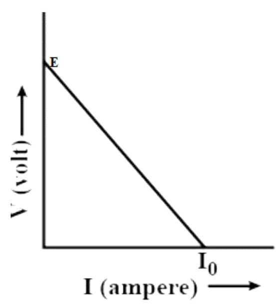
½

½

½

½

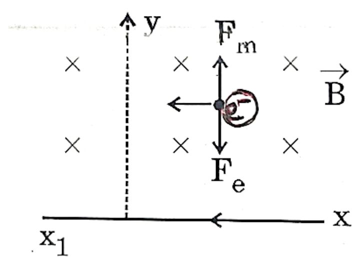
</td><td>2</td></tr>
</table>

21.	Finding the value of V. 2		
	$V - V_o = IR$	½	
	$V - 0.7 = (15x10^{-3}) \times 1000$	1	
	$V = 15.7$ volt	½	2
	SECTION C		
22.	(a) Obtaining the relationship between V, E, R and r 1 (b) Graph showing variation of V as a function of I 1 Determining EMF and internal resistance from graph ½ + ½		
	(a) Current drawn from the cell $(I) = \frac{E}{r+R}$	½	
	Potential difference (V)=IR $V = \frac{ER}{r+R}$	½	
	(b) 	1	
	Slope of the graph is equal to internal resistance of the cell.	½	
	The intercept on Y-axis gives the emf of the cell.	½	3

23. (a)

(i) Diagram showing direction of electric and magnetic fields	1
(ii) Naming forces acting on the charged particle	1
(iii) Finding the value of υ_0	1

(i)



1

(ii) Electric force ½

Magnetic force ½

Alternatively: -

$F_E = eE$

$F_B = evB$

½

(iii) $ev_oB = eE$

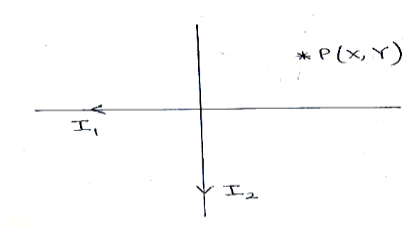
$$v_o \text{ x } \left[\frac{\mu_o I}{2\pi d}\right] = E$$

$$v_o = \frac{(2\pi d)E}{\mu_o I}$$ ½

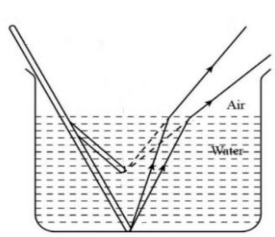
OR

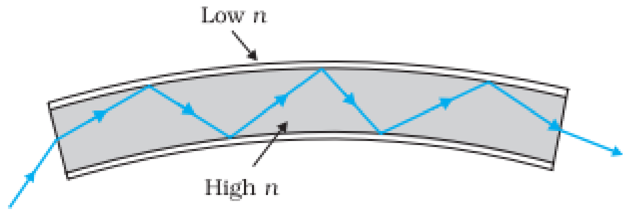
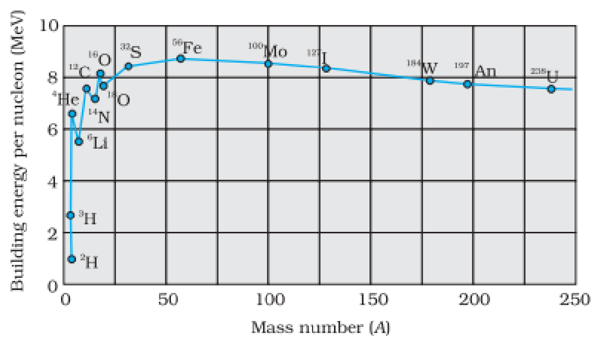
(b)

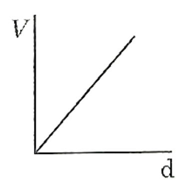
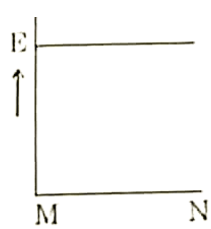
Finding the magnitude and direction of the net magnetic field	2+1



	Magnetic field due to conductor carrying current I_1 $(\vec{B}_1)=\frac{\mu_0 I_1}{2\pi Y}(-\hat{k})$ Magnetic field due to conductor Carrying current I_2 $(\vec{B}_2)=\frac{\mu_0 I_2}{2\pi X}(\hat{k})$ $\vec{B}_P = \vec{B}_1 + \vec{B}_2$ $\vec{B}_P = \frac{\mu_0}{2\pi}\left[\frac{I_2}{X} - \frac{I_1}{Y}\right]\hat{k}$ Direction will be along the Z-axis.	½ ½ 1 1	3
24.	(a) Statement of Lenz's law ½ (b) (i) Identifying the machine ½ (ii) Naming parts P and Q and R ½ (iii) Giving polarities ½ (iv) Two ways of increasing output voltage ½ +½ (a) Lenz's law- The polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it. (b) (i) AC generator (ii) P – Slip rings Q – Carbon brushes R- Armature coil (iii) Left side of the magnet is North & right side is South or vice-versa. (iv) (Any two) -By increasing the number of turns in the armature coil. -By increasing the speed of rotation of the armature coil. -By increasing the strength of the magnetic field B.	 ½ ½ ½ ½ ½ + ½	3

25.	(a) Describing the direction of magnetic field 1 (b) To state whether wavelength of radiowaves & microwaves is greater or lesser than visible light 1 (c) Use of: (i) Infrared waves ½ (ii) Gamma rays ½ (a) Magnetic field oscillates in the east-west direction as it is mutually perpendicular to the direction of electric field. (b) Wavelength of the radiowaves and microwaves is longer than visible light. (c) (i) Use of infrared waves: - (Any one) - Used for physical therapy. - Used for maintaining average temperature of the earth. - Used in Earth satellites for military purposes & to observe growth of crops. - Used in remote control (ii)Use of Gamma rays: - (Any one) - Used in treatment of cancer. - Used in diagnostic imaging. - Used to sterilize medical equipment	 1 1 ½ ½	 3
26.	(a) Effect on the width of the beam 1 (b) Ray diagram 1 (c) Diagram showing transmission 1 (a) Width of the parallel beam of light increases in water. **<u>Alternatively</u>**: - If a student explains using diagram, full credit to be given. (b) Due to refraction of light, the image of the portion immersed in water appears to be raised.  	 1 1	

	(c) 	1	3
27.	(a) Showing variation of binding energy per nucleon with mass number — 1 Significance of binding curve — ½ (b) (i) Stating the type of reaction — ½ (ii) To state whether total mass of nuclei increases, decreases or remains unchanged — ½ (iii) Stating whether process requires energy or produces energy — ½ (a)  **Note**: - Full credit to be given even if the values are not shown. Significance of the binding energy curve – (Any one) - Why lighter nuclei undergo fusion and heavier nuclei undergo fission. - Nuclear forces are short ranged. - Energy is released in both nuclear fission and nuclear fusion. (b) (i) Nuclear fusion (ii) Decreases (iii) Energy is produced	1 ½ ½ ½ ½	3

28.	(a) Defining majority and minority charge carries in an extrinsic semiconductor ½+½ (b) Describing movement of the charge carriers when pn-junction diode is forward biased 1 (c) Estimating Dynamic resistance 1 (a) In an extrinsic semiconductor, the charge carriers whose number density is large are known as majority charge carriers. In an extrinsic semiconductor, the charge carriers whose number density is small are known as minority charge carriers. (b) Due to the applied forward voltage, electrons from n-side cross the depletion region and reach p-side. Similarly, holes from p-side cross the junction and reach the n-side. Due to the movement of these charge carriers current is produced. (c) At V = -0.6 volt, I = 0, so dynamic resistance is infinite.	½+½ 1 1	3
	SECTION D		
29.	(i) (C) $\frac{E}{4}$ (ii) (D)  (iii) (C)  (iv) (A) $(\vec{E}_1+\vec{E}_2).\vec{d}$ OR (C) CK	1 1 1 1	4

30.	(i) (B) are parallel to each other. (ii) (C) me (iii) Full 1 mark to be awarded to all the students who have attempted this part of the question. OR (B) $\frac{1}{2}, \frac{1}{2}$ (iv) (D) 13.3 μm	1 1 1 1	4
	SECTION E		
31.	(a) (i) Calculating final potential - on sphere A 1 - on shell B 1 (ii) Two characteristics of of equipotential surface ½+½ Finding potential at (4m,3m) 2 (i) Potential on sphere A = V = $\frac{Q}{4\pi\varepsilon_o r}$ Charge on sphere A = $4\pi\varepsilon_0 r$ V The charge is transferred to shell B. Potential on shell B = $\frac{1}{4\pi\varepsilon_0}$ x $\frac{4\pi\varepsilon_0 rV}{R}$ Potential on shell B = $\frac{rV}{R}$ Potential on sphere A = Potential on shell B (ii) Characteristics of equipotential surfaces: - (Any two) - Potential at all points on the surface is same. - Equipotential surface is normal to the direction of the electric field. - The work done in moving a charge on an equipotential surface is zero.	½ ½ 1 ½+½	

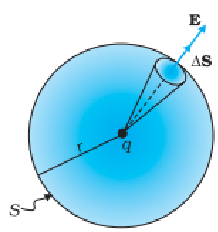
$V_0 - V = E\,d = 50 \times 4$ ½
$V_0 - V = 200$ V ½
$V = 220$ V – 200 V ½
$V = 20$ V ½

OR

(b)

(i) Difference between an open surface and a closed surface	½
Diagram of elementary surface vector $\overrightarrow{ds}$	1
(ii) Definition of electric flux	1
Significance of Gaussian Surface	½
Reason	½
(iii) Finding charge Q	1½

(i) Open Surface – A surface which does not enclose a volume. ½
Closed Surface – A surface which does enclose a volume.



1

(ii) Electric flux is defined as the number of electric field lines crossing an area normally. 1

<u>Alternatively</u>-

$\phi = \vec{E}.\vec{A}$

<u>Alternatively</u>-

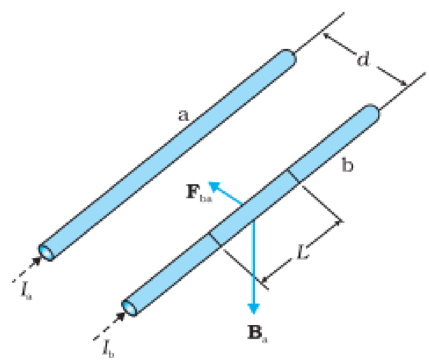
$\phi = EA\cos\theta$

<u>Significance of Gaussian Surface: -</u>

It helps in finding the electric field in a simpler way. ½

<u>Reason: -</u>

Because any electric field line from the charge which enters the surface at one point will exit at another, resulting in a net zero flux. ½

	(iii) Total charge enclosed by $S_1 = (-3-2+9)\,\mu C = 4\,\mu C$ Total charge enclosed by $S_2 = Q + 4\,\mu C$ $\phi_{s_2} = 4\phi_{s_1}$ $\frac{Q + 4\mu C}{\varepsilon_O} = 4\left(\frac{4\mu C}{\varepsilon_O}\right)$ $Q = 12\,\mu C$	½ ½ ½	5
32.	(a) (i) Source of force ½ Obtaining expression for force 1½ Definition of 'ampere' 1 (ii) Finding work done by the magnetic force 1 (iii) Necessary conditions 1 <u>Reason</u> – (i) The source of force is the interaction between the field produced by the current carrying conductor and the external field in which it is placed.  Two long parallel conductors a & b, separated by a distance d, carrying currents I_a and I_b, respectively. The magnetic field due to a, $B_a = \frac{\mu_0 I_a}{2\pi d}$ The force F_{ba}, is the force on a segment L of 'b' due to 'a'. $F_{ba} = I_b L B_a$ $= \frac{\mu_0 I_a I_b}{2\pi d} L$ Definition – The 'ampere' is that value of steady current which, when maintained in each of the two very long, straight, parallel conductors of negligible cross-section, and	 ½ ½ 1 1	

placed one metre apart in vacuum, would produce on each of these conductors a force equal to 2×10^{-7} newton per metre of length.

(ii) Work done by the magnetic force on the charge is zero as force is perpendicular to $\vec{v}$. 1

(iii) The velocity ($\vec{v}$) is at an arbitrary angle θ w.r.t the magnetic field ($\vec{B}$). 1

OR

(b)

(i) Explanation	1
(ii) Obtaining relation for $\vec{M}$, and direction of $\vec{M}$.	1+1
(iii) Net force on coil	1
Obtaining orientation	½
Showing flux is maximum	½

(i) The two faces of a current carrying loop behave like two poles of a magnet therefore can be considered as a magnetic dipole placed along its axis. 1

(ii) Magnetic moment (M) α Current (I)

α Area (A)

$$\therefore \vec{M} = I\vec{A}$$ 1

Direction is same as the area vector. 1

Alternatively: -

Magnetic moment is perpendicular to the plane of the coil.

(iii) Net force acting on the coil is zero. 1

The potential energy (U_B) of a current carrying loop in an external magnetic field $= -\vec{M}.\vec{B}$

For the coil to be in stable equilibrium U_B should be minimum so $\theta = 0^o$. ½

Therefore, magnetic flux (ϕ) due to the total field $= (B_{coil} + B_{ext})A$, which is its maximum value. ½

Alternatively: -

Orientation of stable equilibrium is one where the area vector A of the loop is in the direction of external magnetic field. In this orientation, the magnetic field produced by the loop is in the same direction as external field, both normal to the plane of the loop, thus giving rise to maximum flux of the total field. 5

33.	(a) (i) Calculating magnification 2½ (ii) Showing emergent ray is normal 1½ Finding refractive index 1 (i) As the pencil lies between f and 2f such that one end of the pencil coincides with 2f. Position of the other end $(u) = -\left(2f - \frac{f}{4}\right) = -\frac{7f}{4}$ Magnification $(m) = \frac{f}{f-u}$ $= \frac{-f}{-f-\left(-\frac{7f}{4}\right)}$ $m = -\frac{4}{3}$ **<u>Alternatively: -</u>** As the pencil lies between f and 2f such that one end of the pencil coincides with 2f. Position of the other end $(u) = -\left(2f - \frac{f}{4}\right) = -\frac{7f}{4}$ $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ $\frac{1}{v} - \frac{4}{7f} = -\frac{1}{f}$ $\frac{1}{v} = -\frac{1}{f} + \frac{4}{7f}$ $v = -\frac{7f}{3}$ $m = -\frac{v}{u} = -\frac{4}{3}$	 ½ ½ ½ 1 ½ ½ ½ 1	

(ii) For prism;

$i + e = A + \delta$ ½

$45^o + e = 30^o + 15^o$ ½

$\therefore e = 0^o$ ½

Hence, $r_2 = 0^o$

$\therefore$ Emergent ray is perpendicular to face AC.

<u>Alternatively</u>: - If the same is shown using diagram full credit to be given.

$r_1 + r_2 = A$

As $r_2 = 0$, hence $r_1 = 30^o$ ½

Refractive index(n) = $\frac{\sin i}{\sin r}$

$= \frac{\sin 45^o}{\sin 30^o}$

$n = \sqrt{2}$ ½

OR

(b)

(i) (1) Calculating distance of the third bright fringe from central maximum	1
(2) Finding the least distance	1
(ii) (1) Diagram showing variation of intensity with angle of diffraction	1
Writing expression for value of angle corresponding to zero intensity	1
(2) Difference between diffraction of light and sound waves	1

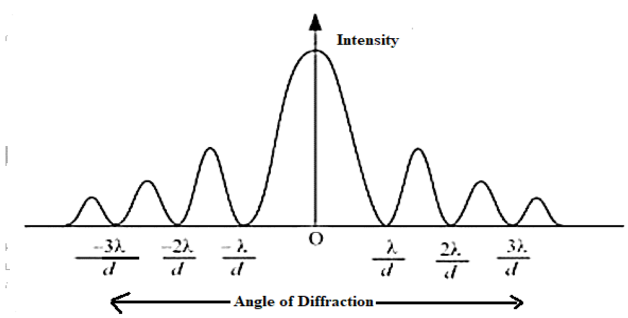
(i)

(1) Distance of the nth bright fringe from the central maximum(x_n) = $\frac{n\lambda D}{d}$ ½

For n = 3

$x_3 = \frac{3 x 600 x 10^{-9} x 1}{1 x 10^{-9}}$

$= 1800 m$ ½

	(2) $n_1\lambda_1 = n_2\lambda_2$ $n_1 x\ 600 = n_2\ x\ 480$ $\frac{n_1}{n_2} = \frac{480}{600}$ $\frac{n_1}{n_2} = \frac{4}{5}$	½	
	Position of the 4^{th} bright fringe of 600 nm = 4 x 600 = 2400 m	½	
	<u>Alternatively</u>: - Position of the 5^{th} bright fringe of 480 nm = 5 x 480 = 2400 m		
	<u>Alternatively</u>: - $(n\text{-}1)\lambda_1 = n\lambda_2$ (n-1) x 600 = n x 450 on solving n = 4	½	
	Position of the 4^{th} bright fringe of 600 nm = 4 x 600 = 2400 m Position of the 5^{th} bright fringe of 480 nm = 5 x 480 = 2400 m	½	
	(ii) (1) 	1	
	Angle of diffraction for zero intensity, $\theta = \frac{n\lambda}{a}$; n = 0, 1, 2, ………..	1	
	(2) Diffraction of the light waves is not generally seen as compared to diffraction of sound waves as light waves have low wavelength.	1	5

General Instructions :

Read the following instructions carefully and follow them :

(i) *This question paper contains **33** questions. **All** questions are **compulsory**.*

(ii) *This question paper is divided into **five** sections – **Sections A, B, C, D** and **E**.*

(iii) *In **Section A** – Questions no. **1** to **16** are Multiple Choice type questions. Each question carries **1** mark.*

(iv) *In **Section B** – Questions no. **17** to **21** are Very Short Answer type questions. Each question carries **2** marks.*

(v) *In **Section C** – Questions no. **22** to **28** are Short Answer type questions. Each question carries **3** marks.*

(vi) *In **Section D** – Questions no. **29** and **30** are case study-based questions. Each question carries **4** marks.*

(vii) *In **Section E** – Questions no. **31** to **33** are Long Answer type questions. Each question carries **5** marks.*

(viii) *There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.*

(ix) *Kindly note that there is a separate question paper for Visually Impaired candidates.*

(x) *Use of calculators is **not** allowed.*

You may use the following values of physical constants wherever necessary :

$c = 3 \times 10^8$ m/s

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8{\cdot}854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

Mass of electron (m_e) = $9{\cdot}1 \times 10^{-31}$ kg

Mass of neutron = $1{\cdot}675 \times 10^{-27}$ kg

Mass of proton = $1{\cdot}673 \times 10^{-27}$ kg

Avogadro's number = $6{\cdot}023 \times 10^{23}$ per gram mole

Boltzmann constant = $1{\cdot}38 \times 10^{-23}$ JK^{-1}

SECTION A

1. A body acquires charge $8{\cdot}0 \times 10^{-12}$ C. The mass of the body :

(A) increases by $4{\cdot}5 \times 10^{-7}$ kg

(B) decreases by $1{\cdot}0 \times 10^{-6}$ kg

(C) decreases by $4{\cdot}55 \times 10^{-23}$ kg

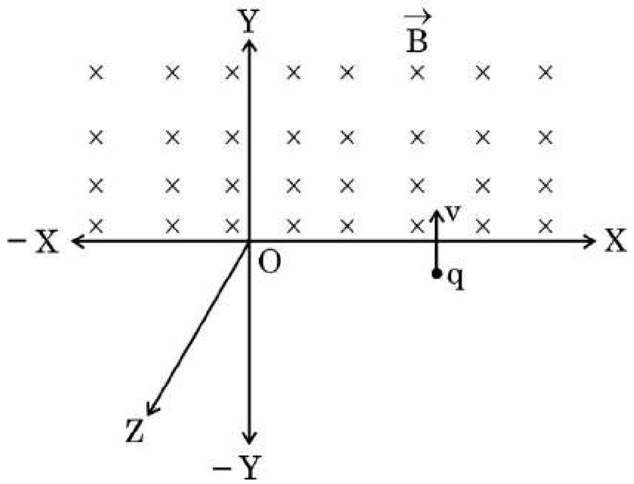
(D) increases by $9{\cdot}1 \times 10^{-23}$ kg

2. A current flows through a cylindrical conductor of radius R. The current density at a point in the conductor is $j = \alpha r$ (along its axis), here α is a constant and r is distance from the axis of the conductor. The current flowing through the portion of the conductor from $r = 0$ to $r = \frac{R}{2}$ is proportional to :

(A) R | (B) R^2

(C) R^3 | (D) R^4

3. A particle having charge +q enters a uniform magnetic field $\vec{B}$ as shown in the figure. The particle will describe :



(A) a circular path in XZ plane

(B) a semicircular path in XY plane

(C) a helical path with its axis parallel to Y-axis

(D) a semicircular path in YZ plane

4. A bar magnet is initially at right angles to a uniform magnetic field. The magnet is rotated till the torque acting on it becomes one-half of its initial value. The angle through which the bar magnet is rotated is :

(A) 30° (B) 45°

(C) 60° (D) 75°

5. Which one out of the following materials is ***not*** paramagnetic ?

(A) Aluminium

(B) Sodium Chloride

(C) Calcium

(D) Copper Chloride

6. An ammeter connected in series in an ac circuit reads 10 A. The maximum value of current at any instant in the circuit is :

(A) $10\sqrt{2}$ A (B) $\frac{10}{\sqrt{2}}$ A

(C) $\frac{10}{\pi}$ A (D) $\frac{10}{\sqrt{2}\,\pi}$ A

7. The amplitude of electric field in an electromagnetic wave in free space is 1000 Vm^{-1}. The amplitude of the magnetic field in this electromagnetic wave is :

(A) $3{\cdot}0 \times 10^{-3}$ T

(B) $3{\cdot}33 \times 10^{-8}$ T

(C) $3{\cdot}0 \times 10^{11}$ T

(D) $3{\cdot}33 \times 10^{-6}$ T

8. The magnification produced by a spherical mirror is – 2·0. The mirror used and the nature of the image formed will be

(A) Convex and virtual

(B) Concave and real

(C) Concave and virtual

(D) Convex and real

9. Choose the correct statement :

(A) Photons of light show diffraction whereas electrons do not show diffraction.

(B) Electrons have momentum whereas photons do not have momentum.

(C) Photons of light and electrons both exhibit dual nature.

(D) All electromagnetic radiations do not have photons.

10. A beam of red light and a beam of blue light have equal intensities. Which of the following statements is true ?

(A) The blue beam has more number of photons than the red beam.

(B) The red beam has more number of photons than the blue beam.

(C) Wavelength of red light is lesser than wavelength of blue light.

(D) The blue light beam has lesser energy per photon than that in the red light beam.

11. Which of the following is an electrical conductor at room temperature ?

(A) Sn

(B) Mica

(C) Si

(D) C

12. A long straight wire is held vertically and carries a steady current in upward direction. The shape of magnetic field lines produced by the current-carrying wire are :

(A) horizontal straight lines directed radially out from the wire.

(B) straight lines parallel to the current-carrying wire.

(C) concentric horizonal circles around the wire.

(D) coaxial helixes around the wire.

*Questions number **13** to **16** are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below.*

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is ***not*** the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Both Assertion (A) and Reason (R) are false.

13. *Assertion (A) :* n-type semiconductor is not negatively charged.

Reason (R) : Neutral pentavalent impurity atom doped in intrinsic semiconductor (neutral) donates its fifth unpaired electron to the crystal lattice and becomes a positive donor.

14. *Assertion (A) :* A series LCR circuit behaves as a pure resistive circuit at resonance.

Reason (R) : At resonance, $X_L = X_C$ gives $\omega = \frac{1}{\sqrt{LC}}$.

15. *Assertion (A) :* In double slit experiment if one slit is closed, diffraction pattern due to the other slit will appear on the screen.

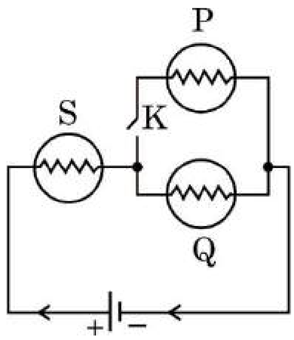
Reason (R) : For interference, at least two waves are required.

16. *Assertion (A) :* For monochromatic incident radiation, the emitted photoelectrons from a given metal have speed ranging from zero to a certain maximum value.

Reason (R) : Each metal has a definite work function.

SECTION B

17. (a) In the given figure, three identical bulbs P, Q and S are connected to a battery.



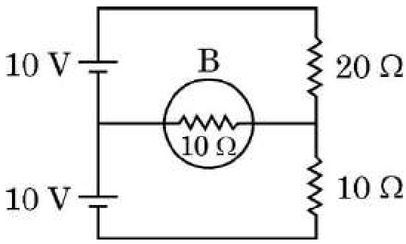
(i) Compare the brightness of bulbs P and Q with that of bulb S when key K is closed.

(ii) Compare the brightness of the bulbs S and Q when the key K is opened.

Justify your answer in both cases. *2*

OR

(b) Two cells of emf 10 V each, two resistors of 20 Ω and 10 Ω and a bulb B of 10 Ω resistance are connected together as shown in the figure. Find the current that flows through the bulb. *2*



18. Find the angle of diffraction (in degrees) for first secondary maximum of the pattern due to diffraction at a single slit. The width of the slit and wavelength of light used are 0·55 mm and 550 nm, respectively. *2*

19. An equiconvex lens is made of glass of refractive index 1·55. If the focal length of the lens is 15·0 cm, calculate the radius of curvature of its surfaces. *2*

20. Calculate the mass of an α-particle in atomic mass unit (u). Given,

Mass of a normal helium atom = 4·002603 u

Mass of carbon atom = $1{\cdot}9926 \times 10^{-26}$ kg *2*

21. In an intrinsic semiconductor, carrier's concentration is $5 \times 10^8\ m^{-3}$. On doping with impurity atoms, the hole concentration becomes $8 \times 10^{12}\ m^{-3}$.

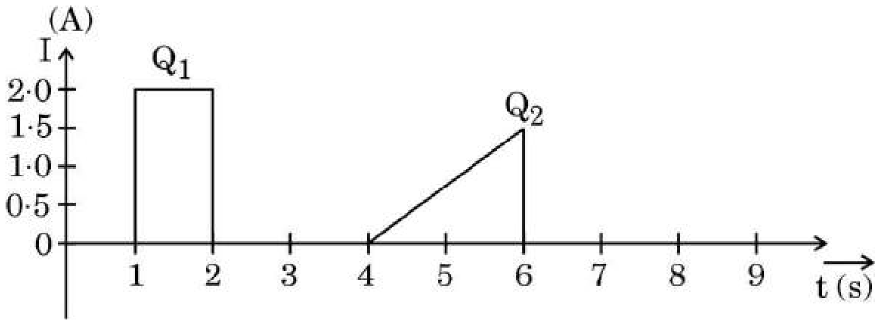
(a) Identify (i) the type of dopant and (ii) the extrinsic semiconductor so formed.

(b) Calculate the electron concentration in the extrinsic semiconductor. *2*

SECTION C

22. (a) (i) Derive an expression for the resistivity of a conductor in terms of number density of free electrons and relaxation time.

(ii) The figure shows the plot of current through a cross-section of wire over two different time intervals. Compare the charges (Q_1 and Q_2) that pass through the cross-section during these time intervals. *3*



OR

(b) (i) A battery of emf E and internal resistance r is connected to a variable external resistance R.

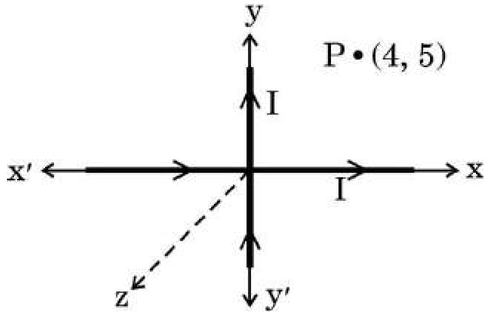
(I) Obtain the expression for current I in the circuit and the value of maximum current the battery can supply.

(II) Obtain the terminal voltage V across the battery and its maximum possible value.

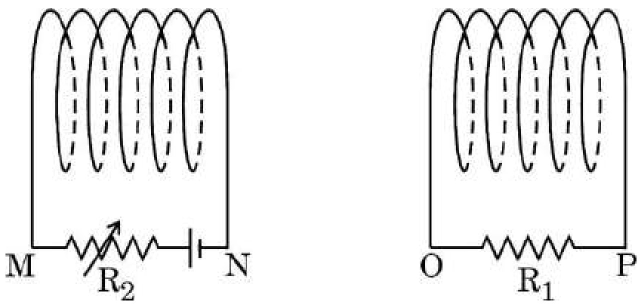
(ii) The above battery sends a current I_1 when $R = R_1$ and a current I_2 when $R = R_2$. Obtain the internal resistance of the battery in terms of I_1, I_2, R_1 and R_2. *3*

23. (a) Write vector form of Biot-Savart law.

(b) Two insulated long straight wires, each carrying 2·0 A current are kept along xx' and yy' axis as shown in the figure. Find the magnitude and direction of resultant magnetic field at point P (4m, 5m). *3*



24. Two coils '1' and '2' are placed close to each other as shown in the figure. Find the direction of induced current in coil '1' in each of the following situations, justifying your answers : *3*



(a) Coil '2' is moving towards coil '1'.

(b) Coil '2' is moving away from coil '1'.

(c) The resistance connected with coil '2' is increased keeping both the coils stationary.

25. (a) State any three characteristics of electromagnetic waves.

(b) Briefly explain how and where the displacement current exists during the charging of a capacitor. *3*

26. A double slit set-up was initially placed in a tank filled with water and the interference pattern was obtained using a laser light. When water is replaced by a transparent liquid of refractive index $n > n_{water}$, what will be the effect on the following ? *3*

(a) Speed, frequency and wavelength of the light of laser beam.

(b) The fringe width, shape of interference fringes and shift in the position of central maximum.

27. Explain the following observations using Einstein's photoelectric equation : *3*

(a) Photoelectric emission does not occur from a surface when the frequency of the light incident on it is less than a certain minimum value.

(b) It is the frequency, and not the intensity of the incident light which affects the maximum kinetic energy of the photoelectrons.

(c) The cut-off voltage (V_0) versus frequency (ν) of the incident light curve is a straight line with a slope $\frac{h}{e}$.

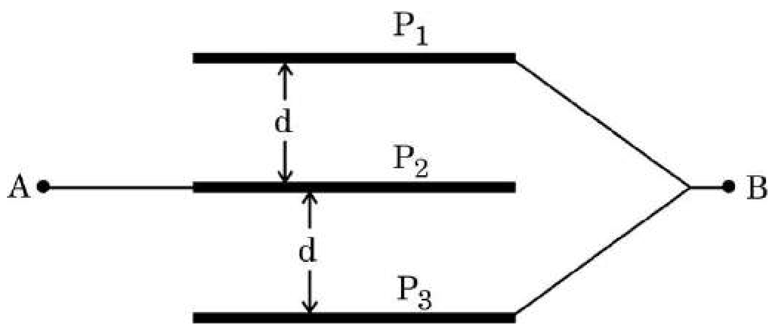
28. (a) What are majority and minority charge carriers of p-type and n-type semiconductors ?

(b) Explain briefly the formation of diffusion current and drift current in a p-n junction diode. *3*

SECTION D

*Questions number **29** and **30** are Case Study-based questions. Read the following paragraphs and answer the questions that follow.*

29. A parallel plate capacitor consists of two conducting plates kept generally parallel to each other at a distance. When the capacitor is charged, the charge resides on the inner surfaces of the plates and an electric field is set up between them. Thus, electrostatic energy is stored in the capacitor. The figure shows three large square metallic plates, each of side 'L' held parallel and equidistant from each other. The space between P_1 and P_2 and P_2 and P_3 is completely filled with mica sheets of dielectric constant 'K'. The plate P_2 is connected to point A and other plates P_1 and P_3 are connected to point B. Point A is maintained at a positive potential with respect to point B and the potential difference between A and B is V.



(i) The capacitance of the system between A and B will be : *1*

(A) $\frac{\varepsilon_0 KL^2}{d}$ (B) $\frac{\varepsilon_0 KL^2}{2d}$

(C) $\frac{2\varepsilon_0 KL^2}{d}$ (D) $\frac{2\varepsilon_0 Kd}{L^2}$

(ii) The charge on plate P_1 is : *1*

(A) $\frac{\varepsilon_0 VKL^2}{2d}$ (B) $\frac{\varepsilon_0 VKL^2}{d}$

(C) $\frac{2\varepsilon_0 VKL^2}{d}$ (D) $\frac{\varepsilon_0 VKL^2}{4d}$

(iii) The electric field in the region between P_1 and P_2 is : *1*

(A) $\frac{V}{d}$ (B) $\frac{2V}{d}$

(C) $\frac{V}{2d}$ (D) $\frac{d}{V}$

(iv) (a) The separation between the plates of same area (L^2) of a parallel plate air capacitor having capacitance equal to that of this system, will be : *1*

(A) $\frac{d}{K}$ (B) $\frac{2d}{K}$

(C) $\frac{d}{2K}$ (D) $\frac{d}{4K}$

OR

(b) If the source of potential difference applied between A and B is removed, and then A and B are connected by a conducting wire, the net charge on the system will be : *1*

(A) $\frac{\varepsilon_0 VKL^2}{4d}$ (B) $\frac{\varepsilon_0 VKL^2}{2d}$

(C) $\frac{\varepsilon_0 VKL^2}{d}$ (D) Zero

30. A hydrogen atom consists of an electron revolving in a circular orbit of radius r with certain velocity v around a proton located at the nucleus of the atom. The electrostatic force of attraction between the revolving electron and the proton provides the requisite centripetal force to keep it in the orbit. According to Bohr's model, an electron can revolve only in certain stable orbits. The angular momentum of the electron in these orbits is some integral multiple of $\frac{h}{2\pi}$, where h is the Planck's constant.

Further, when an electron makes a transition from one orbit of higher energy to that of lower energy, a photon is emitted having energy equal to the difference between energies of the initial and final states. Assuming the mass and charge of an electron as m and e respectively, answer the following questions.

(i) The expression for the speed of electron v in terms of radius of the orbit (r) and physical constant ($K = \frac{1}{4\pi\varepsilon_0}$) is : *1*

(A) $\frac{Ke^2}{mr}$ (B) $\frac{Ke^2}{mr^2}$

(C) $\sqrt{\frac{Ke^2}{mr}}$ (D) $\sqrt{\frac{Ke^2}{mr^2}}$

(ii) The total energy of the atom in terms of r and physical constant K is : *1*

(A) $\frac{Ke^2}{r}$ (B) $-\frac{Ke^2}{2r}$

(C) $\frac{Ke^2}{2r}$ (D) $\frac{3}{2}\frac{Ke^2}{r}$

(iii) A photon of wavelength 500 nm is emitted when an electron makes a transition from one state to the other state in an atom. The change in the total energy of the electron and change in its kinetic energy in eV as per Bohr's model, respectively will be : *1*

(A) 2·48, – 2·48 (B) – 1·24, 1·24

(C) – 2·48, 2·48 (D) 1·24, – 1·24

(iv) (a) In Bohr's model of hydrogen atom, the frequency of revolution of electron in its n^{th} orbit is proportional to : *1*

(A) n

(B) $\frac{1}{n}$

(C) $\frac{1}{n^2}$

(D) $\frac{1}{n^3}$

OR

(b) An electron makes a transition from $-3{\cdot}4$ eV state to the ground state in hydrogen atom. Its radius of orbit changes by : (radius of orbit of electron in ground state = $0{\cdot}53$ Å) *1*

(A) 0·53 Å

(B) 1·06 Å

(C) 1·59 Å

(D) 2·12 Å

SECTION E

31. (a) (i) Two point charges + q and – q are held at (a, 0) and (– a, 0) in x-y plane. Obtain an expression for the net electric field due to the charges at a point (0, y). Hence, find electric field at a far off point (y >> a).

(ii) Three point charges of – 2 nC, – 1 nC, and + 5 nC are kept at the vertices A, B and C of an equilateral triangle of side 0·2 m. Find the total amount of work done in shifting the charges from A to A_1, B to B_1 and C to C_1. Here A_1, B_1 and C_1 are the midpoints of sides AB, BC and CA, respectively. *5*

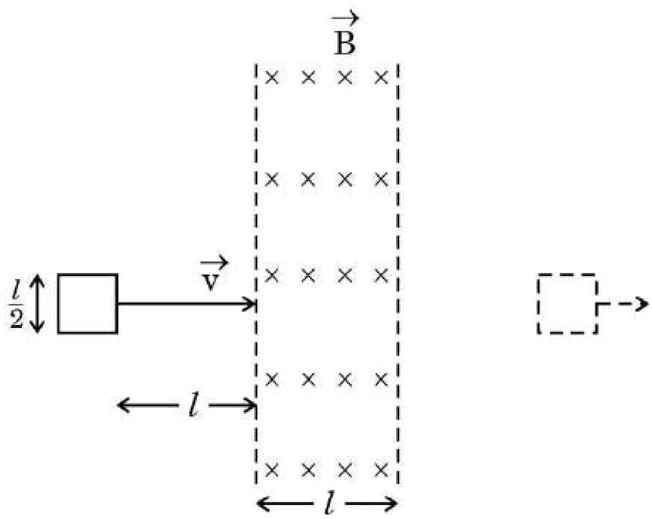
OR

(b) (i) Show that Gauss's theorem is consistent with Coulomb's law. Using it, derive an expression for the electric field due to a uniformly charged thin spherical shell of radius r at a point at a distance y from the centre of the shell such that (I) $y > r$, and (II) $y < r$.

(ii) A point charge of $+ 2$ nC is kept at the origin of a three-dimensional coordinate system. Find the type and magnitude of the charge which should be kept at (0, 0, – 6m) so that the potential due to the system becomes zero at (0, 0, 2m). *5*

32. (a) (i) State Lenz's law and explain how this law is a consequence of conservation of energy principle.

(ii) A square shaped loop of side $\frac{l}{2}$ is initially lying outside a region of uniform magnetic field $\vec{B}$ as shown in the figure. The loop is moved towards right with a constant velocity $\vec{v}$ till it goes out of the region of magnetic field.



(I) What will be the directions of induced current when the loop enters the field and when it leaves the field ?

(II) Draw the plots showing the variation of magnetic flux ϕ linked with the loop with time t and variation of induced emf E with time t. Mark the relevant values of E, ϕ and t on the graphs. *5*

OR

(b) (i) Differentiate between peak and rms values of alternating current. How are they related ?

(ii) A current element X is connected across an ac source of emf $V = V_0 \sin 2\pi\nu t$. It is found that the voltage leads the current in phase by $\frac{\pi}{2}$ radian. If element X was replaced by element Y, the voltage lags behind the current in phase by $\frac{\pi}{2}$ radian.

(I) Identify elements X and Y by drawing phasor diagrams.

(II) Obtain the condition of resonance when both elements X and Y are connected in series to the source and obtain expression for resonant frequency. What is the impedance value in this case ? *5*

33. (a) (i) An object is placed 30 cm from a thin convex lens of focal length 10 cm. The lens forms a sharp image on a screen. If a thin concave lens is placed in contact with the convex lens, the sharp image on the screen is formed when the screen is moved by 45 cm from its initial position. Calculate the focal length of the concave lens.

(ii) Calculate the angle of minimum deviation of an equilateral prism. The refractive index of the prism is $\sqrt{3}$. Calculate the angle of incidence for this case of minimum deviation also. *5*

OR

(b) (i) A physics teacher wants to demonstrate interference with the help of double slit experiment using a laser beam of 633 nm wavelength. Since the hall is large enough, interference pattern is formed on the wall 5·0 m from the slits. For clear and comfortable view by all the students they want the fringe width 5 mm.

(I) Find the slit separation for obtaining the desired interference pattern.

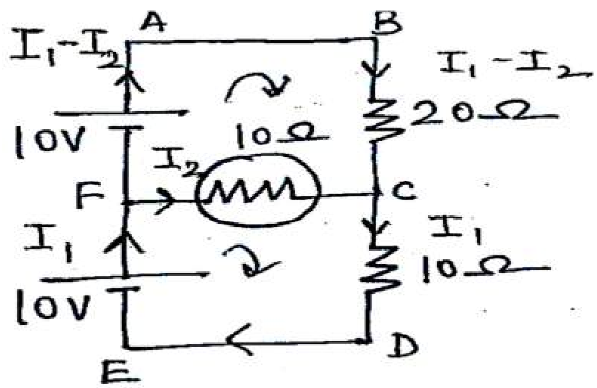
(II) How far will the first minimum be from the central maximum ?

(ii) A parallel beam of light of wavelength 650 nm passes through a slit of width 0·6 mm. The diffraction pattern is obtained on a screen kept 60 cm away from the slit. Find the distance between first order minima on both sides of the central maximum. *5*

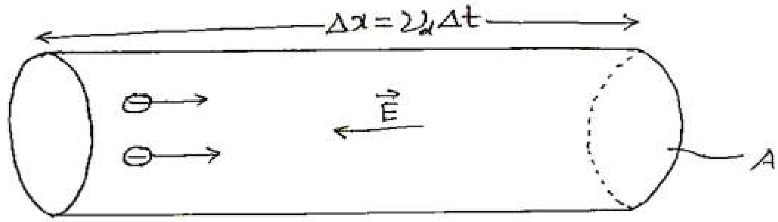
Marking Scheme Strictly Confidential (For Internal and Restricted use only) Senior School Certificate Examination, 2025 SUBJECT NAME PHYSICS (PAPER CODE 55/4/1)	
General Instructions: -	
1	You are aware that evaluation is the most important process in the actual and correct assessment of the candidates. A small mistake in evaluation may lead to serious problems which may affect the future of the candidates, education system and teaching profession. To avoid mistakes, it is requested that before starting evaluation, you must read and understand the spot evaluation guidelines carefully.
2	**"Evaluation policy is a confidential policy as it is related to the confidentiality of the examinations conducted, Evaluation done and several other aspects. Its' leakage to public in any manner could lead to derailment of the examination system and affect the life and future of millions of candidates. Sharing this policy/document to anyone, publishing in any magazine and printing in News Paper/Website etc may invite action under various rules of the Board and IPC."**
3	Evaluation is to be done as per instructions provided in the Marking Scheme. It should not be done according to one's own interpretation or any other consideration. Marking Scheme should be strictly adhered to and religiously followed. **However, while evaluating, answers which are based on latest information or knowledge and/or are innovative, they may be assessed for their correctness otherwise and due marks be awarded to them. In class-X, while evaluating two competency-based questions, please try to understand given answer and even if reply is not from marking scheme but correct competency is enumerated by the candidate, due marks should be awarded.**
4	The Marking scheme carries only suggested value points for the answers These are in the nature of Guidelines only and do not constitute the complete answer. The students can have their own expression and if the expression is correct, the due marks should be awarded accordingly.
5	The Head-Examiner must go through the first five answer books evaluated by each evaluator on the first day, to ensure that evaluation has been carried out as per the instructions given in the Marking Scheme. If there is any variation, the same should be zero after delibration and discussion. The remaining answer books meant for evaluation shall be given only after ensuring that there is no significant variation in the marking of individual evaluators.
6	Evaluators will mark(√) wherever answer is correct. For wrong answer CROSS 'X" be marked. Evaluators will not put right (✓) while evaluating which gives an impression that answer is correct and no marks are awarded. **This is most common mistake which evaluators are committing.**
7	If a question has parts, please award marks on the right-hand side for each part. Marks awarded for different parts of the question should then be totaled up and written in the left-hand margin and encircled. This may be followed strictly.
8	If a question does not have any parts, marks must be awarded in the left-hand margin and encircled. This may also be followed strictly.
9	If a student has attempted an extra question, answer of the question deserving more marks should be retained and the other answer scored out with a note **"Extra Question"**.
10	No marks to be deducted for the cumulative effect of an error. It should be penalized only once.
11	A full scale of marks ____70______(example 0 to 80/70/60/50/40/30 marks as given in Question Paper) has to be used. Please do not hesitate to award full marks if the answer

	deserves it.
12	Every examiner has to necessarily do evaluation work for full working hours i.e., 8 hours every day and evaluate 20 answer books per day in main subjects and 25 answer books per day in other subjects (Details are given in Spot Guidelines).This is in view of the reduced syllabus and number of questions in question paper.
13	Ensure that you do not make the following common types of errors committed by the Examiner in the past:- ● Leaving answer or part thereof unassessed in an answer book. ● Giving more marks for an answer than assigned to it. ● Wrong totaling of marks awarded on an answer. ● Wrong transfer of marks from the inside pages of the answer book to the title page. ● Wrong question wise totaling on the title page. ● Wrong totaling of marks of the two columns on the title page. ● Wrong grand total. ● Marks in words and figures not tallying/not same. ● Wrong transfer of marks from the answer book to online award list. ● Answers marked as correct, but marks not awarded. (Ensure that the right tick mark is correctly and clearly indicated. It should merely be a line. Same is with the X for incorrect answer.) ● Half or a part of answer marked correct and the rest as wrong, but no marks awarded.
14	While evaluating the answer books if the answer is found to be totally incorrect, it should be marked as cross (X) and awarded zero (0)Marks.
15	Any un assessed portion, non-carrying over of marks to the title page, or totaling error detected by the candidate shall damage the prestige of all the personnel engaged in the evaluation work as also of the Board. Hence, in order to uphold the prestige of all concerned, it is again reiterated that the instructions be followed meticulously and judiciously.
16	The Examiners should acquaint themselves with the guidelines given in the "**Guidelines for spot Evaluation**" before starting the actual evaluation.
17	Every Examiner shall also ensure that all the answers are evaluated, marks carried over to the title page, correctly totaled and written in figures and words.
18	The candidates are entitled to obtain photocopy of the Answer Book on request on payment of the prescribed processing fee. All Examiners/Additional Head Examiners/Head Examiners are once again reminded that they must ensure that evaluation is carried out strictly as per value points for each answer as given in the Marking Scheme.

MARKING SCHEME: PHYSICS(042)			
Code: 55/4/1			
Q.No.	**VALUE POINTS/EXPECTED ANSWERS**	**Marks**	**Total Marks**
	SECTION A		
1.	**(C)** decreases by 4.55×10^{-23} kg	**1**	**1**
2.	**(C)** R^3	**1**	**1**
3.	**(B)** a semicircular path in XY plane	**1**	**1**
4.	**(C)** 60^0	**1**	**1**
5.	**(B)** Sodium Chloride	**1**	**1**
6.	**(A)** $10\sqrt{2}$A	**1**	**1**
7.	**(D)** 3.33×10^{-6}T	**1**	**1**
8.	**(B)** Concave and real	**1**	**1**
9.	**(C)** Photons of light and electrons both exhibit dual nature	**1**	**1**
10.	**(B)** The red beam has more numbers of photons than the blue beam	**1**	**1**
11.	**(A)** Sn	**1**	**1**
12.	**(C)** Concentric horizontal circles around the wire	**1**	**1**
13.	**(A)** Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A)	**1**	**1**
14.	**(A)** Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A)	**1**	**1**
15.	**(C)** Assertion (A) is true but Reason (R) is false.	**1**	**1**
16.	**(B)** Both Assertion (A) and Reason (R) are true but reason (R) is not the correct explanation of the Assertion (A)	**1**	**1**
	SECTION-B		
17.	(a) (i) Comparison of brightness of bulbs P and Q with bulb S ½ Justification ½ (ii) Comparison of brightness of bulb S with Q ½ Justification ½ (i) Brightness of the bulb 'S' will be more than bulbs 'P' and 'Q' The current flowing through the bulb 'S' is twice of the current in bulbs 'P' and 'Q'. (ii) Brightness of the bulb 'S' and 'Q'will be same The current flowing through both bulbs is same. **Alternatively-** (i) Brightness of the bulb 'S' will be more than bulbs 'P' and 'Q' The potential difference across 'S' is twice than the potential	 ½ ½ ½ ½	

	difference across bulbs ‘P’ and ‘Q’ (ii) Brightness of both bulbs ‘S’ and ‘Q’ is same. The potential difference across ‘S’ and ‘Q’ will be same. **OR** (b) Finding the current through the bulb ‘B’ 2  By applying Kirchhoff’s loop rule to closed loops ABCFA and FCDEF $2I_1-3I_2=1$----(1) $I_1+I_2=1$-----(2) On solving, Current through the bulb, $I_2=\frac{1}{5}A$	½ ½ ½ ½	2
18.	Finding the angle of diffraction for first secondary maximum. 2 $\theta=(2n+1)\frac{\lambda}{2a}$ For first secondary maxima n=1 $\theta=\frac{3\lambda}{2a}$ $\theta=\frac{3\times550\times10^{-9}}{2\times0.55\times10^{-3}}$ $\theta=1.5\times10^{-3}\text{radian}=0.086\,\text{degree}$	½ ½ ½ ½	2
19.	Calculation of radius of curvature 2 $\frac{1}{f}=(n_{21}-1)\left[\frac{1}{R_1}-\frac{1}{R_2}\right]$	½	

	$R_1 = R$ and $R_2 = -R$ $\frac{1}{15} = (1.55-1)\left[\frac{2}{R}\right]$ $R = 16.5$ cm	½ ½ ½	2
20.	Calculation of mass of an α-particle in u 2 $1u = \frac{1}{12}$ mass of carbon atom $= \frac{1.9926\times10^{-26}\text{kg}}{12} = 1.66\times10^{-27}\,kg$ mass of an electron $= 9.1\times10^{-31}$kg mass of two electrons $= \frac{2\times9.1\times10^{-31}}{1.66\times10^{-27}}$ $= 0.00109638$ u mass of α-particle = mass of the normal helium atom - mass of two electrons $= 4.0026030 - 0.00109638$ $= 4.00150662$ u	½ ½ ½ ½	2
21.	(a) (i) Identifying the type of dopant ½ (ii) Identifying the type of extrinsic semiconductor ½ (b) Calculating the electron concentration 1 (a) (i) Trivalent (ii) p – type semi conductor (b) Electron concentration $n_e = \frac{n_i^2}{n_h}$ $n_e = \frac{(5\times10^8)^2}{8\times10^{12}}$ $n_e = 3.125\times10^4\,m^{-3}$	½ ½ ½ ½	2
	SECTION-C		
22.	**(a)** (i) Deriving the expression for resistivity of a conductor 2 (ii) Comparison of charges Q_1 and Q_2 1		



Total charge transported along E is

$$I\Delta t=\frac{e^2A}{m}\tau\, n\Delta tE$$ ½

$$\frac{I}{A}=\frac{ne^2}{m}\tau E$$ ½

$$J=\frac{1}{\rho}E$$ ½

$$\rho=\frac{m}{ne^2\tau}$$ ½

Alternatively-

Current in the conductor-

$$I=neAv_d$$

$$\frac{I}{A}=ne\frac{eE}{m}\tau$$

$$J=\frac{ne^2\tau}{m}E$$

$$J=\frac{1}{\rho}E$$

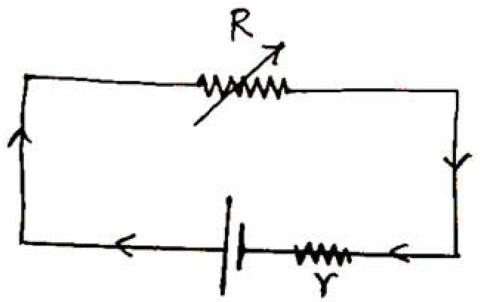
$$\rho=\frac{m}{ne^2\tau}$$

(ii) From given graph

$$\frac{Q_1}{Q_2}=\frac{A_1\,(\text{Area of rectangle})}{A_2\,(\text{Area of triangle})}$$ ½

$$\frac{Q_1}{Q_2}=\frac{2}{3/2}$$

$$Q_1>Q_2$$ ½

	OR		
	(b) (i) (I) ● Obtaining the expression for current ½ ● Finding value of maximum current ½ (II) Obtaining terminal voltage V and its maximum possible value 1 (ii) Obtaining the internal resistance of the battery 1		
			
	• $V = E - Ir$ $IR = E - Ir$ $I = \frac{E}{R+r}$	½	
	For maximum value of current R=0 $I_{max} = \frac{E}{r}$	½	
	(II) V= V_+ + V_- -Ir $V = E - Ir$	½	
	$V_{max} = E$, when I=0	½	
	(ii) $I_1R_1 + I_1r = I_2R_2 + I_2r$	½	
	$r = \frac{I_2R_2 - I_1R_1}{I_1 - I_2}$	½	3
23.	(a) Vector form of Biot – Savart Law 1 (b) Finding , • Magnitude of resultant magnetic field 1½ • Direction of resultant magnetic field ½		
	(a) $d\vec{B} = \frac{\mu_o}{4\pi}\frac{I(\vec{dl}\times\vec{r})}{r^3}$	1	

	(b) As $B = \frac{\mu_o}{4\pi}\frac{2I}{a}$ ∴ B_1 = Magnetic field due to current carrying wire along XX' $\vec{B}_1 = \frac{\mu_o}{4\pi}\frac{2I}{a} = \frac{2\times2\times10^{-7}}{5} = (8\times10^{-8}\,T)(\hat{k})$ B_2 = Magnetic field due to current carrying wire along YY' $\vec{B}_2 = \frac{\mu_o}{4\pi}\frac{2I}{a} = \frac{2\times2\times10^{-7}}{4} = 10\times10^{-8}T\,(-\hat{k})$ $\vec{B}_{net} = \vec{B}_2 + \vec{B}_1$ $= 2\times10^{-8}T\,(-\hat{k})$ • Direction of resultant magnetic field along –Z axis.	½ ½ ½ ½	3
24.	Finding direction of induced current in coil and justification (a) coil ‘2’ is moving toward coil ‘1’ ½+½ (b) coil ‘2’ is moving away from coil ‘1’ ½+½ (c) Resistance connected with coil ‘2’ is increased keeping both the coils stationary ½+½ (a) Induced current will be clockwise. Due to the direction flow of current in coil 2, the face approaching to coil 1 behaves like south pole. Induced polarity on coil 1 viewed from the side of coil 2 will be south pole (b) Induced current will be Anticlockwise Due to direction of flow of current in coil 2, face going away from coil 1 behaves like south pole. Induced polarity on coil 1 viewed from the side of coil 2, will be north pole. (c) Induced current will be Anticlockwise Till the resistance in coil 2 is increasing, the magnetic flux associated with coil 1 is decreasing. Hence according to Lenz’s law current will induce in coil 1, momentarily and after that no induced current in coil	½ ½ ½ ½ ½ ½	3
25.	(a) Three characteristics of electro- magnetic wave **1½** (b) Explanation of displacement current, • how **1** • Where it exists ½ (a) (Any three) • Electromagnetic wave carries energy. • Electromagnetic wave carries momentum. • Electromagnetic wave moves with velocity of light in vacuum. • In electromagnetic wave, electric field vector, magnetic field vector	½ ½ ½	

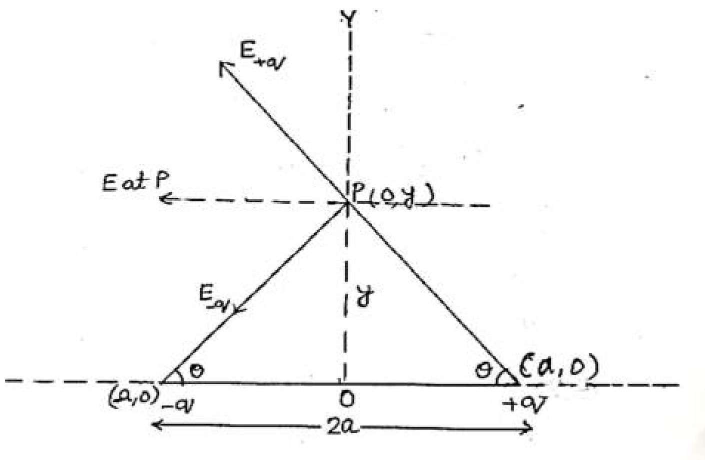
	and direction of propagation, all are mutually perpendicular. • Electromagnetic waves are transverse in nature. • Electromagnetic waves do not require a physical medium to propagate and can travel through a vacuum. • Electromagnetic waves consist of oscillating electric and magnetic fields. (b) • During charging of capacitor, time varying electric field / electric flux between the plates of capacitor induces the displacement current. • Displacement current exists between the plates of capacitor.	1 ½	**3**
26.	Effect on (a) Speed, frequency and wavelength of light 1½ (b) Fringe width, shape of fringes and shift of position of central maximum 1½ (a) • Speed of light will decrease • Frequency remains unaffected • Wavelength decreases (b) • Fringe width decreases • Shapes does not change • Position of central maxima does not change.	½ ½ ½ ½ ½ ½	**3**

27.	Explanation of (a) Photoelectric emission 1 (b) Dependency of maximum kinetic energy on frequency only 1 (c) Explanation of slope of cut off voltage versus frequency graph 1		
	(a) Einstein Photo electric equation		
	$h\nu = h\nu_o + K_{max}$	½	
	$K_{max} = h(\nu - \nu_o)$		
	For $\nu < \nu_o$, K_{max} will be negative	½	
	Hence, Photoelectric emission is not possible.		
	(b) According to Einstein Photoelectric equation		
	$K_{max} = h(\nu - \nu_o)$	½	
	Hence $K_{max} \alpha \nu$	½	
	It shows K_{max} depends upon frequency only and not depends upon intensity.		
	(c) $eV_o = h\nu - h\nu_o$		
	$V_o = \frac{h}{e}\nu - \frac{h}{e}\nu_o$	½	
	This equation represents the equation of straight line (y = mx + c) with the slope $\frac{h}{e}$.	½	3
28.	(a) Majority and minority charge carriers in p-type and n-type semiconductor 2 (b) Brief explanation for formation of diffusion current and drift current 1		
	(a) In p-type semiconductor		
	Majority charge carriers - holes	½	
	Minority charge carriers - electrons	½	
	In n-type semiconductors		
	Majority charge carriers - electrons	½	
	Minority charge carriers – holes	½	
	(b) Diffusion current – during the formation of p n junction , and due to the concentration gradient across p and n – sides , holes diffuse from p side to n	½	

	side ($p \rightarrow n$) and electrons diffuse from n – side to p – side ($n \rightarrow p$). This motion of charge carriers gives rise to diffusion current across the junction. Drift current –Due to electric field at junction, an electron on p – side of the junction moves to n- side and a hole on n – side of the junction moves to p- side. This motion of charge carriers due to electric field gives drift current.	½	3
	SECTION-D		
29.	(i) (C) $\frac{2\varepsilon_o KL^2}{d}$ (ii) (B) $\frac{\varepsilon_o VKL^2}{d}$ (iii) (A) $\frac{V}{d}$ (iv) (a) (C) $\frac{d}{2K}$ OR (b) (D) Zero	**1** **1** **1** **1**	**4**
30.	(i) (C) $\sqrt{\frac{Ke^2}{mr}}$ (ii) (B) $\frac{-Ke^2}{2r}$ (iii) (C) $-2.48, 2.48$ (iv) (a) (D) $\frac{1}{n^3}$ OR (b) (C) $1.59\ \mathring{A}$	**1** **1** **1** **1**	**4**

31.	**(a)**		

(i) Finding electric field at a far off point (y>>a)	3
(ii) Calculation of work done in shifting the charges	2



½

Magnitude of electric field due to the two charges +q and -q are given by

$$E_{+q} = \frac{q}{4\pi\varepsilon_o}\frac{1}{y^2+a^2}$$ ½

$$E_{-q} = \frac{q}{4\pi\varepsilon_o}\frac{1}{y^2+a^2}$$ ½

Components normal to the dipole axis cancel out.

The components along the dipole axis add up.

The total electric field is opposite to the dipole moment will be given by-

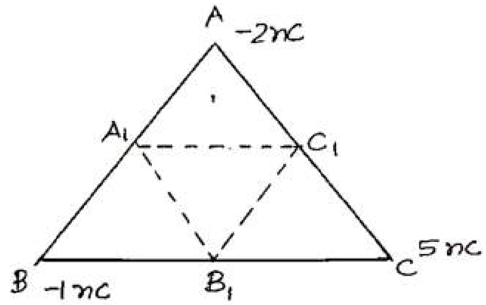
$$\vec{E} = -\left(E_{+q}+E_{-q}\right)\cos\theta\,\hat{p}$$ ½

$$= -\frac{2qa}{4\pi\varepsilon_o\left(y^2+a^2\right)^{3/2}}\hat{p}$$ ($\hat{p}$ is a unit vector along dipole moment) ½

At large distance (y>>a)

$$\vec{E} = \frac{-2qa}{4\pi\varepsilon_o y^3}\hat{p}$$ ½

(ii)



Initial electrostatic potential energy of the system

$$U_1=\frac{1}{4\pi\varepsilon_o}\left(\frac{q_Aq_B}{AB}+\frac{q_Cq_A}{AC}+\frac{q_Cq_B}{BC}\right)$$ ½

$$=\frac{9\times10^9}{0.2}\left[(-2\times-1)+(-2\times5)+(-1\times5)\right]\times10^{-18}$$

U_1= -5.85×10^{-7}J ½

$$U_2=\frac{1}{4\pi\varepsilon_o}\left(\frac{q_{A_1}q_{B_1}}{A_1B_1}+\frac{q_{C_1}q_{A_1}}{A_1C_1}+\frac{q_{c_1}q_{B_1}}{B_1C_1}\right)$$ ½

U_2= -11.7×10^{-7}J ½

$W=U_2-U_1=-5.85\times10^{-7}$J

OR

(b)

(i)	
• Showing consistency of Gauss's theorem with Coulomb's law	1
• Derivation for electric field due to uniformly charged thin spherical shell at (I) y > r (II) y < r	2
(ii) Finding type and magnitude of charge	2

(i)

- Gauss's theorem is based on the inverse square dependence on distance contained in the coulomb's law. **1**

  Alternatively-

  According to Gauss's theorem

$$\oint \vec{E}.d\vec{s} = \frac{q}{\varepsilon_o}$$ ½

$$E = \frac{1}{4\pi\varepsilon_o}\frac{q}{r^2}$$

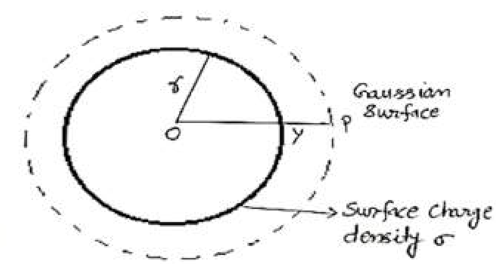
According to Coulomb's law, force on charge q_o in this field

$$F = \frac{1}{4\pi\varepsilon_o}\frac{qq_o}{r^2}$$ ½

Therefore, Gauss's law is consistent with Coulomb's law

- (I) For y > r

(i)



Electric flux through Gaussian surface $E \times 4\pi y^2$

The charge enclosed by the surface $\sigma \times 4\pi r^2$

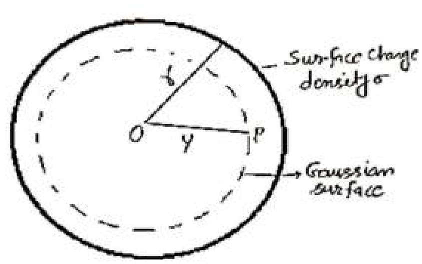
Using Gauss theorem ½

$$E(4\pi y^2) = \frac{\sigma 4\pi r^2}{\varepsilon_o}$$

$$\vec{E} = \frac{q}{4\pi\varepsilon_0 y^2}\hat{r}$$ ½

(II) For y < r

(ii)



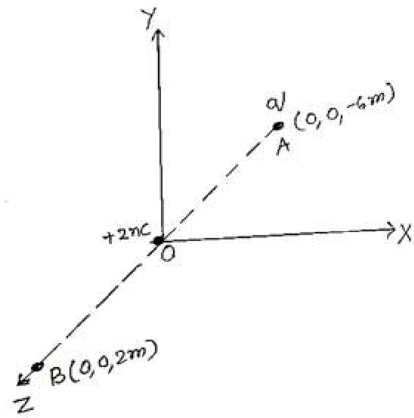
The charge enclosed by Gaussian surface = 0 ½

Using Gauss theorem

Electric flux $= E(4\pi y^2) = 0$

i.e. $E = 0 \quad (y < r)$ ½

(ii)



Let the charge is kept at A be q

Potential at point B due to charge at the origin O and charge (q) at A

$V = V_1 + V_2$ ½

$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{2\times10^{-9}}{2} + \frac{q}{6+2}\right]$ ½

$\frac{1}{4\pi\varepsilon_0}\left[10^{-9} + \frac{q}{8}\right] = 0$ ½

$q = -8\times10^{-9}$C ½ **5**

32. **(a)**

(i)

- Statement of Lenz's law ½
- Explaining, how this law is a consequence of law of conservation of energy ½

(ii)

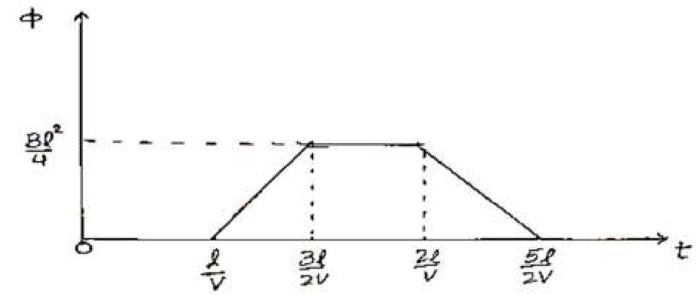
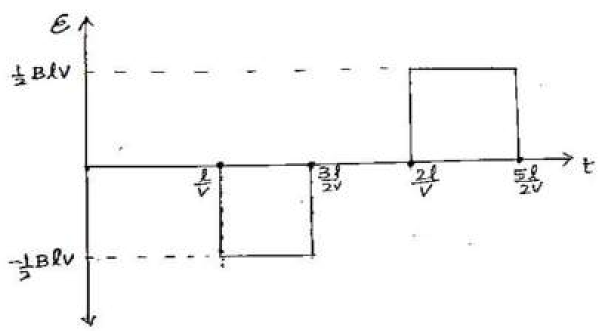
(I) Direction of induced current when loop enters and loop leaves ½+½

(II) Plots showing variation of

magnetic flux (ϕ) with time (t), 1

induced emf (E) with time (t) and 1

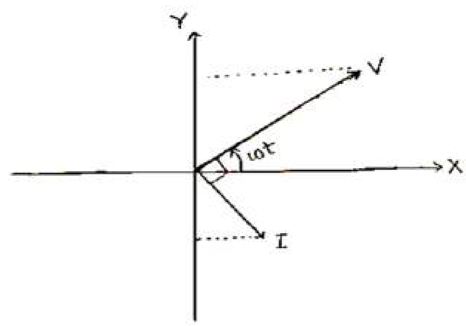
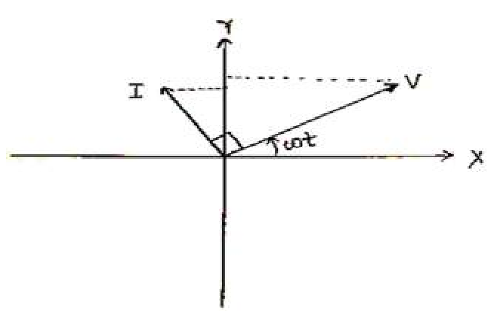
relevant values E, (ϕ) and t on the graph 1

	Lenz's law – Polarity of the induced emf is such that it tends to produce a current, which opposes the change in magnetic flux that produces it.	½	
	When magnet is moved closer/ away from the loop, same/ opposite pole is developed on the approaching face of the loop. So mechanical work is required to move a magnet which gets converted into electrical energy which is consistent with the law of conservation of energy.	½	
	(ii) (I) • Anticlockwise • Clockwise	 ½ ½	
	(II) 	1½	
		1½	

OR

(b)

(i)	
Difference between Peak value and rms value of ac	1
Relation	½
(ii) (I) Identification of elements X and Y by phasor diagram	1
(II) Obtaining	
• Resonance condition	1
• Expression for resonant frequency	1
• Impedance value	½

	(i) Peak value - It is the maximum value of Alternating current. rms value – It is the equivalent dc current that would produce the same average power loss as alternating current.	**1**	
	Alternatively- Peak value - It is the maximum value of Alternating current. rms value- It is the effective value of an ac representing the equivalent dc, that would produce the same heating effect in same resistor in same time period.		
	Relation $I_{rms}=\frac{I_o}{\sqrt{2}}$	½	
	(ii) (I) X- Inductor (L) 	½	
	Y- Capacitor (C) 	½	

	(II) Impedance of the circuit $$Z = (X_L - X_C)$$ At resonance $Z = 0$ $$X_L = X_C$$ $$\omega L = \frac{1}{\omega C}$$ $$\omega^2 = \frac{1}{LC}, \qquad \omega = \frac{1}{\sqrt{LC}}$$ $$\nu = \frac{1}{2\pi\sqrt{LC}}$$ Impedance at resonance $Z=0$	½ ½ ½ ½ ½	5
33.	**(a)** (i) Calculation of focal length of concave lens 3 (ii) Calculation of • Angle of minimum deviation 1 • Angle of incidence 1 For real image form by Convex lens $$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u_1}$$ $$\frac{1}{10} = \frac{1}{v_1} - \frac{1}{(-30)}$$ $v_1 = 15\,cm$ For Combination of lenses, let the focal length of combination of lens is f_3 $$\frac{1}{f_3} = \frac{1}{v_3} - \frac{1}{u_3}$$ $$\frac{1}{f_3} = \frac{1}{(15+45)} + \frac{1}{30}$$ $f_3 = 20cm$ Let the focal length of concave lens is f_2 $$\frac{1}{f_3} = \frac{1}{f_1} + \frac{1}{f_2}$$ $$\frac{1}{f_2} = \frac{1}{20} - \frac{1}{10}$$	½ ½ ½ ½ ½	

$f_2 = -20 cm$ ½

(ii)

Angle of minimum deviation

$$\mu = \frac{\text{Sin}\,\frac{(A+\delta_m)}{2}}{\text{Sin}\,\frac{A}{2}}$$ ½

$$\sqrt{3} = \frac{\text{Sin}\,\frac{(60^\circ+\delta_m)}{2}}{\text{Sin } 30}$$

$$\frac{\sqrt{3}}{2} = Sin\frac{(A+\delta_m)}{2}$$

$$60^\circ = \frac{(A+\delta_m)}{2}$$

$$\delta_m = 60^o$$ ½

Angle of incidence

$$i + e = A + \delta$$

$$2i = A + \delta_m$$ ½

$$i = \frac{A+\delta_m}{2}$$

$$i = 60^\circ$$ ½

OR

(b)

(i)

(I) Finding the slit separation 1½

(II) Calculation of distance between central maximum and first minimum 1½

(ii) Calculation of distance between first order minima on both sides of central maxima 2

(i)

(I) Slit separation

$$\beta = \frac{D\lambda}{d}$$ ½

	$d=\frac{D\lambda}{\beta}$ $=\frac{633\times10^{-9}\times5}{5\times10^{-3}}$ $=633\times10^{-6}\,m$ $=633\mu m$ (II) Distance of first minimum from central maximum $x_n=\frac{(2n-1)\lambda D}{2d}$ n =1 $x=\frac{633\times10^{-9}\times5}{2\times5\times10^{-3}}$ $x=316.5\times10^{-6}m$ $x=316.5\mu m$ (ii) Distance between first order minima on both the side $W=\frac{2D\lambda}{d}$ $=\frac{2\times650\times10^{-9}}{0.6\times10^{-3}}\times60\times10^{-2}$ $=1.3\times10^{-3}m$	½ ½ ½ ½ ½ ½ 1 ½	5

General Instructions :

Read the following instructions carefully and follow them :

(i) *This question paper contains **33** questions. **All** questions are **compulsory**.*

(ii) *This question paper is divided into **five** sections – **Sections A, B, C, D** and **E**.*

(iii) *In **Section A** – Questions no. **1** to **16** are Multiple Choice type questions. Each question carries **1** mark.*

(iv) *In **Section B** – Questions no. **17** to **21** are Very Short Answer type questions. Each question carries **2** marks.*

(v) *In **Section C** – Questions no. **22** to **28** are Short Answer type questions. Each question carries **3** marks.*

(vi) *In **Section D** – Questions no. **29** and **30** are case study-based questions. Each question carries **4** marks.*

(vii) *In **Section E** – Questions no. **31** to **33** are Long Answer type questions. Each question carries **5** marks.*

(viii) *There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.*

(ix) *Kindly note that there is a separate question paper for Visually Impaired candidates.*

(x) *Use of calculators is **not** allowed.*

You may use the following values of physical constants wherever necessary :

$c = 3 \times 10^{8}$ m/s

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8{\cdot}854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^{9}$ N m^2 C^{-2}

Mass of electron (m_e) = $9{\cdot}1 \times 10^{-31}$ kg

Mass of neutron = $1{\cdot}675 \times 10^{-27}$ kg

Mass of proton = $1{\cdot}673 \times 10^{-27}$ kg

Avogadro's number = $6{\cdot}023 \times 10^{23}$ per gram mole

Boltzmann constant = $1{\cdot}38 \times 10^{-23}$ JK^{-1}

SECTION A

1. A metal sheet is inserted between the plates of a parallel plate capacitor of capacitance C. If the sheet partly occupies the space between the plates, the capacitance :

(A) remains C

(B) becomes greater than C

(C) becomes less than C

(D) becomes zero

2. The electric field at a point in a region is given by $\vec{E} = \alpha \frac{\vec{r}}{|\vec{r}|^3}$, where α is a constant and r is the distance of the point from the origin. The magnitude of potential of the point is :

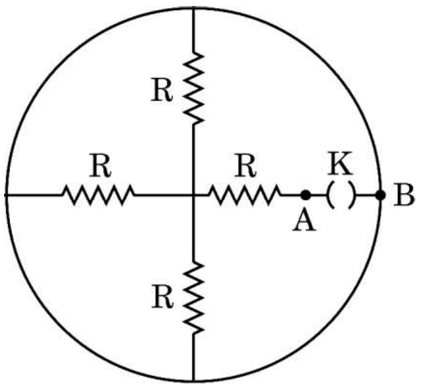
(A) $\frac{\alpha}{r}$

(B) $\frac{\alpha r^2}{2}$

(C) $\frac{\alpha}{2 r^2}$

(D) $-\frac{\alpha}{r}$

3. Four resistors, each of resistance R and a key K are connected as shown in the figure. The equivalent resistance between points A and B when key K is open, will be :



(A) 4R

(B) ∞

(C) $\frac{R}{4}$

(D) $\frac{4R}{3}$

4. A charged particle gains a speed of 10^6 ms^{-1}, when accelerated from rest through a potential difference 10 kV. It enters a region of magnetic field of 0·4 T such that $\vec{v} \perp \vec{B}$. The radius of circular path described by it is :

(A) 2·5 cm

(B) 5 cm

(C) 8 cm

(D) 10 cm

5. A current of $\left(\frac{10}{\pi}\right)$A is maintained in a circular loop of radius 14 cm. The value of dipole moment associated with the loop is :

(A) $0{\cdot}019$ Am^2 (B) $0{\cdot}14$ Am^2

(C) $0{\cdot}196$ Am^2 (D) $0{\cdot}615$ Am^2

6. The magnetic flux linked with a coil changes with time t as $\phi = (8t^2 + 5t + 7)$, where t is in seconds and ϕ is in Wb. The value of emf induced in the coil at $t = 4$ s is :

(A) 32 V (B) 37 V

(C) 64 V (D) 69 V

7. Which of the following rays coming from the Sun plays an important role in maintaining the Earth's warmth ?

(A) Infrared rays (B) γ rays

(C) UV rays (D) Visible light rays

8. The dimensions of $(\mu\varepsilon)^{-1}$, where ε is permittivity and μ is permeability of a medium, are :

(A) $[M^0 L^1 T^{-1}]$ (B) $[M^0 L^2 T^{-2}]$

(C) $[M^1 L^2 T^{-2}]$ (D) $[M^1 L^{-1} T^1]$

9. Which of the following electromagnetic waves has photons of largest momentum ?

(A) X-rays (B) AM radio waves

(C) Microwaves (D) TV waves

10. A compound microscope has an objective and an eyepiece of focal lengths f_o and f_e, respectively. To obtain a large magnification of a small object, the microscope should have :

(A) f_o and f_e small, and $f_e > f_o$ (B) f_o and f_e small, and $f_o > f_e$

(C) f_o and f_e large, and $f_e > f_o$ (D) f_o and f_e large, and $f_o > f_e$

11. Two coherent light waves, each having amplitude 'a', superpose to produce an interference pattern on a screen. The intensity of light as seen on the screen varies between :

(A) 0 and $2a^2$ (B) 0 and $4a^2$

(C) a^2 and $2a^2$ (D) $2a^2$ and $4a^2$

12. The kinetic energy of an alpha particle is four times the kinetic energy of a proton. The ratio $\left(\frac{\lambda_\alpha}{\lambda_p}\right)$ of de Broglie wavelengths associated with them will be :

(A) $\frac{1}{16}$ (B) $\frac{1}{8}$

(C) $\frac{1}{4}$ (D) $\frac{1}{2}$

*Questions number **13** to **16** are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below.*

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is ***not*** the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Both Assertion (A) and Reason (R) are false.

13. *Assertion (A) :* The impurities in p-type Si are not pentavalent atoms.

Reason (R) : The hole density in valance band in p-type semiconductor is almost equal to the acceptor density.

14. *Assertion (A) :* During formation of a nucleus, the mass defect produced is the source of the binding energy of the nucleus.

Reason (R) : For all nuclei, the value of binding energy per nucleon increases with mass number.

15. *Assertion (A) :* The Balmer series in hydrogen atom spectrum is formed when the electron jumps from higher energy state to the ground state.

Reason (R) : In Bohr's model of hydrogen atom, the electron can jump between successive orbits only.

16. *Assertion (A) :* In Rutherford's alpha particle scattering experiment, the presence of only few alpha particles at angle of scattering π led him to the discovery of nucleus.

Reason (R) : The size of nucleus is approximately 10^{-5} times the size of an atom and therefore only few alpha particles are rebounded.

SECTION B

17. The threshold frequency for a given metal is $3{\cdot}6 \times 10^{14}$ Hz. If monochromatic radiations of frequency $6{\cdot}8 \times 10^{14}$ Hz are incident on this metal, find the cut-off potential for the photoelectrons. *2*

18. (a) A point object is placed in air at a distance R/3 in front of a convex surface of radius of curvature R, separating air from a medium of refractive index n (< 4). Find the nature and position of the image formed. *2*

OR

(b) In Young's double slit experimental set-up, the intensity of the central maximum is I_0. Calculate the intensity at a point where the path difference between two interfering waves is $\lambda/3$. *2*

19. A voltmeter of resistance 1000 Ω can measure up to 25 V. How will you convert it so that it can read up to 250 V ? *2*

20. When a neutron collides with ${}^{235}_{92}U$, the nucleus gives ${}^{140}_{54}Xe$ and ${}^{94}_{38}Sr$ as fission products and two neutrons are ejected. Calculate the mass defect and the energy released (in MeV) in the process. Given : *2*

$$m\left({}^{235}_{92}U\right) = 235{\cdot}04393 \text{ u}, \quad m\left({}^{140}_{54}Xe\right) = 139{\cdot}92164 \text{ u}$$

$$m\left({}^{94}_{38}Sr\right) = 93{\cdot}91536 \text{ u}, \quad {}^{1}_{0}n = 1{\cdot}00866 \text{ u}$$

$$1 \text{ u} = 931 \text{ MeV/c}^2$$

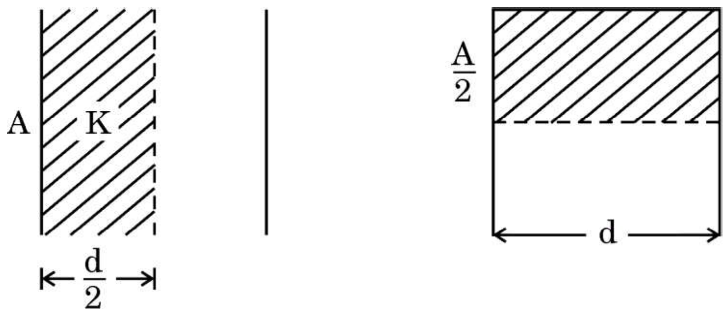
21. The resistance of a wire at 25°C is 10·0 Ω. When heated to 125°C, its resistance becomes 10·5 Ω. Find (i) the temperature coefficient of resistance of the wire, and (ii) the resistance of the wire at 425°C. *2*

SECTION C

22. (a) Draw the energy-band diagrams for conductors, semiconductors and insulators at T = 0 K. How is an electron-hole pair formed in a semiconductor at room temperature ?

(b) Carbon and silicon both, are members of IV group of periodic table and have the same lattice structure. Carbon is an insulator whereas silicon is a semiconductor. Explain. *3*

23. A parallel plate capacitor has plate area A and plate separation d. Half of the space between the plates is filled with a material of dielectric constant K in two ways as shown in the figure.



(a) (b)

Find the values of the capacitance of the capacitors in the two cases. *3*

24. In Young's double slit experiment, the separation between the two slits is 1·0 mm and the screen is 1·0 m away from the slits. A beam of light consisting of two wavelengths 500 nm and 600 nm is used to obtain interference fringes. Calculate : *3*

(a) the distance between the first maxima for the two wavelengths.

(b) the least distance from the central maximum, where the bright fringes due to both the wavelengths coincide.

25. Differentiate between half-wave and full-wave rectification. With the help of a circuit diagram, explain the working of a full-wave rectifier. *3*

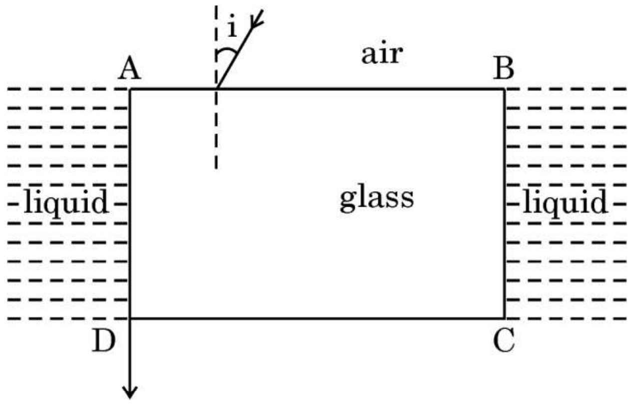
26. An electron of mass m and charge $-e$ is revolving anticlockwise around the nucleus of an atom.

(a) Obtain the expression for the magnetic dipole moment (μ) of the atom.

(b) If $\vec{L}$ is the angular momentum of electron, show that

$$\vec{\mu} = -\left(\frac{e}{2m}\right)\vec{L}.$$ *3*

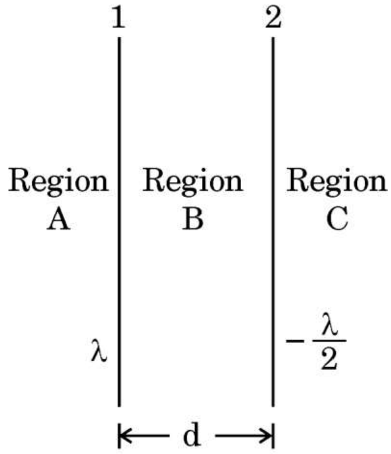
27. A rectangular glass slab ABCD (refractive index 1·5) is surrounded by a transparent liquid (refractive index 1·25) as shown in the figure. A ray of light is incident on face AB at an angle i such that it is refracted out grazing the face AD. Find the value of angle i. *3*



28. (a) Two small solid metal balls A and B of radii R and 2R having charge densities 2σ and 3σ respectively are kept far apart. Find the charge densities on A and B after they are connected by a conducting wire. *3*

OR

(b) Two infinitely long straight wires '1' and '2' are placed d distance apart, parallel to each other, as shown in the figure. They are uniformly charged having charge densities λ and $-\frac{\lambda}{2}$ respectively. Locate the position of the point from wire '1' at which the net electric field is zero and identify the region in which it lies. *3*



SECTION D

*Questions number **29** and **30** are Case Study-based questions. Read the following paragraphs and answer the questions that follow.*

29. A galvanometer is an instrument used to show the direction and strength of the current passing through it. In a galvanometer, a coil placed in a magnetic field experiences a torque and hence gets deflected when a current passes through it. The name is derived from the surname of Italian scientist L. Galvani, who in 1791 discovered that electric current makes a dead frog's leg jerk. A spring attached with the coil provides a counter torque.

In equilibrium, the deflecting torque is balanced by the restoring torque of the spring and we have :

$$NBAI = k\phi$$

where N is the total number of turns in the coil
A is the area of cross-section of each turn
B is the radial magnetic field
k is the torsional constant of the spring
ϕ is the angular deflection of the coil

As the current (I_g) which produces full scale deflection in the galvanometer is very small, the galvanometer cannot as such be used to measure current in electric circuits. A small resistance, called shunt, of a suitable value is connected with the galvanometer to convert it into an ammeter of desired range. By using a higher resistance, a galvanometer can also be converted into a voltmeter.

(i) The value of the current sensitivity of a galvanometer is given by : *1*

(A) $\frac{k}{NBA}$ (B) $\frac{NBA}{k}$

(C) $\frac{kBA}{N}$ (D) $\frac{kNB}{A}$

(ii) A galvanometer of resistance 6 Ω shows full scale deflection for a current of 0·2 A. The value of shunt to be used with this galvanometer to convert it into an ammeter of range (0 – 5 A) is : *1*

(A) 0·25 Ω (B) 0·30 Ω

(C) 0·50 Ω (D) 6·0 Ω

(iii) The value of resistance of the ammeter in case (ii) will be : *1*

(A) 0·20 Ω (B) 0·24 Ω

(C) 6·0 Ω (D) 6·25 Ω

(iv) (a) A galvanometer is converted into a voltmeter of range (0 – V) by connecting with it, a resistance R_1. If R_1 is replaced by R_2, the range becomes (0 – 2 V). The resistance of the galvanometer is : *1*

(A) $(R_2 - 2R_1)$ (B) $(R_2 - R_1)$

(C) $(R_1 + R_2)$ (D) $(R_1 - 2R_2)$

OR

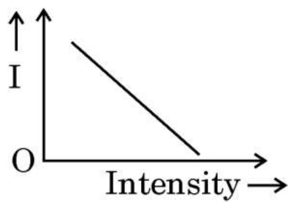
(b) A current of 5 mA flows through a galvanometer. Its coil has 100 turns, each of area of cross-section 18 cm^2 and is suspended in a magnetic field 0·20 T. The deflecting torque acting on the coil will be : *1*

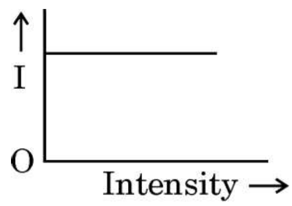
(A) $3·6 \times 10^{-3}$ Nm (B) $1·8 \times 10^{-4}$ Nm

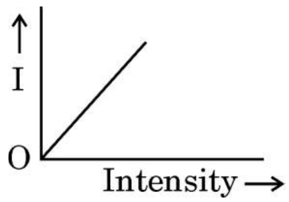
(C) $2·4 \times 10^{-3}$ Nm (D) $1·2 \times 10^{-4}$ Nm

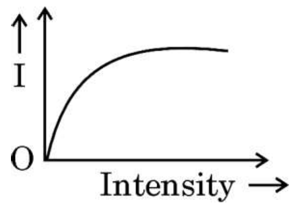
30. Einstein explained photoelectric effect on the basis of Planck's quantum theory, where light travels in the form of small bundles of energy called photons. The energy of each photon is hν, where ν is the frequency of incident light and h is Planck's constant. The number of photons in a beam of light determines the intensity of the incident light. A photon incident on a metal surface transfers its total energy hν to a free electron in the metal. A part of this energy is used in ejecting the electron from the metal and is called its work function. The rest of the energy is carried by the ejected electron as its kinetic energy.

(i) Which of the following graphs shows the variation of photoelectric current I with the intensity of light ? *1*

(A)


(B)


(C)


(D)


(ii) When the frequency of the incident light is increased without changing its intensity, the saturation current : *1*

(A) increases linearly

(B) decreases

(C) increases non-linearly

(D) remains the same

(iii) Which of the following graphs can be used to obtain the value of Planck's constant ? *1*

(A) Photocurrent versus Intensity of incident light

(B) Photocurrent versus Frequency of incident light

(C) Cut-off potential versus Frequency of incident light

(D) Cut-off potential versus Intensity of incident light

(iv) (a) Red light, yellow light and blue light of the same intensity are incident on a metal surface successively. K_R, K_Y and K_B represent the maximum kinetic energy of photoelectrons respectively, then : *1*

(A) $K_R > K_Y > K_B$ (B) $K_Y > K_B > K_R$

(C) $K_B > K_Y > K_R$ (D) $K_R > K_B > K_Y$

OR

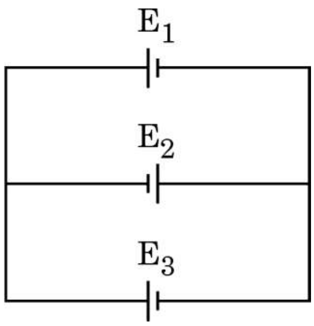
(b) Which of the following metals exhibits photoelectric effect with visible light ? *1*

(A) Caesium (B) Zinc

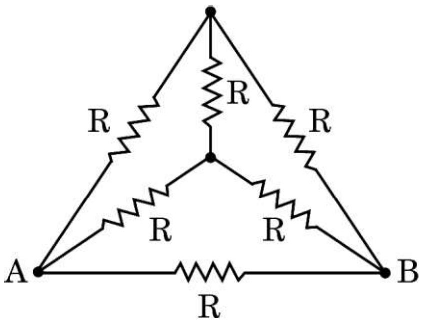
(C) Cadmium (D) Magnesium

SECTION E

31. (a) (i) Three batteries E_1, E_2 and E_3 of emfs and internal resistances (4 V, 2 Ω), (2 V, 4 Ω) and (6 V, 2 Ω) respectively are connected as shown in the figure. Find the values of the currents passing through batteries E_1, E_2 and E_3.

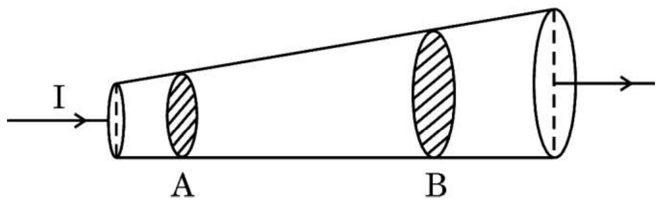


(ii) The ends of six wires, each of resistance R (= 10 Ω) are joined as shown in the figure. The points A and B of the arrangement are connected in a circuit. Find the value of the effective resistance offered by it to the circuit. *5*



OR

(b) (i) Current I (= 1 A) is passing through a copper rod ($n = 8{\cdot}5 \times 10^{28}\ m^{-3}$) of varying cross-sections as shown in the figure. The areas of cross-section at points A and B along its length are $1{\cdot}0 \times 10^{-7}\ m^2$ and $2{\cdot}0 \times 10^{-7}\ m^2$ respectively. Calculate :



(I) the ratio of electric fields at points A and B.

(II) the drift velocity of free electrons at point B.

(ii) Two point charges q_1 (= 16 μC) and q_2(= 1 μC) are placed at points $\vec{r_1} = (3\ m)\hat{i}$ and $\vec{r_2} = (4\ m)\hat{j}$. Find the net electric field $\vec{E}$ at point $\vec{r} = (3\ m)\hat{i} + (4\ m)\hat{j}$. *5*

32. (a) (i) Define self-inductance of a coil. Derive the expression for the energy required to build up a current I in a coil of self-inductance L.

(ii) The currents passing through two inductors of self-inductances 10 mH and 20 mH increase with time at the same rate.

Draw graphs showing the variation of :

(I) the magnitude of emf induced with the rate of change of current in each inductor.

(II) the energy stored in each inductor with the current flowing through it. *5*

OR

(b) (i) Define the term mutual inductance. Deduce the expression for the mutual inductance of two long coaxial solenoids of the same length having different radii and different number of turns.

(ii) The current through an inductor is uniformly increased from zero to 2 A in 40 s. An emf of 5 mV is induced during this period. Find the flux linked with the inductor at t = 10 s. *5*

33. (a) (i) Draw a ray diagram of a reflecting telescope (Cassegrain) and explain the formation of image. State two important advantages that a reflecting telescope has over a refracting telescope.

(ii) In a refracting telescope, the focal length of the objective is 50 times the focal length of the eyepiece. When the final image is formed at infinity, the length of the tube is 102 cm. Find the focal lengths of the two lenses. *5*

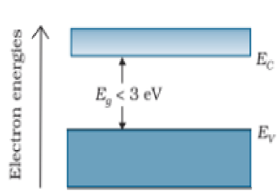
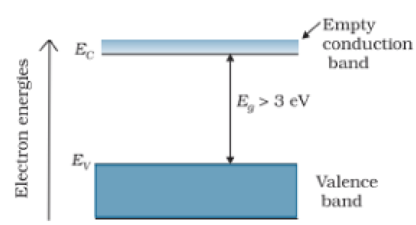
OR

(b) (i) Write any two advantages of a compound microscope over a simple microscope. Draw a ray diagram for the image formation at the near point by a compound microscope and explain it.

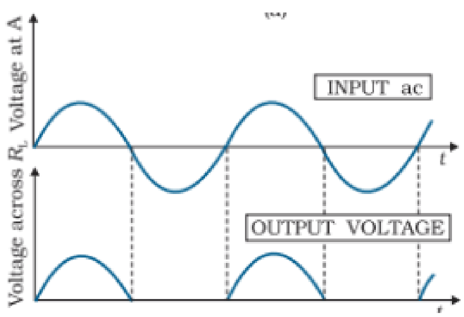
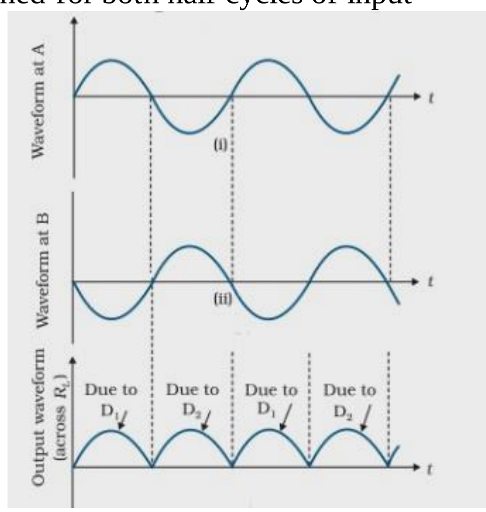
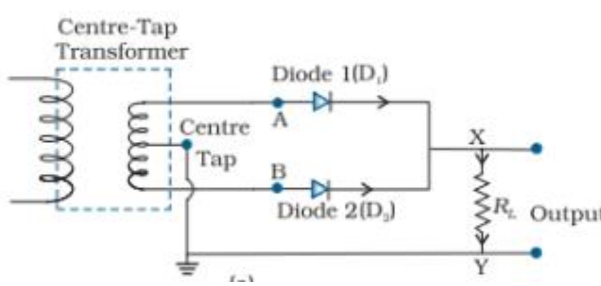
(ii) A thin planoconcave lens with its curved face of radius of curvature R is made of glass of refractive index n_1. It is placed coaxially in contact with a thin equiconvex lens of same radius of curvature of refractive index n_2. Obtain the power of the combination lens. *5*

MARKING SCHEME: PHYSICS(042)			
Code: 55/5/1			
Q.No.	**VALUE POINTS/EXPECTED ANSWERS**	**Marks**	**Total Marks**
	SECTION A		
1	(B) becomes greater than C	**1**	**1**
2	(A) $\frac{\alpha}{r}$	**1**	**1**
3	(D) $\frac{4R}{3}$	**1**	**1**
4	(B) 5 cm	**1**	**1**
5	(C) 0.196 Am^2	**1**	**1**
6	(D) 69 V	**1**	**1**
7	(A) Infrared rays	**1**	**1**
8	(B) $\left[M^0L^2T^{-2}\right]$	**1**	**1**
9	(A) X rays	**1**	**1**
10	(A) f_0 and f_e small, and $f_e > f_0$	**1**	**1**
11	(B) 0 and $4a^2$	**1**	**1**
12	(C) $\frac{1}{4}$	**1**	**1**
13	(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is the not the correct explanation of the Assertion (A)	**1**	**1**
14	(C) Assertion (A) is true, but Reason (R) is false	**1**	**1**
15	(D) Both Assertion (A) and reason (R) are false	**1**	**1**
16	(A) Both assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the assertion (A).	**1**	**1**
	SECTION - B		
17	Finding the cut-off potential 2 $eV_0 = h(\upsilon - \upsilon_0)$ $V_0 = \frac{6.63\times10^{-34}\times(6.8-3.6)\times10^{14}}{1.6\times10^{-19}}$ $=1.33\text{V}$	½ 1 ½	**2**
18	(a) Finding nature and position of the image 1 + 1 For refraction at convex surface $\frac{n_1}{-u}+\frac{n_2}{v}=\frac{n_2-n_1}{R}$	½	

	$\frac{n}{v} = \frac{[n-1-3]}{R}$ $v = \frac{nR}{n-4}$ For all values of n < 4, the value of v is negative and greater than R Therefore the nature of image is virtual and is formed in front of convex surface. **OR** (b) Calculating intensity for the path difference $\lambda/3$ 2 $\phi = \frac{2\pi}{\lambda}\times\Delta x$ $= \frac{2\pi}{\lambda}\times\frac{\lambda}{3}$ $= \frac{2\pi}{3}$ $I' = 4I\ Cos^2\ \phi/2$ $\quad Given\ 4I = I_0$ $= I_0\ Cos^2\ 2\pi/6$ $= \frac{I_0}{4}$ Note: If a student attempt by using $I = I_1 + I_2 + 2\sqrt{I_1 I_2}Cos\phi$ **,**award full credit for correct answer.	½ 1 ½ ½ ½ ½	2
19	Conversion of voltmeter to read upto 250V 2 $I = \frac{V}{R}$ $= \frac{25}{1000}$ $= 25\times10^{-3}$ A Resistance to be connected to voltmeter $R' = \frac{V'}{I} - R$ $= \frac{250}{25\times10^{-3}} - 1000$ $= 9000\Omega$ This 9000 Ω is in series with voltmeter.	½ ½ ½ ½	2

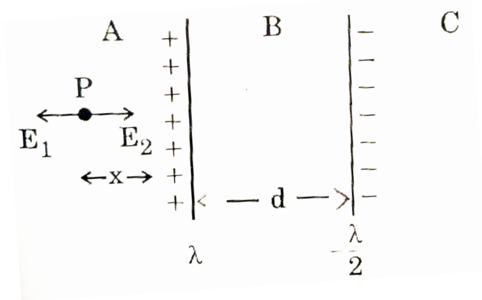
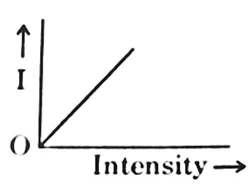
20	Calculation of mass defect and energy released 1 ½ + ½ $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{192}_{54}Xe + ^{94}_{38}Sr + 2(^{1}_{0}n)$ $\Delta m = m(^{1}_{0}n) + m(^{235}_{92}U) - (m(^{140}_{54}Xe) + m(^{94}_{38}Sr) + 2\times m(^{1}_{0}n))$ $= 1.00866 + 235.04393 - 139.92164 - 93.91536 - 2\times 1.00866$ $= 0.19827\,u$ Energy released $= \Delta m \times 931 MeV$ $= 0.19827 \times 931$ MeV $= 184.59$ MeV	½ ½ ½ ½	2
21	Finding (i) temperature coefficient of resistance 1 ½ (ii) resistance of wire at 425 °C ½ (i) $R_2 = R_1(1+\alpha(t_2-t_1))$ $10.5 = 10(1+\alpha\times 100)$ $\alpha = 5\times 10^{-4}/^{o}C$ (ii) $R_{425} = R_{25}(1+\alpha(425-25))$ $= 10(1+5\times 10^{-4}\times 400)$ $= 12\Omega$	½ ½ ½ ½	2
	SECTION - C		
22	a) Drawing energy band diagrams ½ + ½ + ½ Formation of electron hole pair ½ b) Explanation 1 (a)  CONDUCTORS  SEMICONDUCTORS  INSULATORS	½ ½ + ½	

	At room temperature, thermal energy is sufficient for electrons to make them free from the bonds and create a vacancy called hole. Hence electron hole pair is formed. (b) The valence electron in carbon and silicon lie in the second and third orbit respectively. So, the energy required to take out an electron will be less for silicon as compared to carbon. Hence number of free electrons for conduction in silicon are significant but negligibly small for carbon.	½ 1	 3
23	Finding the values of capacitance in two cases 1 ½ + 1 ½ a) $\frac{1}{C} = \frac{1}{K\left(\frac{\varepsilon_0 A}{d/2}\right)} + \frac{1}{\frac{\varepsilon_0 A}{d/2}}$ $\frac{1}{C} = \frac{d}{2K\varepsilon_0 A} + \frac{d}{2\varepsilon_0 A}$ $= \left(\frac{1}{K}+1\right)\frac{d}{2\varepsilon_0 A}$ $C = \left(\frac{2K}{K+1}\right)\frac{\varepsilon_0 A}{d}$ b) $C = \frac{\varepsilon_0 AK}{2d} + \frac{\varepsilon_0 A}{2d}$ $= \left(\frac{K+1}{2}\right)\frac{\varepsilon_0 A}{d}$	 ½ ½ ½ 1 ½	 3
24	a) Calculating distance between first maxima for two wavelengths 1 ½ b) Calculating least distance from central maxima 1 ½ a) Distance $= \frac{n\lambda_1 D}{d} - \frac{n\lambda_2 D}{d}$ For n=1 Distance $= \frac{(600-500)\times10^{-9}\times1}{10^{-3}}$ $=10^{-4}\,m$ b) $n\lambda_1 \frac{D}{d} = (n+1)\lambda_2 \frac{D}{d}$ $n\times 600\times10^{-9} = (n+1)\times 500\times10^{-9}$ $n = 5$ $x = 5\times\frac{\lambda_1 D}{d}$	 ½ ½ ½ ½ ½	

	$= \dfrac{5\times600\times10^{-9}\times1}{10^{-3}} \quad = 3mm$	½	
	Alternatively $n_1\lambda_1 = n_2\lambda_2$	½	
	$\dfrac{n_1}{n_2} = \dfrac{5}{6}$	½	
	therefore n = 5		
	Position of 5th bright for λ_1(600 nm) $x = 5\times\dfrac{\lambda_1 D}{d} = 3$ mm	½	3
25	Difference between half wave and full wave rectification 1 Working of full wave rectifier 2		
	In half wave rectification there is output in one half of input cycle, whereas in full wave rectification, output is obtained for both half cycles of input (positive and negative)	1	
	Alternatively   Half wave Rectification Full wave Rectification		
	Working of full wave rectifier: 	1	
	Suppose the input voltage to A with respect to the centre-tap at any instant is positive. At that instant, voltage at B being out of phase will be negative. So, diode D_1 gets forward biased and conducts (while D_2 being reverse biased is not conducting). Hence, during this positive half cycle we get an output current (and output voltage across the load resistor R_L). In the course of ac cycle when the voltage at A becomes negative with respect to		

	centre tap, the voltage at B would be positive. In this part of the cycle diode D_1 would not conduct but diode D_2 would, giving an output current and output voltage (across R_L) during the negative half cycle of the input ac.	1	3
26	a) Obtaining expression for magnetic dipole moment 1½ b) To Show $\vec{\mu} = -\left(\frac{e}{2m}\right)\vec{L}$ 1½		
	a) $\mu = IA$	½	
	$= \frac{e}{T} \times A$		
	$= \frac{e}{\frac{2\pi r}{v}} \times \pi r^2$	½	
	$= \frac{1}{2} evr$	½	
	b) $L = mvr$	½	
	$\mu = \frac{evr \times m}{2 \times m}$		
	$= \left(\frac{e}{2m}\right) L$	½	
	Direction of $\vec{\mu}$ is opposite to that of $\vec{L}$ $\vec{\mu} = -\left(\frac{e}{2m}\right)\vec{L}$	½	3
27	Finding value of angle i 3		
	For glass- liquid interface $\sin i_c = \frac{1}{n_{21}}$	½	
	$= \frac{1.25}{1.5}$	½	
	$= \frac{5}{6}$	½	
	$i_c + r = 90^0$	½	
	$\sin r = \sqrt{1 - \cos^2 r} = \frac{\sqrt{11}}{6}$		
	Since $\frac{Sin\ i}{Sin\ r} = n$	½	

	Therefore, $Sin\ i = \frac{\sqrt{11}}{4}$ or $i = Sin^{-1}\frac{\sqrt{11}}{4}$	½	3
28	(a) Finding charge densities on A and B — 3 For ball A $q_1 = 2\sigma \times 4\pi R^2$ $= 8\pi R^2\sigma$ For ball B $q_2 = 3\sigma \times 4\pi(2R)^2$ $= 48\pi R^2\sigma$ Total charge (Q) $= q_1 + q_2$ $= 56\pi R^2\sigma$ When balls A and B are connected by a wire, their potentials will be equal Let q be the charge on ball A and (Q – q) be the charge on the ball B after connecting wire. $\frac{K\,q}{R} = \frac{K(Q - q)}{2R}$ $2q = Q-q$ $q = \frac{Q}{3}$ $= \frac{56\pi R^2\sigma}{3}$ $Q - \frac{Q}{3} = \frac{112\pi R^2\sigma}{3}$ $\sigma_A = \frac{\frac{56\pi R^2\sigma}{3}}{4\pi R^2}$ $= \frac{14}{3}\sigma$ $\sigma_B = \frac{\frac{112\pi R^2\sigma}{3}}{4\pi(2R)^2}$ $= \frac{7}{3}\sigma$ OR (b) Location of point at which net electric field is zero — 2½ Identification of Region — ½	 ½ ½ ½ ½ ½ ½	

	 Electric field due to wire 1 and wire 2 at point P $E_1 = \dfrac{\lambda}{2\pi\varepsilon_0 x}$ $E_2 = \dfrac{\lambda/2}{2\pi\varepsilon_0 (x+d)}$ At P, Net electric field is zero $E_1 = E_2$ $\dfrac{\lambda}{2\pi\varepsilon_0 x} = \dfrac{\lambda}{2\times 2\pi\varepsilon_0 (x+d)}$ $x = -2d$ Negative sign indicates that point lies in the region C. At a distance 2d from wire 1 electric field is zero. (**Note** : Award full credit if a student finds the position by taking point in region C directly)	½ ½ ½ ½ ½ ½	3
	SECTION D		
29	(i) (B) $\dfrac{NBA}{K}$ (ii) (A) 0.25 Ω (iii) (B) 0.24 Ω (iv) (a) (A) (R_2 - $2R_1$) OR (b) (B) 1.8 x 10^{-4} Nm	**1** **1** **1** **1**	**4**
30	(i) (C)  (ii) (D) Remains the same (iii) (C) cut– off potential versus frequency of incident light (iv) (a) (C) $K_B > K_Y > K_R$	**1** **1** **1** **1**	

	OR (b) (A) Caesium		**4**

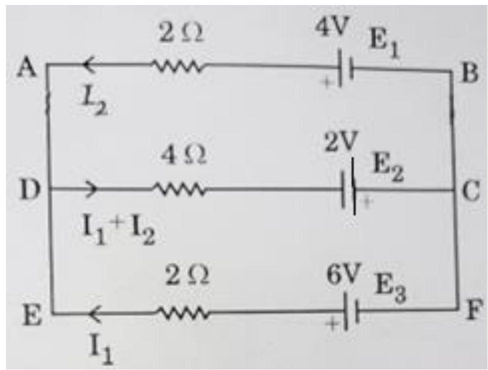
SECTION E

31

(a)

(i)	Finding current through batteries E_1, E_2 and E_3	3
(ii)	Finding effective resistance	2

i)



½

In closed loop ABCD, using Kirchhoff's loop law

$4I_1 + 6I_2 = 6$ …………………………..(1) ½

Similarly In closed loop CDFE

$6I_1 + 4I_2 = 8$ …………………………..(2) ½

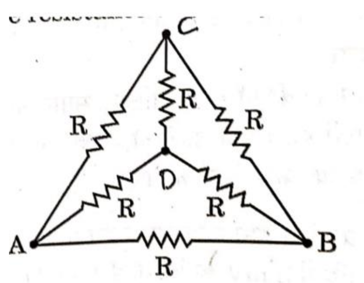
Solving eqn. (1) and (2)

$I_2 = \frac{1}{5}A$ ½

$I_1 = \frac{6}{5}A$ ½

$I_1 + I_2 = \frac{7}{5}A$ ½

ii)



Resistances R_{AC}, R_{CB} , R_{AD} , and R_{DB} form a balanced Wheatstone bridge

Hence current through R_{CD} is zero and will not contribute to equivalent resistance. ½

The equivalent resistance of bridge is R, is in parallel with R_{AB}

Series combinations of R_{AC} & R_{CB} and R_{AD} & R_{DB} is in parallel with R_{AB} ½

$$\frac{1}{R_{eq}} = \frac{1}{R} + \frac{1}{R}$$ ½

$$R_{eq} = \frac{R}{2}$$ ½

Given R = 10Ω, Therefore R_{eq} = 5Ω

OR

(b)

(i)	Calculating		
	(I)	ratio of electric fields at points A & B	1 ½
	(II)	drift velocity of free electrons at point B	1 ½
(ii)	Finding net electric field at point $\vec{r}$		2

(i) (I) $\vec{j} = \sigma \vec{E}$ ½

$$\frac{j_A}{j_B} = \frac{E_A}{E_B}$$

$$= \frac{I/A_A}{I/A_B}$$ ½

$$= \frac{A_B}{A_A}$$

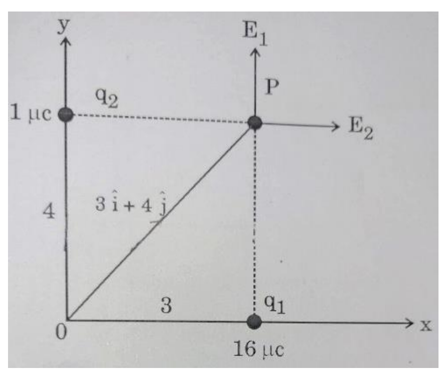
$$= \frac{2}{1}$$ ½

(II) $$v_d = \frac{I}{neA}$$ ½

$$= \frac{1}{8.5\times10^{28}\times1.6\times10^{-19}\times2\times10^{-7}}$$ ½

$$= 3.6\times10^{-4}\ m/s$$ ½

(ii)



$$\vec{E} = \frac{Kq}{r^2}\hat{r}$$ ½

$$\vec{E}_1 = \frac{9\times10^9\times16\times10^{-6}}{(4)^2}\hat{j}$$

$$= 9\times10^3\ \hat{j}$$ ½

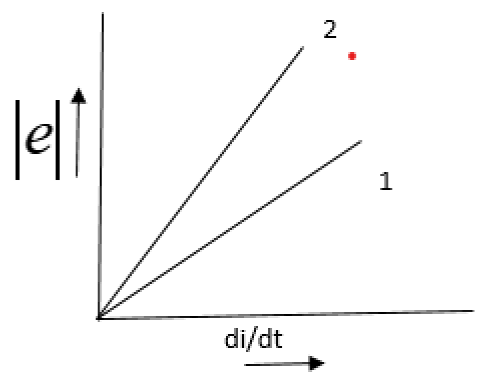
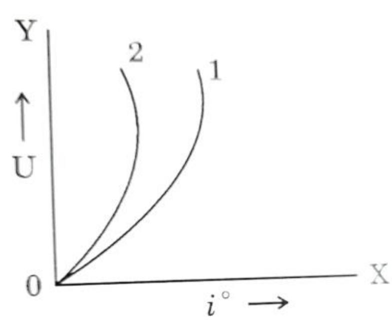
$$\vec{E}_2 = \frac{9\times10^9\times1\times10^{-6}}{(3)^2}\ \hat{i}$$ ½

$$= 10^3\ \hat{i}$$

$$\vec{E}_{net} = (\hat{i} + 9\hat{j})\,10^3\ N/C$$ ½

NOTE: Award full credit of this part if a student finds magnitude and direction separately.

5

32	(a) i) Defining self – inductance 1 Deriving expression for energy 1 ii) Drawing graphs showing the variation of (I) Magnitude of emf induced with rate of change of current 1½ (II) Energy stored with current 1½			
	Self Inductance is magnetic flux linked with a coil when the current through the coil is unity. **Alternatively** Self Inductance is the induced emf induced in the coil when rate of change of current through the coil is unity.	**1**		
	To maintain growth of current, power has to be supplied from external source. $P = \|e\|\|I\|$	½		
	$= \frac{dW}{dt} = LI\frac{dI}{dt}$ $dW = LIdI$ $W = \int LIdI$ $= \frac{1}{2}LI^2$	½		
	(I) $E = -L\frac{dI}{dt}$	½		
		**1**		
	(II) $U = \frac{1}{2}LI^2$ Parabolic graph obtained.	½		
		**1**		
	(1 indicates 10mH) & (2 indicates 20mH)			

OR

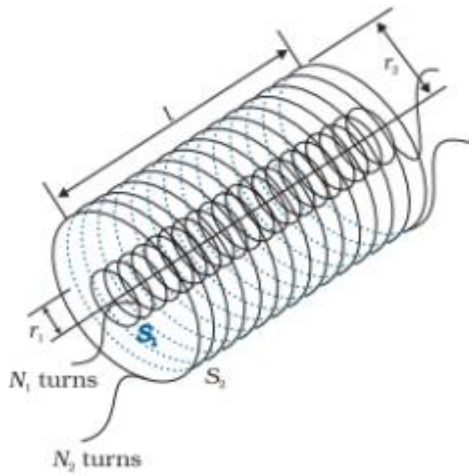
(a)

(i)	Defining mutual inductance	1
	Deducing expression for mutual inductance	2
(ii)	Finding flux linked with the inductor	2

(i) Mutual inductance is defined as the induced emf in primary coil when the current in secondary coil changes at the unit rate. **1**

Alternatively

Mutual inductance is defined as the magnetic flux linked with the primary coil when the current in secondary coil is unity.



½

Consider two long co-axial solenoids each of length l. Radius of inner solenoid S_1 is r_1 and number of turns per unit length is n_1.

The corresponding quantities for outer solenoid S_2 are r_2 and n_2 respectively. Let N_1 and N_2 be the total number of turns of coils S_1 and S_2 respectively.

When a current I_2 is set up through S_2, it sets up magnetic flux through S_1.

$$N_1\phi_1 = M_{12}I_2$$ ½

$$= (n_1 l)\times(\pi r_1^2)\times(\mu_0 n_2 I_2)$$ ½

$$= \mu_0 n_1 n_2 \pi r_1^2 l\, I_2$$ ½

$$M_{12} = \mu_0 n_1 n_2 \pi r_1^2 l = M_{21}$$

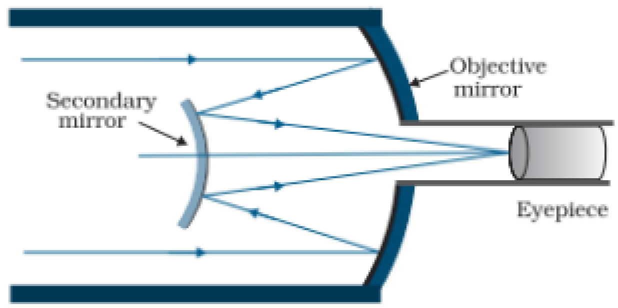
(ii)

$$|e| = L\frac{dI}{dt}$$ ½

$$L = \frac{e}{dI/dt}$$

$$= \frac{5\times10^{-3}}{2/40}$$

$$= 0.1\text{H}$$ ½

	$\phi = LI$ $= 0.1 \times \frac{2}{40} \times 10$ $= 0.05\ Wb$	½ ½	5
33	(a) Drawing ray diagram of reflecting telescope — 1 Explanation of formation of image — 1 Advantages — ½ + ½ (b) Finding focal lengths of the two lenses — 2		
	(i) 	1	
	The parallel rays from a distant object are reflected by a large concave mirror. These rays are then reflected by a convex mirror placed just before the focus of concave mirror and are converged to a point outside the hole. The final image is viewed through eye piece.	1	
	Advantages (any two) 1) No chromatic aberration. 2) Less spherical aberration 3) Less mechanical support required 4) Brighter Image 5) High resolving power. 6) High magnifying power	½ + ½	
	(ii) For image at infinity $\lvert f_0 \rvert + \lvert f_e \rvert = L$	½	
	According to question $f_0 = 50 \times f_e$	½	
	$f_e + 50fe = 102$		
	$f_e = 2$ cm	½	
	$f_0 = 100$ cm	½	
	OR		
	(b) (i) Two advantages of a compound microscope over simple microscope — ½ + ½ Drawing ray diagram and Explanation — 1 + 1 (ii) Obtaining power of combined lens — 2		

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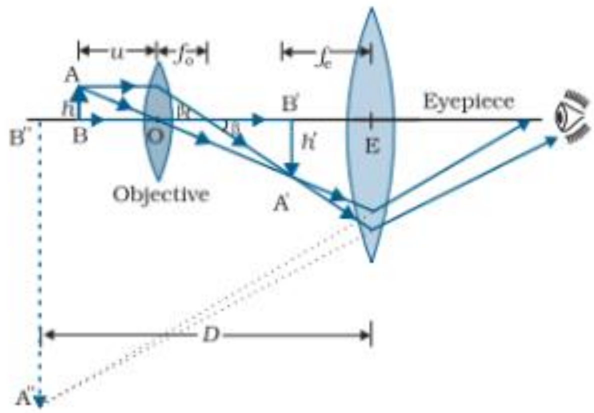
(i) Advantages (any two)

1) Larger magnification
2) Brighter image

Any other valid advantage



(deduct ½ mark for not showing arrow for ray diagram)

The lens nearest the object, called the objective, forms a real, inverted, magnified image of the object. This serves as the object for the second lens, the eye piece, functions like a simple microscope and produces final image which is enlarged and virtual.

(ii) Power of plano concave lens $= P_1 = \frac{-(n_1-1)}{R}$

Power of convex lens $= P_2 = (n_2-1)\left(\frac{2}{R}\right)$

$P = P_1 + P_2$

$= \frac{(2n_2 - n_1 - 1)}{R}$

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½ + ½

1

1

½

½

½

½

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5

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#

General Instructions :

Read the following instructions carefully and follow them :

(i) *This question paper contains **33** questions. **All** questions are **compulsory**.*

(ii) *This question paper is divided into **five** sections – **Sections A, B, C, D** and **E**.*

(iii) *In **Section A** – Questions no. **1** to **16** are Multiple Choice type questions. Each question carries **1** mark.*

(iv) *In **Section B** – Questions no. **17** to **21** are Very Short Answer type questions. Each question carries **2** marks.*

(v) *In **Section C** – Questions no. **22** to **28** are Short Answer type questions. Each question carries **3** marks.*

(vi) *In **Section D** – Questions no. **29** and **30** are case study-based questions. Each question carries **4** marks.*

(vii) *In **Section E** – Questions no. **31** to **33** are Long Answer type questions. Each question carries **5** marks.*

(viii) *There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.*

(ix) *Kindly note that there is a separate question paper for Visually Impaired candidates.*

(x) *Use of calculators is **not** allowed.*

You may use the following values of physical constants wherever necessary :

$c = 3 \times 10^{8}$ m/s

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8{\cdot}854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^{9}$ N m^2 C^{-2}

Mass of electron (m_e) = $9{\cdot}1 \times 10^{-31}$ kg

Mass of neutron = $1{\cdot}675 \times 10^{-27}$ kg

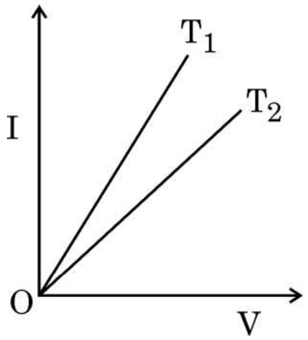
Mass of proton = $1{\cdot}673 \times 10^{-27}$ kg

Avogadro's number = $6{\cdot}023 \times 10^{23}$ per gram mole

Boltzmann constant = $1{\cdot}38 \times 10^{-23}$ JK^{-1}

SECTION A

1. The figure shows the voltage (V) versus the current (I) graphs for a wire at two temperatures T_1 and T_2. One can conclude that :



(A) $T_2 = 2T_1$ (B) $T_1 > T_2$

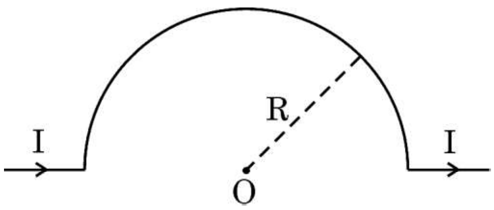
(C) $T_1 = T_2 / 3$ (D) $T_1 < T_2$

2. If R_s and R_p are the equivalent resistances of n resistors, each of value R, in series and parallel combinations respectively, then the value of $(R_s - R_p)$ is :

(A) $\left(\frac{n^2-1}{n^2}\right)R$ (B) $\left(\frac{n^2+1}{n^2-1}\right)R$

(C) $\left(\frac{n^2-1}{n}\right)R$ (D) $\frac{(n^2+1)R}{n^2}$

3. The value of magnetic field at point O in the given figure is :



(A) $\frac{\mu_0 I}{2\pi R}$ (B) $\frac{\mu_0 I}{\pi R}$

(C) $\frac{\mu_0 I}{4R}$ (D) $\frac{\mu_0 I}{R}$

4. A piece of a diamagnetic material, free to move when placed in a uniform magnetic field :

(A) moves along the field

(B) moves opposite to the field

(C) moves perpendicular to the field

(D) does not move at all

5. A galvanometer can be converted into an ammeter of desired range by connecting a :

(A) small resistance in series (B) large resistance in series

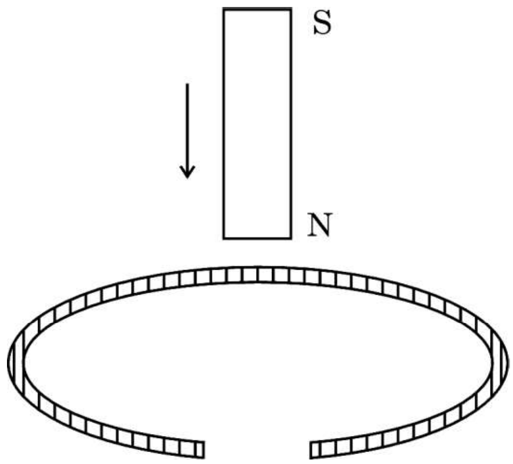
(C) small resistance in parallel (D) large resistance in parallel

6. A proton and an α-particle enter with the same velocity $\vec{v}$ in a uniform magnetic field $\vec{B}$ such that $\vec{v} \perp \vec{B}$. The ratio of the radii of their paths is :

(A) 2 (B) $\frac{1}{2}$

(C) $\frac{1}{4}$ (D) 4

7. A vertically held bar magnet is dropped along the axis of a copper ring having a cut as shown in the diagram. The acceleration of the falling magnet is :



(A) zero (B) less than g

(C) g (D) greater than g

8. An ac source is connected to a resistor and an inductor in series. The voltage across the resistor and inductor are 8 V and 6 V respectively. The voltage of the source is :

(A) 10 V (B) 12 V

(C) 14 V (D) 16 V

9. Two coherent waves, each of intensity I_0, produce interference pattern on a screen. The average intensity of light on the screen is :

(A) zero (B) I_0

(C) $2I_0$ (D) $4I_0$

10. The work function of a material is 2·21 eV. Which of the following ***cannot*** produce photoelectrons from it ?

(A) Red light (B) Blue light

(C) Violet light (D) Green light

11. The momentum (in kg m/s) of a photon of frequency $6{\cdot}0 \times 10^{14}$ Hz is :

(A) $6{\cdot}63 \times 10^{-25}$

(B) $1{\cdot}326 \times 10^{-27}$

(C) $2{\cdot}652 \times 10^{-26}$

(D) $3{\cdot}978 \times 10^{-24}$

12. Inside a nucleus, the nuclear forces between proton and proton, proton and neutron, neutron and neutron are F_{pp}, F_{pn} and F_{nn} respectively. Then :

(A) $F_{pp} > F_{pn} > F_{nn}$

(B) $F_{pn} > F_{nn} > F_{pp}$

(C) $F_{nn} > F_{pp} > F_{pn}$

(D) $F_{pp} = F_{pn} = F_{nn}$

*Questions number **13** to **16** are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below.*

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is ***not*** the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Both Assertion (A) and Reason (R) are false.

13. *Assertion (A) :* In a reflecting telescope, the image does not have chromatic aberration.

Reason (R) : Chromatic aberration occurs only due to refraction of light through an optical medium.

14. *Assertion (A) :* A hole is an apparent free particle with effective positive electronic charge.

Reason (R) : A hole is not necessarily a vacancy left behind by an electron in the valence band.

15. *Assertion (A) :* X-rays are produced when slow moving electrons are stopped by a metal target of high atomic number.

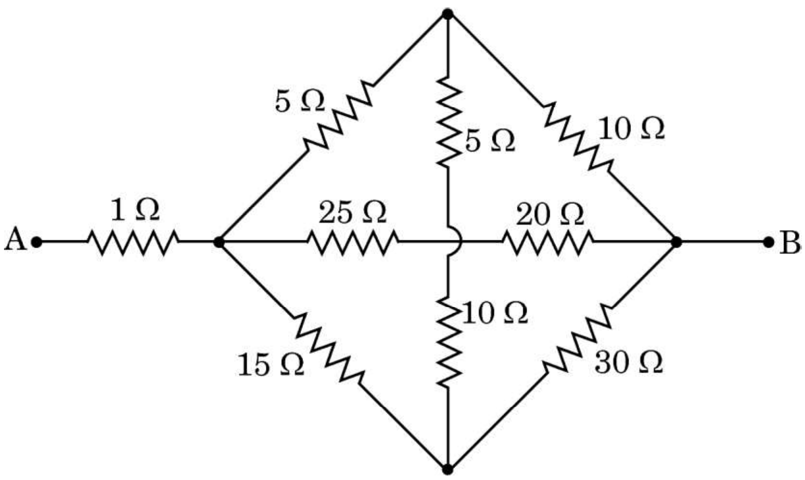
Reason (R) : X-rays consist of low-energy photons.

16. *Assertion (A) :* The binding energy per nucleon is practically constant for mass number in the range $(30 < A < 170)$.

Reason (R) : Nuclear forces between the nucleons for mass numbers in the range $(30 < A < 170)$ are not short-range.

SECTION B

17. Find the equivalent resistance between points A and B for the network shown in the figure. *2*



18. (a) Find the intensity at a point on the screen in Young's double slit experiment, at which the interfering waves of intensity I_0 each, have a path difference of (i) $\frac{\lambda}{3}$, and (ii) $\frac{\lambda}{2}$. *2*

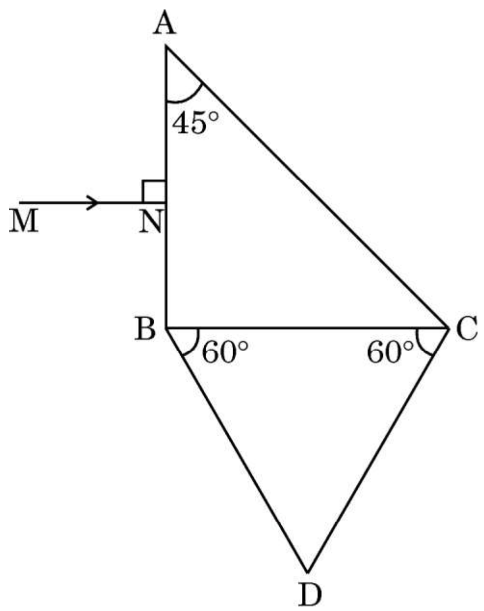
OR

(b) A point source of light in air is kept at a distance of 12 cm in front of a convex spherical surface of glass of refractive index 1·5 and radius of curvature 30 cm. Find the nature and position of the image formed. *2*

19. A laser beam of frequency $3{\cdot}0 \times 10^{14}$ Hz produces average power of 9 mW. Find (i) the energy of photon of the beam, and (ii) the number of photons emitted per second on an average by the source. *2*

#

20. A right angled isosceles glass prism ABC is kept in contact with an equilateral triangular prism DBC as shown in the figure. Both prisms are made of the same glass of refractive index 1·6. Trace the path of the ray MN incident normally on face AB as it passes through the combination. *2*



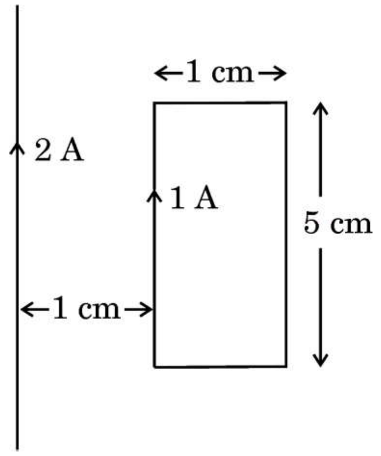
21. In an n-type semiconductor electron-hole combination is a continuous process at room temperature. Yet the electron concentration is always greater than the hole concentration in it. Explain. *2*

SECTION C

22. What is the difference between 'emf' and 'terminal voltage' of a cell ?

Two cells of emfs E_1 and E_2 and internal resistances r_1 and r_2 are connected in parallel. Derive an expression for the emf and internal resistance of the equivalent cell. *3*

23. A rectangular loop carries a current of 1 A. A straight long wire carrying 2 A current is kept near the loop in the same plane as shown in the figure.



Find : *3*

(i) the torque acting on the loop, and

(ii) the magnitude and direction of the net force on the loop.

24. (a) State Lenz's law. A rod MN of length L is rotated about an axis passing through its end M perpendicular to its length, with a constant angular velocity ω in a uniform magnetic field $\vec{B}$ parallel to the axis. Obtain an expression for emf induced between its ends. *3*

OR

(b) Define 'self-inductance' of a coil. Derive an expression for self-inductance of a long solenoid of cross-sectional area A and length l, having n turns per unit length. *3*

25. Name the electromagnetic wave used (i) in radar, (ii) in eye surgery and (iii) as diagnostic tool in medicine. Write their wavelength range also. *3*

26. Draw a ray diagram showing the image formation when a concave mirror produces a real, inverted and magnified image of an object and hence obtain the mirror formula. *3*

27. How is the necessary force provided to an electron to keep it moving in a circular orbit according to Bohr model of hydrogen atom ? Derive an expression for the total energy of an electron moving in an orbit of radius r in hydrogen atom. Give the significance of negative sign in this expression. *3*

28. (a) Consider the so-called 'D-T reaction' (Deuterium-Tritium reaction). In a thermonuclear fusion reactor, the following nuclear reaction occurs :

$$ {}^{2}_{1}H + {}^{3}_{1}H \longrightarrow {}^{4}_{2}He + {}^{1}_{0}n + Q $$

Find the amount of energy released in the reaction.

Given :

$m\left({}^{2}_{1}H\right) = 2 \cdot 014102 \text{ u}$

$m\left({}^{3}_{1}H\right) = 3 \cdot 016049 \text{ u}$

$m\left({}^{4}_{2}He\right) = 4 \cdot 002603 \text{ u}$

$m\left({}^{1}_{0}n\right) = 1 \cdot 008665 \text{ u}$

$1 \text{ u} = 931 \text{ MeV/c}^2$

(b) Show that the nuclear density is independent of mass number. *3*

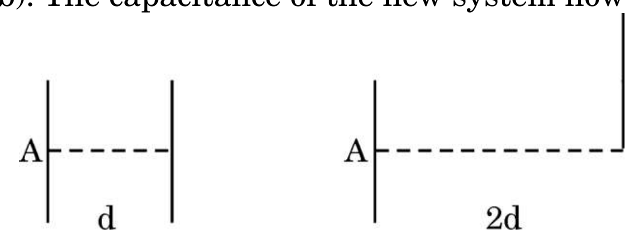
SECTION D

*Questions number **29** and **30** are case study-based questions. Read the following paragraphs and answer the questions that follow.*

29. A capacitor is a system of two conductors separated by an insulator. In practice, the two conductors have charges Q and – Q with potential difference $V = V_1 - V_2$ between them. The ratio $\frac{Q}{V}$ is a constant, denoted by C and is called the capacitance of the capacitor. It is independent of Q or V. It depends only on the geometrical configuration (shape, size, separation) of the two conductors and the medium separating the conductors. When a parallel plate capacitor is charged, the electric field E_0 is localised between the plates and is uniform throughout. When a slab of a dielectric is inserted between the charged plates (charge density σ), the dielectric is polarised by the field. Consequently opposite charges appear on the faces of the slab, near the plates, with surface charge density of magnitude σ_p. For a linear dielectric σ_p is proportional to E_0. Introduction of a dielectric changes the electric field, and hence, the capacitance of a capacitor, and hence, the energy stored in the capacitor.

Like resistors, capacitors can also be arranged in series or in parallel or in a combination of series and parallel.

(i) Consider a capacitor of capacitance C, with plate area A and plate separation d, filled with air [Fig. (a)]. The distance between the plates is increased to 2d and one of the plates is shifted as shown in Fig. (b). The capacitance of the new system now is : *1*



(a) (b)

(A) $\frac{C}{4}$ (B) $\frac{C}{2}$

(C) 2C (D) 4C

(ii) A slab (area A and thickness d_1) of a linear dielectric of dielectric constant K is inserted between charged plates (charge density σ) of a parallel plate capacitor [plate area A and plate separation d ($> d_1$)] and opposite charges with charge density of magnitude σ_p appear on the faces of the slab. The dielectric constant K is given by : *1*

(A) $\dfrac{\sigma + \sigma_p}{\sigma}$ (B) $\dfrac{\sigma}{\sigma - \sigma_p}$

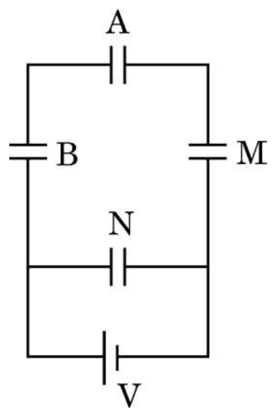
(C) $\dfrac{\sigma + \sigma_p}{\sigma_p}$ (D) $\dfrac{\sigma}{\sigma_p}$

(iii) An electric field E is established between the plates of an air filled parallel plate capacitor, with charges Q and – Q. V is the volume of the space enclosed between the plates. The energy stored in the capacitor is : *1*

(A) $\frac{1}{2} \varepsilon_0 E^2$ (B) $\varepsilon_0 Q^2 E$

(C) $\frac{1}{2} \varepsilon_0 E^2 V$ (D) $\varepsilon_0 E Q V$

(iv) (a) Three capacitors A, B and M, each of capacitance C are connected to a capacitor N of capacitance 2C and a battery as shown in the figure. If the charges on A and N are Q and Q′ respectively, then $\dfrac{Q'}{Q}$ is : *1*



(A) $\dfrac{1}{6}$ (B) $\dfrac{1}{3}$

(C) 3 (D) 6

OR

(b) A slab (area A and thickness $\frac{d}{2}$) of dielectric constant K is inserted in a parallel plate capacitor of plate area A and plate separation d. If C and C_0 are the capacitances of the capacitors with and without the dielectric, then $\frac{C}{C_0}$ is : *1*

(A) $\frac{K+1}{2K}$ (B) $\frac{2K}{K+1}$

(C) $\frac{K}{K-1}$ (D) $\frac{K-1}{K}$

30. Extrinsic semiconductors are made by doping pure or intrinsic semiconductors with suitable impurity. There are two type of dopants used in doping, Si or Ge, and using them p-type and n-type semiconductors can be obtained. A p-n junction is the basic building block of many semiconductor devices. Two important processes occur during the formation of a p-n junction : diffusion and drift. When such a junction is formed, a 'depletion layer' is created consisting of immobile ion-cores. This is responsible for a junction potential barrier. The width of a depletion layer and the height of potential barrier changes when a junction is forward-biased or reverse-biased. A semiconductor diode is basically a p-n junction with metallic contacts provided at the ends for application of an external voltage. Using diodes, alternating voltages can be rectified.

(i) Which of the following is a donor impurity atom for Ge ? *1*

(A) Boron (B) Antimony

(C) Aluminium (D) Indium

(ii) When a pentavalent atom occupies the position of an atom in the crystal lattice of Si, four of its electrons form covalent bonds with four silicon neighbours, while the fifth remains bound to the parent atom. The energy required to set this electron free is about : *1*

(A) 0·5 eV (B) 0·1 eV

(C) 0·05 eV (D) 0·01 eV

(iii) During formation of a p-n junction : *1*

(A) a layer of negative charge on n-side and a layer of positive charge on p-side appear.

(B) a layer of positive charge on n-side and a layer of negative charge on p-side appear.

(C) the electrons on p-side of the junction move to n-side initially.

(D) initially diffusion current is small and drift current is large.

(iv) (a) In reverse-biased p-n junction : *1*

(A) the drift current is of the order of few mA.

(B) the applied voltage mostly drops across the depletion region.

(C) the depletion region width decreases.

(D) the current increases with increase in applied voltage.

OR

(b) The output frequency of a full-wave rectifier with 50 Hz as input frequency is : *1*

(A) 25 Hz (B) 50 Hz

(C) 100 Hz (D) 200 Hz

SECTION E

31. (a) (i) Write the principle of working of an ac generator. Draw its labelled diagram and explain its working.

(ii) A resistor of 400 Ω, an inductor of $\left(\frac{5}{\pi}\right)$H and a capacitor of $\left(\frac{50}{\pi}\right)$μF are joined in series across an ac source $v = 140 \sin (100\pi)t$ V. Find the rms voltages across these three circuit elements. The algebraic sum of these voltages is more than the rms voltage of source. Explain. *5*

OR

(b) (i) Write the principle of working of a transformer. With the help of a labelled diagram, explain the working of a step-up transformer.

(ii) An ideal transformer is designed to convert 50 V into 250 V. It draws 200 W power from an ac source whose instantaneous voltage is given by $v_i = 20 \sin(100\pi)t$ V.

Find :

(I) rms value of input current.

(II) expression for instantaneous output voltage.

(III) expression for instantaneous output current. *5*

32. (a) (i) Draw a ray diagram to show the image formation by a compound microscope. Obtain the expression for the total magnification of the microscope when the final image is formed at infinity.

(ii) In a compound microscope, an object is placed at a distance of 1·5 cm from the objective of focal length 1·25 cm. The eyepiece has a focal length of 5 cm. The final image is formed at infinity. Calculate the distance between the objective and the eyepiece. *5*

OR

(b) (i) Using Huygens' principle, explain the refraction of a plane wavefront, propagating in air, at a plane interface between air and glass. Hence verify Snell's law.

(ii) Use mirror formula to deduce that a convex mirror always produces a virtual image of an object kept in front of it. *5*

33. (a) (i) The electric field in a region is given by $\vec{E} = 40x\,\hat{i}$ N/C. Find the amount of work done in taking a unit positive charge from a point (0, 3m) to the point (5m, 0).

(ii) A charge Q is distributed over two concentric hollow spheres of radii r and R (> r) such that their surface charge densities are equal. Find :

(I) the electric field, and

(II) the potential

at their common centre. *5*

OR

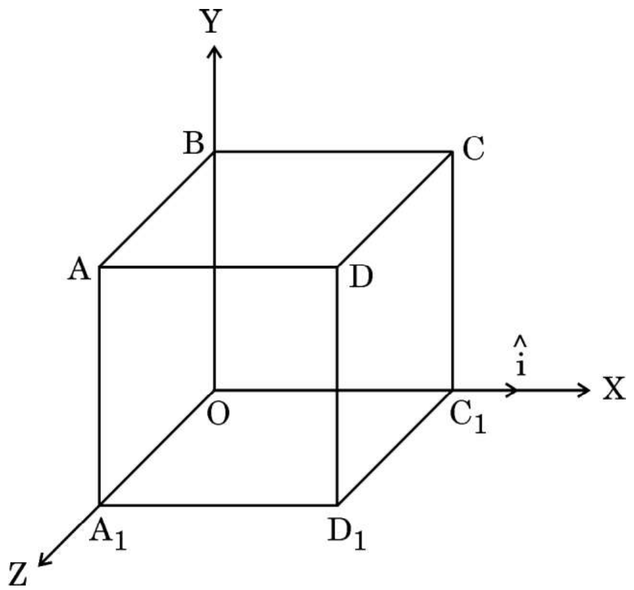
(b) (i) Obtain an expression for the electric field $\vec{E}$ due to a dipole of dipole moment $\vec{p}$ at a point on its equatorial plane and specify its direction. Hence, find the value of electric field :

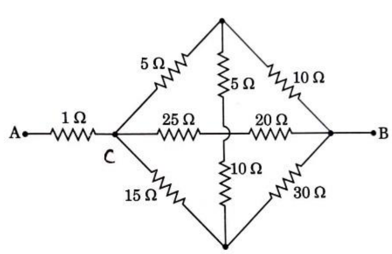
(I) at the centre of the dipole (r = 0), and

(II) at a point r >> a,

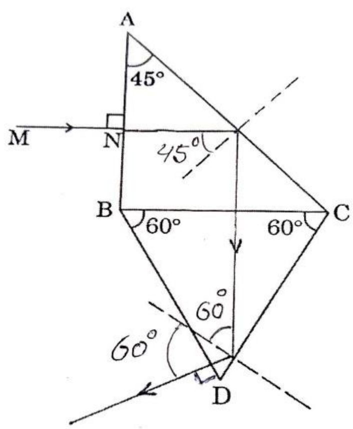
where 2a is the length of the dipole.

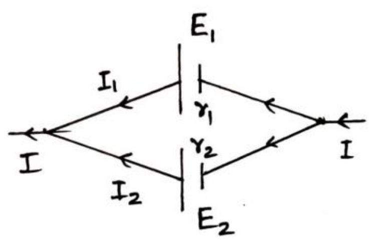
(ii) An electric field $\vec{E} = (10x + 5)\hat{i}$ N/C exists in a region in which a cube of side L is kept as shown in the figure. Here x and L are in metres. Calculate the net flux through the cube. *5*

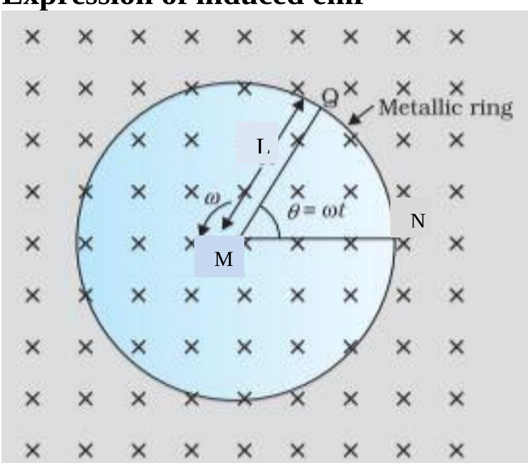


MARKING SCHEME: PHYSICS(042)			
Code: 55/6/1			
Q.No.	**VALUE POINTS/EXPECTED ANSWERS**	**Marks**	**Total Marks**
	SECTION A		
1.	(D) $T_1 < T_2$	1	1
2.	(C) $\left[\frac{n^2-1}{n}\right]R$	1	1
3.	(C) $\frac{\mu_0 I}{4R}$	1	1
4.	(D) does not move at all	1	1
5.	(C) small resistance in parallel	1	1
6.	(B) $\frac{1}{2}$	1	1
7.	(C) g	1	1
8.	(A) 10 V	1	1
9.	(C) $2I_0$	1	1
10.	(A) Red Light	1	1
11.	(B) 1.326×10^{-27}	1	1
12.	(D) $F_{pp} = F_{pn} = F_{nn}$	1	1
13.	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A)	1	1
14.	(C) Assertion (A) is true, But Reason (R) is false.	1	1
15.	(D) Both Assertion (A) and Reason (R) are false.	1	1
16.	(C) Assertion (A) is true, But Reason (R) is false.	1	1
	SECTION B		
17.	Finding equivalent resistance between points A and B 2 Resistance between points C and B $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ $\frac{1}{R} = \frac{1}{15} + \frac{1}{45} + \frac{1}{45}$ R = 9 Ω Equivalent resistance between points A and B  	½ ½	

	$R_{eq} = R_1 + R_2$ R_{eq} = 1 + 9 = 10 Ω	½ ½	2
18.	(a) Finding the intensity for path difference of (i) $\frac{\lambda}{3}$ 1 (ii) $\frac{\lambda}{2}$ 1 (i) $\Delta\phi = \frac{2\pi}{\lambda}.\Delta x$ $\Delta\phi = \frac{2\pi}{\lambda}.\frac{\lambda}{3} = \frac{2\pi}{3}$ $I = 4I_0 \cos^2 \frac{\phi}{2}$ $I = 4I_0 \cos^2 \frac{\pi}{3}$ $I = I_0$ (ii) $\Delta\phi = \frac{2\pi}{\lambda}.\frac{\lambda}{2} = \pi$ $I = 4I_0 \cos^2 \frac{\pi}{2}$ $I = 0$ OR (b) Finding- The position of the image 1½ The nature of the image ½ $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$ $\frac{1.5}{v} - \frac{1}{(-12)} = \frac{1.5-1}{30}$ v = -22.5 cm Image is virtual and erect.	½ ½ ½ ½ ½ ½ ½ ½	**2**

19.	Finding- (i) The energy of photon of the beam 1 (ii) The average number of photons emitted per second (N) 1 (i) $E = h\nu$ $= 6.63\times10^{-34}\times3.0\times10^{14}$ $= 1.99\times10^{-19}$ J (ii) $N = \frac{P}{E}$ $= \frac{9\times10^{-3}}{1.99\times10^{-19}}$ $= 4.5\times10^{16}$	½ ½ ½ ½	2
20.	Tracing the path of ray MN 2  Note: Please deduct ½ mark for not showing arrows with the rays.	1 1	2
21.	Explanation for higher electron concentration in n-type semiconductor in comparison to hole concentration 2 In a doped semiconductor the total number of conduction electrons is due to the electrons contributed by donors and those generated intrinsically, while the total number of holes is only due to the holes from the intrinsic sources.	2	2

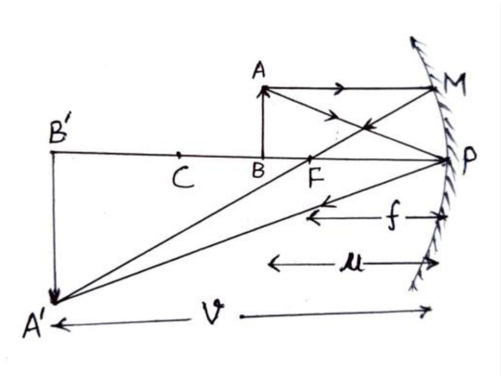
	SECTION - C		
22.	• Difference between emf and terminal voltage of a cell 1 Deriving expression for- • Equivalent emf of combination of cells 1½ • Equivalent internal resistance of combination of cells ½ (Any one difference) 1. Potential difference between the terminals of a cell in open circuit is emf and in closed circuit it is terminal voltage. 2. An emf does not depend on the external resistance, while terminal voltage depends on external resistance. 3. emf is the cause and terminal voltage is the effect.  $V = E_1 - I_1 r_1$ $V = E_2 - I_2 r_2$ $I = I_1 + I_2$ $I = \left(\dfrac{E_1 - V}{r_1}\right) + \left(\dfrac{E_2 - V}{r_2}\right)$ On comparing above equation with $I = \dfrac{E_{eq} - V}{r_{eq}}$ $E_{eq} = \dfrac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$ $r_{eq} = \dfrac{r_1 r_2}{r_1 + r_2}$	1 ½ ½ ½ ½	3
23.	Finding- (i) The torque acting on the loop 1 (ii) The magnitude and direction of net force 2 (i) $\tau = mB\sin\theta$ As $\vec{m}$ and $\vec{B}$ are in same direction, $\theta = 0^0$ $\tau = 0$ (ii) $F = \dfrac{\mu_0 I_1 I_2 l}{2\pi r}$	½ ½ ½	

	$F_{net} = \frac{\mu_0 I_1 I_2 l}{2\pi}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$ $= \frac{4\pi \times 10^{-7} \times 2 \times 1 \times 5 \times 10^{-2}}{2\pi \times 10^{-2}}\left(1 - \frac{1}{2}\right)$ $F_{net} = 1 \times 10^{-6}$ N Net force on the loop is towards the long straight wire.	 ½ ½ ½	 3
24.	(a) Stating Lenz's law — 1 Obtaining expression for induced emf — 2 **Lenz's law** The polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it. **Expression of induced emf**  The magnitude of the emf generated across the length dr of the rod as it moves at right angles to the magnetic field is given by $d\varepsilon = B\text{v}\,dr$ $\varepsilon = \int d\varepsilon$ $= \int_0^L B\text{v}\,dr$ $\varepsilon = \int_0^L B\omega r\,dr$ $\varepsilon = \frac{1}{2}BL^2\omega$ **Alternatively:** Area of the sector (QMN) = $\frac{1}{2}L^2\theta$	 1 ½ ½ ½ ½ ½	

	Induced emf is $\varepsilon = B \times \frac{d}{dt}\left(\frac{1}{2}L^2\theta\right)$ $\varepsilon = \frac{1}{2}BL^2\frac{d\theta}{dt}$ $\varepsilon = \frac{1}{2}BL^2\omega$ OR (b) Definition of self inductance 1 Deriving expression for self inductance for a long solenoid 2 Self inductance of a coil is the ratio of the flux linkage to the current flowing in the coil. **Alternatively:** Self inductance of a coil is defined as the flux linked with the coil when unit current flows through it. **Alternatively**: Self inductance of a coil may be defined as the magnitude of emf induced in the coil when current changes at the rate of 1 A/s in the coil. **Expression for self inductance of a long solenoid:** The magnetic field due to current flowing in the solenoid, B = $\mu_0 nI$ Total flux linked with the given solenoid $N\phi_B = (nl)(\mu_0 nI)\,\mathrm{A}$ $N\phi_B = \mu_0 n^2\,\mathrm{A}\,lI$ Self inductance $L = \frac{N\phi_B}{I}$ $L = \mu_0 n^2\,\mathrm{A}\,l$	½ ½ ½ 1 ½ ½ ½ ½	 3
25.	Naming the electromagnetic waves 1½ Writing wavelength range 1½ The electromagnetic waves used are (i) Microwaves (ii) Ultraviolet / Infrared (iii) X-Rays Wavelength range of electromagnetic waves used (i) 0.1 m to 1 mm (ii) 400 nm to 1 nm / 1mm to 700 nm (iii) 1 nm to 10^{-3} nm	 ½ ½ ½ ½ ½ ½	 3

26.

Drawing the ray diagram	1
Obtaining the mirror formula	2



1

Note: Please deduct ½ mark of this diagram if not showing arrows with the rays.

In similar triangles

$\Delta A'B'F$ *and* ΔMPF

$$\frac{A'B'}{MP}=\frac{B'F}{FP}$$

or $\dfrac{A'B'}{AB}=\dfrac{B'F}{FP}$ $\quad(\because MP=AB)$ ---------(1) ½

In similar triangles $\Delta A'B'P$ *and* ΔABP

$\dfrac{A'B'}{AB}=\dfrac{PB'}{PB}$ -------(2) ½

from equation (1) and (2)

$$\frac{B'F}{FP}=\frac{PB'}{PB}$$

$$\frac{PB'-PF}{FP}=\frac{PB'}{PB}$$

$\dfrac{(-v)-(-f)}{(-f)}=\dfrac{(-v)}{(-u)}$ ½

on solving we get

$\dfrac{1}{v}+\dfrac{1}{u}=\dfrac{1}{f}$ ½

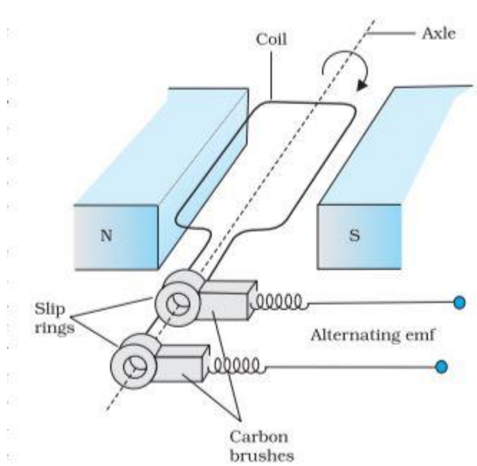
3

27.

• To state the necessary force for revolving electron around the nucleus	½
• Deriving the expression for total energy of electron in hydrogen atom	2
• Significance of negative sign	½

The electrostatic force of attraction between the electrons and the nucleus provides the necessary centripetal force required to an electron to revolve in the orbit. ½

	$\frac{mv^2}{r}=\frac{e^2}{4\pi\varepsilon_0 r^2}$ -------(1) (Z = 1 for hydrogen atom) Kinetic energy of the electron $K=\frac{1}{2}mv^2$ $K=\frac{e^2}{8\pi\varepsilon_0 r}$ (from eq (1)) Potential energy of the electron $U=\frac{-e^2}{4\pi\varepsilon_0 r}$ $\left(\because U=\frac{q_1 q_2}{4\pi\varepsilon_0 r}\right)$ Total energy of the electron E = K + U $E=\frac{-e^2}{8\pi\varepsilon_0 r}$ Note: Full credit of this part should be given if a student shows this derivation using alternative method Negative sign signifies that electron is bound to the nucleus OR force is attractive.	½ ½ ½ ½ ½	3
28.	Finding the amount of energy released 2 Showing the nuclear density is independent of mass number 1 $\Delta m=\left[m({}^2_1H)+m({}^3_1H)\right]-\left[m({}^4_2He)+m({}^1_0\text{n})\right]$ = (2.014102 + 3.016049) – (4.002603 + 1.008665) = 0.018883u Q = $\Delta m\times 931$ = 0.018883 × 931 MeV Q = 17.58 MeV Nuclear density = $\frac{\text{Mass of nucleus}}{\text{Volume of nucleus}}$ $\rho=\frac{mA}{\frac{4}{3}\pi R^3}$ $R=R_0 A^{1/3}$ $\rho=\frac{3m}{4\pi R_0^3}$ Independent of mass number (A)	½ ½ ½ ½ ½ ½	3

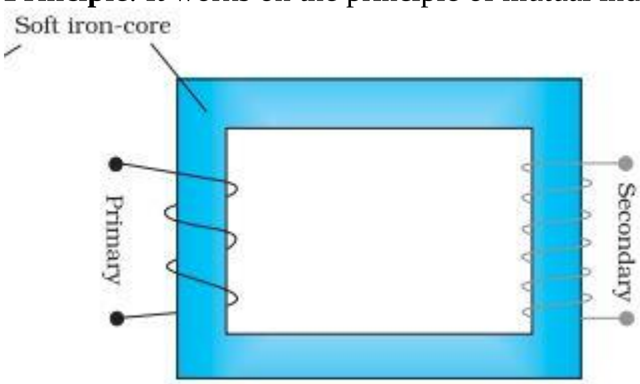
	SECTION - D		
29.	(i) (A) $\left(\frac{C}{4}\right)$ (ii) (B) $\frac{\sigma}{\sigma-\sigma_p}$ (iii) (C) $\frac{1}{2}\varepsilon_0 E^2 V$ (iv) (a) (D) 6 OR (b) (B) $\frac{2K}{K+1}$	1 1 1 1	4
30.	(i) (B) Antimony (ii) (C) 0.05 eV (iii) (B) A layer of positive charge on n side and a layer of negative charge on p side appear (iv) (a) (B) The applied voltage mostly drops across the depletion region OR (b) (C) 100 Hz	1 1 1 1	4
	SECTION - E		
31.	**(a)** (i) Writing principle of ac generator 1 Labelled diagram of ac generator 1 Working of ac generator 1 (ii) Finding rms voltages across three circuit elements 1½ Explanation of the algebraic sum of rms voltages across three circuit elements is more than the rms voltage source ½ **(i) Principle:** It works on the principle of electromagnetic induction. 	1 1	

	Working: The coil is mechanically rotated in the uniform magnetic field. The rotation of the coil causes the magnetic flux through it to change, so an emf is induced in the coil.	1	
	(i) $Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$		
	$= \sqrt{(400)^2 + \left(100\pi \times \frac{5}{\pi} - \frac{1}{100\pi \times \frac{50}{\pi} \times 10^{-6}}\right)^2}$		
	$= 500\,\Omega$		
	$I_{rms} = \frac{V_{rms}}{Z}$		
	$I_{rms} = \frac{140}{\sqrt{2} \times 500} = \frac{0.28}{\sqrt{2}}$ A		
	$(V_{rms})_R = I_{rms}\ R$		
	$= \frac{0.28}{\sqrt{2}} \times 400$		
	$= \frac{112}{\sqrt{2}} = 56\sqrt{2}$ V	½	
	$(V_{rms})_L = I_{rms}\ \omega \mathrm{L}$		
	$= \frac{0.28}{\sqrt{2}} \times 500$		
	$= \frac{140}{\sqrt{2}} = 70\sqrt{2}$ V	½	
	$(V_{rms})_C = I_{rms}\ \frac{1}{\omega C}$		
	$= \frac{0.28}{\sqrt{2}} \times 200$		
	$= \frac{56}{\sqrt{2}} = 28\sqrt{2}$ V	½	
	The algebraic sum of voltages is more than the rms voltage of source because voltages across R, L and C are not in phase.	½	
	OR		

(b)

(i)	Writing principle of transformer	1
	Labelled diagram of step-up transformer	1
	Working of step-up transformer	1
(ii)	Finding-	
	• rms value of input current	1
	• expression for instantaneous output voltage	½
	• expression for instantaneous output current	½

(i) **Principle**: It works on the principle of mutual induction. 1



1

Working: When an alternating voltage is applied to the primary, the resulting current produces an alternating magnetic flux which links the secondary and induces an emf in it. Since the no. of turns are more in secondary windings an emf induced is proportional to the no. of turns. Therefore more emf is developed across the secondary windings. 1

(ii) $P_i = V_p I_p$ ½

$$200 = \frac{20}{\sqrt{2}} I_p$$ ½

$$I_p = 10\sqrt{2}\text{A}$$

$$\frac{V_o}{V_i} = \frac{250}{50}$$

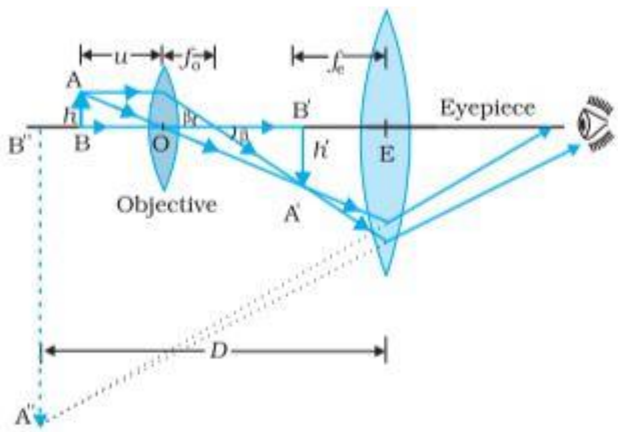
$$5 = \frac{V_o}{V_i}$$

$$V_o = 100\sin(100\pi)\,\text{t V}$$ ½

$$\text{P}_o = (V_o)_{rms}(I_o)_{rms}$$

$$200 = \frac{100}{\sqrt{2}}(I_o)_{rms}$$

$$(I_o)_{rms} = 2\sqrt{2}\text{A}$$

	$\therefore I_o = \left(2\sqrt{2}\right)\sqrt{2}\sin(100\pi)t$ $I_o = 4\sin(100\pi)t\,A$	½	**5**
32.	(a) (i) Drawing ray diagram of compound microscope — 1½ Obtaining an expression for total magnification — 1½ (ii) Calculating distance between the objective and the eye-piece — 2		
	(i)  Note: Deduct ½ mark for not showing arrows with the rays.	1½	
	Magnification produced by objective $m_0 = \frac{h'}{h} = \frac{L}{f_o}$	½	
	Magnification produced by eye-piece $m_e = 1 + \frac{D}{f_e}$ If the final image is formed at infinity $m_e = \frac{D}{f_e}$	½	
	Total magnification $m = m_0 \times m_e$ $= \left(\frac{L}{f_o}\right)\left(\frac{D}{f_e}\right)$	½	
	(ii) $\frac{1}{v_o} - \frac{1}{u_o} = \frac{1}{f_0}$	½	
	$\frac{1}{v_o} - \frac{1}{(-1.5)} = \frac{1}{1.25}$ $v_o = 7.5\text{cm}$	½	

$L = |v_o| + |f_e|$ as final image is formed at infinity ($v_e = \infty, u_e = f_e$) ½

L = 7.5 + 5

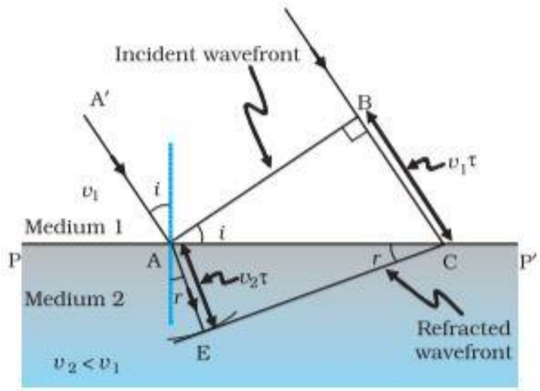
L= 12.5 cm ½

OR

(b)

(i) Explaining the refraction of a plane wavefront	1
Verification of Snell's law	2
(ii) Deducing that a convex mirror always produces a virtual image of an object	2

(i)



1

$$\sin i = \frac{BC}{AC} = \frac{v_1\tau}{AC}$$ ½

$$\sin r = \frac{AE}{AC} = \frac{v_2\tau}{AC}$$ ½

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2}$$

$$\frac{\sin i}{\sin r} = \frac{c/n_1}{c/n_2}$$ ½

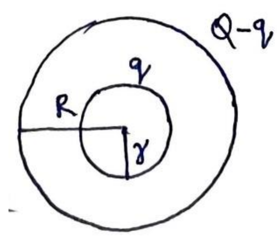
$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1} \text{ or } n_1 \sin i = n_2 \sin r$$ ½

(ii) $$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$ ½

$u < 0$, $f > 0$

$$\frac{1}{v} + \frac{1}{(-u)} = \frac{1}{f}$$ ½

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u}$$ ½

	$\frac{1}{v}$ is positive $\therefore$ v is positive $\Rightarrow$ virtual image	½	5
33.	(i) Finding the amount of work done — 2 (ii) Finding (I) The electric field at their common centre — 1 (II) The potential at their common centre — 2		
	(a) (i) $V = -\int \vec{E} \cdot \overrightarrow{dr}$ $= -\int 40\,x\,dx$ $= -20\,x^2$	½	
	Potential at A (0, 3m), V_A = 0 Potential at B (5m, 0), V_B = -500 V	½	
	Work done in taking a unit positive charge from a point (0, 3m) to the point (5m, 0) $W = q(V_B - V_A)$ $= 1(-500 - 0)$	½	
	$W = -500\,J$	½	
	(ii) (I) Electric field at the common centre will be zero as the charge enclosed by the inner sphere is zero.	1	
			
	Alternatively: $q_{en} = 0$ $\phi_E = 0$	½	
	$\oint \vec{E}.\overrightarrow{ds} = 0$ $E = 0$	½	
	(II) $\because$ Surface charge densities are equal $\frac{q}{4\pi r^2} = \frac{Q-q}{4\pi R^2}$	½	

$$q = \frac{Qr^2}{R^2 + r^2}$$ ½

Potential at common centre

$$V = \frac{kq}{r} + \frac{k(Q\text{-}q)}{R}$$ ½

$$V = \frac{k}{r}\frac{Qr^2}{(R^2+r^2)} + \frac{k}{R}\left[Q - \frac{Qr^2}{(R^2+r^2)}\right]$$

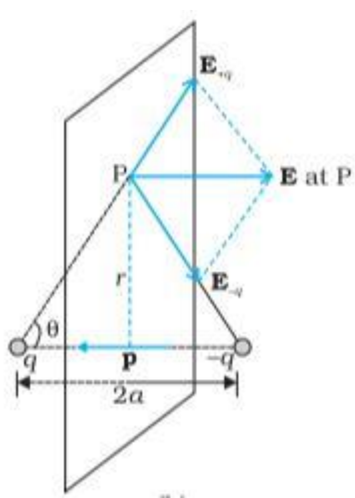
$$V = \frac{kQ(R+r)}{R^2+r^2}$$ ½

OR

(b)

(i)	Obtaining expression for electric field due to a dipole on its equatorial plane	2
	Finding electric field:	
	(I) At centre of the dipole	½
	(II) At a point r >> a	½
(ii)	Calculating net electric flux through cube	2

(i)



½

The magnitudes of the electric field due to two charges +q and -q are

$$E_{+q} = \frac{q}{4\pi\varepsilon_0}\frac{1}{(r^2+a^2)}$$

$$E_{-q} = \frac{q}{4\pi\varepsilon_0}\frac{1}{(r^2+a^2)}$$ ½

The total electric field

$$\vec{E} = -\left(E_{+q} + E_{-q}\right)\cos\theta\,\hat{p}$$

	$\vec{E}=-\dfrac{\vec{p}}{4\pi\varepsilon_0\left(r^2+a^2\right)^{3/2}}$	½	
	Direction of electric field is opposite to dipole moment ($\vec{p}$)	½	
	(I) At centre of dipole, r = 0		
	$\vec{E}=-\dfrac{-\vec{p}}{4\pi\varepsilon_0 a^3}$	½	
	(II) At a point r>>a		
	$\vec{E}=-\dfrac{-\vec{p}}{4\pi\varepsilon_0 r^3}$	½	
	(ii) $\vec{E}=(10x+5)\hat{i}$ N/C		
	$\phi_L=\int\vec{E}.\vec{ds}$ $=-E_L(L^2)$ $=-5L^2$	½	
	$\phi_R=E_R(L^2)$ $=(10L+5)L^2$	½	
	$\phi_{net}=\phi_L+\phi_R$ $=-5L^2+(10L+5)L^2$	½	
	$=10L^3$ Nm^2/C	½	5

General Instructions :

Read the following instructions carefully and follow them :

(i) *This question paper contains **33** questions. **All** questions are **compulsory**.*

(ii) *This question paper is divided into **five** sections – **Sections A, B, C, D** and **E**.*

(iii) *In **Section A** – Questions no. **1** to **16** are Multiple Choice type questions. Each question carries **1** mark.*

(iv) *In **Section B** – Questions no. **17** to **21** are Very Short Answer type questions. Each question carries **2** marks.*

(v) *In **Section C** – Questions no. **22** to **28** are Short Answer type questions. Each question carries **3** marks.*

(vi) *In **Section D** – Questions no. **29** and **30** are case study-based questions. Each question carries **4** marks.*

(vii) *In **Section E** – Questions no. **31** to **33** are Long Answer type questions. Each question carries **5** marks.*

(viii) *There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.*

(ix) *Kindly note that there is a separate question paper for Visually Impaired candidates.*

(x) *Use of calculators is **not** allowed.*

You may use the following values of physical constants wherever necessary :

$c = 3 \times 10^8$ m/s

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8{\cdot}854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

Mass of electron (m_e) = $9{\cdot}1 \times 10^{-31}$ kg

Mass of neutron = $1{\cdot}675 \times 10^{-27}$ kg

Mass of proton = $1{\cdot}673 \times 10^{-27}$ kg

Avogadro's number = $6{\cdot}023 \times 10^{23}$ per gram mole

Boltzmann constant = $1{\cdot}38 \times 10^{-23}$ JK^{-1}

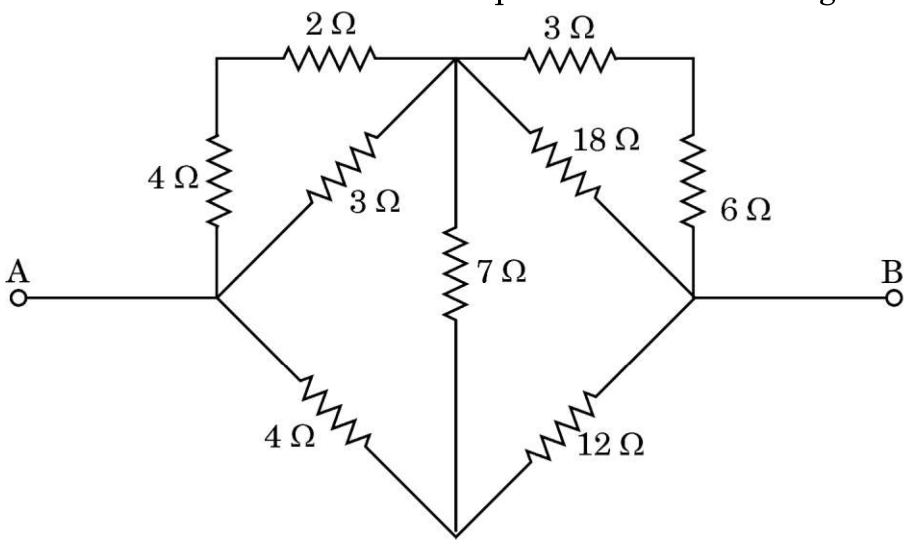
SECTION A

1. Two horizontal plates, separated by 1 cm, are arranged one above the other. A particle of mass 5 mg and charge 2 nC is released in air between the plates. The potential difference that should be applied to the plates so that the particle remains suspended between them, is :

(A) 250 V (B) 200 V

(C) 100 V (D) 50 V

2. The effective resistance between points A and B in the given circuit is :



(A) 6 Ω (B) $\frac{8}{3}$ Ω

(C) $\frac{16}{3}$ Ω (D) 2 Ω

3. A rectangular coil of area A is kept in a uniform magnetic field $\vec{B}$ such that the plane of the coil makes an angle α with $\vec{B}$. The magnetic flux linked with the coil is :

(A) BA sin α (B) BA cos α

(C) BA (D) zero

4. An alternating current is given by $I = I_0 \cos(100\pi)t$. The least time the current takes to decrease from its maximum value to zero will be :

(A) $\left(\frac{1}{200}\right)$ s (B) $\left(\frac{1}{150}\right)$ s

(C) $\left(\frac{1}{100}\right)$ s (D) $\left(\frac{1}{50}\right)$ s

5. A capacitor and an inductor are connected in series across an ac source of voltage of variable frequency. The frequency is increased continuously. The nature of the circuit before and after the resonance will be :

(A) inductive only

(B) capacitive only

(C) capacitive and inductive respectively

(D) inductive and capacitive respectively

6. A metal rod of length 50 cm is held vertically and moved with a velocity of 10 m/s towards east. The horizontal component of the Earth's magnetic field at the place is 0·4 G. The emf induced across the ends of the rod is :

(A) 0·1 mV (B) 0·2 mV

(C) 0·8 mV (D) 1·6 mV

7. The dimensions of 'self-inductance' are :

(A) $[M\,L\,T^{-2}\,A^{-2}]$

(B) $[M\,L^2\,T^{-1}\,A^{-1}]$

(C) $[M\,L^{-1}\,T^{-2}\,A^{-2}]$

(D) $[M\,L^2\,T^{-2}\,A^{-2}]$

8. The frequency of a photon of energy 1·326 eV is :

(A) $1{\cdot}18 \times 10^{14}$ Hz

(B) $3{\cdot}20 \times 10^{14}$ Hz

(C) $4{\cdot}20 \times 10^{15}$ Hz

(D) $4{\cdot}80 \times 10^{15}$ Hz

9. Germanium crystal is doped at room temperature with a minute quantity of boron. The charge carriers in the doped semiconductors will be :

(A) electrons only

(B) holes only

(C) holes and few electrons

(D) electrons and few holes

10. Out of the four options given, in which transition will the emitted photon have the maximum wavelength ?

(A) n = 4 to n = 3 (B) n = 3 to n = 2

(C) n = 2 to n = 1 (D) n = 3 to n = 1

11. A p-n junction diode is forward biased. As a result,

(A) both the potential barrier height and the width of depletion layer decrease.

(B) both the potential barrier height and the width of depletion layer increase.

(C) the potential barrier height decreases and the width of depletion layer increases.

(D) the potential barrier height increases and the width of depletion layer decreases.

12. Isotones are the nuclides having :

(A) same mass numbers

(B) same atomic numbers

(C) same neutron number, but different atomic number

(D) different neutron number, and different mass number

*Questions number **13** to **16** are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below.*

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is ***not*** the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Both Assertion (A) and Reason (R) are false.

13. *Assertion (A) :* A charged particle is moving with velocity v in x-y plane, making an angle $\theta \, (0 < \theta < \frac{\pi}{2})$ with x-axis. If a uniform magnetic field $\vec{B}$ is applied in the region, along y-axis, the particle will move in a helical path with its axis parallel to x-axis.

Reason (R) : The direction of the magnetic force acting on a charged particle moving in a magnetic field is along the velocity of the particle.

14. *Assertion (A) :* A ray of light is incident normally on the face of a prism. The emergent ray will graze along the opposite face of the prism when the critical angle at glass-air interface is equal to the angle of the prism.

Reason (R) : The refractive index of a prism depends on angle of the prism.

15. *Assertion (A) :* EM waves do not require a medium for their propagation.

Reason (R) : EM waves are transverse waves.

16. *Assertion (A) :* The minimum negative potential applied to the anode in a photoelectric experiment at which photoelectric current becomes zero, is called cut-off voltage.

Reason (R) : The threshold frequency for a metal is the minimum frequency of incident radiation below which emission of photoelectrons does not take place.

SECTION B

17. A cell of emf E and internal resistance r is connected across a resistor of variable resistance R. Show graphically the variation of

(a) the terminal voltage across the cell,

(b) the current supplied by the cell,

with R as it is increased from 0 to the maximum value. *2*

18. (a) Using the mirror equation and the formula of magnification, deduce that "the virtual image produced by a convex mirror is always diminished in size and is located between the pole and the focus." *2*

OR

(b) A convex lens of focal length 10 cm, a concave lens of focal length 15 cm and a third lens of unknown focal length are placed coaxially in contact. If the focal length of the combination is +12 cm, find the nature and focal length of the third lens, if all lenses are thin. Will the answer change if the lenses were thick ? *2*

19. Write two differences in the patterns of double-slit interference experiment and single-slit diffraction experiment.
Light waves from two pinholes illuminated by two sodium lamps do not produce interference patterns. Explain why. *2*

20. Draw energy band diagrams of n-type and p-type semiconductors at temperature T > 0 K. Show the donor/acceptor energy levels with the order of difference of their energies from the bands. *2*

21. Briefly explain how energy is produced in stars, giving two examples of the nuclear reactions involved. *2*

SECTION C

22. Three cells A, B and C of emfs 2 V, 3 V and 5 V respectively are connected in parallel to each other. Their internal resistances are 5 Ω, 5 Ω and 1 Ω respectively. Calculate the currents flowing through the cells A, B and C. *3*

23. (a) (i) Write Biot-Savart's law in vector form.

(ii) Two identical circular coils A and B, each of radius R, carrying currents I and $\sqrt{3}$ I respectively, are placed concentrically in XY and YZ planes respectively. Find the magnitude and direction of the net magnetic field at their common centre. *3*

OR

(b) (i) A rectangular loop of sides l and b carries a current I clockwise. Write the magnetic moment $\vec{m}$ of the loop and show its direction in a diagram.

(ii) The loop is placed in a uniform magnetic field $\vec{B}$ and is free to rotate about an axis which is perpendicular to $\vec{B}$. Prove that the loop experiences no net force, but a torque $\vec{\tau} = \vec{m} \times \vec{B}$. *3*

24. (a) State Faraday's law of electromagnetic induction and explain the role of negative sign in its expression.

(b) Explain, with an example, that Lenz's law is consistent with the law of conservation of energy. *3*

25. (a) Differentiate between 'conduction current' and 'displacement current', giving one similarity and one dissimilarity between them.

(b) Explain the existence of electromagnetic waves in free space, using the concept of displacement current. *3*

26. (a) Define 'work function' of a metal. How can its value be determined from a graph between stopping potential and frequency of the incident radiation ?

(b) The work function of a metal is 2·4 eV. A stopping potential of 0·6 V is required to reduce the photocurrent to zero, in a photoelectric experiment. Calculate the wavelength of light used. *3*

27. Write the mathematical forms of three postulates of Bohr's theory of the hydrogen atom. Using them prove that, for an electron revolving in the n^{th} orbit,

(a) the radius of the orbit is proportional to n^2, and

(b) the total energy of the atom is proportional to $\left(\frac{1}{n^2}\right)$. *3*

28. Explain the process of formation of 'depletion layer' and 'potential barrier' in a p-n junction region of a diode, with the help of a suitable diagram. Which feature of junction diode makes it suitable for its use as a rectifier ? *3*

SECTION D

*Questions number **29** and **30** are case study-based questions. Read the following paragraphs and answer the questions that follow.*

29. In a metallic conductor, an electron, moving due to thermal motion, suffers collisions with the heavy fixed ions but after collision, it will emerge out with the same speed but in random directions. If we consider all the electrons, their average velocity will be zero. When an electric field is applied, electrons move with an average velocity, known as drift velocity (v_d). The average time between successive collisions is known as relaxation time (τ). The magnitude of drift velocity per unit electric field is called mobility (μ).

An expression for current through the conductor can be obtained in terms of drift velocity, number of electrons per unit volume (n), electronic charge (– e), and the cross-sectional area (A) of the conductor. This expression leads to an expression between current density ($\hat{j}$) and the electric field ($\vec{E}$). Hence, an expression for resistivity (ρ) of a metal is obtained. This expression helps us to understand increase in resistivity of a metal with increase in its temperature, in terms of change in the relaxation time (τ) and change in the number density of electrons (n).

(i) Consider two cylindrical conductors A and B, made of the same metal connected in series to a battery. The length and the radius of B are twice that of A. If μ_A and μ_B are the mobility of electrons in A and B respectively, then $\frac{\mu_A}{\mu_B}$ is : *1*

(A) $\frac{1}{2}$

(B) $\frac{1}{4}$

(C) 2

(D) 1

(ii) A wire of length 0·5 m and cross-sectional area $1 \cdot 0 \times 10^{-7}$ m^2 is connected to a battery of 2 V that maintains a current of 1·5 A in it. The conductivity of the material of the wire (in Ω^{-1} m^{-1}) is : *1*

(A) $2 \cdot 5 \times 10^4$

(B) $3 \cdot 0 \times 10^5$

(C) $3 \cdot 75 \times 10^6$

(D) $5 \cdot 0 \times 10^7$

(iii) The temperature coefficient of resistance of nichrome is $1 \cdot 70 \times 10^{-4}$ °C^{-1}. In order to increase resistance of a nichrome wire by 8·5%, the temperature of the wire should be increased by : *1*

(A) 250°C

(B) 500°C

(C) 850°C

(D) 1000°C

(iv) (a) Consider the contribution of the following two factors I and II in resistivity of a metal :

I. Relaxation time of electrons

II. Number of electrons per unit volume

The resistivity of a metal increases with increase in its temperature because : *1*

(A) I decreases and II increases.

(B) I increases and II is almost constant.

(C) Both I and II increase.

(D) I decreases and II is almost constant.

OR

(b) A steady current flows in a copper wire of non-uniform cross-section. Consider the following three physical quantities :

I. Electric field

II. Current density

III. Drift speed

Then at the different points along the wire : *1*

(A) II and III change, but I is constant.

(B) I and II change, but III is constant.

(C) I and III change, but II is constant.

(D) All I, II and III change.

30. When light travels from an optically denser medium to an optically rarer medium, at the interface it is partly reflected back into the same medium and partly refracted to the second medium. The angle of incidence corresponding to an angle of refraction 90° is called the critical angle (i_c) for the given pair of media. This angle is related to the refractive index of medium 1 with respect to medium 2.

Refraction of light through a prism involves refraction at two plane interfaces. A relation for the refractive index of the material of the prism can be obtained in terms of the refracting angle of the prism and the angle of minimum deviation. For a thin prism, this relation reduces to a simple equation.

Laws of refraction are also valid for refraction of light at a spherical interface. When an object is placed in front of a spherical surface separating two media, its image is formed. A relation between object and image distance, in terms of refractive indices of two media and the radius of curvature of the spherical surface can be obtained. Using this relation for two surfaces of a lens, 'lens maker formula' is obtained.

(i) A small bulb is placed at the bottom of a tank containing a transparent liquid (refractive index n) to a depth H. The radius of the circular area of the surface of liquid, through which light from the bulb can emerge out, is R. Then $\left(\frac{R}{H}\right)$ is : *1*

(A) $\frac{1}{\sqrt{n^2 - 1}}$

(B) $\sqrt{n^2 - 1}$

(C) $\frac{1}{\sqrt{n^2 + 1}}$

(D) $\sqrt{n^2 + 1}$

(ii) (a) A parallel beam of light is incident on a face of a prism with refracting angle 60°. The angle of minimum deviation is found to be 30°. The refractive index of the material of the prism is close to : *1*

(A) 1·3 (B) 1·4

(C) 1·5 (D) 1·6

OR

(b) The angle of minimum deviation for a ray of light incident on a thin prism, made of crown glass (n = 1·52) is D_m. If the prism was made of dense flint glass (n = 1·62) instead of crown glass, the angle of minimum deviation will : *1*

(A) decrease by 4% (B) increase by 4%

(C) decrease by 19% (D) increase by 19%

(iii) An object is placed in front of a convex spherical glass surface (n = 1·5 and radius of curvature R) at a distance of 4R from it. As the object is moved slowly close to the surface, the image formed is : *1*

(A) always real

(B) always virtual

(C) first real and then virtual

(D) first virtual and then real

(iv) A double-convex lens, made of glass of refractive index 1·5, has focal length 10 cm. The radius of curvature of its each face, is : *1*

(A) 10 cm (B) 15 cm

(C) 20 cm (D) 40 cm

SECTION E

31. (a) (i) A parallel plate capacitor with plate area A and plate separation d has a capacitance C_0. A slab of dielectric constant K having area A and thickness $\left(\frac{d}{4}\right)$ is inserted in the capacitor, parallel to the plates. Find the new value of its capacitance.

(ii) You are provided with a large number of 1 μF identical capacitors and a power supply of 1200 V. The dielectric medium used in each capacitor can withstand up to 200 V only. Find the minimum number of capacitors and their arrangement, required to build a capacitor system of equivalent capacitance of 2 μF for use with this supply. *5*

OR

(b) (i) An electric dipole of dipole moment p consists of point charges q and – q, separated by 2a. Derive an expression for electric potential in terms of its dipole moment at a point at a distance x (>> a) from its centre and lying (I) along its axis, and (II) along its bisector line.

(ii) An electric dipole of dipole moment $\vec{p} = (0{\cdot}8\,\hat{i} + 0{\cdot}6\,\hat{j})\,10^{-29}$ Cm is placed in an electric field $\vec{E} = 1{\cdot}0 \times 10^{7}\,\hat{k}\,\frac{V}{m}$. Calculate the magnitude of the torque acting on it and the angle it makes with the x-axis, at this instant. *5*

32. (a) (i) With the help of a labelled diagram, explain the principle of working of a moving coil galvanometer. Write the purpose of using (i) radial magnetic field, and (ii) soft iron core, in it.

(ii) Define current sensitivity of a galvanometer. "Increasing the current sensitivity may not necessarily increase the voltage sensitivity." Give reason. *5*

OR

(b) (i) (I) Write Ampere's circuital law in mathematical form and explain the terms used.

(II) As the current carrying solenoid is made longer, the magnetic field produced outside it approaches zero. Why ?

(III) A flexible loop of irregular shape carrying current when located in an external magnetic field, changes to a circular shape. Give reason.

(ii) A galvanometer of resistance G is converted into a voltmeter to measure up to V volts, by connecting a resistance R_1 in series with the coil. If R_1 is replaced by R_2, then it can only measure up to $\frac{V}{2}$ volt. Find the value of the resistance R_3 (in terms of R_1 and R_2) needed to convert it into a voltmeter that can read up to 2 V. *5*

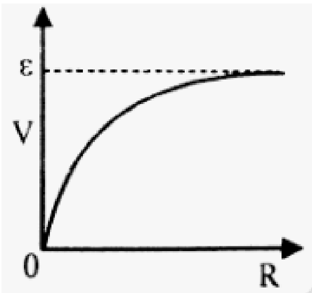
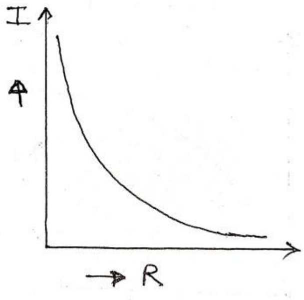
33. (a) (i) Explain with the help of a labelled ray diagram the formation of final image by an astronomical telescope at infinity. Write the expression for its magnifying power.

(ii) The total magnification produced by a compound microscope is 20. The magnification produced by the eyepiece is 5. When the microscope is focussed on a certain object, the distance between the objective and eyepiece is observed to be 14 cm. Calculate the focal lengths of the objective and the eyepiece. (Given that the least distance of distinct vision = 25 cm) *5*

OR

(b) (i) Two coherent light waves, each of intensity I_0 superpose each other and produce interference pattern on a screen. Obtain the expression for the resultant intensity at a point where the phase difference between the waves is ϕ. Write its maximum and minimum possible values.

(ii) In a single slit diffraction experiment, the aperture of the slit is 3 mm and the separation between the slit and the screen is 1·5 m. A monochromatic light of wavelength 600 nm is normally incident on the slit. Calculate the distance of (I) first order minimum, and (II) second order maximum, from the centre of the screen. *5*

MARKING SCHEME : PHYSICS (042)			
CODE: 55/7/1			
Q.NO.	**VALUE POINTS/EXPECTED ANSWERS**	**MARKS**	**TOTAL MARKS**
	SECTION- A		
1.	(A) 250 V	1	1
2.	(C) 16/3 Ω	1	1
3.	(A) BA sin α	1	1
4.	(A) 1/200 s	1	1
5.	(C) capacitive and inductive respectively	1	1
6.	(B) 0.2 mV	1	1
7.	(D) $\left[ML^2T^{-2}A^{-2}\right]$	1	1
8.	(B) 3.20×10^{14} Hz	1	1
9.	(C) holes and few electrons	1	1
10.	(A) n=4 to n=3	1	1
11.	(A) Both the potential barrier height and width of depletion layer decrease.	1	1
12.	(C) same neutron number but different atomic number.	1	1
13.	(D) Both Assertion (A) and Reason (R) are false.	1	1
14.	(C) Assertion(A) is true and Reason(R) is false.	1	1
15.	(B) Both Assertion(A) and Reason (R) are true but Reason(R) is **not** the correct explanation of Assertion(A).	1	1
16.	(B) Both Assertion(A) and Reason (R) are true but Reason(R) is **not** the correct explanation of Assertion(A).	1	1
	SECTION- B		
17.	Showing variation graphically (a)Terminal voltage with resistance R 1 (b)Current supplied by cell with resistance R 1 (a)  (b) 	1 1	2

18.	(a) Deducing for (a)Size 1 (b)Location of the image produced by convex mirror 1		
	Let, u= nf From the Mirror formula, $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$	½	
	$\frac{1}{v}=\frac{1}{f}-\frac{1}{u}$ $=\frac{1}{f}+\frac{1}{nf}$ $v=\frac{nf}{n+1}$ $n=+ve \quad \therefore v<f$	½	
	$m=\frac{-v}{u}=\frac{1}{n+1}$	½	
	m is always positive & less than 1. **Note**: **Award full credit if correctly concluded by any other method**.	½	
	OR		
	(b) Finding the nature & focal length of lens 1½ Stating answer for changing thickness ½		
	$\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}+\frac{1}{f_3}$	½	
	$\frac{1}{12}=\frac{1}{10}-\frac{1}{15}+\frac{1}{f_3}$ $\frac{1}{f_3}=\frac{5-6+4}{60}$ $f_3=20\,cm$	½	
	Nature: Convex	½	
	Yes	½	2
19.	Difference between Interference & Diffraction patterns 1 Reason 1		

<table>
<tr>
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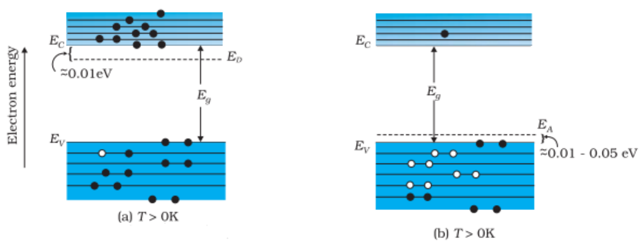
<table>
<tr><th>Interference pattern</th><th>Diffraction pattern</th></tr>
<tr>
<td>1. The interference pattern has a number of equally spaced bright and dark bands.

2. The interference pattern is obtained by superposing two waves originating from the two narrow slits.

3. The maximas are of same intensity.</td>
<td>1. The diffraction pattern has a central bright maximum which is twice as wide as the other maxima.

2. The diffraction pattern is obtained by superposition of a continuous family of waves originating from each point on a single slit.
3. The intensity falls as we go to successive maxima away from the centre, on either side.</td>
</tr>
</table>
(Any two differences)
The light wave coming out of two independent source of light will not have constant phase with time.
Alternatively:
Two sodium lamps are incoherent source of light.
</td>
<td>1

1</td>
<td>2</td>
</tr>
<tr>
<td>20.</td>
<td>
<table>
<tr><td>Drawing Energy band diagram of</td><td></td></tr>
<tr><td>n type semiconductor</td><td>½</td></tr>
<tr><td>p type semiconductor</td><td>½</td></tr>
<tr><td>Showing donor/acceptor energy level</td><td>½+½</td></tr>
</table>


</td>
<td>1+1</td>
<td>2</td>
</tr>
<tr>
<td>21.</td>
<td>
<table>
<tr><td>Explaining energy produced in stars</td><td>1</td></tr>
<tr><td>Two examples of nuclear reactions involved</td><td>½+½</td></tr>
</table>
Energy is produced in stars due to Nuclear fusion.
Two lighter nuclei fuse to form a heavier nucleus which is more stable, hence energy is released.
Alternatively: Due the difference in masses in reactants and products, mass is converted into energy. Hence energy is released.
</td>
<td>½
½</td>
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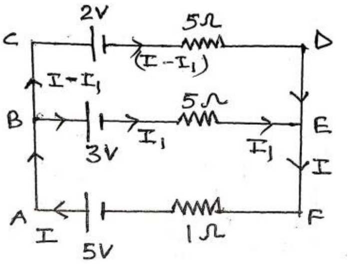
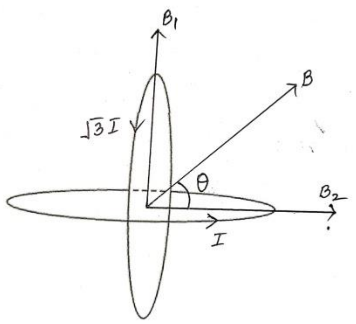
</tr>
</table>

	${}_{1}^{1}H+{}_{1}^{1}H\rightarrow {}_{1}^{2}He+e^{+}+\nu$ ${}_{1}^{2}H+{}_{1}^{2}H\rightarrow {}_{2}^{3}He+{}_{0}^{1}n$ ${}_{2}^{3}He+{}_{2}^{3}He\rightarrow {}_{2}^{4}He+{}_{1}^{1}H+{}_{1}^{1}H$ **Any two above equation.**	½+ ½	2
	SECTION- C		
22.	Calculating the current through cells A, B and C 3  In loop ABEFA, $5\text{-}3\text{-}5I_1\text{-}I=0$ $2=5I_1+I \quad -----(1)$ In loop CBEDC, $2-3-5I_1+5I\text{-}5I_1=0$ $-1=10I_1-5I \quad -----(2)$ Solving equation (1) and (2) $I=\frac{5}{7}A$ in arm AF/through the cell of 5V(A) $I_1=\frac{9}{35}A$ in arm BE/through the cell of 3V(B) $I-I_1=\frac{16}{35}A$ in arm CD/through the cell of 2V(C)	½ ½ ½ ½ ½ ½	3
23.	(a) (i)Writing Biot-Savart's Law in vector form 1 (ii)Finding magnitude & direction of net magnetic field at centre of two current carrying coils 2 (i) $\overrightarrow{dB}=\frac{\mu_0}{4\pi}\frac{I(\overrightarrow{dl}\times\vec{r})}{r^3}$ (ii) $B_1=\frac{\mu_0 I}{2R}$ $B_2=\frac{\mu_0\sqrt{3}I}{2R}$ $B=\sqrt{B_1^2+B_2^2}$ $\therefore B=\frac{\mu_0 I}{2R}\sqrt{1+3}$  	1 ½ ½	

$$B = \frac{\mu_0 I}{R}$$ ½

$$\tan\theta = \frac{B_1}{B_2} = \frac{1}{\sqrt{3}}$$ ½

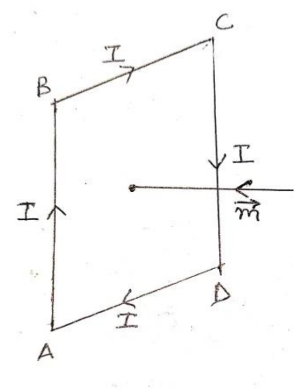
Direction of net magnetic field is 30° with direction of B_2/ 60° with the direction of B_1.

OR

(b)

Writing the expression for magnetic moment & showing its direction	1
Proving no net force	1
Torque $(\vec{\tau}) = \vec{m} \times \vec{B}$	1

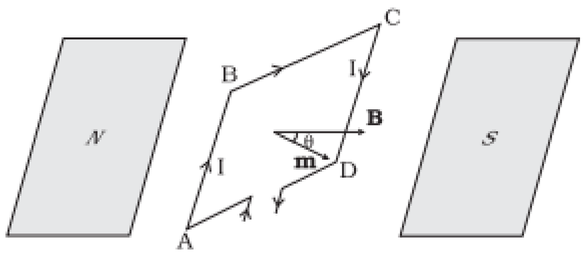
(i) $\vec{m} = I\vec{A}$ ½



½

(ii) $F_1 = F_2 = IbB \quad F_1 = \text{Force on AB into the plane}$ ½

$F_2 = \text{Force on CD out of the plane}$



Since forces are equal & opposite so net force = 0 ½

Both forces form a couple, magnitude of torque acting on the coil is

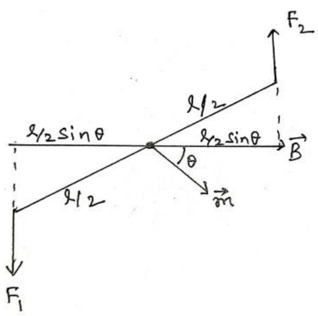
$$\therefore \tau = F_1 \frac{l}{2}\sin\theta + F_2 \frac{l}{2}\sin\theta$$ ½

$= I\,b\,B\,l\sin\theta$

$= I\,A\,B\,\sin\theta$

$= m\,B\sin\theta$

$\vec{\tau} = \vec{m} \times \vec{B}$ ½



Alternatively:

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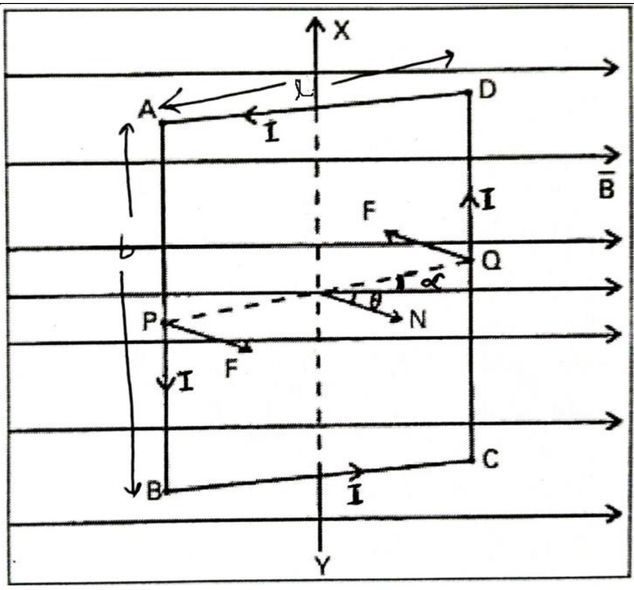

If the plane of the current carrying coil makes an angle $\propto$ with the magnetic field

$\vec{F}_{DA} = -\vec{F}_{Bc}$ (cancel each other)

Force on the arm DC is into the plane of the paper

$|F_{DC}| = IbB$

Force on the arm AB is out of the plane of the paper.

$|F_{AB}| = IbB$

Since forces are equal & opposite so net force = 0

Both of them form a couple and magnitude of torque acting on the coil is

τ=either force $\times$perpendicular distance between the two forces.

$\tau = IbB \times l \sin\theta$

$= IAB \sin\theta$

$\vec{\tau} = I\vec{A} \times \vec{B}$

$\vec{\tau} = \vec{m} \times \vec{B}$
</td>
<td>½

½

½

½</td>
<td>3</td>
</tr>
<tr>
<td>24.</td>
<td>

(a)Stating Faraday's law of electromagnetic Induction 1
Explaining the role of negative sign 1
(b)Explaining consistency of Lenz law with conservation of energy 1

(a) The magnitude of induced emf in a circuit is equal to the time rate of change of magnetic flux.

Mathematically, $e = -\frac{d\Phi}{dt}$

Negative sign indicates that the direction of induced emf and hence induced current in closed loop opposes its cause.

(b) When magnet is moved closer/away from the loop, same/ opposite pole is developed on the approaching face of the loop. So, mechanical work is required to move a magnet which gets
</td>
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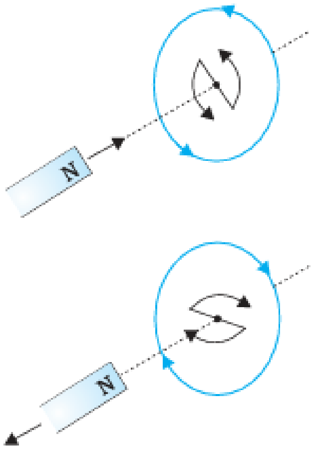
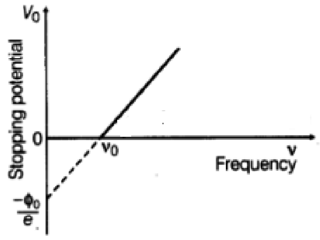
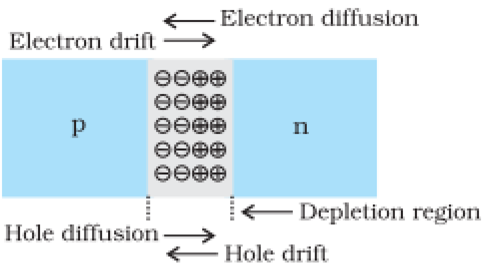
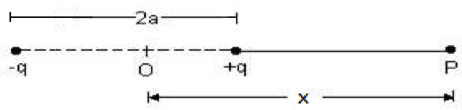
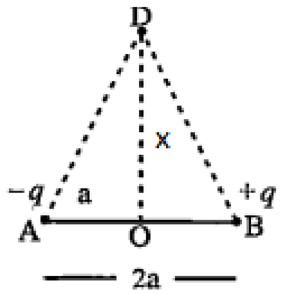
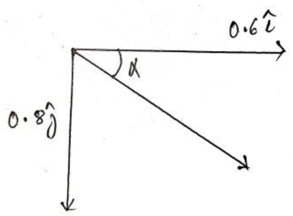
	converted into electrical energy which is consistent with law of conservation of energy.  **(Note: Please do not deduct marks for not showing figures)**		3
25.	(a)Similarity & dissimilarity between conduction & displacement current 1+1 (b)Explaining existence of em wave in free space 1 (a) **<u>Similarity</u>** Both give rise to magnetic field. **<u>Dissimilarity(any one)</u>** • Conduction current is due to flow of charges in the conductor. • Displacement current arises due to change in electric field/ time varying electric flux. (b) A magnetic field, changing with time, gives rise to an electric field. Then, an electric field changing with time gives rise to a magnetic field and is a consequence of the displacement current being a source of a magnetic field. Thus, time- dependent electric and magnetic fields give rise to each other and hence em wave is generated. **(Note: Please award ½ mark of this part if a child writes the expression only)** $\oint \vec{B}.\vec{dl} = \mu_0 I_c + \mu_0 \varepsilon_0 \frac{d\Phi_e}{dt}$	1 1 1	3
26.	(a)Defining work function ½ Determining the value of work function from graph 1 (b)Calculating wavelength of light 1½ Minimum energy required by an electron to escape from metal surface. The intercept on the y axis for a graph between stopping potential & frequency gives ϕ_0/e .	½	

	$\therefore\ \phi_0 = e \times$ intercept on y-axis. **<u>Alternatively</u>**: Work function $\phi_0 = h \times$ intercept on x-axis. **(Note: Please award ½ mark, even if a student draws the following graph instead of determining the value of work function)**  (b) $eV_0 = \frac{hc}{\lambda} - \phi_0$ $0.6 = \frac{hc}{\lambda} - 2.4$ $3 = \frac{hc}{\lambda} \Rightarrow 3 \times 1.6 \times 10^{-19} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{\lambda}$ $\lambda = \frac{1241}{3} = 413.6nm$	1 ½ ½ ½	 3
27.	Writing the mathematical form of postulates of Bohr's Theory 1½ Proving, (a) radius of the orbit is proportional to n^2 1 (b) Total energy of the atom is proportional to $1/n^2$ ½ Mathematical form of postulates of Bohr's Theory (i) $E_n = \frac{-13.6}{n^2} eV$ **Alternatively** : Electron revolve in stable orbits with definite energy called stationary orbits. (ii) $L = mvr = \frac{nh}{2\pi}$ (iii) $h\nu = E_f - E_i$ (a) $\frac{mv^2}{r} = \frac{Ze^2}{r^2}$ -----(1) $mvr = \frac{nh}{2\pi}$ -----(2) Solving (1) & (2) $r = n^2 \left(\frac{h}{2\pi}\right)^2 \frac{4\pi\varepsilon_0}{me^2}$ ----(3)	½ ½ ½ ½ ½	

	Since energy in the orbit $E_n = \dfrac{-e^2}{8\pi\varepsilon_0 r}$ Using eq (3) $E_n = \dfrac{-me^4}{8n^2\varepsilon_0^2h^2}$ or $E_n \propto \dfrac{1}{n^2}$	½	3
28.	Explaining the formation of depletion layer and potential barrier 1+1 Feature of junction diode for its use as rectifier 1 When an electron diffuses from n-side to p-side, it leaves behind an ionized donor on n side. Similarly when a hole diffuses from p-side to n-side, it leaves behind an ionized acceptor on p side. This space charge region consisting of immobile ions on either side of the junction is known as depletion layer. As diffusion process continues, width of depletion layer increases and consequently strength of electric field increases across the junction and thus the drift current. The potential that prevents the movement of electron from n region into p region is called potential barrier.  **(Note: Please award full credit of formation of depletion layer, even if a student draws above diagram)** Diode allows current to pass only when it is forward biased as resistance is small, whereas in reverse bias, its resistance is very large. **Alternatively**: Diode is unidirectional.	1 1 1	3
	SECTION -D		
29.	(i) (D) 1 (ii) (C) 3.75×10^6 (iii) (B) 500^0 C (iv) (a) (D) I decreases and II is almost constant **OR** (b) (D) All I, II and III change	1 1 1 1	4
30.	(i) (A) $1/\sqrt{n^2-1}$ (ii) (a) (B) 1.4 **OR**	1 1	

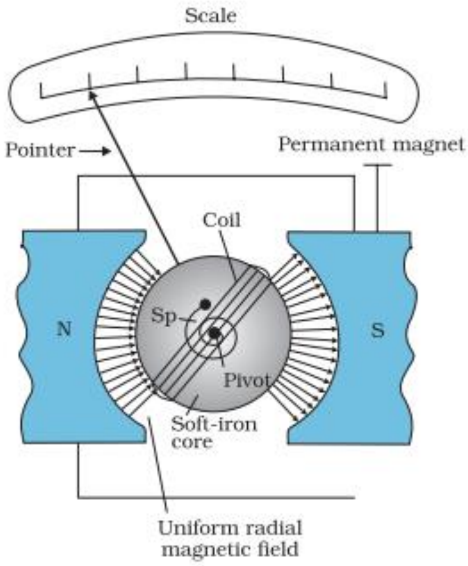
	(b) (D) increase by 19%. (iii) (C) First real and then virtual (iv) (A) 10cm	 1 1	 4
	SECTION- E		
31.	(a) (i) Finding the new value of capacitance 3 (ii) Finding the number of capacitors 2 (i) $C_0 = \frac{\varepsilon_0 A}{d}$ $C = \frac{\varepsilon_0 A}{(d-t) + \frac{t}{K}}$ $t = d/4$ $C = \frac{\varepsilon_0 A}{\left(d - \frac{d}{4}\right) + \frac{d}{4K}} = \frac{\varepsilon_0 A}{d\left(\frac{3}{4} + \frac{1}{4K}\right)}$ $= C_0 \frac{4K}{(3K+1)}$ **Alternatively**: When dielectric is inserted, the electric field between the plates is $E= E_0/K$ The potential difference will be $V = E_0\left(\frac{3d}{4}\right) + E\left(\frac{d}{4}\right)$ $= E_0\left(\frac{3d}{4}\right) + \frac{E_0}{K}\left(\frac{d}{4}\right)$ $= V_0\left(\frac{3}{4} + \frac{1}{4K}\right)$ $V = V_0\left(\frac{3K+1}{4K}\right)$ $C = \frac{Q_0}{V} = \left(\frac{4K}{3K+1}\right)\frac{Q_0}{V_0}$ $C = C_0\left(\frac{4K}{3K+1}\right)$ (ii) Each capacitance can withstand 200V No. of capacitors in each row = $\frac{1200}{200} = 6$ Net capacitance of each row= 1/6 μF Number of rows = n $C_{eq} = C_1 + C_2 + \_\_\_\_\_\_ + C_n$ $C_{eq} = \frac{1}{6} + \frac{1}{6} + ----- n$ $2 = \frac{n}{6}$	 ½ ½ 1 1 ½ ½ 1 1 ½ ½	

	$\therefore n = 12$	½	
	Total no. of capacitors in the arrangement = 6 × 12		
	= 72	½	
	OR		
	(b) (i) Deriving the expression of electric potential due to dipole I. along its axis 1½ II. along its bisector line 1½ (ii) Calculating the torque 2		
	I. Along its axis		
	$V_- = \frac{-kq}{x+a}$ 		
	$V_+ = \frac{kq}{x-a}$	½	
	$V = V_- + V_+$		
	$= kq\left(\frac{-1}{x+a} + \frac{1}{x-a}\right)$		
	$= kq\frac{2a}{\left(x^2 - a^2\right)} = \frac{kp}{x^2 - a^2}$	½	
	$x \gg a \quad \therefore V = \frac{kp}{x^2}$	½	
	II. Along the bisector line		
	$V_- = \frac{kq}{\sqrt{x^2 + a^2}}$ 	½	
	$V_+ = \frac{-kq}{\sqrt{x^2 + a^2}}$	½	
	$V = V_- + V_+$		
	$= 0$	½	
	(ii) $\vec{\tau} = \vec{p} \times \vec{E}$	½	
	$= (0.8\hat{i} + 0.6\hat{j}) \times 10^{-29} \times (1 \times 10^{7})\hat{k}$		
	$= \left[0.8\left(-\hat{j}\right) + 0.6\hat{i}\right] \times 10^{-22}$	½	
	$\tau = \left[\sqrt{(0.8)^2 + (0.6)^2}\right] \times 10^{-22}$		
	$= 10^{-22}\ Nm$	½	
	$\tan\alpha = \frac{\lvert 0.8 \rvert}{0.6}$ 		
	$\alpha = \tan^{-1}\left(\frac{4}{3}\right)$	½	
	$\alpha = 53^0$		5

32.

(a)

(i) Labelled diagram	1
Working principle of moving coil galvanometer	1
Use of (i) Radial magnetic field	½
(ii) Soft iron core	½
(ii) Defining current sensitivity	1
Reason	1



1

Principle:A current carrying coil placed in uniform magnetic field, experiences a torque. — 1

(i) Radial magnetic field makes the scale linear — ½
Alternatively: Radial magnetic field provides maximum Torque.

(ii) Use of soft iron core is to increase the strength of magnetic field/ increase sensitivity of the galvanometer. — ½

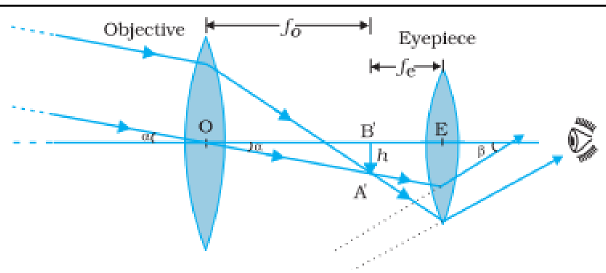
(ii) **Current sensitivity** is defined as deflection per unit current. — 1
<u>**Alternatively**</u>:

$$I_s = \frac{\Phi}{I} = \frac{NAB}{k}$$

Voltage sensitivity $V_s = \frac{\Phi}{V} = \left(\frac{NAB}{k}\right)\frac{I}{V} = \left(\frac{NAB}{k}\right)\frac{1}{R}$ — ½

Increase in number of turns, increases the current sensitivity and resistance of the galvanometer in the same proportion of current sensitivity therefore Voltage sensitivity remains unchanged. — ½

OR

	(b) (i) (I) Writing Ampere circuital law & explaining the terms. 1 (II) Reason for magnetic field outside long solenoid approaching zero 1 (III) Reason for irregular shaped loop changing to circular loop in uniform magnetic field 1 (ii) Finding the value of Resistance R_3 2		
	(i) **(I)** $\oint \vec{B}.\vec{dl} = \mu_0 I_e$	½	
	I_e= Total current through the surface B= Magnetic field dl = length of small element	½	
	(II) As length of solenoid increases, it appears like a long cylindrical metal sheet, so field outside approaches zero.	1	
	(III) For a given perimeter, a circle encloses greater area than any other shape, which maximizes the flux.	1	
	(ii) $R_1 = \frac{V}{I_g} - G \quad \Rightarrow \frac{V}{I_g} = R_1 + G$ -----(1)	½	
	$R_2 = \frac{V}{2I_g} - G \quad \Rightarrow \frac{V}{2I_g} = R_2 + G$ -----(2)	½	
	Solving (1) & (2) $G = R_1 - 2R_2$	½	
	$R_3 = \frac{2V}{I_g} - G$ -----(3) Solving using eq (1) & (3) $R_3 = 3R_1 - 2R_2$	½	5
33.	(a) (i) Drawing labeled Diagram 1½ Explanation ½ Writing expression of Magnifying power 1 (ii) Calculating the focal length of objective & eye piece 2		
		1½	
	(Note: Deduct ½ mark, for not showing arrows with the rays)		

<table>
<tr><td></td><td>
Light from distant object enters the objective lens & forms a real image A'B' at f_o.
This image A'B' acts as an object for eye piece and eye piece forms a magnified image at infinity.

Magnifying Power = f_o / f_e
(ii) Image is formed at least distance of distinct vision
$20 = m_o \times m_e$
$m_o = \frac{20}{5} = 4$
$m_e = 1 + \frac{D}{f_e}$
$f_e = \frac{25}{4} cm$
$\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e}$
$\frac{1}{-25} - \frac{1}{u_e} = \frac{4}{25}$
$u_e = -5cm$
$L = v_0 + |u_e|$
$v_0 = 9cm$
Given, $\frac{v_0}{u_0} = 4$
$\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0}$
$\frac{1}{f_0} = \frac{1}{9} - \left(-\frac{4}{9}\right)$
$f_0 = \frac{9}{5} cm$

OR
(b)
(i) Obtaining the expression for resultant intensity of interference pattern 2
Writing maximum & minimum values of resultant intensity 1
(ii) Calculating the distance of
(I) First order minimum 1
(II) Second order maximum from centre of screen 1

(i) $y_1 = a\cos\omega t$
$y_2 = a\cos(\omega t + \phi)$
According to Principle of Superposition
</td><td>
½

1

½

½

½

½

½
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	$y = y_1 + y_2$ $= a\left[\cos\omega t + \cos(\omega t + \phi)\right]$ $= 2a\cos\phi/2 \cos(\omega t + \phi/2)$ $y = A\cos\left(\omega t + \phi/2\right)$ where, $A = 2a\cos\phi/2$ $I = kA^2$ $I = k\left(4a^2\cos^2\phi/2\right)$ $I = 4I_0\cos^2\phi/2$	½ ½ ½	
	<u>Alternatively</u>: If student writes $I = I_1 + I_1 + 2\sqrt{I_1 I_1}\cos\phi$ **(award one mark)**		
	Maximum value $I = 4I_0$ Minimum value $I = 0$	½ ½	
	(ii) **(I)** Position of first order minimum $y = \frac{n\lambda D}{a}$ $y_1 = \frac{\lambda D}{a}$ $= \frac{600\times10^{-9}\times1.5}{3\times10^{-3}} = 3\times10^{-4}\,\text{m}$	 ½ ½	
	(II) Position of second order maximum $y_n = (2n+1)\frac{\lambda D}{2a}$ $n = 2,\quad y_2 = \frac{5\lambda D}{2a}$ $= \frac{5\times600\times10^{-9}\times1.5}{2\times3\times10^{-3}} = 7.5\times10^{-4}\,\text{m}$	 ½ ½	5

General Instructions :

Read the following instructions carefully and follow them :

(i) *This question paper contains* ***33*** *questions.* ***All*** *questions are* ***compulsory****.*

(ii) *This question paper is divided into* ***five*** *sections –* ***Sections A, B, C, D*** *and* ***E****.*

(iii) *In* ***Section A*** *– Questions no.* ***1*** *to* ***16*** *are Multiple Choice type questions. Each question carries* ***1*** *mark.*

(iv) *In* ***Section B*** *– Questions no.* ***17*** *to* ***21*** *are Very Short Answer type questions. Each question carries* ***2*** *marks.*

(v) *In* ***Section C*** *– Questions no.* ***22*** *to* ***28*** *are Short Answer type questions. Each question carries* ***3*** *marks.*

(vi) *In* ***Section D*** *– Questions no.* ***29*** *and* ***30*** *are case study-based questions. Each question carries* ***4*** *marks.*

(vii) *In* ***Section E*** *– Questions no.* ***31*** *to* ***33*** *are Long Answer type questions. Each question carries* ***5*** *marks.*

(viii) *There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.*

(ix) *Kindly note that there is a separate question paper for Visually Impaired candidates.*

(x) *Use of calculators is* ***not*** *allowed.*

You may use the following values of physical constants wherever necessary :

$c = 3 \times 10^{8}$ m/s

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8{\cdot}854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^{9}$ N m^2 C^{-2}

Mass of electron (m_e) = $9{\cdot}1 \times 10^{-31}$ kg

Mass of neutron = $1{\cdot}675 \times 10^{-27}$ kg

Mass of proton = $1{\cdot}673 \times 10^{-27}$ kg

Avogadro's number = $6{\cdot}023 \times 10^{23}$ per gram mole

Boltzmann constant = $1{\cdot}38 \times 10^{-23}$ JK^{-1}

SECTION A

1. A small metallic sphere S of charge +q is placed exactly at a point midway between two-point charges A (+Q) and B (+Q) where Q >> q. If the sphere is slightly displaced towards charge A and released, then :

(A) it will move further towards A

(B) it will move towards B

(C) it will oscillate about its original position

(D) it will not move at all

2. In a Rutherford scattering experiment, when an alpha particle of mass m_1 approaches a target nucleus of charge Ze and mass m_2, the distance of the closest approach is d_0. The energy of the particle is :

(A) directly proportional to Z

(B) inversely proportional to Z

(C) directly proportional to mass m_2

(D) directly proportional to $m_1 m_2$

3. The potential energy of a pair of nucleons is minimum when they are separated by about :

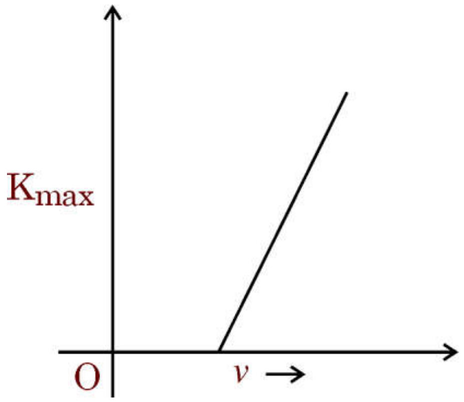
(A) $0{\cdot}8 \times 10^{-15}$ m

(B) $0{\cdot}8 \times 10^{-10}$ m

(C) $2{\cdot}0 \times 10^{-13}$ m

(D) $2{\cdot}0 \times 10^{-14}$ m

4. The figure shows the variation of maximum kinetic energy (K_{max}) of emitted electrons as a function of the frequency ν of radiation incident on a photosensitive surface. The slope of the curve is :



(A) h
(B) $\frac{h}{\nu}$
(C) $\frac{h}{e}$
(D) he

5. Whenever a magnet is moved either towards or away from a conducting coil, an emf is induced whose magnitude is independent of the :

(A) number of turns in the coil
(B) resistance of the coil
(C) speed with which the magnet is moved
(D) area of the coil

6. Electromagnetic radiation used to kill germs in water purifiers is :

(A) Microwaves
(B) Ultraviolet rays
(C) Gamma rays
(D) Radio waves

7. A galvanometer having a coil resistance of 48 Ω shows full-scale deflection for a current of 2·0 A. It can be converted into an ammeter of range (0 – 10 A) by connecting :

(A) in series a resistance of 8 Ω
(B) in parallel a resistance of 8 Ω
(C) in parallel a resistance of 12 Ω
(D) in series a resistance of 12 Ω

8. A rectangular loop of area vector $\vec{A} = [\hat{i} + \sqrt{3}\ \hat{j}] \times 10^{-2}\ m^2$ is placed in a magnetic field $\vec{B} = [4{\cdot}0t^2 + 2{\cdot}0]\ \hat{i}$, where B is in tesla and t in seconds. At t = 1·0 s, the magnitude of induced emf in the loop is :

(A) 80 mV (B) 0·11 V

(C) 0·22 V (D) 0·8 V

9. A charge Q is enclosed by a spherical Gaussian surface of radius R. If the radius is doubled, then the total electric flux through the surface :

(A) becomes four times (B) remains the same

(C) becomes half (D) becomes twice

10. The average value of voltage of 220 V ac mains during its positive half cycle will be :

(A) 156 V (B) 198 V

(C) 220 V (D) zero

11. Two parallel beams of protons moving in the same direction will :

(A) attract each other

(B) repel each other

(C) be deflected normal to the plane containing the two beams

(D) not interact with each other

12. Which of the following assumptions has been used to obtain the relation $\frac{v_s}{v_p} = \frac{N_s}{N_p}$ for a transformer ?

(A) The resistance of the primary coil is large.

(B) The same flux links both the primary and the secondary coils.

(C) The resistance of secondary coil is large.

(D) The transformer is 100% efficient.

Questions number ***13*** *to* ***16*** *are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below.*

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is ***not*** the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Both Assertion (A) and Reason (R) are false.

13. *Assertion (A) :* Electrostatic force is a conservative force.

Reason (R) : In an electrostatic field, the work done between two points per unit positive charge depends on the path followed.

14. *Assertion (A) :* The image of an object placed between f and 2f from a convex lens can be seen on a screen. If the screen is removed, image is not formed.

Reason (R) : Rays from a given point on the object placed between f and 2f, after passing through a convex lens, do not converge on a point in space.

15. *Assertion (A) :* In process of photoelectric emission using a monochromatic light, all emitted electrons do not have the same kinetic energy.

Reason (R) : If radiation falling on a photosensitive surface consists of different wavelengths, the energy of emitted photoelectrons by absorbing photons of different wavelengths, shall be different.

16. *Assertion (A) :* The electrical conductivity of a pure Ge crystal increases with increase in its temperature.

Reason (R) : The number of electrons excited by thermal excitation from the valence band to the conduction band, in a semiconductor, increases with increase in temperature.

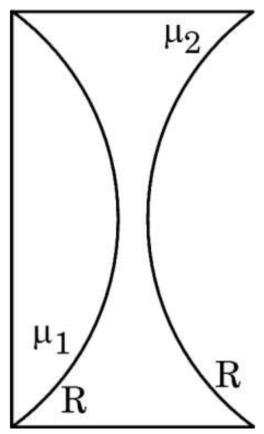
SECTION B

17. The work function of Caesium is 2·14 eV.

(a) Find the threshold frequency for Caesium.

(b) Find the wavelength of the incident light if the photocurrent is brought to zero by a stopping potential of 0·86 V. *2*

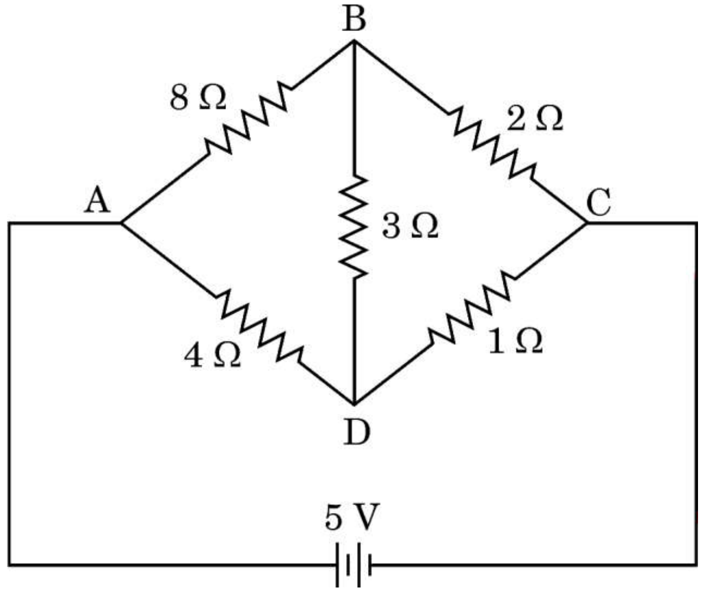
18. (a) A plano-convex lens of refractive index μ_1 is placed coaxially in contact with a biconcave lens of refractive index μ_2 as shown in the figure. All curved faces are of radius of curvature R each. Obtain the expression for the focal length of the combined lens. *2*



OR

(b) A convex lens is kept coaxially on the left side of a concave mirror at a distance of 5f from it where f is focal length of each of them. An object is kept at a distance of 2f on the left side of the convex lens. Draw the ray diagram showing the formation of the image by the combination. Find the distance of the final image from the mirror. *2*

19. The figure shows a network of resistors connected across a battery. Find the current supplied by the battery of emf 5 V and internal resistance $\frac{2}{3}$ Ω. *2*



20. With the help of a circuit diagram, describe the method to obtain p-n junction diode characteristic when it is forward biased. Draw the shape of the characteristic. *2*

21. Light of wavelength 640 nm incident on the slits in a Young's double-slit experiment produces an interference pattern of fringe width 7·2 mm. Calculate the wavelength of light which will produce a pattern of fringe width 8·1 mm. *2*

SECTION C

22. Define electric flux. Is it a scalar or a vector quantity ?

A point charge q is kept at a distance of $\frac{d}{2}$ directly above the centre of a square of side d. Use Gauss' law to obtain the expression for the electric flux through the square.

If the point charge is now moved to a point at a distance 'd' from the centre of the square and the side of the square is doubled, explain how the electric flux through the square will be affected. *3*

23. Depict the variation of electric and magnetic fields in an electromagnetic wave as it propagates along z-axis. In a plane electromagnetic wave in free space, the electric field oscillates sinusoidally at a frequency of $1{\cdot}5 \times 10^{10}$ Hz with amplitude 36 Vm^{-1}. Find :

(a) the wavelength of the wave, and

(b) the amplitude of the associated magnetic field. *3*

24. Write the three postulates of Bohr model of hydrogen atom. Show that, in this model, the frequency of revolution of an electron in its n^{th} orbit is proportional to $\left(\frac{1}{n^3}\right)$. *3*

25. (a) A 20 μF capacitor is connected to a 220 V, $\frac{125}{\pi}$ Hz ac source.

(i) Find the capacitive reactance and the peak value of current in the circuit.

(ii) If the frequency of the ac source is doubled, by what factor will the capacitive reactance and the current be changed ? *3*

OR

(b) An electron (mass 9×10^{-31} kg and charge $1{\cdot}6 \times 10^{-19}$ C) is moving in a circle with a speed of $3{\cdot}2 \times 10^7$ m/s in a magnetic field of $4{\cdot}5 \times 10^{-4}$ T perpendicular to it.

Calculate : *3*

(i) the radius of the circular path,

(ii) its frequency of rotation, and

(iii) its energy.

26. Define binding energy (BE) of a nucleus. An unstable nucleus has mass number A = 240 and $\frac{BE}{A} = 7{\cdot}6$ MeV. It splits in two fragments, each of A = 120 with $\frac{BE}{A} = 8{\cdot}5$ MeV. Calculate the energy released. *3*

27. Define the term 'drift velocity' of electrons in a current carrying conductor and derive, in its term, the expression for current flowing through the conductor. *3*

28. A rectangular loop (4 cm × 5 cm) of wire carrying current of 0·25 A is placed in a magnetic field $\vec{B} = [(0{\cdot}20\ T)\hat{j} + (0{\cdot}50\ T)\hat{k}]$ such that outward unit vector normal to the plane of the loop is $(0{\cdot}80\,\hat{i} - 0{\cdot}60\,\hat{j})$.
Calculate :

(a) the magnetic moment $\vec{m}$ of the loop, and

(b) the torque $\vec{\tau}$ acting on the loop. *3*

SECTION D

*Questions number **29** and **30** are case study-based questions. Read the following paragraphs and answer the questions that follow.*

29. A compound microscope is an optical instrument used for observing highly magnified images of tiny objects. It consists of two convex lenses. The lens near the object is called the objective and the lens near the eye is called the eyepiece. The magnifying power of a compound microscope is given by $m = m_o m_e$, where m_o is the magnification produced by objective lens and m_e is the magnification produced by eyepiece. The expression for m_e depends on whether the final image is formed at the near point or at infinity (normal adjustment).

(i) (a) A compound microscope consists of an objective lens of focal length $f_o = 2{\cdot}0$ cm and an eyepiece of focal length $f_e = 6{\cdot}25$ cm separated by a distance of 15 cm. How far should an object be placed from the objective so that the final image is formed at infinity ? *1*

(A) 3·45 cm (B) 5 cm

(C) 1·29 cm (D) 2·59 cm

OR

(b) A person with normal near point 25 cm, using a compound microscope with an objective of focal length 0·8 cm and eyepiece of focal length 2·5 cm can bring an object placed at 0·9 cm from the objective in sharp focus. If the image formed by the objective is at a distance of 2·27 cm from the eyepiece, the separation between the lenses is : *1*

(A) 7·47 cm (B) 8·47 cm

(C) 9·47 cm (D) 10·47 cm

(ii) A compound microscope consists of an objective of focal length 2 cm and an eyepiece of focal length 10 cm. The eyepiece is kept 20 cm away from the objective. Find the magnifying power of the microscope if the final image is formed at infinity. *1*

(A) 7 (B) 10

(C) 14 (D) 16

(iii) The intermediate image formed in a compound microscope is : *1*

(A) real, inverted and magnified

(B) real, erect and magnified

(C) virtual, erect and magnified

(D) virtual, inverted and magnified

(iv) The focal lengths of the objective and the eyepiece of a compound microscope are f_o and f_e respectively. Which of the following statements is correct, in normal adjustment ? *1*

(A) The object is at a distance less than f_o from the objective.

(B) The object is at a distance more than f_o and less than $2f_o$ from the objective.

(C) The intermediate image is formed at a distance slightly more than f_e from the eyepiece.

(D) The intermediate image is formed at $2f_e$ from the eyepiece.

30. According to the band theory of solids, a semiconductor has a valence band and a conduction band separated by a gap, known as energy band gap. Pure semiconductors are called intrinsic semiconductors. At room temperature, some electrons from the valence band can acquire enough energy to cross the band gap and enter the conduction band. The number of conduction electrons is equal to the number of holes is an intrinsic semiconductor. The number of charge carriers can be changed by doping of a suitable impurity in a pure semiconductor. Such semiconductors are known as extrinsic semiconductors. These are of two types (n-type and p-type).

A p-n junction is the basic building block of semiconductor devices. Two important processes occur during formation of a p-n junction : diffusion and drift. A 'depletion layer' is formed in a p-n junction. This is responsible for a junction potential barrier. A semiconductor diode is basically a p-n junction with metallic contacts provided at the ends for the application of an external voltage. A diode can be forward-biased or reverse-biased. The barrier height and the depletion layer width in a p-n junction changes depending on the nature of the biasing.

(i) (a) Which of the following statements is ***not*** true ? *1*

(A) The resistance of an intrinsic semiconductor decreases with the increase of temperature.

(B) Doping pure Si with trivalent impurities gives p-type semiconductors.

(C) The majority charge carriers in n-type semiconductors are holes.

(D) A p-n junction can act as a semiconductor diode.

OR

(b) In a unbiased p-n junction : *1*

(A) the diffusion current is zero everywhere.

(B) the drift current is zero everywhere.

(C) the electric potential is zero everywhere.

(D) the drift current and the diffusion current cancel each other.

(ii) The impurity atoms with which pure Ge should be doped to convert it into an n-type semiconductor, is : *1*

(A) Boron (B) Phosphorous

(C) Aluminium (D) Indium

(iii) The energy band gap in Ge at 0 K is about : *1*

(A) 0·72 eV (B) 1·1 eV

(C) 3·0 eV (D) 5·4 eV

(iv) In a p-n junction diode under reverse bias, the barrier height : *1*

(A) is reduced and the depletion layer width decreases.

(B) is reduced and the depletion layer width increases.

(C) increases and the depletion layer width also increases.

(D) increases and the depletion layer width decreases.

SECTION E

31. (a) (i) A series combination of L, C and R is connected to an ac source $V = V_m \sin \omega t$. Obtain :

(I) the impedance of the circuit using phasor diagram,

(II) the expression for the instantaneous current I, and

(III) the phase relationship of current to the applied voltage.

(ii) Define power factor of an ac circuit. State the conditions under which it is :

(I) maximum,

(II) minimum. *5*

OR

(b) (i) Prove that the voltage is ahead of the current in phase by $\frac{\pi}{2}$ rad in an ac circuit containing an ideal inductor.

(ii) The currents through two inductors of self-inductance 12 mH and 24 mH are increasing with time at the same rate. Draw graphs showing the variation of the :

(I) magnitude of emf induced with the rate of change of current in each inductor.

(II) energy stored in each inductor with the current flowing through it. *5*

32. (a) (i) A parallel plate capacitor A of capacitance C is charged by a battery to a potential 'V'. The battery is disconnected and an uncharged identical capacitor B is connected across it. Calculate for the capacitor A the new value of the :

(I) charge

(II) potential difference

(III) energy stored

Justify your answers.

(ii) Draw the pattern of electric field lines due to :

(I) positively charged conducting sphere, and

(II) an electric dipole. *5*

OR

(b) (i) Write Coulomb's law of electrostatics in vector form. Apply it to determine the electric field at a point due to a system of point charges.

(ii) ABC is an equilateral triangle of side l. Two point charges +2 μC each, are located at points B and C. Find the sign and magnitude of the point charge q to be kept at the midpoint M of the side BC, so that the net electric field at point A becomes zero. *5*

33. (a) A ray of light is incident on one face of a triangular glass prism of refractive index n and is refracted out from the opposite face. Deduce the expression for refractive index of glass prism in terms of the angle of minimum deviation and angle of the prism. Write the condition on n for refraction to take place on the opposite face. *5*

OR

(b) State Huygens principle. Using it, draw a diagram and discuss the case of refraction of plane wave of light from a rarer medium to a denser medium at their plane interface. Hence derive Snell's law. *5*

MARKING SCHEME: PHYSICS(042)			
Code: 55/S/1			
Q. No.	**VALUE POINTS/EXPECTED ANSWERS**	**Marks**	**Total Marks**
	SECTION A	1	1
1.	(C) It will oscillate about its original position	1	1
2.	(A) directly proportional to Z.	1	1
3.	(A) 0.8×10^{-15} m	1	1
4.	(A) h	1	1
5.	(B) the resistance of the coil	1	1
6.	(B) Ultraviolet rays	1	1
7.	(C) In parallel a resistance of 12 Ω	1	1
8.	(A) 80 mV	1	1
9.	(B) Remains the same	1	1
10.	(B) 198 V	1	1
11.	(A) Attract each other	1	1
12.	(B) The same flux links both the primary and secondary coils	1	1
13.	(C) Assertion (A) is true, but reason (R) is false	1	1
14.	(D) Both Assertion (A) and Reason (R) are false.	1	1
15.	(B) Both Assertion (A)and Reason (R)are true ,but Reason (R) is not the correct explanation of the Assertion (A).	1	1
16.	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is correct explanation of Assertion (A).	1	1
SECTION - B			
17.	(a) Finding the threshold frequency for Caesium 1 (b) Finding the wavelength of the incident light 1		
	(a) $\frac{\phi_0}{h} = \nu_0$	½	
	$= \frac{2.14 \times 1.6 \times 10^{-19}}{6.63 \times 10^{-34}}$ $= 5.16 \times 10^{14}$ Hz	½	
	(b) $\frac{hc}{\lambda} = K_{max} + \phi_0$	½	
	$\lambda = \frac{hc}{K_{max} + \phi_0}$ $\lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{(2.14 + 0.86) \times 1.6 \times 10^{-19}}$ $\lambda = 4.14 \times 10^{-7}$ m	½	2
18.	(a) Expression for the focal length of combined lens 2		

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

For plano convex lens

$$\frac{1}{f_1} = (\mu_1 - 1)\left(\frac{1}{\infty} - \frac{1}{-R}\right)$$ ½

$$\frac{1}{f_1} = \frac{(\mu_1 - 1)}{R}$$

For concave lens

$$\frac{1}{f_2} = (\mu_2 - 1)\left(\frac{1}{-R} - \frac{1}{R}\right)$$ ½

$$\frac{1}{f_2} = -2\frac{(\mu_2 - 1)}{R}$$

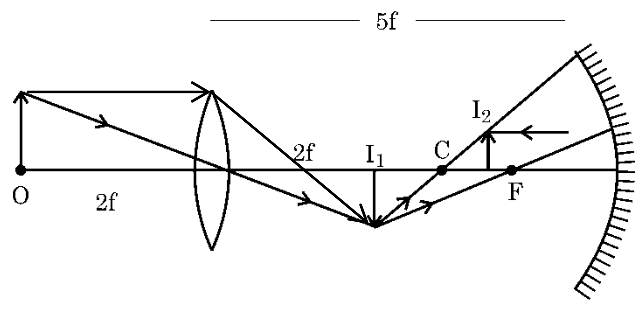
$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$ ½

$$f = \frac{R}{\mu_1 - 2\mu_2 + 1}$$ ½

OR

(b)

• Ray diagram	1
• Calculation of distance of final image from the mirror	1



1

$$u = -3f$$

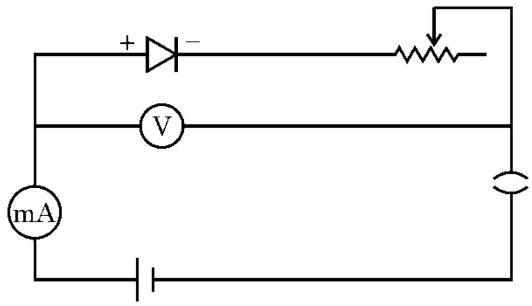
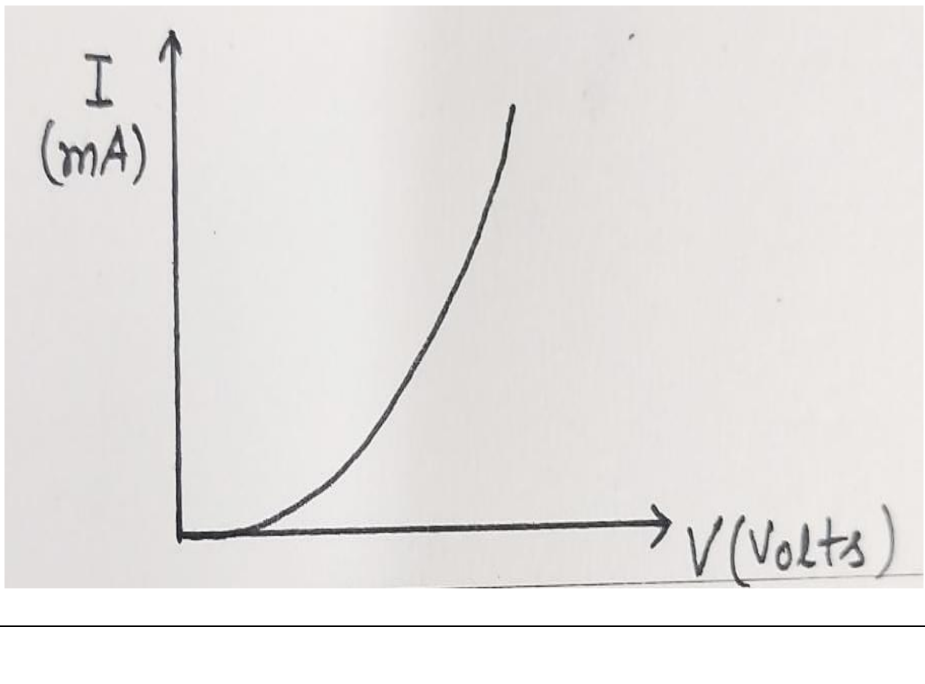
$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$ ½

$$\frac{-1}{f} = -\frac{1}{3f} + \frac{1}{v}$$

$$v = \frac{-3}{2}f$$ ½ 2

19.

Finding the current supplied by the battery	2

	$\frac{R_{AB}}{R_{BC}} = \frac{R_{AD}}{R_{DC}} = \frac{4}{1}$ The bridge is balanced. Resistance of the circuit between points A and C. $\frac{1}{R} = \frac{1}{(8+2)} + \frac{1}{(4+1)}$ $R = \frac{10}{3}\Omega$ $I = \frac{E}{R+r}$ $I = \frac{5}{\frac{10}{3}+\frac{2}{3}}$ $I = 1.25\,A$	½ ½ ½ ½	2
20.	• Circuit diagram for characteristics of a p-n junction diode 1 • Describing the method to obtain p-n junction diode characteristics ½ • Drawing the shape of characteristics ½ •  • A very small current flows till the applied voltage reaches the barrier potential in the forward bias p-n junction diode. Diode current increases significantly when applied voltage becomes greater than barrier potential. •  	1 ½ ½	2

<table>
<tr><td>21.</td><td>

Calculation of the wavelength of light	2

$$\beta = \frac{D\lambda}{d}$$

$$\frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2}$$

$$\lambda_2 = \frac{\beta_1}{\beta_2}\times\lambda_1$$

$$\lambda_2 = \frac{8.1}{7.2}\times 640$$

$$\lambda_2 = 720\,\text{nm}$$

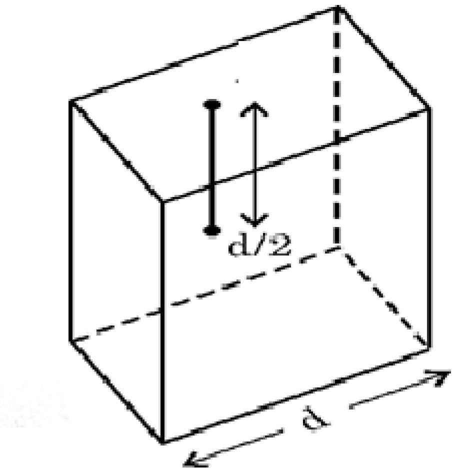
</td><td>½
½
½
½</td><td>2</td></tr>
<tr><td colspan="4">SECTION - C</td></tr>
<tr><td>22.</td><td>

• Defining electric flux	½
• Stating scalar or vector quantity	½
• Obtaining expression for the electric flux through the square	1
• Effect on electric flux through the square	1

Electric flux : The electric flux may be defined as the number of electric lines of force crossing through a surface normal to the surface.

$$\phi = \oint \vec{E}.d\vec{s}$$

Electric flux is a scalar quantity.
Draw a cube of side d such that it completely encloses the charge q.

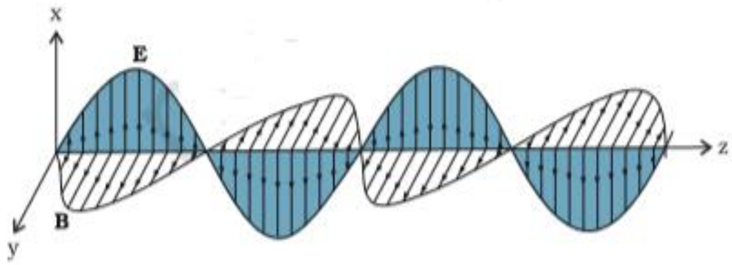


Total flux through the cube, $\phi_E = \frac{q_{en}}{\varepsilon_0}$

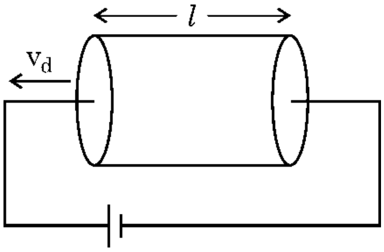
Flux through one face (square) $= \frac{q_{en}}{6\varepsilon_0}$

If a charge is now moved to the point of a distance d from the center of square and side of the square is doubled, then electric flux through square remains unchanged because electric flux through a closed surface depends only on the amount of charge contained inside the closed surface and is independent of the size of the Gaussian surface.

</td><td>½
½
½
½
1</td><td>3</td></tr>
</table>

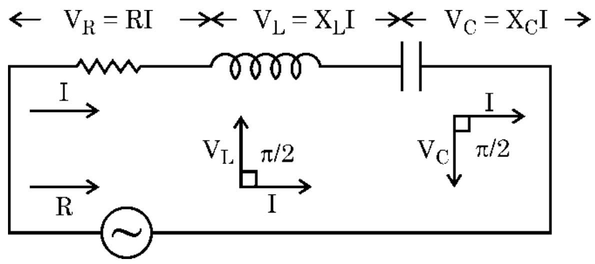
23.	• Depicting the variation of electric and magnetic fields of an electromagnetic wave along z-axis 1 • Finding a) The wavelength of the wave 1 b) The amplitude of the associated magnetic field 1 a)  $\lambda = \frac{c}{v}$ $= \frac{3\times10^{8}}{1.5\times10^{10}} = 2\times10^{-2} = 0.02\,m$ b) $B_0 = \frac{E_0}{c}$ $= \frac{36}{3\times10^{8}}$ $= 1.2\times10^{-7}$ T	1 ½ ½ ½ ½	3
24.	• Writing three postulates of Bohr's model of hydrogen atom 1½ • Showing that the frequency of revolution of an electron in its nth orbit $\alpha \frac{1}{n_3}$ 1 ½ Bohr's Postulates (i) An electron in an atom could revolve in certain stable orbits without the emission of radiant energy. (ii) Electron revolves around the nucleus only in those orbits for which the angular momentum is some integral multiple of h/2π. (iii) An electron might make a transition from one of its specified non-radiating orbits to another of lower energy. When it does so, a photon is emitted having energy equal to the energy difference between the initial and final states. The frequency of the emitted photon is then given by $h\nu = E_i - E_f$ As frequency of revolution of electron is given by $\nu = \frac{v}{2\pi r}$ ....(1)	½ ½ ½	

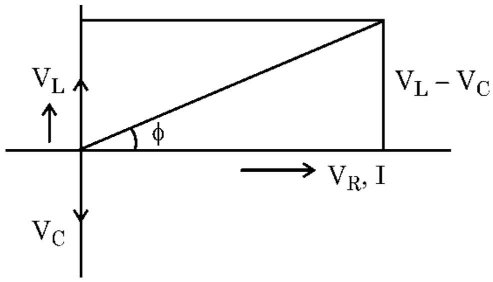
	In Bohr's model the velocity of the electron in the nth orbit is $$v_n = \frac{e^2}{2\varepsilon_0 nh}$$ $$v_n \ \alpha \ \frac{1}{n}\text{..............................(2)}$$ and radius of the electron in the nth orbit is $$r_n = \frac{\varepsilon_0 n^2 h^2}{\pi m e^2}$$ $$r_n \ \alpha \ n^2 \text{ --(3)}$$ Using (3) and (2) in (1) $$v \ \alpha \ \frac{1}{n^3}$$	½ ½ ½	3
25.	(a) i. Finding capacitive reactance and Peak value of current 1+1 ii. Finding change in capacitive reactance and current ½ + ½ (i) $$X_c = \frac{1}{2\pi\nu C}$$ $$= \frac{1}{2\pi \times \frac{125}{\pi} \times 20 \times 10^{-6}}$$ $$= 200\ \Omega$$ $$I_0 = \frac{V_0}{X_C}$$ $$= \frac{220 \times 1.414}{200}$$ $$= 1.6\text{ A or } 1.1\sqrt{2}\text{ A}$$ (ii) X_c becomes half Current becomes double. OR Calculating (i) Radius of the circular path 1 (ii) Frequency of rotation 1 (iii) Energy 1 (i) $$r = \frac{mv}{qB}$$ $$= \frac{9 \times 10^{-31} \times 3.2 \times 10^7}{1.6 \times 10^{-19} \times 4.5 \times 10^{-4}}$$ $$= 0.4\text{ m}$$ (ii) $$\upsilon = \frac{v}{2\pi r}$$	½ ½ ½ ½ ½ ½ ½ ½ ½	

	$= \frac{3.2 \times 10^7}{2\pi \times 0.4}$ $= \frac{4}{\pi} \times 10^7$ Hz	½	
	(iii) $E = \frac{1}{2} mv^2$	½	
	$= \frac{1}{2} \times 9 \times 10^{-31} \times 3.2 \times 3.2 \times 10^{14}$ $= 4.608 \times 10^{-16}$ J	½	3
26.	• Defining binding energy 1 • Calculating energy released 2 Binding energy : Energy released in bringing all the nucleons of a nucleus together to form a nucleus. Alternatively – Energy required to separate the nucleons from the nucleus.	1	
	Binding Energy of X, $B.E_X = 240 \times 7.6$ $= 1824$ MeV	½	
	Binding Energy of Y, $B.E_Y = 120 \times 8.5 = 1020$ MeV	½	
	Energy released $E = 2(B.E_Y) - (B.E_X)$	½	
	$= (2 \times 1020) - 1824$ $= 216$ MeV	½	3
27.	• Defining drift velocity 1 • Deriving expression for current flowing through the conductor in terms of drift velocity 2 The drift velocity is defined as average velocity with which free electrons in a conductor get drifted under the influence of electric field applied across the conductor.	1	
	Let us consider a conductor of length *l* and cross-sectional area A connected across the battery of voltage V.  		
	Let n be the electron density current flowing through the conductor is given by $I = \frac{\text{Total charge}}{\text{time}}$ …. (1)	½	

	i.e. $Q = nA\,L \times e$ …. (2) $t = \frac{L}{v_d}$ …. (3) Using (2) and (3) in (1) $I = \frac{Q}{t} = \frac{nALe}{L/v_d}$ $I = neAv_d$	½ ½ ½	3
28.	Calculating (a) The magnetic moment $\vec{m}$ of the loop 1 ½ (b) the torque $\vec{\tau}$ acting on the loop 1 ½ (a) $\vec{m} = I\vec{A} = I\lvert\vec{A}\rvert\hat{n}$ $= 0.25\text{ A} \times (4 \times 5 \times 10^{-4}\text{ m}^2)\,[0.8\hat{i} - 0.6\hat{j}]$ $= 5 \times 10^{-4}\,(0.8\hat{i} - 0.6\hat{j})\text{ A m}^2$ (b) $\vec{t} = \vec{m} \times \vec{B}$ $= 5 \times 10^{-4}(0.8\hat{i} - 0.6\hat{j}) \times (0.2\hat{j} + 0.5\hat{k})\text{ N m}$ $= 5 \times 10^{-4}(0.16\hat{k} - 0.4\hat{j} - 0.3\hat{i})\text{ N m}$ $= 5 \times 10^{-4}(-0.3\hat{i} - 0.4\hat{j} + 0.16\hat{k})\text{ N m}$	½ ½ ½ ½ ½ ½	3
SECTION - D			
29.	(i) (a) (D) 2.59 cm OR (b) (C) 9.47 cm (ii) (B) 10 (iii) (A) Real inverted and magnified. iv) (B) The object is at a distance more than f_0 and less than 2 f_0 from the objective	1 1 1 1	4
30.	(i) (a) (C) Majority charge carrier is n type semiconductors are holes. OR (b) (D) The drift current and the diffusion current cancel each other. (ii) (B) Phosphorus (iii) (A) 0.72 eV (iv) (C) Increases and the depletion layer width also increases.	1 1 1 1	4
SECTION – E			
31.	(a) (i) Obtaining (I) Impedance of the circuit using phase diagram 2 (II) Expression for the instantaneous current ½ (III) Phase relationship of current to the applied voltage ½ (ii) Defining power factor of ac circuit 1 Stating conditions in which power factor is (I) Maximum ½ (II) Minimum ½ (a) (i) (I) Let resistance R, inductor L and capacitor C be connected in series		

with an alternate e.m.f.





½

$$\varepsilon = \sqrt{I^2[R^2 + (X_L - X_c)^2]}$$ ½

$$Z = \frac{\varepsilon}{I}$$ ½

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$ ½

(II) $I_m = \frac{V_m}{Z}\sin(\omega t - \phi)$ ½

(III) Phase angle $\tan\phi = \frac{V_L - V_C}{V_R}$ ½

(ii) $P = E_V I_V \cos\phi$ where P = true power and $E_V I_V$ is the apparent power. ϕ is phase difference between current and voltage.
Power factor is defined as the ratio of true power to the apparent power. 1

Power factor = $\frac{\textit{True Power (P)}}{\textit{Apparent power } (E_V I_V)} = \cos\phi$

(i) Power factor is maximum when ϕ = 0 purely resistive circuit(It occurs when $\omega = \frac{1}{\sqrt{LC}}$ at resonance in an LCR series circuit). ½

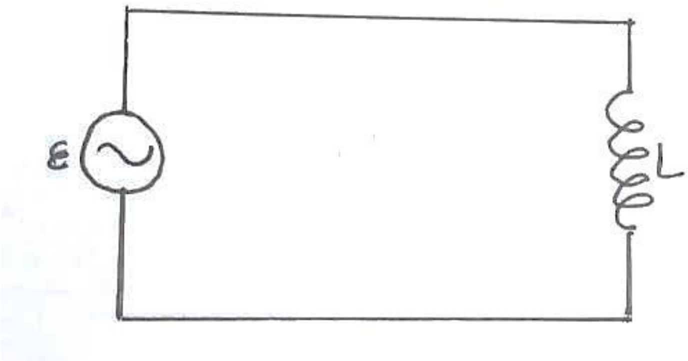
(ii) Power factor is minimum when $\phi = \frac{\pi}{2}$, in pure inductive or capacitive circuit. ½

(b)

(i) Proving that the voltage is ahead of current in phase by π/2 radian in an AC circuit containing an ideal inductor	3
(ii) Drawing graph showing the variations of	
(I) Magnitude of induced emf with rate of change of current	1
(II) Energy stored in inductor with current	1

(i) Let the voltage across the source be

$$\upsilon = \upsilon_m \sin \omega t$$



½

Using Kirchhoff's loop rule

$$\upsilon - L\frac{di}{dt} = 0$$

$$\frac{di}{dt} = \frac{\upsilon}{L} = \frac{\upsilon_m}{L}\sin \omega t$$

$$di = \frac{\upsilon_m}{L}\sin \omega t\, dt$$ 1

Integrating

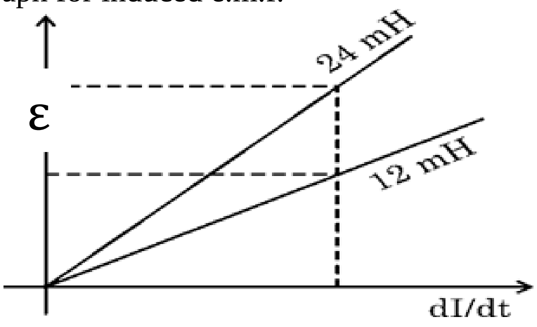
$$i = \frac{\upsilon_m}{\omega L}\cos \omega t$$ ½

$$i = i_m \sin(\omega t - \frac{\pi}{2})$$ ½

This show that current lags behind the voltage by $\frac{\pi}{2}$ rad.

$\therefore$ Voltage is ahead of current in phase by $\frac{\pi}{2}$ rad ½

(ii) (I) Graph for induced e.m.f.



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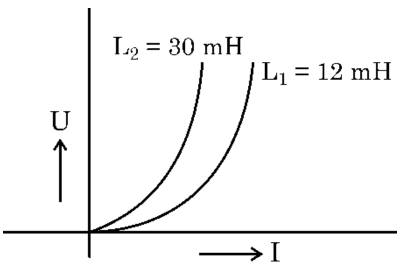
(II) Graph for energy stored



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5

32. (a)

(i) Calculating the new value for the capacitor with justification	
(I) Charge	½ + ½
(II) Potential Difference	½ + ½
(III) Energy stored	½ + ½
(ii) Drawing the pattern of electric field lines for	
(I) Positively charged conducting sphere	1
(II) An electric dipole	1

(i) (I) Charge will become half

Charge will flow from capacitors A (high potential) to capacitor B (low potential) till they achieve equilibrium.

Alternatively

$$q_A = cv \qquad q_B = 0$$

$$V_{common} = \frac{q_A + q_B}{c_A + c_B} = \frac{\text{cv}}{2\text{c}}$$ ½

$$= \frac{\text{v}}{2}$$

$$q_A^{'} = \text{cv}_{common} = \frac{\text{cv}}{2} = \frac{q_A}{2}$$ ½

(II) Potential difference will become half.

$$V_{common} = \frac{q_A + q_B}{c_A + c_B}$$ ½

$$= \frac{\text{cv} + 0}{2\text{c}} = \frac{\text{v}}{2}$$ ½

(III) Energy stored will becomes one fourth

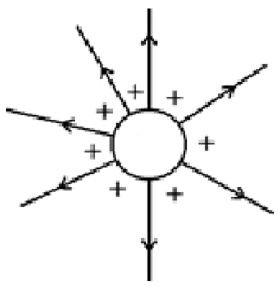
$$U_A = \frac{1}{2}CV^2$$ ½

$$U_A^{'} = \frac{1}{2}CV_{common}^2$$

$$= \frac{1}{2}C\left(\frac{V}{2}\right)^2$$ ½

$$= \frac{U_A}{4}$$

(ii)
(I)



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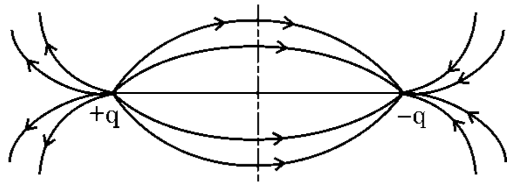
(II)



1

OR

(b)

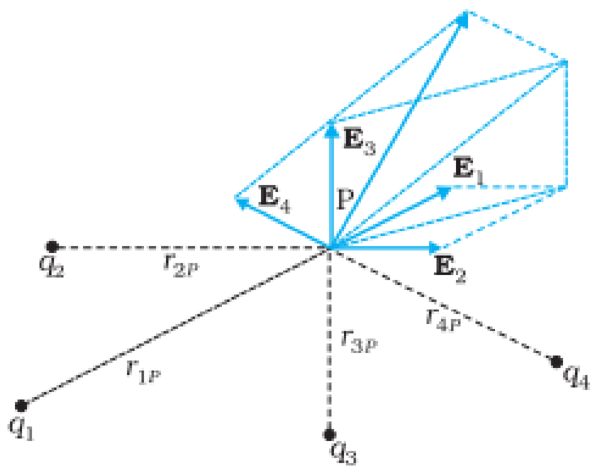
(i) Writing coulomb's law in vector form	1
Determining the electric field due to a system of point charges	2
(ii) Finding sign and magnitude of q	2

(i) $\vec{F}_{21} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1 q_2}{r_{21}^2}\hat{r}_{21}$

Alternative: $\vec{F}_{12} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1 q_2}{r_{12}^2}\hat{r}_{12}$ 1

OR $\vec{F} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1 q_2}{r^2}\hat{r}$

For determining electric field due to a system of point charges



½

$$\vec{E}_1 = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{r_{1p}^2}\hat{r}_{1p}$$

½

$$\vec{E}_2 = \frac{1}{4\pi\varepsilon_0}\frac{q_2}{r_{2p}^2}\hat{r}_{2p}$$

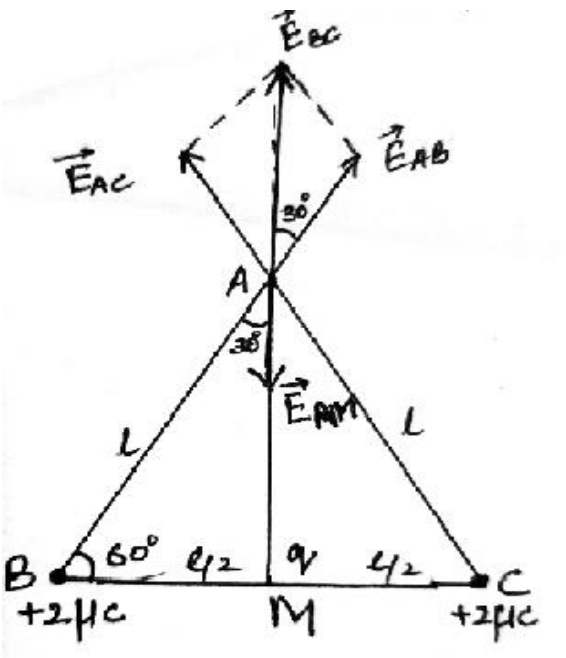
and so on

By superposition principle

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \ldots\ldots\ldots\ldots + \vec{E}_n$$ ½

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\frac{q_i}{r_{ip}^2}\hat{r}_{ip}$$ ½

(ii)



½

From the figure

$$\left|\vec{E}_{AB}\right| = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{r^2}$$

$$= \frac{1}{4\pi\varepsilon_0}\cdot\frac{2\times10^{-6}}{l^2}$$

$$\left|\vec{E}_{AC}\right| = \frac{1}{4\pi\varepsilon_0}\cdot\frac{2\times10^{-6}}{l^2}$$

$\because \quad \left|\vec{E}_{AB}\right| = \left|\vec{E}_{AC}\right|$ ½

$\therefore$ Resultant of $\vec{E}_{AB}$ & $\vec{E}_{AC}$

$$\vec{E}_{BC} = \vec{E}_{AB} + \vec{E}_{AC}$$

$$\left|\vec{E}_{BC}\right| = 2E_{AB}\cos 30^\circ$$

$$\left|\vec{E}_{BC}\right| = \frac{1}{4\pi\varepsilon_0}\cdot\frac{2\times10^{-6}}{l^2}\frac{\sqrt{3}}{2}$$ ½

$$\left|\vec{E}_{AM}\right| = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{\left(\frac{l\sqrt{3}}{2}\right)^2}$$

$\because$ Net electric field at A is zero.

$\therefore \quad E_{AM} = -E_{BC}$

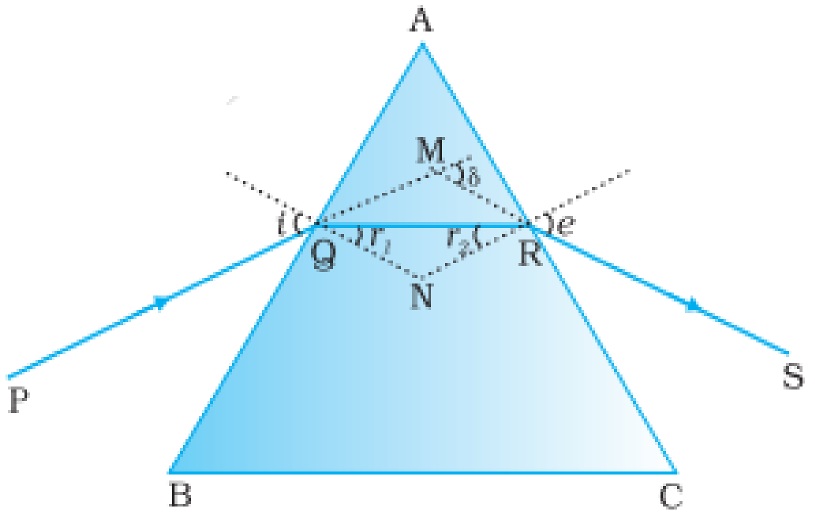
$$\frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{\left(\frac{l\sqrt{3}}{2}\right)^2} = -\frac{2}{4\pi\varepsilon_0}\cdot\frac{2\times10^{-6}}{l^2}\frac{\sqrt{3}}{2}$$

$$q = \frac{-3\sqrt{3}}{2}\times10^{-6}\,\mathrm{C} \ \ or \ \ \frac{-3\sqrt{3}}{2}\,\mu\mathrm{C}$$ ½

5

33. (a)

- Deducing expression for refractive index of glass prism in terms of angle of minimum deviation and angle of prism 4
- Writing condition for n for refraction to place on opposite face of prism



1

$$A + \delta = i + e$$ ½

and $A = r_1 + r_2$ ½

at angle of minimum deviation , $\delta = D_m$

$$i = e\ ,\ r_1 = r_2 = r$$ ½

$$A + D_m = 2i$$

$$i = \frac{A + D_m}{2}$$

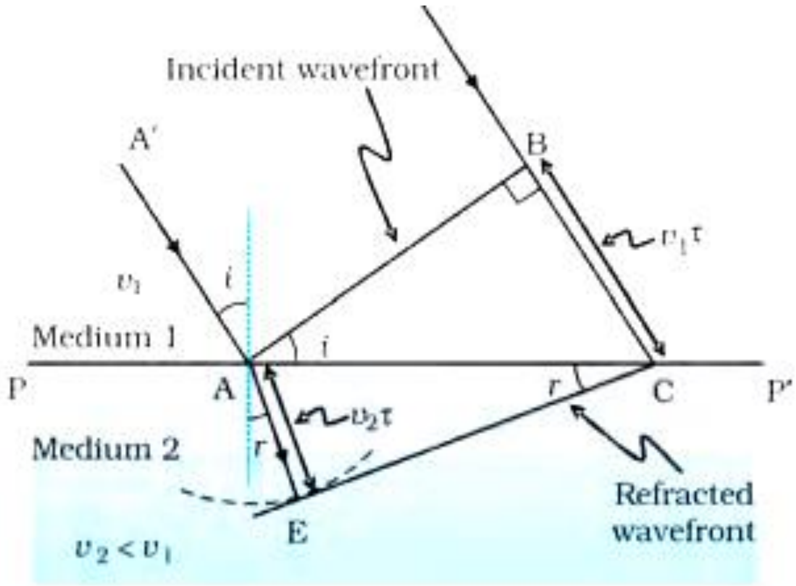
$$A = 2r \Rightarrow r = \frac{A}{2}$$ ½

From Snell's law

$$n = \frac{\sin i}{\sin r}$$ ½

$$n = \frac{\sin\left(\frac{A + D_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$ ½

For refraction to take place on opposite face

	$r_2 < i_c$ $n = \frac{1}{\sin i_c}$ $i_c = \sin^{-1}\left(\frac{1}{n}\right)$ $r_2 < \sin^{-1}\left(\frac{1}{n}\right)$	½ ½	
	OR		
	(b) • Stating Huygen's principle — 1 • Drawing diagram — 1 ½ • Discussing the case of refraction of plane wave of light from rarer to a denser medium — ½ • Deriving Snell's law — 2		
	Huygen's Principle : Each point of the wavefront is the source of a secondary disturbance and the wavelets emanating from these points spread out in all directions with the speed of the wave. These wavelets emanating from the wavefront are usually referred to as secondary wavelets and if we draw a common tangent to all these spheres, we obtain the new position of the wavefront at a later time.	1	
		1 ½	
	Discussion : In time τ distance BC travelled by the incident plane wavefront with the velocity v_1 is $v_1\tau$. To determine the shape of the refracted wave wavefront , draw a sphere of radius $v_2\tau(=AE)$ from point A and draw a tangent from C to E as shown in the diagram. From the above diagram	½	

	$\triangle ABC$ *and* $\triangle AEC$ $\sin i = \dfrac{BC}{AC} = \dfrac{v_1\tau}{AC}$ *and* $\sin r = \dfrac{AE}{AC} = \dfrac{v_2\tau}{AC}$ $\dfrac{\sin i}{\sin r} = \dfrac{v_1}{v_2}$ ....(1) As $n_1 = \dfrac{c}{v_1}$ *and* $n_2 = \dfrac{c}{v_2}$ $\therefore \dfrac{v_1}{v_2} = \dfrac{n_1}{n_2}$ ....(2) From equations (1) and (2) $n_1 \sin i = n_2 \sin r$	½ ½ ½ ½	5