Critical Thinking

Objective Questions

1. A $1\mu A$ beam of protons with a cross-sectional area of 0.5 *sq. mm* is moving with a velocity of $3\times10^4 ms^{-1}$. Then charge density of beam is **[CPMT 2002]**
   (a) $6.6\times10^{-4} C/m^3$ (b) $6.6\times10^{-5} C/m^3$
   (c) $6.6\times10^{-6} C/m^3$ (d) None of these

2. A particle of mass M at rest decays into two particles of masses m_1 and m_2, having non-zero velocities. The ratio of the de-Broglie wavelengths of the particles, λ_1/λ_2 is **[IIT-JEE 1999; KCET 2003]**
   (a) m_1/m_2 (b) m_2/m_1
   (c) 1.0 (d) $\sqrt{m_2}/\sqrt{m_1}$

3. A photon and an electron have equal energy E. $\lambda_{\text{photon}}/\lambda_{\text{electron}}$ is proportional to **[UPSEAT 2003; IIT-JEE (Screening) 2004]**
   (a) $\sqrt{E}$ (b) $1/\sqrt{E}$
   (c) $1/E$ (d) Does not depend upon E

4. When photon of energy 4.25 eV strike the surface of a metal A, the ejected photoelectrons have maximum kinetic energy T_A eV and de-Brolie wavelength λ_A. The maximum kinetic energy of photoelectrons liberated from another metal B by photon of energy 4.70 eV is $T_B=(T_A-1.50)\,eV$. If the de-Broglie wavelength of these photoelectrons is $\lambda_B=2\lambda_A$, then **[IIT-JEE 1994]**
   (a) The work function of A is 2.25 eV
   (b) The work function of B is 4.20 eV
   (c) $T_A=2.00\,eV$
   (d) $T_B=2.75\,eV$

5. An image of the sun is formed by a lens of focal length of 30 *cm* on the metal surface of a photoelectric cell and a photoelectric current I is produced. The lens forming the image is then replaced by another of the same diameter but of focal length 15 *cm*. The photoelectric current in this case is **[Manipal MEE 1995]**
   (a) $\frac{I}{2}$ (b) I
   (c) $2I$ (d) $4I$

6. When an inert gas is filled in the place vacuum in a photo cell, then **[MP PMT 1997]**
   (a) Photo-electric current is decreased
   (b) Photo-electric current is increased
   (c) Photo-electric current remains the same
   (d) Decrease or increase in photo-electric current does not depend upon the gas filled

7. A photon of 1.7×10^{-13} *Joules* is absorbed by a material under special circumstances. The correct statement is **[MP PET 1999; JIPMER 2000]**
   (a) Electrons of the atom of absorbed material will go the higher energy states
   (b) Electron and positron pair will be created
   (c) Only positron will be produced
   (d) Photoelectric effect will occur and electron will be produced

8. The maximum velocity of an electron emitted by light of wavelength λ incident on the surface of a metal of work function ϕ, is **[MP PMT/PET 1998, MP PMT 2003]**
   (a) $\left[\frac{2(hc+\lambda\phi)}{m\lambda}\right]^{1/2}$ (b) $\frac{2(hc-\lambda\phi)}{m}$
   (c) $\left[\frac{2(hc-\lambda\phi)}{m\lambda}\right]^{1/2}$ (d) $\left[\frac{2(h\lambda-\phi)}{m}\right]^{1/2}$
   Where h = Planck's constant, m = mass of electron and c = speed of light.

9. When a point source of monochromatic light is at a distance of 0.2 m from a photoelectric cell, the cut-off voltage and the saturation current are 0.6 *volt* and 18 mA respectively. If the same source is placed 0.6 m away from the photoelectric cell, then **[IIT JEE 1992; MP PMT 1999]**
   (a) The stopping potential will be 0.2 V
   (b) The stopping potential will be 0.6 V
   (c) The saturation current will be 6 mA
   (d) The saturation current will be 18 mA

10. In a photoemissive cell with executing wavelength λ, the fastest electron has speed v. If the exciting wavelength is changed to $3\lambda/4$, the speed of the fastest emitted electron will be **[CBSE PMT 1998]**

(a) $v(3/4)^{1/2}$ (b) $v(4/3)^{1/2}$

(c) Less than $v(4/3)^{1/2}$ (d) Greater than $v(4/3)^{1/2}$

11. Ultraviolet light of wavelength 300 *nm* and intensity 1.0 $watt/m^2$ falls on the surface of a photosensitive material. If 1% of the incident photons produce photoelectrons, then the number of photoelectrons emitted from an area of 1.0 cm^2 of the surface is nearly **[AMU 1995]**

(a) 9.61×10^{14} *per sec* (b) 4.12×10^{13} *per sec*

(c) 1.51×10^{12} *per sec* (d) 2.13×10^{11} *per sec*

12. Photoelectric emission is observed from a metallic surface for frequencies ν_1 and ν_2 of the incident light rays $(\nu_1 > \nu_2)$. If the maximum values of kinetic energy of the photoelectrons emitted in the two cases are in the ratio of $1:k$, then the threshold frequency of the metallic surface is **[EAMCET (Engg.) 2001]**

(a) $\frac{\nu_1-\nu_2}{k-1}$ (b) $\frac{k\nu_1-\nu_2}{k-1}$

(c) $\frac{k\nu_2-\nu_1}{k-1}$ (d) $\frac{\nu_2-\nu_1}{k}$

13. Light from a hydrogen discharge tube is incident on the cathode of a photoelectric cell the work function of the cathode surface is 4.2 *eV*. In order to reduce the photo-current to zero the voltage of the anode relative to the cathode must be made **[DCE 2002]**

(a) – 4.2 *V* (b) – 9.4 *V*

(c) – 17.8 *V* (d) +9.4 *V*

14. Work function of lithium and copper are respectively 2.3 *eV* and 4.0 *eV*. Which one of the metal will be useful for the photoelectric cell working with visible light ? ($h = 6.6\times10^{-34}$ *J-s*, $c = 3\times10^8$ *m/s*) **[DPMT 2003]**

(a) Lithium (b) Copper

(c) Both (d) None of these

15. X-rays of wavelength 0.1 Å allowed to fall on a metal get scattered. The wavelength of scattered radiation is 0.111 Å. If $h = 6.624\times10^{-34}$ *J-s* and $m_0 = 9\times10^{-31}$ *kg*, then the direction of the scattered photons will be

(a) $\cos^{-1}(0.547)$ (b) $\cos^{-1}(0.4484)$

(c) $\cos^{-1}(0.5)$ (d) $\cos^{-1}(0.3)$

16. The largest distance between the interatomic planes of a crystal is $10^{-7}cm$. The upper limit for the wavelength of *X*-rays which can be usefully studied with this crystal is **[CPMT 1984]**

(a) 1 Å (b) 2 Å

(c) 10 Å (d) 20 Å

17. An *X*-ray tube is operating at 50 *kV* and 20 *mA*. The target material of the tube has a mass of 1.0 *kg* and specific heat 495 $J\ kg^{-1}\ {}^oC^{-1}$. One percent of the supplied electric power is converted into *X*-rays and the entire remaining energy goes into heating the target. Then

(a) A suitable target material must have a high melting temperature

(b) A suitable target material must have low thermal conductivity

(c) The average rate of rise of temperature of target would be 2 °*C/s*

(d) The minimum wavelength of the *X*-rays emitted is about $0.25\times10^{-10}\ m$

18. The wavelength of K_α *X*-rays produced by an *X*-ray tube is 0.76 Å. The atomic number of the anode material of the tube is

(a) 20 (b) 60

(c) 40 (d) 80

19. *X*-ray beam of intensity I_0 passes through an absorption plate of thickness *d*. If absorption coefficient of material of plate is μ, the correct statement regarding the transmitted intensity *I* of *X*-ray is **[MP PET 1999]**

(a) $I = I_0(1-e^{-\mu d})$ (b) $I = I_0e^{-\mu d}$

(c) $I = I_0(1-e^{-\mu/d})$ (d) $I = I_0e^{-\mu/d}$

20. The K_α *X*-ray emission line of tungsten occurs at $\lambda = 0.021\ nm$. The energy difference between *K* and *L* levels in this atom is about

(a) 0.51*MeV* (b) 1.2 *MeV*

(c) 59 *KeV* (d) 13.6 eV

21. Electrons with energy 80 *keV* are incident on the tungsten target of an *X*-ray tube. *K* shell electrons of tungsten have ionization energy 72.5 *keV*. *X*-rays emitted by the tube contain only **[IIT-JEE (Screening) 2000]**

(a) A continuous *X*-ray spectrum (Bremsstrahlung) with a minimum wavelength of ~ 0.155Å

(b) A continuous *X*-ray spectrum (Bremsstrahlung] with all wavelengths

(c) The characteristic *X*-rays spectrum of tungsten

(d) A continuous *X*-ray spectrum (Bremsstrahlung) with a minimum wavelength of ~ 0.155Å and the characteristic *X*-ray spectrum of tungsten

22. The *X*-ray wavelength of L_α line of platinum (Z=78) is $1.30 Å$. The *X* –ray wavelength of L_α line of Molybdenum (Z=42) is **[EAMCET (Eng.) 2000]**

(a) 5.41Å (b) 4.20Å

(c) 2.70Å (d) 1.35 Å

23. The ratio of de-Broglie wavelengths of molecules of hydrogen and helium which are at temperature 27°*C* and 127°*C* respectively is

(a) $\frac{1}{2}$ (b) $\sqrt{\frac{3}{8}}$

(c) $\sqrt{\frac{8}{3}}$ (d) 1

24. A silver ball of radius 4.8 *cm* is suspended by a thread in the vacuum chamber. *UV* light of wavelength 200 *nm* is incident on the ball for some times during which a total energy of 1×10^{-7} *J* falls on the surface. Assuming on an average one out of 10^3 photons incident is able to eject electron. The potential on sphere will be

(a) 1 *V* (b) 2 *V*

(c) 3 *V* (d) Zero

25. A photon of wavelength 6630 Å is incident on a totally reflecting surface. The momentum delivered by the photon is equal to

(a) 6.63×10^{-27} *kg-m/sec* (b) 2×10^{-27} *kg-m/sec*

(c) 10^{-27} *kg-m/sec* (d) None of these

26. The ratio of de-Broglie wavelength of a α-particle to that of a proton being subjected to the same magnetic field so that the radii of their path are equal to each other assuming the field induction vector $\vec{B}$ is perpendicular to the velocity vectors of the α-particle and the proton is

(a) 1 (b) $\frac{1}{4}$

(c) $\frac{1}{2}$ (d) 2

27. K_α wavelength emitted by an atom of atomic number $Z = 11$ is λ. Find the atomic number for an atom that emits K_α radiation with wavelength 4λ **[IIT-JEE (Screening) 2005]**

(a) $Z = 6$ (b) $Z = 4$

(c) $Z = 11$ (d) $Z = 44$

28. The potential energy of a particle of mass *m* is given by

$$U(x) = \begin{cases} E_0; & 0 \le x \le 1 \\ 0; & x > 1 \end{cases}$$

λ_1 and λ_2 are the de-Broglie wavelengths of the particle, when $0 \le x \le 1$ and $x > 1$ respectively. If the total energy of particle is $2E_0$, the ratio $\frac{\lambda_1}{\lambda_2}$ will be

[Based on IIT-JEE (Mains) 2005]

(a) 2 (b) 1

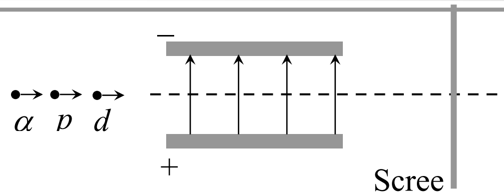
(c) $\sqrt{2}$ (d) $\frac{1}{\sqrt{2}}$

29. Rest mass energy of an electron is 0.51 *MeV*. If this electron is moving with a velocity 0.8 *c* (where *c* is velocity of light in vacuum), then kinetic energy of the electron should be.

(a) 0.28 *MeV* (b) 0.34 *MeV*

(c) 0.39 *MeV* (d) 0.46 *MeV*

30. A proton, a deutron and an α-particle having the same momentum, enters a region of uniform electric field between the parallel plates of a capacitor. The electric field is perpendicular to the initial path of the particles. Then the ratio of deflections suffered by them is



(a) 1 : 2 : 8 (b) 1 : 2 : 4

(c) 1 : 1 : 2 (d) None of these

31. In order to coincide the parabolas formed by singly ionised ions in one spectrograph and doubly ionized ions in the other Thomson's mass spectrograph, the electric fields and magnetic fields are kept in the ratios 1 : 2 and 3 : 2 respectively. Then the ratio of masses of the ions is

(a) 3 : 4 (b) 1 : 3

(c) 9 : 4 (d) None of these

32. Let λ_α, λ_β and λ'_α denote the wavelengths of the X-rays of the K_α, K_β and L_α lines in the characteristic X-rays for a metal

(a) $\lambda_\alpha > \lambda'_\alpha > \lambda_\beta$ (b) $\lambda'_\alpha > \lambda_\beta > \lambda_\alpha$

(c) $\frac{1}{\lambda_\beta} = \frac{1}{\lambda_\alpha} + \frac{1}{\lambda'_\alpha}$ (d) $\frac{1}{\lambda_\alpha} + \frac{1}{\lambda_\beta} = \frac{1}{\lambda'_\alpha}$

33. The minimum intensity of light to be detected by human eye is $10^{-10} W/m^2$. The number of photons of wavelength $5.6 \times 10^{-7} m$ entering the eye, with pupil area $10^{-6} m^2$, per second for vision will be nearly

(a) 100 (b) 200

(c) 300 (d) 400

34. In X-ray tube when the accelerating voltage V is halved, the difference between the wavelength of K_α line and minimum wavelength of continuous X-ray spectrum

(a) Remains constant

(b) Becomes more than two times

(c) Becomes half

(d) Becomes less than two times

35. In a photocell bichromatic light of wavelength 2475 Å and 6000 Å are incident on cathode whose work function is 4.8 *eV*. If a uniform magnetic field of 3×10^{-5} *Tesla* exists parallel to the plate, the radius of the path describe by the photoelectron will be (mass of electron = 9×10^{-31} *kg*)

(a) 1 *cm* (b) 5 *cm*

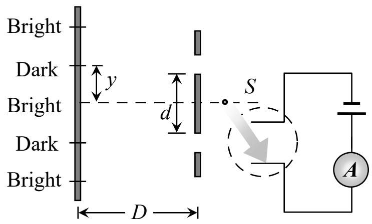
(c) 10 *cm* (d) 25 *cm*

36. Two metallic plates A and B, each of area $5 \times 10^{-4} m^2$ are placed parallel to each other at a separation of 1 *cm*. Plate B carries a positive charge of 33.7 *pc*. A monochromatic beam of light, with photons of energy 5 *eV* each, starts falling on plate A at $t = 0$, so that 10^{16} photons fall on it per square meter per second. Assume that one photoelectron is emitted for every 10^6 incident photons. Also assume that all the emitted photoelectrons are collected by plate B and the work function of plate A remains constant at the value 2 *eV*. Electric field between the plates at the end of 10 seconds is

(a) 2×10^3 *N/C* (b) 10^3 *N/C*

(c) 5×10^3 *N/C* (d) Zero

37. In the following arrangement $y = 1.0$ *mm*, $d = 0.24$ *mm* and $D = 1.2$ *m*. The work function of the material of the emitter is 2.2 *eV*. The stopping potential V needed to stop the photo current will be



(a) 0.9 *V* (b) 0.5 *V*

(c) 0.4 *V* (d) 0.1 *V*

38. The eye can detect 5×10^4 photons per square metre per sec of green light ($\lambda = 5000$ Å) while the ear can detect $10^{-13} (W/m^2)$. The factor by which the eye is more sensitive as a power detector than the ear is close to

(a) 5 (b) 10

(c) 10^6 (d) 15

39. A photon collides with a stationary hydrogen atom in ground state inelastically. Energy of the colliding photon is 10.2 *eV*. After a time interval of the order of micro second another photon collides with same hydrogen atom inelastically with an energy of 15 *eV*. What will be observed by the detector

[IIT-JEE (Screening) 2005]

(a) 2 photon of energy 10.2 eV

(b) 2 photon of energy of 1.4 eV

(c) One photon of energy 10.2 eV and an electron of energy 1.4 eV

(d) One photon of energy 10.2 eV and another photon of 1.4 eV

GQ Graphical Questions

1. The curve drawn between velocity and frequency of photon in vacuum will be a

[MP PET 2000]

(a) Straight line parallel to frequency axis

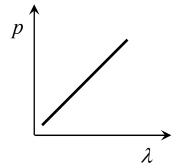
(b) Straight line parallel to velocity axis

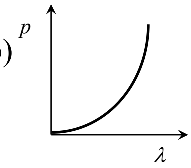
(c) Straight line passing through origin and making an angle of 45° with frequency axis

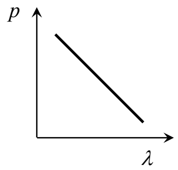
(d) Hyperbola

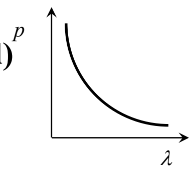
2. Which of the following figure represents the variation of particle momentum and the associated de-Broglie wavelength

[AIIMS 1982]

(a) 

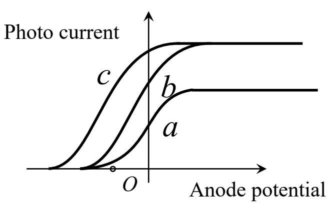
(b) 

(c) 

(d) 

3. The figure shows the variation of photocurrent with anode potential for a photo-sensitive surface for three different radiations. Let I_a, I_b and I_c be the intensities and f_a, f_b and f_c be the frequencies for the curves a, b and c respectively

[IIT-JEE (Screening) 2004]



(a) $f_a = f_b$ and $I_a \neq I_b$

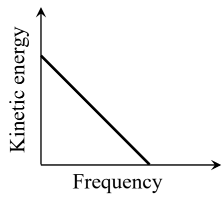
(b) $f_a = f_c$ and $I_a = I_c$

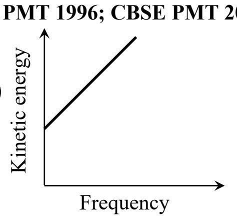
(c) $f_a = f_b$ and $I_a = I_b$

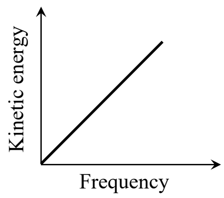
(d) $f_a = f_b$ and $I_a = I_b$

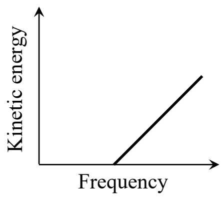
4. According to Einstein's photoelectric equation, the graph between the kinetic energy of photoelectrons ejected and the frequency of incident radiation is

[MP PMT 1994; CBSE PMT 1996; CBSE PMT 2004]

(a) 

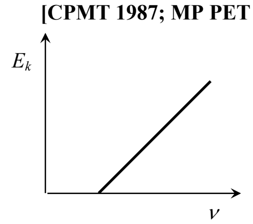
(b) 

(c) 

(d) 

5. For the photoelectric effect, the maximum kinetic energy E_k of the emitted photoelectrons is plotted against the frequency ν of the incident photons as shown in the figure. The slope of the curve gives

[CPMT 1987; MP PET 2001; DPMT 2002]



(a) Charge of the electron

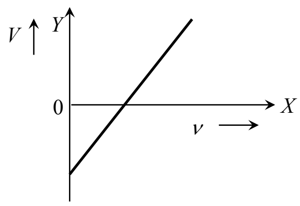
(b) Work function of the metal

(c) Planck's constant

(d) Ratio of the Planck's constant to electronic charge

6. The stopping potential V for photoelectric emission from a metal surface is plotted along Y-axis and frequency ν of incident light along X-axis. A straight line is obtained as shown. Planck's constant is given by

[CPMT 1987; Similar to MP PMT 2000; Kerala PET 2001]



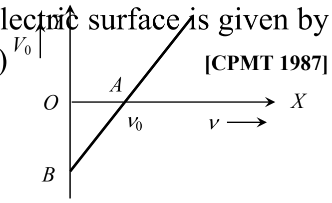
(a) Slope of the line

(b) Product of slope on the line and charge on the electron

(c) Product of intercept along Y-axis and mass of the electron

(d) Product of Slope and mass of electron

7. In an experiment on photoelectric effect the frequency f of the incident light is plotted against the stopping potential V_0. The work function of the photoelectric surface is given by (e is electronic charge) **[CPMT 1987]**



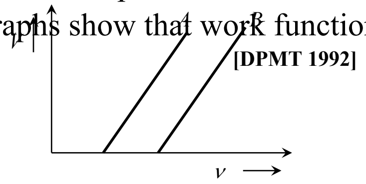
(a) $OB \times e$ in eV

(b) OB in *volt*

(c) OA in eV

(d) The slope of the line AB

8. The stopping potential as a function of the frequency of the incident radiation is plotted for two different photoelectric surfaces A and B. The graphs show that work function of A is **[DPMT 1992]**



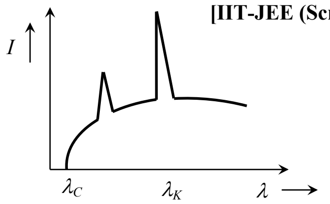
(a) Greater than that of B

(b) Smaller than that of B

(c) Equal to that of B

(d) No inference can be drawn about their work functions from the given graphs

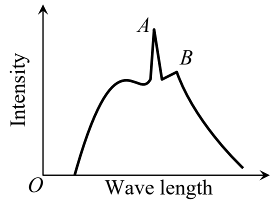
9. The intensity of X-rays from a Coolidge tube is plotted against wavelength as shown in the figure. The minimum wavelength found is λ_c and the wavelength of the K_α line is λ_k. As the accelerating voltage is increased **[IIT-JEE (Screening) 2001]**



(a) $(\lambda_K - \lambda_C)$ increases (b) $(\lambda_K - \lambda_C)$ decreases

(c) λ_K increases (d) λ_K decreases

10. The figure represents the observed intensity of X-rays emitted by an X-ray tube as a function of wavelength. The sharp peaks A and B denote **[CBSE PMT 1995]**

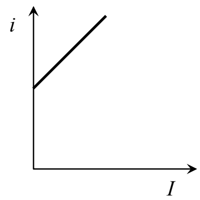


(a) Band spectrum (b) Continuous spectrum

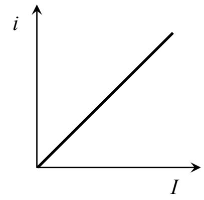
(c) Characteristic radiations (d) White radiations

11. The graph between intensity of light falling on a metallic plate (I) with the current (i) generated is **[DCE 2001]**

(a)



(b)



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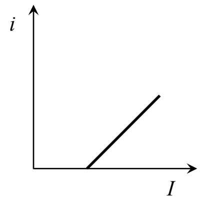
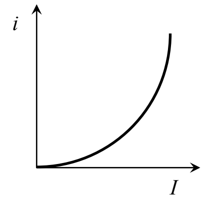
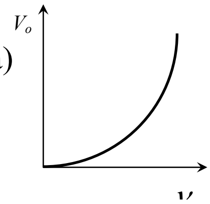


(d)

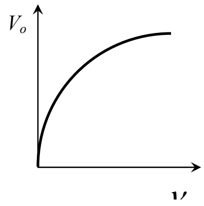


12. For a photoelectric cell the graph showing the variation of cut of voltage (V_o) with frequency (ν) of incident light is best represented by **[DCE 2001; MP PET 2003]**

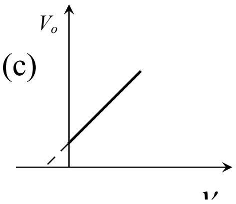
(a)



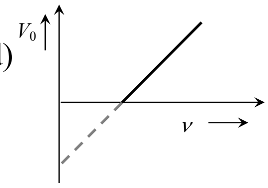
(b)



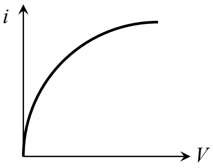
(c)

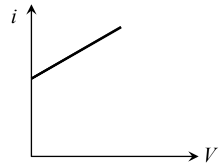


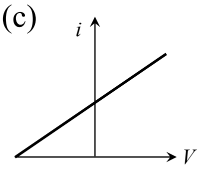
(d)

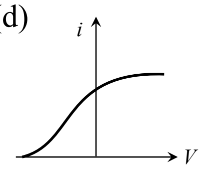


13. The curve between current (i) and potential difference (V) for a photo cell will be

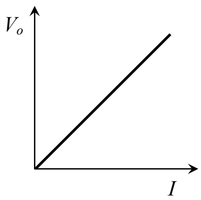
(a) 

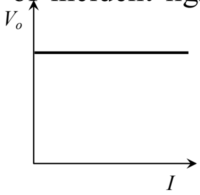
(b) 

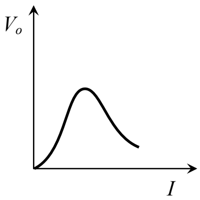
(c) 

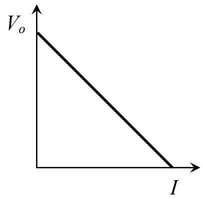
(d) 

14. The correct curve between the stopping potential (V) and intensity of incident light (I) is

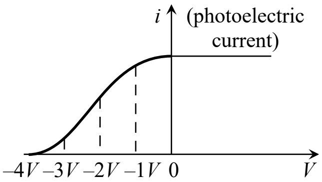
(a) 

(b) 

(c) 

(d) 

15. The value of stopping potential in the following diagram



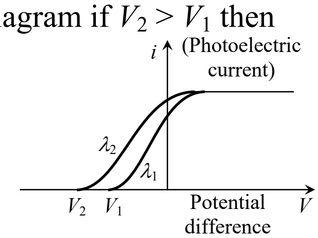
(a) – 4V

(b) – 3 V

(c) – 2V

(d) – 1 V

16. In the following diagram if $V_2 > V_1$ then



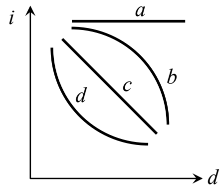
(a) $\lambda_1 = \sqrt{\lambda_2}$

(b) $\lambda_1 < \lambda_2$

(c) $\lambda_1 = \lambda_2$

(d) $\lambda_1 > \lambda_2$

17. A point source of light is used in an experiment on photoelectric effect. Which of the following curves best represents the variation of photo current (i) with distance (d) of the source from the emitter



(a) a

(b) b

(c) c

(d) d

18. According to Einstein's photoelectric equation, the plot of the kinetic energy of the emitted photo electrons from a metal versus the frequency, of the incident radiation gives a straight line whose slope

[AIEEE 2004]

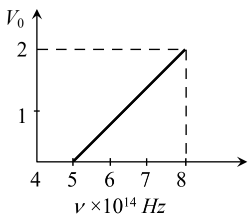
(a) Is the same for all metals and independent of the intensity of the radiation

(b) Depends on the intensity of the radiation

(c) Depends both on the intensity of the radiation and the metal used

(d) Depends on the nature of the metals used

19. The stopping potential (V_0) versus frequency (ν) plot of a substance is shown in figure the threshold wave length is



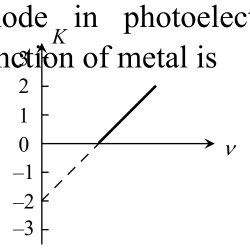
(a) $5\times10^{14}\,m$

(b) 6000Å

(c) 5000 Å

(d) Can not be estimated from given data

20. Figure represents a graph of kinetic energy (K) of photoelectrons (in eV) and frequency (ν) for a metal used as cathode in photoelectric experiment. The work function of metal is



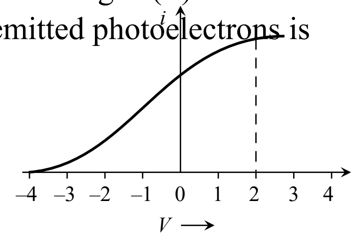
(a) 1 eV

(b) 1.5 eV

(c) 2 eV

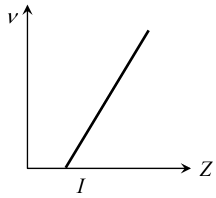
(d) 3 eV

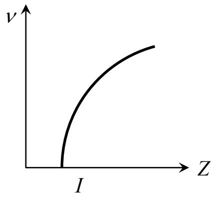
21. Figure represents the graph of photo current I versus applied voltage (V). The maximum energy of the emitted photoelectrons is

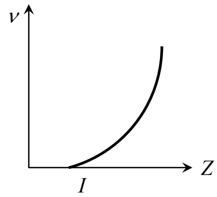


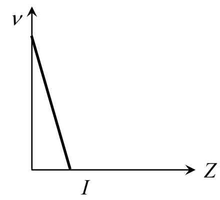
(a) 2eV
(b) 4 eV
(c) 0 eV
(d) 4 J

22. The graph that correctly represents the relation of frequency ν of a particular characteristic X-ray with the atomic number Z of the material is

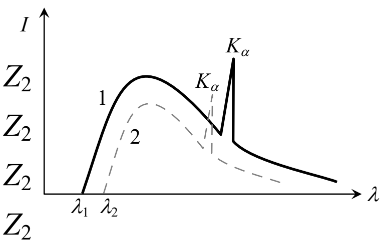
(a) 

(b) 

(c) 

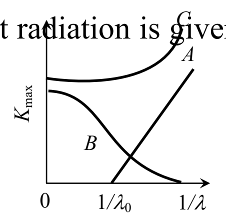
(d) 

23. The intensity distribution of X-rays from two coolidge tubes operated on different voltages V_1 and V_2 and using different target materials of atomic numbers Z_1 and Z_2 is shown in the figure. Which one of the following inequalities is true?



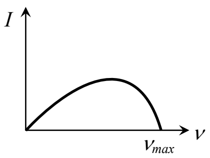
(a) $V_1 > V_2, Z_1 < Z_2$
(b) $V_1 > V_2, Z_1 > Z_2$
(c) $V_1 < V_2, Z_1 > Z_2$
(d) $V_1 = V_2, Z_1 < Z_2$

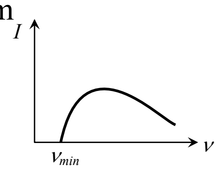
24. The correct graph between the maximum energy of a photoelectron and the inverse of wavelength of the incident radiation is given by the curve

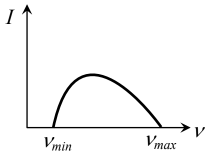


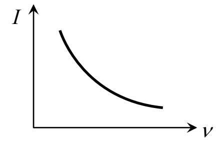
(a) A
(b) B
(c) C
(d) None of the above

25. The continuous x-ray spectrum obtained from a Coolidge tube is of the form

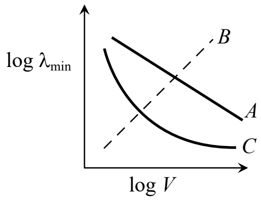
(a) 

(b) 

(c) 

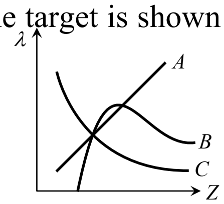
(d) 

26. The dependence of the short wavelength limit λ_{min} on the accelerating potential V is represented by the curve of figure



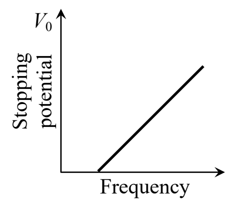
(a) A
(b) B
(c) C
(d) None of these

27. The variation of wavelength λ of the K_α line with atomic number Z of the target is shown by the following curve of



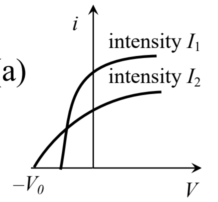
(a) A
(b) B
(c) C
(d) None of these

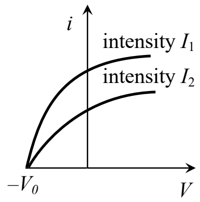
28. In the graph given below. If the slope is 4.12×10^{-15} V-sec, then value of 'h' should be

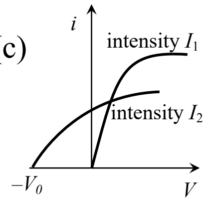


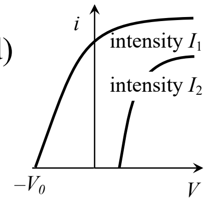
(a) 6.6×10^{-31} J-sec
(b) 6.6×10^{-34} J-sec
(c) $9.1\times10-31$ J-sec
(d) None of these

29. The curves (a), (b) (c) and (d) show the variation between the applied potential difference (V) and the photoelectric current (i), at two different intensities of light ($I_1 > I_2$). In which figure is the correct variation shown

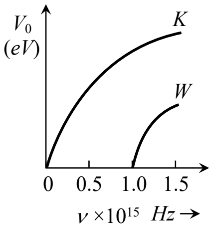
(a)


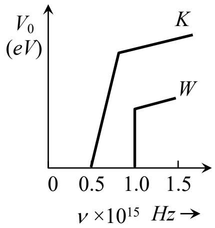
(b)


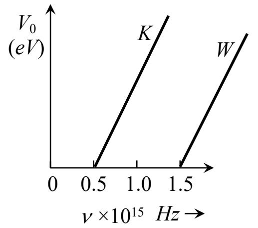
(c)


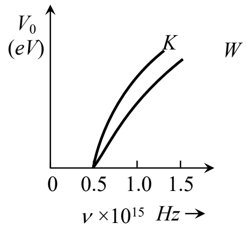
(d)


30. The figure showing the correct relationship between the stopping potential V_0 and the frequency ν of light for potassium and tungsten is

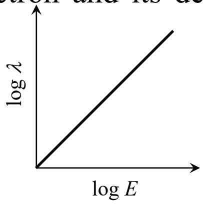
(a)


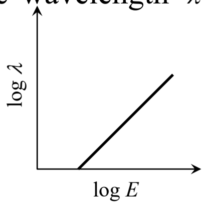
(b)


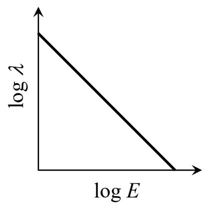
(c)


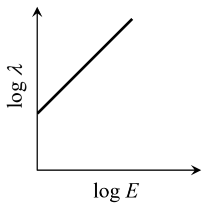
(d)


31. The log-log graph between the energy E of an electron and its de-Broglie wavelength λ will be

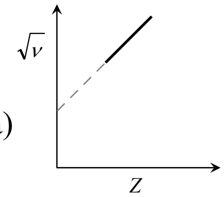
(a)


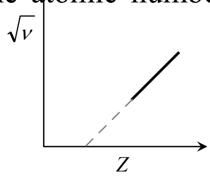
(b)


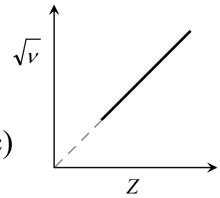
(c)


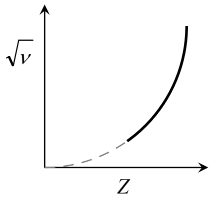
(d)


32. The graph between the square root of the frequency of a specific line of characteristic spectrum of X-rays and the atomic number of the target will be

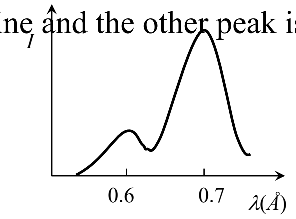
(a)


(b)


(c)


(d)


33. In the diagram a graph between the intensity of X-rays emitted by a molybdenum target and the wavelength is shown, when electrons of 30 keV are incident on the target. In the graph one peak is of K_α line and the other peak is of K_β line



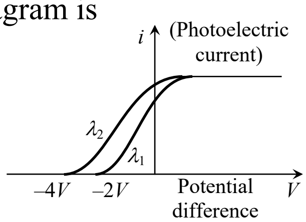
(a) First peak is of K_α line at 0.6 Å

(b) Highest peak is of K_α line at 0.7 Å

(c) If the energy of incident particles is increased, then the peaks will shift towards left

(d) If the energy of incident particles is increased, then the peaks will shift towards right

34. The maximum value of stopping potential in the following diagram is



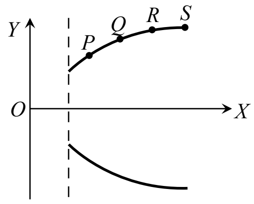
(a) – 4V

(b) – 1V

(c) – 3V

(d) $-2V$

35. In a parabola spectrograph, the velocities of four positive ions P, Q, R and S are v_1, v_2, v_3 and v_4 respectively



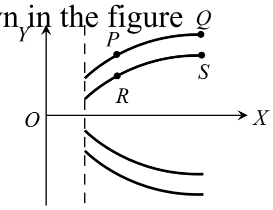
(a) $v_1 > v_2 > v_3 > v_4$

(b) $v_1 < v_2 < v_3 < v_4$

(c) $v_1 = v_2 = v_3 = v_4$

(d) $v_1 << v_2 > v_3 < v_4$

36. In Thomson spectrograph experiment, four positive ions P, Q, R and S are situated on Y-X curve a shown in the figure



(a) The specific charge of R and S are same

(b) The masses of P and S are same

(c) The specific charges of Q and R are same

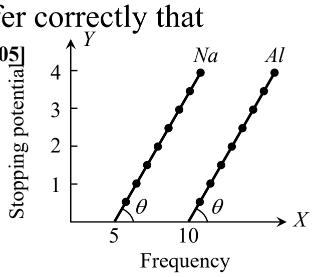
(d) The velocities of R and S are same

37. The slope of frequency of incident light and stopping potential graph for a given surface will be **[MP PET 1999; MP PMT 2000; JIPMER 2001, 02; UPSEAT 2003]**

(a) h (b) h/e

(c) eh (d) e

38. From the figure describing photoelectric effect we may infer correctly that **[KCET 2005]**



(a) Na and Al both have the same threshold frequency

(b) Maximum kinetic energy for both the metals depend linearly on the frequency

(c) The stopping potentials are different for Na and Al for the same change in frequency

(d) Al is a better photo sensitive material than Na

Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below:

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c) If assertion is true but reason is false.

(d) If the assertion and reason both are false.

(e) If assertion is false but reason is true.

1. Assertion : The energy (E) and momentum (p) of a photon are related by $p = E/c$.

Reason : The photon behaves like a particle. **[AIIMS 2005]**

2. Assertion : Photoelectric effect demonstrates the wave nature of light.

Reason : The number of photoelectrons is proportional to the frequency of light. **[AIIMS 2004]**

3. Assertion : When the speed of an electron increases its specific charge decreases.

Reason : Specific charge is the ratio of the charge to mass. **[AIIMS 2001]**

4. Assertion : X-ray travel with the speed of light.

Reason : X-rays are electromagnetic rays. **[AIIMS 2001]**

5. Assertion : Mass of moving photon varies inversely as the wavelength.

Reason : Energy of the particle $= \text{Mass} \times (\text{Speed of light})^2$ **[AIIMS 2000]**

6. Assertion : Kinetic energy of photo electrons emitted by a photosensitive surface depends upon the intensity of incident photon.

Reason : The ejection of electrons from metallic surface is possible with frequency of incident photon below the threshold frequency. [AIIMS 1999]

7. Assertion : Separation of isotope is possible because of the difference in electron numbers of isotope.

Reason : Isotope of an element can be separated by using a mass spectrometer. [AIIMS 1999]

8. Assertion : The specific charge of positive rays is not constant.

Reason : The mass of ions varies with speed. [AIIMS 1999]

9. Assertion : Photosensitivity of a metal is high if its work function is small.

Reason : Work function $= hf_0$ where f_0 is the threshold frequency. [AIIMS 1997]

10. Assertion : The de-Broglie wavelength of a molecule varies inversely as the square root of temperature.

Reason : The root mean square velocity of the molecule depends on the temperature. [AIIMS 1997]

11. Assertion : An electron is not deflected on passing through certain region of space. This observation confirms that there is no magnetic field in that region.

Reason : The deflection of electron depends on angle between velocity of electron and direction of magnetic field.

12. Assertion : Electric conduction in gases is possible at normal pressure.

Reason : The electric conduction in gases depends only upon the potential difference between the electrodes.

13. Assertion : Light is produced in gases in the process of electric discharge through them at high pressure.

Reason : At high pressure electrons of gaseous atoms collide and reach and excited state.

14. Assertion : If different gases are filled turn by turn at the same pressure in the discharge tube the discharge in them takes place at the same potential.

Reason : The discharge depends only on the pressure of discharge tube and not on the ionisation potential of gas.

15. Assertion : An electric field is preferred in comparison to magnetic field for detecting the electron beam in a television picture tube.

Reason : Electric field require low voltage.

16. Assertion : The specific charge for positive rays is a characteristic constant.

Reason : The specific charge depends on charge and mass of positive ions present in positive rays.

17. Assertion : In Millikan's experiment for the determination of charge on an electron, oil drops of any size can be used.

Reason : Millikan's experiment determine the charge on electron, by simply measuring the terminal velocity.

18. Assertion : In the process of photoelectric emission, all the emitted photoelectrons have the same kinetic energy.

Reason : The photon transfers its whole energy to the electron of the atom in photoelectric effect.

19. Assertion : In photoelectric effect, on increasing the intensity of light,

both the number of electrons emitted and kinetic energy of each of them get increased but photoelectric current remains unchanged.

Reason : The photoelectric current depends only on wavelength of light.

20. Assertion : Though light of a single frequency (monochromatic) is incident on a metal, the energies of emitted photoelectrons are different.

Reason : The energy of electrons emitted from inside the metal surface is lost in collision with the other atoms in the metal.

21. Assertion : The threshold frequency of photoelectric effect supports the particle nature of sunlight.

Reason : If frequency of incident light is less than the threshold frequency, electrons are not emitted from metal surface.

22. Assertion : In photoemissive cell inert gas is used.

Reason : Inert gas in the photoemissive cell gives greater current.

23. Assertion : X-rays cannot be diffracted by means of grating.

Reason : X-rays does not obey Bragg's law.

24. Assertion : X-rays can penetrate through the flesh but not through the bones.

Reason : The penetrating power of X-rays depends on voltage.

25. Assertion : Intensity of X-rays can be controlled by adjusting the filament current and voltage.

Reason : The intensity of X-rays does not depend on number of X-ray photons emitted per second from the target.

26. Assertion : Anode of Coolidge tube gets heated up at time of emission of X-rays.

Reason : The anode of Coolidge tube is made of a material of high melting point.

27. Assertion : Penetrating power of X-rays increases with the increasing the wavelength.

Reason : The penetrating power of X-rays increases with the frequency of X-rays.

28. Assertion : X-rays are used for studying the structure of crystals.

Reason : The distance between the atoms of crystals is of the order of wavelength of X-rays.

29. Assertion : The phenomenon of X-ray production is basically inverse of photoelectric effect.

Reason : X-rays are electromagnetic waves.

30. Assertion : Soft and hard X-rays differ in frequency as well as velocity.

Reason : The penetrating power of hard X-rays is more than the penetrating power of soft X-rays.

Answers

Cathode Rays and Positive Rays

1	b	2	b	3	d	4	b	5	d
6	a	7	d	8	b	9	c	10	b
11	c	12	b	13	d	14	b	15	d
16	c	17	c	18	b	19	c	20	b
21	b	22	c	23	c	24	d	25	c
26	d	27	b	28	b	29	c	30	a
31	a	32	c	33	a	34	a	35	b
36	b	37	a	38	d	39	b	40	a
41	c	42	d	43	d	44	c	45	b
46	c	47	a	48	d	49	c	50	c
51	c	52	b	53	b	54	b	55	d
56	d	57	c	58	a	59	b	60	a
61	b	62	b	63	c	64	c	65	b
66	b	67	a	68	a	69	d	70	b
71	a	72	c						

Matter Waves

1	b	2	c	3	a	4	a	5	a
6	b	7	a	8	a	9	d	10	a
11	b	12	a	13	c	14	b	15	b
16	d	17	c	18	b	19	c	20	d
21	b	22	c	23	a	24	a	25	b
26	b	27	c	28	a	29	d	30	b
31	a	32	b	33	c	34	a	35	a
36	a	37	c	38	c	39	d	40	a
41	d	42	d	43	d				

Photon and Photoelectric Effect

1	d	2	d	3	c	4	a	5	a
6	b	7	d	8	b	9	b	10	a
11	b	12	b	13	b	14	c	15	a
16	a	17	b	18	a	19	a	20	c
21	d	22	c	23	b	24	a	25	a
26	a	27	a	28	c	29	d	30	c
31	c	32	a	33	e	34	a	35	d
36	c	37	d	38	c	39	d	40	b
41	a	42	c	43	d	44	d	45	d
46	c	47	c	48	b	49	c	50	a
51	a	52	b	53	d	54	b	55	a
56	d	57	d	58	b	59	b	60	a
61	c	62	b	63	b	64	c	65	a
66	d	67	d	68	c	69	b	70	a
71	d	72	a	73	c	74	c	75	b
76	c	77	a	78	a	79	b	80	c
81	b	82	d	83	c	84	c	85	b
86	c	87	a	88	b	89	c	90	d
91	a	92	a	93	a	94	b	95	c
96	b	97	d	98	a	99	b	100	b
101	a	102	d	103	a	104	b	105	b
106	a	107	a	108	b	109	a	110	b
111	c	112	b	113	a	114	c	115	c
116	b	117	c	118	d	119	a	120	c
121	c	122	c	123	b	124	a	125	a
126	a	127	a	128	c	129	d	130	b
131	d	132	b	133	c	134	d	135	c
136	c	137	d	138	b	139	c	140	c
141	a	142	d	143	b	144	d	145	b
146	c	147	a	148	a	149	c	150	d
151	d	152	b	153	a	154	c	155	a
156	a								

X-Rays

1	c	2	c	3	a	4	a	5	d
6	b	7	a	8	b	9	c	10	c
11	c	12	b	13	c	14	c	15	b
16	c	17	b	18	c	19	d	20	a
21	a	22	b	23	a	24	c	25	d
26	a	27	d	28	c	29	b	30	b
31	c	32	c	33	b	34	c	35	c
36	d	37	a	38	d	39	d	40	c
41	d	42	b	43	c	44	b	45	a
46	c	47	a	48	d	49	c	50	b
51	c	52	a	53	b	54	d	55	b
56	d	57	d	58	c	59	a	60	a
61	a	62	b	63	b	64	b	65	b
66	a	67	b	68	d	69	d	70	d
71	d	72	a	73	c	74	c	75	c
76	d	77	b	78	a	79	d	80	a
81	b	82	c	83	c	84	d	85	a
86	d	87	a	88	d	89	c	90	b
91	a	92	b	93	d	94	a	95	d
96	d	97	b	98	b	99	d	100	c
101	c	102	b	103	b	104	b	105	d
106	a	107	d	108	d	109	b	110	c
111	a								

Critical Thinking Questions

1	b	2	c	3	b	4	abc	5	d
6	b	7	b	8	c	9	b	10	d
11	c	12	b	13	b	14	a	15	a
16	d	17	acd	18	c	19	b	20	c
21	d	22	a	23	c	24	c	25	b
26	c	27	a	28	c	29	b	30	a
31	c	32	c	33	c	34	d	35	b
36	a	37	a	38	a	39	c		

Graphical Questions

1	a	2	d	3	a	4	d	5	c
6	b	7	a	8	b	9	a	10	c
11	b	12	d	13	d	14	b	15	a
16	d	17	d	18	a	19	b	20	c
21	b	22	c	23	a	24	a	25	a
26	a	27	c	28	b	29	b	30	c
31	c	32	b	33	b	34	a	35	a

36	a	37	b	38	b				

Assertion and Reason

1	a	2	d	3	b	4	a	5	b
6	d	7	e	8	b	9	b	10	a
11	e	12	d	13	d	14	d	15	d
16	b	17	e	18	e	19	d	20	a
21	b	22	a	23	c	24	b	25	c
26	b	27	e	28	a	29	b	30	e

Answers and Solutions

Cathode Rays and Positive Rays

1. (b) Electric field $=\frac{V}{d}=\frac{250}{2.5\times 10^{-2}}=10000\ V/m$.

2. (b)

3. (d) In Millikan's experiment, drops of non-volatile liquid (cloak oil) are used to prevent evaporation.

4. (b) $E=eV=2e\times 5=10\ eV$

5. (d) $E=eV=1.6\times 10^{-19}\times 10^{5}=1.6\times 10^{-14}\ J$

6. (a) Any charge in the universe is given by

$q=ne\Rightarrow e=\frac{q}{n}$ (where n is an integer)

$$q_1:q_2:q_3:q_4:q_5:q_6::n_1:n_2:n_3:n_4:n_5:n_6$$

$$6.563:8.204:11.5:13.13:16.48:18.09::n_1:n_2:n_3:n_4:n_5:n_6$$

Divide by 6.563

$$1:1.25:1.75:2.0:2.5:2.75::n_1:n_2:n_3:n_4:n_5:n_6$$

Multiplied by 4

$$4:5:7:8:10:11::n_1:n_2:n_3:n_4:n_5:n_6$$

$$e=\frac{q_1+q_2+q_3+q_4+q_5+q_6}{n_1+n_2+n_3+n_4+n_5+n_6}=\frac{73.967\times 10^{-19}}{45}$$

$$=1.641\times 10^{-19}\ C$$

(**Note :** If you take 45.0743 in place of 45, you will get the exact value)

7. (d) Because magnetic force always points perpendicular to the particle velocity. That is why velocity remains unchanged thereby keeping energy $\left(\frac{1}{2}mv^2\right)$ and momentum (mv) unchanged.

8. (b)

9. (c) Mass is basically a constant term for any physical application at low velocity. But in accordance with Einstein's theory of relativity, at higher speeds the mass of the particle change according to formula

$$m=\frac{m_0}{\sqrt{1-(v^2/c^2)}}$$

10. (b) Refer Q.No. 9. Here the velocity of electron increases, so as per Einstein's equation mass of the electron increases, hence the specific charge $\frac{e}{m}$ decreases.

11. (c) If the voltage given is V, then the energy of electron

$$\frac{1}{2}mv^2=eV\Rightarrow v=\sqrt{\frac{2eV}{m}}$$

$$=\sqrt{\frac{2\times 1.6\times 10^{-19}\times 1000}{9.1\times 10^{-31}}}=1.875\times 10^{7}\approx 1.9\times 10^{7}\ m/s$$

12. (b)

13. (d) Momentum $p=mv$ and $v=\sqrt{\frac{2QV}{m}}$

$$\Rightarrow p=\sqrt{2QmV}\Rightarrow p\propto\sqrt{Qm}\Rightarrow$$

$$\frac{p_e}{p_\alpha}=\sqrt{\frac{e\times m_e}{2e\times m_\alpha}}=\sqrt{\frac{m_e}{2m_\alpha}}$$

14. (b) In an electric field, a force opposite to the direction of electric field acts on negatively charged particles (*i.e.* from lower potential to higher potential).

15. (d)

16. (c) $QE=mg\Rightarrow Q=\frac{mg}{E}\Rightarrow n=\frac{mgd}{Ve}$

$$\Rightarrow n=\frac{1.8\times 10^{-14}\times 10\times 0.9\times 10^{-2}}{2\times 10^{3}\times 1.6\times 10^{-19}}=5$$

17. (c)

18. (b) In Millikan's experiment, the charges present on the oil drops are the integral multiples, so $2e$ and $10e(1.6\times 10^{-18}\ C)$ charges are present.

19. (c) $eE=evB\Rightarrow v=\frac{E}{B}=\frac{3\times 10^{4}}{2\times 10^{-3}}=1.5\times 10^{7}\ m/s$

20. (b)

21. (b) Charged particles trace a circular path in a perpendicular magnetic field.

22. (c) $\frac{e}{m}=\frac{1.6\times10^{-19}}{9.1\times10^{-31}}=1.76\times10^{11}\,C/kg$

23. (c)

24. (d) Light consists of photons and cathode rays consists of electrons. However both effect the photographic plate.

25. (c)

26. (d)

27. (b) For ionisation, high energy electrons are required.

28. (b) $v=\frac{E}{B}=\frac{20}{0.5}=40\,m/\text{sec}.$

29. (c) Higher the voltage, higher is the *KE*. Higher the work function, smaller is the *KE*.

30. (a) Time period of revolution of electron $T=\frac{2\pi}{\omega}=\frac{2\pi r}{v}$

Hence corresponding electric current $i=\frac{e}{T}=\frac{ev}{2\pi r}$

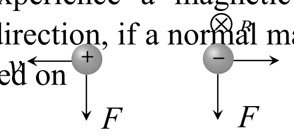
$\Rightarrow i=\frac{1.6\times10^{-19}\times2\times10^{6}}{2\times3.14\times0.5\times10^{-10}}=1\,mA.$

31. (a) $K=Q.V=1.6\times10^{-19}\times100=1.6\times10^{-17}$ *Joules*

32. (c) $K=Q.V=1e\times1\,Volt=1\,eV$

33. (a) Kinetic energy $\propto$ Potential difference

34. (a) In discharge tube cathode rays (a beam of negative particles) and canal rays (positive rays) moves opposite to each other. They will experience a magnetic force in the same direction, if a normal magnetic field is switched on



35. (b) $n=\frac{Q}{e}=\frac{6.35\times10^{-19}}{1.6\times10^{-19}}\approx4$

36. (b)

37. (a) When cathode rays strike the metal plate, they transfer their energy to plate.

38. (d) Cathode rays are beam of electrons.

39. (b) $K=QV=e\times V=eV$

40. (a) $\frac{1}{2}mv^2=QV\Rightarrow v=\sqrt{\frac{2QV}{m}}=\sqrt{2\left(\frac{e}{m}\right)V}$

$\Rightarrow v=\sqrt{2\times1.6\times10^{11}\times200}=8\times10^{6}\,m/s.$

41. (c) Speed of the cathode rays is $10^{7}\,m/\text{sec}-3\times10^{7}\,m/s$

42. (d) $QE=mg\Rightarrow mg=\frac{QV}{d}$

43. (d)

44. (c) In the condition of no deflection $\frac{e}{m}=\frac{E^2}{2VB^2}\Rightarrow$ If m is increased by 208 times then B should be increased $\sqrt{208}=14.4$ times

45. (b) The colour of the positive column in a discharge tube depends on the type of gas e.g. For air, colour is purple red, for H_2, colour is Blue etc.

46. (c)

47. (a) $v=\frac{p}{m}=\frac{h}{m\lambda}=\frac{6.6\times10^{-34}}{9.1\times10^{-31}\times10^{-10}}=7.25\times10^{6}\,m/s$

48. (d) Cathode rays are stream of negative charged particle, so they deflect in electric field.

49. (c) $\frac{e}{m}=\frac{E^2}{2VB^2}=\frac{(3.6\times10^{4})^2}{2\times2.5\times10^{3}\times(1.2\times10^{-3})^2}$

$=1.8\times10^{11}\,C/kg.$

50. (c) Specific charge $=\frac{q}{m}$; Ratio $=\frac{\left(\frac{q}{m}\right)_\alpha}{\left(\frac{q}{m}\right)_p}=\frac{q_\alpha}{q_p}\times\frac{m_p}{m_\alpha}=\frac{1}{2}.$

51. (c) $v=\frac{E}{B}$; where $E=\frac{V}{d}=\frac{1000}{1\times10^{-2}}=10^{5}\,V/m$

$\Rightarrow v=\frac{10^{5}}{1}=10^{5}\,m/s.$

52. (b)

53. (b)

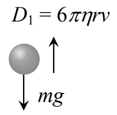
54. (b)

55. (d) In Thomson's mass spectrograph $\vec{E}\parallel\vec{B}$

56. (d)

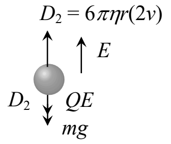
57. (c) In the absence of electric field (*i.e.* $E = 0$)

$mg = 6\pi\eta rv$ ...(i)



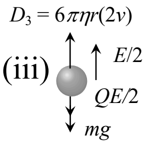
In the presence of Electric field

$mg + QE = 6\pi\eta r(2v)$ ...(ii)



When Electric field to reduced to $E/2$

$mg + Q(E/2) = 6\pi\eta r(v')$ ...(iii)



After solving (i), (ii) and (iii)

We get $v' = \frac{3}{2}v$

58. (a) $v = \sqrt{\frac{2eV}{m}} = \sqrt{\frac{2\times 1.6\times 10^{-19}\times 45.5}{9.1\times 10^{-31}}} = 4\times 10^6\ m/s$

59. (b) $i = \frac{Q}{t} = \frac{ne}{t} = 1.8\times 10^{14}\times 1.6\times 10^{-19} = 28.8\times 10^{-6}\ A$

$= 29\ \mu A$

60. (a) $\because\ m_e < m_p < m_\alpha \Rightarrow \left(\frac{q}{m}\right)_e > \left(\frac{q}{m}\right)_p > \left(\frac{q}{m}\right)_\alpha$

61. (b) Acceleration $a = \frac{QE}{m} = \frac{(3e)E}{2m}$

62. (b) $\frac{1}{2}mv^2 = eV \Rightarrow \frac{e}{m} = \frac{v^2}{2V} = \frac{(8.4\times 10^6)^2}{2\times 200} = 1.76\times 10^{11}\ \frac{C}{kg}$.

63. (c) $K = Q\Delta V = (2e)\times 10^6\ V = 2\times 10^6\ eV = 2\ MeV$

64. (c) Positive rays consist of positive ions.

65. (b) $2r = \frac{2mv}{qB} \Rightarrow 2r \propto \frac{m}{q} \Rightarrow \frac{m}{q}$ is maximum for C^{+}

66. (b) $v = \frac{E}{B} = \frac{1.125\times 10^{-6}}{3\times 10^{-10}} = 3750\ m/s$

67. (a) Positive rays was discovered by J.J. Thomson.

68. (a)

69. (d) If electron oscillate with a frequency of 1 *GHz*, it does not radiate any energy, which corresponds a definite wavelength. It only radiate when it jump from one orbit to another orbit.

70. (b) $eV = \frac{1}{2}mv^2 \Rightarrow v^2 = \frac{2eV}{m} \Rightarrow v = \sqrt{\frac{2eV}{m}}$

71. (a)

72. (c) $eE = mg \Rightarrow e = \frac{mg}{E} = \frac{16\times 10^{-6}\times 10}{10^6} = 16\times 10^{-11}\ C$.

Matter Waves

1. (b)

2. (c) According to de-Broglie hypothesis.

3. (a) $\lambda = \frac{h}{p} = \frac{h}{mv}$

4. (a) $\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$: $\therefore E = \frac{h^2}{2m\lambda^2}$

λ is same for all, so $E \propto \frac{1}{m}$. Hence energy will be maximum for particle with lesser mass.

5. (a) Particle is photon and it travels with the velocity equal to light in vacuum.

6. (b) $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE}}$; $\therefore \lambda \propto \frac{1}{\sqrt{E}}$ (h and m = constant)

7. (a) $\lambda = \frac{h}{m_1v_1} = \frac{h}{m_2v_2}$; $\therefore \frac{v_1}{v_2} = \frac{m_2}{m_1} = \frac{4}{1}$

8. (a) $\frac{1}{2}mv^2 = E \Rightarrow mv = \sqrt{2mE}$; $\therefore \lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$

9. (d) $\left\{\begin{array}{l}\text{Photoelectric effect} \rightarrow \text{Particle nature} \\ \text{Diffraction} \rightarrow \text{Wave nature}\end{array}\right\}$ Dual nature

10. (a) $mvr = \frac{nh}{2\pi}$ According to Bohr's theory

$\Rightarrow 2\pi r = n\left(\frac{h}{mv}\right) = n\lambda$ for $n = 1$, $\lambda = 2\pi r$

11. (b) $\lambda = \frac{h}{\sqrt{2mE}} \Rightarrow \lambda \propto \frac{1}{\sqrt{m}}$ (E = same)

12. (a) $\lambda = \frac{h}{\sqrt{2mE}} \Rightarrow \lambda \propto \frac{1}{\sqrt{m}} \Rightarrow \frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{m_\alpha}{m_p}} = \frac{2}{1}$

13. (c) $\lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2m_\alpha Q_\alpha V}}$

On putting $Q_\alpha = 2\times 1.6\times 10^{-19}\ C$

$m_\alpha = 4m_p = 4\times 1.67\times 10^{-27}\ kg \Rightarrow \lambda = \frac{0.101}{\sqrt{V}}\ Å$

14. (b)

15. (b) $\lambda = \frac{h}{\sqrt{2mE}} \Rightarrow \lambda \propto \frac{1}{\sqrt{E}} \Rightarrow \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{E_2}{E_1}}$

$\Rightarrow \frac{10^{-10}}{0.5\times10^{-10}} = \sqrt{\frac{E_2}{E_1}} \Rightarrow E_2 = 4E_1$

Hence added energy $= E_2 - E_1 = 3E_1$

16. (d) $\lambda = \frac{h}{\sqrt{2mE}} = \frac{6.6\times10^{-34}}{\sqrt{2\times9\times10^{-31}\times80\times1.6\times10^{-19}}} = 1.4\,\mathring{A}$

17. (c) $\lambda = \frac{h}{mv} \Rightarrow \lambda \propto \frac{1}{m}$

18. (b) If an electron and a photon propagates in the from of waves having the same wavelength, it implies that they have same momentum. This is according to de-Broglie equation, $p \propto \frac{1}{\lambda}$

19. (c) $\lambda = \frac{h}{p} \Rightarrow \lambda \propto \frac{1}{p}$

20. (d) In photoelectric effect particle nature of electron is shown. While in electron microscope, beam of electron is considered as electron wave.

21. (b) $K_{\text{particle}} = \frac{1}{2}mv^2$ also $\lambda = \frac{h}{mv}$

$\Rightarrow K_{\text{particle}} = \frac{1}{2}\left(\frac{h}{\lambda v}\right).v^2 = \frac{vh}{2\lambda}$ ...(i)

$K_{\text{photon}} = \frac{hc}{\lambda}$ ...(ii)

$\therefore \frac{K_{\text{particle}}}{K_{\text{photon}}} = \frac{v}{2c} = \frac{2.25\times10^8}{2\times3\times10^8} = \frac{3}{8}$

22. (c) $2\pi rn = \lambda \Rightarrow n = \frac{\lambda}{2\pi r} = \frac{10^{-9}}{2\times3.14\times5.13\times10^{-11}} = 3$

23. (a) By using $\lambda_{electron} = \frac{h}{m_e v} \Rightarrow v = \frac{h}{m_e\lambda_e}$

$= \frac{6.6\times10^{-34}}{9.1\times10^{-31}\times10^{-10}} = 7.25\times10^6\,m/s.$

24. (a) By using $\lambda = \frac{h}{\sqrt{2mE}}$ $E = 10^{-32}\,J$ = Constant for both particles. Hence $\lambda \propto \frac{1}{\sqrt{m}}$ Since $m_p > m_e$ so $\lambda_p < \lambda_e$.

25. (b) By using $\lambda \propto \frac{1}{\sqrt{V}} \Rightarrow \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{V_2}{V_1}} \Rightarrow$

$\frac{10^{-10}}{\lambda_2} = \sqrt{\frac{600}{150}} = 2 \Rightarrow \lambda_2 = 0.5\,\mathring{A}.$

26. (b) $\lambda = \frac{h}{mv_{rms}} \Rightarrow \lambda = \frac{6.6\times10^{-34}}{2\times1.67\times10^{-27}\times3\times10^3} = 0.66\,\mathring{A}$

27. (c) $\lambda \propto \frac{1}{p} \Rightarrow \frac{\Delta p}{p} = -\frac{\Delta\lambda}{\lambda} \Rightarrow \left|\frac{\Delta p}{p}\right| = \left|\frac{\Delta\lambda}{\lambda}\right|$

$\Rightarrow \frac{p_0}{p} = \frac{0.25}{100} = \frac{1}{400} \Rightarrow p = 400\,p_0.$

28. (a) $\lambda_{neutron} \propto \frac{1}{\sqrt{T}} \Rightarrow \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{T_2}{T_1}}$

$\Rightarrow \frac{\lambda}{\lambda_2} = \sqrt{\frac{(273+927)}{(273+27)}} = \sqrt{\frac{1200}{300}} = 2 \Rightarrow \lambda_2 = \frac{\lambda}{2}.$

29. (d) $\lambda = \frac{h}{\sqrt{2mE}} \Rightarrow E \propto \frac{1}{\sqrt{m}}$ (λ = constant)

$\because m_e < m_p$ so $E_e > E_p$

30. (b)

31. (a) Wavelength of photon will be greater than that of electron because mass of photon is less than that of electron $\Rightarrow \lambda_{\text{ph}} > \lambda_e$

32. (b) $\lambda = \frac{h}{\sqrt{2mE}} \Rightarrow E = \frac{h^2}{2m\lambda^2}$

$= \frac{(6.6\times10^{-34})^2}{2\times9.1\times10^{-31}\times(0.3\times10^{-9})^2} = 2.65\times10^{-18}\,J$

$= 16.8\,eV$

33. (c) $\lambda = \frac{h}{\sqrt{2mQV}} \Rightarrow \lambda \propto \frac{1}{\sqrt{mQ}} \Rightarrow \frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{m_\alpha Q_\alpha}{m_p Q_p}}$

$= \sqrt{\frac{4m_p\times2Q_p}{m_p\times Q_p}} = 2\sqrt{2}$

34. (a) $\lambda = \frac{h}{p} \Rightarrow p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{2\times10^{-6}}$

$= 3.31\times10^{-28}\,kg\text{-}m/\sec$

35. (a) $\lambda = \frac{h}{mv} = \frac{6.6\times10^{-34}}{1\times2000} = 3.3\times10^{-37}\,m = 3.3\times10^{-27}\,\mathring{A}$

36. (a) $\lambda = \frac{h}{\sqrt{2mE}} = \frac{6.6\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times5\times1.6\times10^{-19}}}$

$= 5.469\times10^{-10}\,m = 5.47\,\mathring{A}$

37. (c) $\lambda = \frac{h}{\sqrt{2mQV}} = \frac{6.6\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times1.6\times10^{-19}\times100}}$

$= 1.23\,\mathring{A}$

38. (c) The De-Broglie wavelength is $\lambda = \frac{h}{|p|} = \frac{h}{|I|}$

$\Rightarrow \lambda \propto \frac{1}{|I|}$

39. (d) Davission and Germer proved the wave nature of electron by performing an experiment.

40. (a) $\lambda = \frac{h}{\sqrt{2mE}} \Rightarrow \lambda \propto \frac{1}{\sqrt{E}}.$

41. (d) $\lambda = \frac{\hbar}{\sqrt{2mE}}$; $\frac{\lambda'}{\lambda} = \sqrt{\frac{E}{E'}} \Rightarrow \frac{E}{E'} = \left(\frac{0.5}{1}\right)^2 \Rightarrow$

$E' = \frac{E}{0.25} = 4E$

The energy should be added to decrease wavelength.

$= E' - E = 3E$

42. (d)

43. (d)

Photon and Photoelectric Effect

1. (d) $p = \frac{h\nu}{c} \Rightarrow \nu = \frac{pc}{h} = \frac{3.3\times10^{-29}\times3\times10^8}{6.6\times10^{-34}} = 1.5\times10^{13}\,Hz$

2. (d)

3. (c) $p = \frac{E}{c} \Rightarrow E = p\times c = 2\times10^{-16}\times(3\times10^{10}) = 6\times10^{-6}\,erg.$

4. (a)

5. (a) $p = \frac{h}{\lambda} = \frac{6.6\times10^{-34}}{(5000\times10^{-10})} = 1.3\times10^{-27}\,kg\text{-}m/s$

6. (b) $p = \frac{E}{c} = \frac{h\nu}{c}$

7. (d) $E = h\nu = mc^2 \Rightarrow m = \frac{h\nu}{c^2}$

8. (b) $p = \frac{E}{c} = \frac{h\nu}{c} \Rightarrow \nu = \frac{pc}{h}$

9. (b) $P = \frac{W}{t} = \frac{nhc}{\lambda t} \Rightarrow \left(\frac{n}{t}\right) = \frac{P\lambda}{hc} = \frac{10\times10^3\times300}{6.6\times10^{-34}\times3\times10^8}$

$= 1.5\times10^{31}$

10. (a) Momentum of photon $p = \frac{E}{c}$

$\Rightarrow$ Velocity of photon $c = \frac{E}{p}$

11. (b) By using $E(eV) = \frac{12375}{\lambda(Å)}$

$\Rightarrow \lambda = \frac{12375}{2.48} = 4989.9\,Å \approx 5000\,Å$

12. (b) $E = \frac{hc}{\lambda} = \frac{3\times10^8\times6.62\times10^{-34}}{0.21\times1.6\times10^{-19}} = 5.9\times10^{-6}\,eV$

13. (b) Momentum of photon

$p = \frac{h}{\lambda} = \frac{6.6\times10^{-34}}{10^{-10}} = 6.6\times10^{-24}$ kg - m/sec.

14. (c) $E \propto \frac{1}{\lambda} \Rightarrow \frac{2.5}{E'} = \frac{1}{5000} \Rightarrow E' = (2.5)\times5000\,eV$

15. (a) $E = h\nu = 6.6\times10^{-34}\times10^{15} = 6.6\times10^{-19}\,J$

16. (a) Since $h\nu = mc^2$, hence $p = mc = \frac{h\nu}{c} = \frac{h}{\lambda}$

17. (b) $E = h\nu \Rightarrow \nu = \frac{E}{h} = \frac{1\times10^6\times1.6\times10^{-19}}{6.6\times10^{-34}} = 2.4\times10^{20}\,Hz$

18. (a) $p = \frac{h\nu}{c} = \frac{6.6\times10^{-34}\times1.5\times10^{13}}{3\times10^8} = 3.3\times10^{-29}\,kg\text{-}m/\sec$

19. (a) $E = \frac{hc}{\lambda} = \frac{6.62\times10^{-34}\times3\times10^8}{450\times10^{-9}} = 4.4\times10^{-19}\,J$

20. (c) $E = h\nu \Rightarrow \nu = \frac{E}{h} = \frac{66\times1.6\times10^{-19}}{6.6\times10^{-34}} = 16\times10^{15}\,Hz$

21. (d) $E \propto \frac{1}{\lambda}$; also $\lambda_{infrared} > \lambda_{visible}$ so $E_{infrared} < E_{visible}$

22. (c) Energy of photon $E = \frac{hc}{\lambda}$ (Joules) $= \frac{hc}{e\lambda}(eV)$

$\Rightarrow E_{(eV)} = \frac{6.6\times10^{-34}\times3\times10^8}{1.6\times10^{-19}\times\lambda(Å)} = \frac{12375}{\lambda(Å)}$

$\Rightarrow E(keV) = \frac{12.37}{\lambda(Å)} \approx \frac{12.4}{\lambda}$

23. (b) $E = h\nu \Rightarrow 100\times1.6\times10^{-19} = 6.6\times10^{-34}\times\nu$

$\Rightarrow \nu = 2.42\times10^{16}\,Hz.$

24. (a) $p = \frac{h}{\lambda} = \frac{6.6\times10^{-34}}{4400\times10^{-10}} = 1.5\times10^{-27}\,kg.m/s$

and mass $m = \frac{p}{c} = \frac{1.5\times10^{-27}}{3\times10^8} = 5\times10^{-36}\,kg$

25. (a)

26. (a)

27. (a) $E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E}$

28. (c)

29. (d) $E(eV) = \frac{h\nu}{e} = \frac{6.0\times10^{-34}\times10^{12}\times10^6}{1.6\times10^{-19}} = 4.14\times10^3\,eV.$

30. (c) $E = nh\nu \Rightarrow \nu \propto \frac{1}{n} \Rightarrow \frac{n_1}{n_2} = \frac{\gamma_2}{\gamma_1}.$

31. (c) According to Einstein's photoelectric equation.

32. (a) Kinetic energy of photoelectrons depends on the frequency of incident radiations and is independent of the intensity of illumination.

33. (e) In this case, for photoelectric emission the wavelength of incident radiations must be less then $5200\,Å$. Wavelength of ultraviolet radiations is less then this value (5200 Å) but wavelength of infrared radiations is higher than this value.

34. (a) Frequency of light of wavelength $(\lambda = 4000\,Å)$ is $\nu = \frac{c}{\lambda} = \frac{3\times10^8}{4000\times10^{-10}} = 0.75\times10^{15}$ which is less than the given threshold

frequency. Hence no photoelectric emisssion takes place.

35. (d) Refer to the application of photo-cell.

36. (c) Albert Einstein was awarded Nobel Prize in 1921 for discovering the photoelectric effect.

37. (d)

38. (c) Energy of incident light

$$E(eV) = \frac{12375}{3320} = 3.72\,eV$$

$(332\,nm = 3320\,Å)$

According to the relation $E = W_0 + eV_0$

$$\Rightarrow V_0 = \frac{(E - W_0)}{e} = \frac{3.72\,eV - 1.07\,eV}{e} = 2.65\ Volt$$

39. (d)

40. (b) $K_{max} = (h\nu - W_0)$; $\nu =$ frequency of incident light.

41. (a) Refer to threshold frequency.

42. (c) $W_0(eV) = \frac{12375}{\lambda_0} \Rightarrow \lambda_0 = \frac{12375}{4.2} \approx 2955\,Å$

43. (d) Intensity $\propto$ (No. of photons) $\propto$ (No. of photoelectrons)

44. (d) $E = W_0 + K_{max}$; $E = \frac{12375}{3000} = 4.125\ eV$

$$\Rightarrow K_{max} = E - W_0 = 4.125\ eV - 1\ eV = 3.125\ eV$$

$$\Rightarrow \frac{1}{2}mv_{max}^2 = 3.125 \times 1.6 \times 10^{-19}\ J$$

$$\Rightarrow v_{max} = \sqrt{\frac{2 \times 3.125 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31}}} = 1 \times 10^6\,m/s$$

45. (d) Retarding potential $V_0 = \frac{h}{e}(\nu - \nu_0)$

46. (c)

47. (c) $K_{max} = \frac{hc}{\lambda} - W_0 = \frac{6.4 \times 10^{-34} \times 3 \times 10^8}{6400 \times 10^{-10}} - 1.6 \times 10^{-19}$

$$= 1.4 \times 10^{-19}\ J$$

48. (b) $K_{max}(eV) = E(eV) - W_0(eV) = 6.2 - 4.2 = 2\ eV$

$$\therefore\ K_{max}(Joules) = 2 \times 1.6 \times 10^{-19}\ J = 3.2 \times 10^{-19}\ J$$

49. (c) Since $W_0 = \frac{hc}{\lambda_0}$; $\therefore \frac{(W_0)_T}{(W_0)_{Na}} = \frac{\lambda_{Na}}{\lambda_T}$ or

$$\lambda_T = \frac{\lambda_{Na} \times (W_0)_{Na}}{(W_0)_T} = \frac{5460 \times 2.3}{4.5} = 2791\ Å$$

50. (a) $K_{max} = (E - W_0) = (3.4 - 2)\ eV = 1.4\ eV$

51. (a) Energy of incident light $E = \frac{12375}{2000} = 6.18\,eV$

According to relation $E = W_0 + eV_0$

$$\Rightarrow V_0 = \frac{(E - W_0)}{e} = \frac{(6.18\,eV - 5.01\,eV)}{e} = 1.17\ V \approx 1.2\ V$$

52. (b) $W_0 = \frac{12375}{6600} = 1.87\,eV.$

53. (d)

54. (b) $E = h\nu = 6.64 \times 10^{-34} \times 1.0 \times 10^{14} = 6.62 \times 10^{-20}\ J$

55. (a) Number of photons emitted per second

$$n = \frac{p}{h\nu} = \frac{10 \times 10^3}{6.6 \times 10^{-34} \times 880 \times 10^3} = 1.72 \times 10^{31}$$

56. (d) Number of ejected electrons

$$\propto (\text{Intensity}) \propto \frac{1}{(\text{Distance})^2}$$

Therefore an increment of distance two times will reduce the number of ejected electrons to $\frac{1}{4}th$ of the previous one.

57. (d) According to Einstein's photoelectric equation

$$E = W_0 + K_{max} \ \Rightarrow\ V_0 = \frac{hc}{e}\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right]$$

Hence if λ decreases V_0 increases.

58. (b) $W_0 = \frac{12375}{\lambda_0(Å)} = \frac{12375}{5420} = 2.28\,eV$

59. (b) Number of electrons can be measured which are directly proportional to the intensity of radiation.

60. (a) $K_{max} = h\nu - W_0 = 6.6 \times 10^{-34} \times 8 \times 10^{14} - 3.2 \times 10^{-19}$

$$= 2.1 \times 10^{-19}\ J$$

61. (c)

62. (b) $K_{max}(eV) = 12375\left[\frac{1}{\lambda(Å)} - \frac{1}{\lambda_0(Å)}\right]$

$$= 12375\left[\frac{1}{1000} - \frac{1}{2000}\right] = 6.2\,eV$$

63. (b) Stopping potential does not depend on the relative distance between the source and the cell.

64. (c)

65. (a) Energy of incident light

$$E(eV) = \frac{12375}{4000} = 3.09\,eV$$

Stopping potential is $-2V$ so $K_{max} = 2\,eV$

Hence by using $E = W_0 + K_{max}$; $W_0 = 1.09\,eV$ $\approx 1.1\,eV$

66. (d) $\frac{hc}{\lambda} = W_0 + \frac{1}{2}mv_{max}^2$

Assuming W_0 to be negligible in comparison to $\frac{hc}{\lambda}$

i.e. $v_{max}^2 \propto \frac{1}{\lambda} \Rightarrow v_{max} \propto \frac{1}{\sqrt{\lambda}}$.

(On increasing wavelength λ to 4λ, v_{max} becomes half).

67. (d) $W_0 = h\nu_0 \Rightarrow \nu_0 = \frac{W_0}{h} = \frac{2.51 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}}$

$= 6.08 \times 10^{14}$ *Cycle*/ sec.

68. (c)

69. (b)

70. (a) By changing distance of source, photoelectric current changes. But there is no change in stopping potential.

71. (d) $\nu_0 = \frac{W_0}{h} = \frac{3.3 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}} = 8 \times 10^{14}\ Hz$

72. (a) For no emission of photoelectron, energy of incident light < Work function $\Rightarrow h\nu < \phi \Rightarrow \nu < \frac{\phi}{h}$

73. (c) Number of electrons emitted $\propto$ intensity $\propto \frac{1}{(\text{distance})^2}$

$\Rightarrow \frac{n_1}{n_2} = \left(\frac{d_2}{d_1}\right)^2 = \left(\frac{2}{1}\right) = 4 \Rightarrow n_2 = \frac{n_1}{4}$

74. (c) $E = \frac{hc}{\lambda} - W_0$ and $2E = \frac{hc}{\lambda'} - W_0$

$\Rightarrow \frac{\lambda'}{\lambda} = \frac{E + W_0}{2E + W_0} \Rightarrow \lambda' = \lambda\left(\frac{1 + W_0/E}{2 + W_0/E}\right)$

Since $\frac{(1 + W_0/E)}{(2 + W_0/E)} > \frac{1}{2}$ so $\lambda' > \frac{\lambda}{2}$

75. (b) Stopping potential $V_0 = \frac{hc}{e}\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right]$. As λ decreases so V_0 increases.

76. (c) $W.(eV) = \frac{12375}{\lambda_0(\mathring{A})} \Rightarrow \lambda_0 = \frac{12375}{4.125} = 3000\mathring{A}$

77. (a) Intensity increases means more photons of same energy will emit more electrons of same energy, hence only photoelectric current increases.

78. (a) $E = W_0 + K_{max}$; $E = \frac{12375}{5000} = 2.475\ eV$

$\therefore K_{max} = E - W_0 = 2.475 - 1.9 = 0.57\ eV$

79. (b)

80. (c) $\lambda_0 = \frac{hc}{W_0} = \frac{12400}{4} = 3100\mathring{A} = 310\ nm$

81. (b) $K_{max} = (|V_s|)eV \Rightarrow |V_s| = 4\ V$

82. (d) Threshold wavelength $\lambda_0 = \frac{12375}{2.1} = 5892.8\ \mathring{A}$

83. (c) $P = \frac{nhc}{\lambda t} \Rightarrow \frac{n}{t} = \frac{P.\lambda}{hc} = \frac{100 \times 5000 \times 10^{-10}}{6.6 \times 10^{-34} \times 3 \times 10^8}$

$= 2.50 \times 10^{20}$

84. (c) $E = W_0 + K_{max} \Rightarrow K_{max} = E - W_0 = h\nu - W_0$

$\Rightarrow K_1 = h\nu - W_0$ and $K_2 = 2h\nu - W_0 \Rightarrow K_2 > 2K_1$

85. (b) Work function $= \frac{hc}{\lambda_0}$; where λ_0 is threshold wavelength.

$\therefore \frac{W_{0_1}}{W_{0_2}} = \frac{\lambda_{0_2}}{\lambda_{0_1}} = \frac{2}{1}$

86. (c) $W_0 = \frac{hc}{\lambda_0} = \frac{6.625 \times 10^{-34} \times 3 \times 10^8}{5000 \times 10^{-10}} J = 4 \times 10^{-19}\ J$

87. (a) The work function has no effect on current so long as $h\nu > W_0$. The photoelectric current is proportional to the intensity of light. Since there is no change in the intensity of light, therefore $I_1 = I_2$.

88. (b) Number of photons emitted is proportional to the intensity. Also $\frac{hc}{\lambda} = W_0 + E$.

89. (c) Photoelectric current $\propto$ Intensity of light

90. (d) $V_0 = \frac{(E - W_0)}{e} = \frac{(2eV - 0.6\ eV)}{e} = 1.4\ V$

91. (a) $\lambda_r > \lambda_y > \lambda_g$. Here threshold wavelength $< \lambda_y$.

92. (a) For electron emission $\lambda_{incident} < \lambda_0$

93. (a) $K_{max} = (|V_0|)eV = 2eV$.

94. (b) Threshold wavelength for *Na*,

$\lambda_{Na} = \frac{12375}{2} = 6187.5\mathring{A}$

Also $\lambda_{Cu} = \frac{12375}{4} = 3093.75$

Since $\lambda_{Na} > 4000\mathring{A}$; So *Na* is suitable.

95. (c) By using $E = W_0 + K_{max}$

$E = \frac{12375}{5000} = 2.475\ eV$ and $K_{max} = eV_0 = 1.36\ eV$

So $2.475 = W_0 + 1.36 \Rightarrow W_0 = 1.1\ eV$.

96. (b) For emission of electrons incident energy of each photon must be greater than work function (threshold energy).

97. (d) K_{max} of photoelectrons doesn't depends upon intensity of incident light.

98. (a) By using $E = W_0 + \frac{1}{2}mv_{max}^2$ where

$E = \frac{12375}{2000} = 6.18\ eV$

$\Rightarrow 6.18\ eV = 4.2\ eV + \frac{1}{2}mv_{max}^2 \Rightarrow 1.98\ eV = \frac{1}{2}mv_{max}^2$

$\Rightarrow 1.98 \times 1.6 \times 10^{-19} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v_{max}^2$

$\Rightarrow v_{max} = 8.4 \times 10^5\ m/s$

99. (b) By using $E = W_0 + \frac{1}{2}mv_{max}^2$; where

$E = \frac{12375}{4558} = 2.71\ eV$

$\Rightarrow 2.71\ eV = 2.5\ eV + \frac{1}{2} \times 9.1 \times 10^{-31} \times v_{max}^2$

$\Rightarrow 0.21 \times 1.6 \times 10^{-19} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v_{max}^2$

$\Rightarrow v_{max} = 2.65 \times 10^5\ m/s$

100. (b) $E = W_0 + K_{max}$ .....(i)

$\Rightarrow hf = W_A + K_A$ .....(ii)

and $2hf = W_B + K_B = 2W_A + K_B$ $\left(\because \frac{W_A}{W_B} = \frac{1}{2}\right)$

Dividing equation (i) by (ii)

$\frac{1}{2} = \frac{W_A + K_A}{2W_A + K_B} \Rightarrow \frac{K_A}{K_B} = \frac{1}{2}$

101. (a)

102. (d) Stopping potential depends upon the energy of photon

103. (a) $\lambda_0 = \frac{12375}{W_0(eV)} = \frac{12375}{3} = 4125 Å$

104. (b) With decrease in wavelength of incident photons, energy of photoelectrons increases.

105. (b)

106. (a) By using $\frac{hc}{\lambda} = W_0 + \frac{1}{2}mv^2$

$\Rightarrow \frac{hc}{400 \times 10^{-9}} = W_0 + \frac{1}{2}mv^2$ .....(i)

and $\frac{hc}{250 \times 10^{-9}} = W_0 + \frac{1}{2}m(2v)^2$ .....(ii)

On solving (i) and (ii)

$\frac{1}{2}mv^2 = \frac{hc}{3}\left[\frac{1}{250 \times 10^{-9}} - \frac{1}{400 \times 10^{-9}}\right]$ .....(iii)

From equation (i) and (iii) $W_0 = 2hc \times 10^6\ J$.

107. (a) $E = W_0 + eV_0 \Rightarrow 4eV = 2eV + eV_0 \Rightarrow V_0 = 2\ volt$

108. (b)

109. (a) $W_0 = \frac{12375}{6800} = 1.8eV$

110. (b) With the increase in intensity of light photoelectric current increases, but Kinetic energy of ejected electron, stopping potential and work function remains unchanged.

111. (c) $E = h\nu = 6.6 \times 10^{-34} \times 8 \times 10^{15} = 5.28 \times 10^{-18}\ J = 33eV$

By using $E = W_0 + K_{max} \Rightarrow K_{max} = E - W_0$

$= 33 - 6.125 = 27eV$

112. (b) $\lambda = \frac{12375}{W_0} = \frac{12375}{2} = 6187.5 Å = 620\ nm$

113. (a) Minimum kinetic energy is always zero.

114. (c) Speed of photon is $3 \times 10^8\ m/s$ in vacuum.

115. (c) Minimum frequency : $W_0 = h\nu_0$

$\Rightarrow \nu_0 = \frac{W_0}{h} = \frac{1.65 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}} = 4 \times 10^{14}\ Hz$

116. (b) By using $E = W_0 + K_{max} \Rightarrow K_{max} = E - W_0$

Hence, $K_1 = 1 - 0.5 = 0.5$

and $K_2 = 2.5 - 0.5 = 2 \Rightarrow \frac{K_1}{K_2} = \frac{1}{4}$.

117. (c) $W_0 \propto \frac{1}{\lambda} \Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{(W_0)_2}{(W_0)_1} = \frac{4.5}{2.3} = \frac{2}{1}$.

118. (d) $K_{max} = eV_0 \Rightarrow eV_0 = 4eV \Rightarrow V_0 = 4\ V$

119. (a) Number of photo electrons

(N) $\propto$ Intensity $\propto \frac{1}{d^2} \Rightarrow \frac{N_1}{N_2} = \left(\frac{d_2}{d_1}\right)^2$

$\Rightarrow \frac{N_1}{N_2} = \left(\frac{100}{50}\right)^2 = \frac{4}{1} \Rightarrow N_2 = \frac{N_1}{4}$.

120. (c) $P = \frac{W}{t} = \frac{nhc}{\lambda t} \Rightarrow 10^3 = \frac{n \times 6.6 \times 10^{-34} \times 3 \times 10^8}{198.6 \times 1}$

$\Rightarrow n = 10^{30}$.

121. (c) $p = \frac{nhc}{\lambda t} \Rightarrow 100 = \frac{n \times 6 \times 10^{-34} \times 3 \times 10^8}{540 \times 10^{-9} \times 1} \Rightarrow n = 3 \times 10^{20}$

122. (c) $\frac{1}{2}mv_{max}^2 = eV_0 \Rightarrow v_{max} = \sqrt{2\left(\frac{e}{m}\right)V_0}$

$= \sqrt{2 \times 1.8 \times 10^{11} \times 9} = 1.8 \times 10^6\ m/s$

123. (b) $\frac{hc}{\lambda} = W_0 + K_{max} \Rightarrow \frac{hc}{\lambda_A} = W_0 + K_A$

...(i)

and $\frac{hc}{\lambda_B} = W_0 + K_B$ ...(ii)

Subtracting (i) from (ii),

$hc\left[\frac{1}{\lambda_B} - \frac{1}{\lambda_A}\right] = K_B - K_A$

$\Rightarrow hc\left[\frac{1}{\lambda_B} - \frac{1}{2\lambda_B}\right] = K_B - K_A \Rightarrow \frac{hc}{2\lambda_B} = K_B - K_A$ ...(iii)

From (ii) and (iii), $2K_B - 2K_A = W_0 + K_B$

$\Rightarrow K_B - 2K_A = W_0$

$\Rightarrow K_A = \frac{K_B}{2} - \frac{W_0}{2}$ which gives $K_A < \frac{K_B}{2}$.

124. (a) $\lambda_0 = \frac{12375}{6500} = 1.9\ eV \approx 2eV$.

125. (a) $\lambda_{X-ray} < \lambda_{UV-ray}$

126. (a)

$E = h\nu_0 + K_{max} \Rightarrow h(4\nu_0) = h\nu_0 + K_{max} \Rightarrow K_{max} = 3h\nu_0$.

127. (a)

128. (c) $W_0 = \frac{12375}{2.3} = 5380\mathring{A}$.

129. (d)

130. (b) Using Einstein photoelectric equation

$E = W_0 + K_{max}$

$hf_1 = W_0 + \frac{1}{2}mv_1^2$ .....(i)

$hf_2 = W_0 + \frac{1}{2}mv_2^2$ .....(ii)

$\Rightarrow h(f_1 - f_2) = \frac{1}{2}m(v_1^2 - v_2^2) \Rightarrow (v_1^2 - v_2^2) = \frac{2h}{m}(f_1 - f_2)$

131. (d)

132. (b) By using $\frac{hc}{e}\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right) = V_0$

$\Rightarrow \frac{hc}{e}\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right) = 4.8$ .....(i)

and $\frac{hc}{e}\left(\frac{1}{2\lambda} - \frac{1}{\lambda_0}\right) = 1.6$ .....(ii)

From equation (i) by (ii), $\frac{\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)}{\left(\frac{1}{2\lambda} - \frac{1}{\lambda_0}\right)} = \frac{4.8}{1.6} \Rightarrow \lambda_0 = 4\lambda$.

133. (c)

134. (d) $E = W_0 + K_{max}$. From the given data E is 6.78 eV (for λ= 1824 $\mathring{A}$) or $10.17\,eV$ (for $\lambda = 1216\ \mathring{A}$)

$\therefore\ W_0 = E - K_{max} = 6.78 - 5.3 = 1.48\,eV$

or

$W_0 = 10.17 - 8.7 = 1.47\,eV$.

135. (c) $E = \frac{hc}{\lambda} \Rightarrow \frac{E_1}{E_2} = \frac{\lambda_1}{\lambda_2} \Rightarrow \frac{3.32\times10^{-19}}{E_2} = \frac{4000}{6000}$

$\Rightarrow E_2 = 4.98\times10^{-19}\,J = 3.1\,eV$.

136. (c) Number of waves $= \frac{10^{-3}}{4000\times10^{-10}} = 0.25\times10^4$

137. (d) Velocity of photon $c = \nu\lambda$

138. (b) $\lambda_0 = \frac{12375}{6.825} = 1813\,\mathring{A} \approx 1800\mathring{A}$

139. (c) Work function $W_0 = h\nu_0 = 6.6\times10^{-34}\times1.6\times10^{15}$

$= 1.056\times10^{-18}\,J = 6.6\,eV$

From $E = W_0 + K_{max} \Rightarrow K_{max} = E - W_0 = 1.4\,eV$

140. (c) $P = \frac{h}{\lambda}, E = \frac{hc}{\lambda} \Rightarrow E = Pc$

141. (a) $E = \frac{hc}{\lambda} \Rightarrow \frac{E_1}{E_2} = \frac{300}{150} = \frac{2}{1}$

142. (d)

143. (b) If frequency of incident light increases, kinetic energy of photoelectron also increases.

144. (d) Photoelectric effect can be explained on the basis of spectrum of an atom.

145. (b) $W_0 = \frac{12375}{\lambda_0} = \frac{12375}{5420} = 2.28\,eV$

146. (c)

147. (a) $E = \frac{12375}{\lambda} = \frac{12375}{5000} = 2.47\,eV \approx 2.5\,eV$

148. (a) Momentum $p = \frac{E}{c} \Rightarrow E^2 = p^2c^2$

149. (c) Energy of incident radiations (in eV)

$= \frac{12375}{4100} = 3.01\,eV$

Work function of metal A and B are less then $3.01eV$, so A and B will emit photo electrons.

150. (d) From $E = W_0 + \frac{1}{2}mv_{max}^2$

$\Rightarrow \quad 2h\nu_0 = h\nu_0 + \frac{1}{2}mv_1^2 \quad \Rightarrow \quad h\nu_0 = \frac{1}{2}mv_1^2$ .....(i)

and $\quad 5h\nu_0 = h\nu_0 + \frac{1}{2}mv_2^2 \quad \Rightarrow \quad 4h\nu_0 = \frac{1}{2}mv_2^2$ .....(ii)

Dividing equation (ii) by (i) $\left(\frac{v_2}{v_1}\right)^2 = \frac{4}{1}$

$\Rightarrow v_2 = 2v_1 = 2 \times 4 \times 10^6 = 8 \times 10^6\, m/s$

151. (d) Number of photoelectrons $\propto \frac{1}{(\text{Distance})^2}$.

152. (b) The value of saturation current depends on intensity. It is independent of stopping potential

153. (a) In tungsten, photoemission take place with a light of wavelength 2300 Å. As emission of electron is inversely proportional to wavelength, all the wavelengths smaller then 2300 Å will cause emission of electrons.

154. (c) Stopping potential = $1.8\, eV - 1.2\, eV = 0.6\, eV$.

155. (a)

156. (a) $K.E. = h\nu - h\nu_0 = 8\; eV - \left(\frac{6 \times 10^{-34} \times 1.6 \times 10^{15}}{1.6 \times 10^{-19}}\, eV\right)$

$= 8\; eV - 6\; eV = 2\; eV$

X-Rays

1. (c) $\lambda_{min} = \frac{12375}{50 \times 10^3}\, Å = 0.247 = 0.25\, Å$.

2. (c) X-rays are electromagnetic waves of wavelength ranging from 0.1 to $100\, Å$.

3. (a) Penetrating power is greater for lower wavelength.

4. (a)

5. (d) From the formula

$$V = \frac{12375}{\lambda_{min}} = \frac{12375}{0.3094} = 39.99\; kV \approx 40\, kV$$

6. (b) Refer to the application of X-rays.

7. (a)

8. (b)

9. (c)

10. (c) The voltage applied across the X-ray tube is of the range of 10 kV – 80 kV.

11. (c)

12. (b) In X-ray tube, target must be heavy element with high melting point.

13. (c) $\nu \propto (Z-b)^2 \Rightarrow \nu = a(Z-b)^2$

Z = atomic number of element (a, b are constant).

14. (c)

15. (b) X-rays and gamma rays are electromagnetic waves.

16. (c) Since $\lambda_{min} = \frac{12375}{V}\, Å = \frac{12375}{10^5}\, Å = 0.123\, Å$

$E_{max} = \frac{hc}{\lambda_{min}}$;

On putting the values. $E_{max} \cong 10^{-1}\, MeV$.

17. (b) $\lambda_{min} = \frac{hc}{eV}$. where h, c and e are constants.

Hence $\lambda_{min} \propto \frac{1}{V}$

18. (c) Range of X-rays is 0.1Å to 100 Å.

19. (d) The production of X-rays is an atomic property whereas the production of γ-rays is a nuclear property.

20. (a) $\lambda_{min} = \frac{12375}{40,000} = 0.30\, Å$ Hence wavelength less than 0.30 Å is not possible.

21. (a) $\lambda_{min} = \frac{hc}{eV}$

22. (b) $p = \frac{h}{\lambda} = \frac{6.6 \times 10^{-34}}{0.01 \times 10^{-10}} = 6.6 \times 10^{-22}\, kg\text{-}m/\text{sec}$.

23. (a) X-rays are absorbed by the target; they are not reflected by the target.

24. (c)

25. (d)

26. (a)

27. (d)

28. (c)

29. (b) Continuous spectrum of X-rays consists of radiations of all possible wavelength range having a definite short wavelength limit.

30. (b) $\frac{E}{t} = P = \frac{h\nu}{t}$

i.e. Penetrating power $\propto$ energy $\propto$ Frequency

31. (c) In general X-rays have larger wavelength than that of gamma rays.

32. (c) According to Mosley's law $\nu = a(Z-b)^2$ and $\nu \propto \frac{1}{\lambda}$

33. (b) $E = h\nu = eV \Rightarrow \nu \propto V$

34. (c) $E = eV = h\nu_{max} \Rightarrow \nu_{max} = \frac{eV}{h}$

35. (c) $E = eV = h\nu_{max} = \frac{hc}{\lambda_{min}} \Rightarrow \lambda_{min} = \frac{hc}{eV}$

36. (d) $\lambda_{min} = \frac{hc}{eV}$ or $\lambda_{min} \propto \frac{1}{V}$ On increasing potential, λ_{min} decreases.

37. (a) $h\nu_o = eV \therefore \nu_o = \frac{eV}{h} = \frac{1.6 \times 10^{-19} \times 42000}{6.63 \times 10^{-34}} = 10^{19}\ Hz$

38. (d) Nucleus of heavy atom captures electron of *k*-orbit. This is a radioactive process, so vacancy of this electron is filled by an outer electron and *x*-rays are produces.

39. (d) Because they are electromagnetic waves.

40. (c) $\nu_{max} \propto \frac{1}{\lambda_{min}}$ Hard *X*-rays have high frequency and low wavelength.

41. (d) X-rays are electromagnetic in nature so they remains unaffected in electric and magnetic field.

42. (b)

43. (c)

44. (b) *X*-rays have high energy. They penetrate into the solid crystal and used to find out the internal structure.

45. (a) By changing the filament current with the help of rheostat, thermionic emission intensity of *X*-rays can be changed.

46. (c) Applied voltage must be greater than binding energy.

47. (a)

48. (d) $\lambda = \frac{12375}{(40 \times 10^3)} = 0.309 Å \approx 0.31 Å$

49. (c)

50. (b) $\lambda_{min} = \frac{hc}{eV} = \frac{12375}{V} Å = 0.495\ Å \approx 0.5\ Å$

51. (c) $\lambda_{min} = \frac{hc}{eV} = \frac{12375}{V} Å;\ \therefore\ V = \frac{12375}{\lambda \text{ in } Å} = 124\ kV$

52. (a) Mosley's law is $f = a(Z-b)^2$

53. (b) The potential difference across the filament and target determines the energy and thence the penetrating power of *X*-rays.

54. (d) The energy of *X*-ray photon obtained from a coolidge tube by an electronic transition of target atom such as K_α line is obtained from transition from *L* orbit in *K* orbit.

55. (b) $\lambda_{min} = \frac{12375}{V} = \frac{12375}{30 \times 10^3} = 0.4 Å$

56. (d) $\lambda_{min} = \frac{12375}{100 \times 10^3} Å = 0.124\ Å$

57. (d) $\lambda_{min} = \frac{12375}{50000} = 0.025\ nm$

58. (c)

59. (a) Refer theory

60. (a) With the increase in potential difference between anode and cathode energy of striking electrons increases which in turn increases the energy (penetration power) of X-rays.

61. (a)

62. (b)

63. (b) The wavelength range of *X*-ray is 0.1 $Å$ – 100 $Å$.

64. (b) Energy $E = h\nu = h\frac{c}{\lambda}\ \therefore\ \frac{E_1}{E_2} = \frac{\lambda_2}{\lambda_1} = \frac{5000}{1}$

65. (b)

66. (a) Interatomic spacing in a crystal acts as a diffraction grating.

67. (b) The wavelength of the γ-rays is shorter. However the main distinguishing feature is the nature of emission.

68. (d) $h\nu_{max} = eV \Rightarrow \frac{hc}{\lambda_{min}} = eV\ \therefore \lambda_{min} \propto \frac{1}{V}$

69. (d) Hard *X*-rays are of higher energy and the energy of *X*-rays depends on the potential difference between the cathode and the target.

70. (d) Penetration is directly proportional to the energy of radiations.

71. (d) Greater the number of electrons striking the

anode, larger is the number of X-ray photons emitted.

72. (a) $\lambda_{\min} = \frac{12375}{V} \mathring{A} \Rightarrow V = \frac{12375}{1} = 12375\ V$

$= 12.375\ kV \approx 12.42\ kV$

73. (c)

74. (c)

75. (c) $E(eV) = \frac{12375}{1.65} = 7500\ eV = 7.5\ keV.$

76. (d)

77. (b)

78. (a) $\lambda_{\min} = \frac{12375}{40} \mathring{A} = 3.09 \times 10^{-8}\ m$

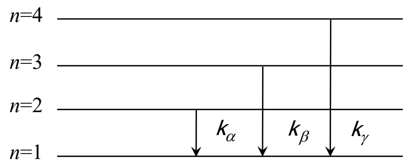
79. (d) Target should be of high atomic number and high melting point

80. (a) Intensity of X-rays depends upon the number of electron striking the target.

81. (b) $E(eV) = \frac{hc}{e\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{1.6 \times 10^{-19} \times 1 \times 10^{-10}} = 12375\ eV$

82. (c) When applied voltage is greater then energy of K-electron, continuous and all characterstic X-rays are emitted.

83. (c)



84. (d) When current through the filament increases, number of emitted electrons also increases. Hence intensity of X-ray increases but no effect on penetration power.

85. (a) $i = \frac{Ne}{t} \Rightarrow \frac{N}{t} = \frac{i}{e} = \frac{3.2 \times 10^{-3}}{1.6 \times 10^{-19}} = 2 \times 10^{16}\ /\ sec$

86. (d)

87. (a) Because X-rays are electromagnetic (Neutral) in nature.

88. (d) $\lambda_{\min} = \frac{hc}{eV} = \frac{6.6 \times ^{-34} \times 3 \times 10^{8}}{1.6 \times 10^{-19}\ V} = \frac{12375}{V} \approx \frac{12400}{V} \mathring{A}$

89. (c) Frequency of hard X-rays is greater than that of soft X-rays.

90. (b)

91. (a) $\lambda_{\min} = \frac{12375}{V} \mathring{A} \Rightarrow V = \frac{12375}{0.4125} = 30\ kV$

92. (b)

93. (d)

94. (a) $\lambda_{\min} = \frac{12375}{40 \times 10^{3}} = 0.309\ \mathring{A} \approx 0.31\ \mathring{A}$

95. (d) $\lambda_{\min} = \frac{hc}{eV} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{1.6 \times 10^{-19} \times 100 \times 10^{3}} = 0.123 \mathring{A}$

96. (d) According to Mosley's law $\nu \propto (Z - b)^2$

For k_α line, $b = 1$, and it has maximum frequency so $\nu_{\max} \propto (Z - 1)^2$

97. (b) The velocity of X-rays is always equal to that of light.

98. (b)

99. (d) $\lambda_{\min} = \frac{12375}{V} \mathring{A} \Rightarrow V = \frac{12375}{2.5} = 4950\ V \simeq 5\ kV.$

100. (c) $\lambda_{\min} = \frac{hc}{eV(\text{energy})}$; when KE (or eV) increases, λ decreases.

101. (c)

102. (b) When a high energy electron incident on heavy metal, it produces X-rays.

103. (b) $\nu = \frac{c}{\lambda} = \frac{3 \times 10^{8}}{1 \times 10^{-10}} = 3 \times 10^{18}\ Hz$

104. (b) $\lambda \propto \frac{1}{Z^2} \Rightarrow \frac{c}{\nu} \propto \frac{1}{Z^2} \Rightarrow \nu \propto Z^2$

105. (d)

106. (a) $eV = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{1.5 \times 10^{-10}}$

$\Rightarrow V = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{1.6 \times 10^{-19} \times 1.5 \times 10^{-10}} = 8280\ Volt.$

107. (d)

108. (d)

109. (b) Required ionisation energy

$= \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{1.54 \times 10^{-10}} J = 12.9 \times 10^{-16} J$

110. (c) $\lambda \propto \frac{1}{(Z-1)^2} \Rightarrow \frac{\lambda_2}{\lambda_1} = \left(\frac{Z_1 - 1}{Z_2 - 1}\right)^2$

$\Rightarrow \frac{\lambda_2}{\lambda} = \left(\frac{43-1}{29-1}\right)^2 = \left(\frac{42}{28}\right)^2 \Rightarrow \lambda_2 = \frac{9}{4}\lambda.$

111. (a)

Critical Thinking Questions

1. (b) For one second, distance = Velocity = $3 \times 10^{4}\ m/\sec$ and $Q = i \times 1 = 10^{-6}\ C$. Charge density $= \frac{\text{Charge}}{\text{Volume}}$

$= \frac{10^{-6}}{3 \times 10^{4} \times 0.5 \times 10^{-6}} = 6.6 \times 10^{-5}\ C/m^3.$

2. (c) By law of conservation of momentum

$0 = m_1\vec{v_1} + m_2\vec{v_2} \Rightarrow m_1\vec{v_1} = -m_2\vec{v_2}$

– *ve* sign indicates that both he particles are moving in opposite direction. Now de-Broglie wavelengths

$\lambda_1 = \frac{h}{m_1 v_1}$ and $\lambda_2 = \frac{h}{m_2 v_2}$; $\therefore \frac{\lambda_1}{\lambda_2} = \frac{m_2 v_2}{m_1 v_1} = 1$

3. (b) $\lambda_{photon} = \frac{hc}{E}$ and $\lambda_{proton} = \frac{h}{\sqrt{2mE}}$

$\Rightarrow \frac{\lambda_{photon}}{\lambda_{electron}} = c\sqrt{\frac{2m}{E}} \Rightarrow \frac{\lambda_{photon}}{\lambda_{electron}} \propto \frac{1}{\sqrt{E}}$

4. (a,b,c) $K_{max} = E - W_0$

$\therefore T_A = 4.25 - (W_0)_A$ ...(i)

$T_B = (T_A - 1.5) = 4.70 - (W_0)_B$ ...(ii)

Equation (i) and (ii) gives $(W_0)_B - (W_0)_A = 1.95\ eV$

De Broglie wave length $\lambda = \frac{h}{\sqrt{2mK}} \Rightarrow \lambda \propto \frac{1}{\sqrt{K}}$

$\Rightarrow \frac{\lambda_B}{\lambda_A} = \sqrt{\frac{K_A}{K_B}} \Rightarrow 2 = \sqrt{\frac{T_A}{T_A - 1.5}} \Rightarrow T_A = 2eV$

From equation (i) and (iii)

$W_A = 2.25\ eV$ and $W_B = 4.20\ eV$.

5. (d)

6. (b) In the presence of inert gas photoelectrons emitted by cathode ionise the gas by collision and hence the current increases.

7. (b) For electron and positron pair production, minimum energy is 1.02 *MeV*.

Energy of photon is given $1.7 \times 10^{-3}\ J = \frac{1.7 \times 10^{-13}}{1.6 \times 10^{-19}}$

$= 1.06\ MeV$.

Since energy of photon is greater than 1.02 *MeV*,

So electron, positron pair will be created.

8. (c) According to Einstein's photoelectric equation

$\frac{hc}{\lambda} = \phi + \frac{1}{2}mv^2 \Rightarrow v = \left[\frac{2(hc - \lambda\phi)}{m\lambda}\right]^{1/2}$

9. (b) Cut off voltage is independent of intensity and hence remains the same. Since distance becomes 3 times, so intensity (I) becomes $\frac{I}{9}$. Hence photo current also decreases by this factor *i.e.* becomes $\frac{18}{9} = 2\,mA$.

10. (d) $h\nu - W_0 = \frac{1}{2}mv_{max}^2 \Rightarrow \frac{hc}{\lambda} - \frac{hc}{\lambda_0} = \frac{1}{2}mv_{max}^2$

$\Rightarrow hc\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right) = \frac{1}{2}mv_{max}^2 \Rightarrow v_{max} = \sqrt{\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)}$

When wavelength is λ and velocity is v, then

$v = \sqrt{\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)}$ …. (i)

When wavelength is $\frac{3\lambda}{4}$ and velocity is v' then

$v' = \sqrt{\frac{2hc}{m}\left[\frac{\lambda_0 - (3\lambda/4)}{(3\lambda/4) \times \lambda_0}\right]}$ ….(ii)

Divide equation (ii) by (i), we get

$\frac{v'}{v} = \sqrt{\frac{[\lambda_0 - (3\lambda/4)]}{\frac{3}{4}\lambda\lambda_0} \times \frac{\lambda\lambda_0}{\lambda_0 - \lambda}}$

$v' = v\left(\frac{4}{3}\right)^{1/2}\sqrt{\frac{[\lambda_0 - (3\lambda/4)]}{\lambda_0 - \lambda}}$ *i.e.* $v' > v\left(\frac{4}{3}\right)^{1/2}$

11. (c) Intensity of light

$I = \frac{Watt}{Area} = \frac{nhc}{A\lambda} \Rightarrow$ Number of photon $n = \frac{IA\lambda}{hc}$

$\therefore$ Number of photo electron $= \frac{1}{100} \times \frac{IA\lambda}{hc}$

$= \frac{1}{100}\frac{1 \times 10^{-4} \times 300 \times 10^{-9}}{6.6 \times 10^{-34} \times 3 \times 10^8} = 1.5 \times 10^{12}$

12. (b) By using $h\nu - h\nu_0 = K_{max}$

$\Rightarrow h(\nu_1 - \nu_0) = K_1$ ….(i)

And $h(\nu_2 - \nu_0) = K_2$ ….(ii)

$\Rightarrow \frac{\nu_1 - \nu_0}{\nu_2 - \nu_0} = \frac{K_1}{K_2} = \frac{1}{K}$, Hence $\nu_0 = \frac{K\nu_1 - \nu_2}{K - 1}$.

13. (b) $E = W_0 + eV_0$

For hydrogen atom, $E = +13.6\,eV$

$\therefore +13.6 = 4.2 + eV_0$

$\Rightarrow V_0 = \frac{(13.6 - 4.2)\,eV}{e} = 9.4\ V$

Potential at anode = – 9.4 V

14. (a) From $\lambda_0 = \frac{12375}{W_0}$

The maximum wavelength of light required for the photoelectron emission, $(\lambda_0)_{Li} = \frac{12375}{2.3} = 5380 Å$.

Similarly $(\lambda_0)_{Cu} = \frac{12375}{4} = 3094$ Å.

Since the wavelength 3094 Å does not in the visible region, but it is in the ultraviolet region. Hence to work with visible light, lithium metal will be used for photoelectric cell.

15. (a) Direction of scattered photon $\cos\phi = 1 - \frac{\Delta\lambda m_e c}{h}$

Here $\Delta\lambda = 0.011$ Å

$\therefore \cos\phi = 1 - \frac{0.011\times10^{-10}\times9.1\times10^{-31}\times3\times10^8}{6.624\times10^{-34}}$

$= 1 - 0.453 = 0.547$

$\therefore \phi = \cos^{-1}(0.547)$

16. (d) Bragg's law, $2d\sin\theta = n\lambda$ or $\lambda = \frac{2d\sin\theta}{n}$

For maximum wavelength, $n_{\min} = 1, (\sin\theta)_{\max} = 1$

$\therefore \lambda_{\max} = 2d$ or $\lambda_{\max} = 2\times10^{-7}\,cm = 20$ Å

17. (a,c,d) $P = VI = 50\times10^3\times20\times10^{-3} = 1000\ W$

Power converted into heat = 990 *W*

$ms\Delta T = 990 \Rightarrow \Delta T = 2^o C/\sec$

Now $\frac{hc}{\lambda_{\min}} = eV \Rightarrow \lambda_{\min} = \frac{hc}{eV} = 0.248\times10^{-10}\,m$

18. (c) The wavelength of *X*-ray lines is given by Rydberg

Formula $\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

For K_α line, $n_1 = 1$ and $n_2 = 2$

$\therefore \frac{1}{\lambda} = RZ^2\left(\frac{3}{4}\right) \Rightarrow Z = \left(\frac{4}{3R\lambda}\right)^{1/2}$

$= \left[\frac{4}{3(1.097\times10^7 m^{-1})(0.76\times10^{-10} m)}\right]^{1/2} = 39.99 \approx 40$

19. (b) If intensity of *X*-ray is decreased by *dI*, when it passes through a length *dx* of absorbing material then, the amount of observed intensity is $\mu I\,dx$.

Thus, $-dI = \mu I\,dx$ or $\frac{dI}{dx} + \mu I = 0$

On solving this equation $I = I_0 e^{-\mu x} = I_0 e^{-\mu d}$ $(x = d)$

20. (c)

$E_K - E_L = \frac{hc}{\lambda}$

$= \frac{(6.6\times10^{-34})\,(3\times10^8)}{(0.021\times10^{-9})\,(1.6\times10^{-19})}\,eV = 59\,keV$

21. (d) Minimum wavelength of continuous *X*-ray spectrum is given by $\lambda_{\min}(\text{in Å}) = \frac{12375}{E(eV)} = \frac{12375}{80\times10^3} \approx 0.155$

Also the energy of the incident electrons (80 *KeV*) is more than the ionization energy of the *K*-shell electrons (*i.e.* 72.5 *KeV*). Therefore characteristic *X*-ray spectrum will also be obtained because energy of incident electron is enough to knock out the electron from *K* or *L* shells.

22. (a) The wave length of L_α line is given by

$\frac{1}{\lambda} = R(z-7.4)^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right) \Rightarrow \lambda \propto \frac{1}{(Z-7.4)^2}$

$\Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{(z_2-7.4)^2}{(z_1-7.4)^2} \Rightarrow \frac{1.30}{\lambda_2} = \frac{(42-7.4)^2}{(78-7.4)^2} \Rightarrow \lambda_2 = 5.41 Å$

23. (c) de-Broglie wavelength $\lambda = \frac{h}{mv_{rms}}$, *rms* velocity of a gas particle at the given temperature (*T*) is given as

$\frac{1}{2}mv_{rms}^2 = \frac{3}{2}kT \Rightarrow v_{rms} = \sqrt{\frac{3kT}{m}} \Rightarrow mv_{rms} = \sqrt{3mkT}$

$\therefore \lambda = \frac{h}{mv_{rms}} = \frac{h}{\sqrt{3mkT}}$

$\Rightarrow \frac{\lambda_H}{\lambda_{He}} = \sqrt{\frac{m_{He}T_{He}}{m_H T_H}} = \sqrt{\frac{4(273+127)}{2(273+27)}} = \sqrt{\frac{8}{3}}$

24. (c) $n = \frac{E\lambda}{hc} = \frac{1\times10^{-7}\times200\times10^{-9}}{6.6\times10^{-34}\times3\times10^8} = 1\times10^{11}$

Number of electrons ejected $= \frac{10^{11}}{10^3} = 10^8$

$\therefore V = \frac{q}{4\pi\varepsilon_0 r} = \frac{(10^8\times1.6\times10^{-19})\times9\times10^9}{4.8\times10^{-2}} = 3\ V$

25. (b) The momentum of the incident radiation is given as $p = \frac{h}{\lambda}$. When the light is totally reflected normal to the surface the direction of the ray is reversed. That means it reverses the direction of it's momentum without changing it's magnitude

$\therefore \Delta p = 2p = \frac{2h}{\lambda} = \frac{2\times6.6\times10^{-34}}{6630\times10^{-10}} = 2\times10^{-27}$ *kg-m/sec.*

26. (c) When a charged particle (charge q, mass m) enters perpendicularly in a magnetic field (B) than, radius of the path described by it $r = \frac{mv}{qB} \Rightarrow mv = qBr$.

Also de-Broglie wavelength $\lambda = \frac{h}{mv}$

$\Rightarrow \lambda = \frac{h}{qBr} \Rightarrow \frac{\lambda_\alpha}{\lambda_p} = \frac{q_p r_p}{q_\alpha r_\alpha} = \frac{1}{2}$

27. (a) $\sqrt{f_1} = \sqrt{\frac{v}{\lambda_1}} = a(11-1)$ and $\sqrt{f_2} = \sqrt{\frac{v}{\lambda_2}} = a(Z-1)$

By dividing, $\sqrt{\frac{\lambda_2}{\lambda_1}} = \frac{10}{Z-1} \Rightarrow \sqrt{\frac{4}{1}} = \frac{10}{Z-1} \Rightarrow Z = 6$

28. (c) $K.E. = 2\ E_0 - E_0 = E_0$ (for $0 \le x \le 1$) $\Rightarrow \lambda_1 = \frac{h}{\sqrt{2mE_0}}$

$K.E. = 2\ E_0$ (for $x > 1$) $\Rightarrow \lambda_2 = \frac{h}{\sqrt{4mE_0}}$

$\Rightarrow \frac{\lambda_1}{\lambda_2} = \sqrt{2}$.

29. (b) Given $m_0c^2 = 0.51\ MeV$ and $v = 0.8\ c$

$K.E.$ of the electron $= mc^2 - m_0c^2$

But $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{m_0}{\sqrt{1-\left(\frac{0.8\ c}{c}\right)^2}} = \frac{m_0}{\sqrt{0.36}} = \frac{m_0}{0.6}$

Now, $mc^2 = \frac{0.51}{0.6}\ MeV = 0.85\ MeV$

$\therefore K.E. = (0.85 - 0.51) MeV = 0.34\ MeV$.

30. (a) The deflection suffered by charged particle in an electric field is $y = \frac{qELD}{mu^2} = \frac{qELD}{p^2/m}$ ($p = mu$)

$\Rightarrow y \propto \frac{qm}{p^2} \Rightarrow y_p : y_d : y_\alpha = \frac{q_p m_p}{p_p^2} : \frac{q_d m_d}{p_d^2} : \frac{q_\alpha m_\alpha}{p_\alpha^2}$

Since $p_\alpha = p_d = p_p$ (given)

$m_p : m_d : m_\alpha = 1 : 2 : 4$ and $q_p : q_d : q_\alpha = 1 : 1 : 2$

$\Rightarrow y_p : y_d : y_\alpha = 1 \times 1 : 1 \times 2 : 2 \times 4 = 1 : 2 : 8$

31. (c) Using $Z^2 = k\left(\frac{q}{m}\right)y$, where $k = \frac{B^2LD}{E}$. For parabolas to coincide in the two photographs, the $\frac{kq}{m}$ should be same for the two cases. Thus, $\frac{B_1^2\ LDe}{E_1 m_1} = \frac{B_2^2 LD(2e)}{E_2 m_2}$

$\Rightarrow \frac{m_1}{m_2} = \left(\frac{B_1}{B_2}\right)^2 \times \left(\frac{E_2}{E_1}\right) \times \frac{1}{2} = \frac{9}{4} \times \frac{2}{1} \times \frac{1}{2} = \frac{9}{4}$

32. (c) According to the energy diagram of X-ray spectra

$\because \Delta E = \frac{hc}{\lambda} \Rightarrow \lambda \propto \frac{1}{\Delta E}$

(ΔE = Energy radiated when e^- jumps from, higher energy orbit to lower energy orbit)

$\because (\Delta E)_{k_\beta} > (\Delta E)_{k_\alpha} > (\Delta E)_{L_\alpha} \therefore \lambda'_\alpha > \lambda_\alpha > \lambda_\beta$

Also $(\Delta E)_{k_\beta} = (\Delta E)_{k_\alpha} + (\Delta E)_{L_\alpha}$

$\Rightarrow \frac{hc}{\lambda_\beta} = \frac{hc}{\lambda_\alpha} + \frac{hc}{\lambda'_\alpha} \Rightarrow \frac{1}{\lambda_\beta} = \frac{1}{\lambda_\alpha} + \frac{1}{\lambda'_\alpha}$

33. (c) By using $I = \frac{P}{A}$; where P = radiation power

$\Rightarrow P = I \times A \Rightarrow \frac{nhc}{t\lambda} = IA \Rightarrow \frac{n}{t} = \frac{IA\lambda}{hc}$

Hence number of photons entering per sec the eye $\left(\frac{n}{t}\right) = \frac{10^{-10} \times 10^{-6} \times 5.6 \times 10^{-7}}{6.6 \times 10^{-34} \times 3 \times 10^8} = 300$.

34. (d) $\Delta\lambda = \lambda_{K_\alpha} - \lambda_{\min}$ When V is halved $\lambda_{\min}$ becomes two times but λ_{K_α} remains the same.

$\therefore \quad \Delta\lambda' = \lambda_{K_\alpha} - 2\lambda_{\min} = 2(\Delta\lambda) - \lambda_{K_a}$

$\therefore \quad \Delta\lambda' < 2(\Delta\lambda)$

35. (b) Energy of photons corresponding to light of wave length λ_1 = 2475 Å is $E_1 = \frac{12375}{2475} = 5\ eV$.

and that corresponding to λ_2 = 6000 Å is

$E_2 = \frac{12375}{6000} = 2.06\ eV$

As $E_2 < W_0$ and $E_1 > W_0$

Photoelectric emission is possible with λ_1 only. Maximum kinetic energy of emitted photoelectrons $K = E - W_0 = 5 - 4.8 = 0.2$ eV.

Photo electrons experiences magnetic force and move along a circular path of radius

$r = \frac{\sqrt{2\ mk}}{QB} = \frac{\sqrt{2 \times 9 \times 10^{-31} \times 0.2 \times 1.6 \times 10^{-19}}}{1.6 \times 10^{-19} \times 3 \times 10^{-5}}$

$= 0.05\ m = 5\ cm$.

36. (a) Number of photoelectrons emitted up to t = 10 sec are

$$n = \frac{\text{(Number of photons per unit area per unit time)} \times (\text{Area} \times \text{Time})}{10^6}$$

$$= \frac{1}{10^6}[(10)^{16} \times (5 \times 10^{-4}) \times (10)] = 5 \times 10^7$$

At time $t = 10$ *sec*

Charge on plate A ; $q_A = +ne = 5 \times 10^7 \times 1.6 \times 10^{-19}$

$= 8 \times 10^{-12}\,C = 8\,pC$

and charge on plate B ; $q_B = 33.7 - 8 = 25.7$ *pc*

Electric field between the plates

$$E = \frac{(q_B - q_A)}{2\varepsilon_0 A} = \frac{(25.7 - 8) \times 10^{-12}}{2 \times 8.85 \times 10^{-12} \times 5 \times 10^{-4}} = 2 \times 10^3 \frac{N}{C}.$$

37. (a) As we know in Young's double slit experiment fringe width = separation between two consecutive fringe or dark fringes $= \beta = \frac{\lambda D}{d}$

Here $\beta = 2y \Rightarrow 2y = \frac{\lambda D}{d} \Rightarrow \lambda = \frac{2yd}{D}$

$$\Rightarrow \lambda = \frac{2 \times 1 \times 10^{-3} \times 0.24 \times 10^{-3}}{1.2} = 4 \times 10^{-7}\,m = 4000\,\mathring{A}$$

Energy of light incident on photo plate

$$E(eV) = \frac{12375}{4000} = 3.1\,eV$$

According to Eienstein photoelectric equation

$E = W_0 + eV_0 \Rightarrow V_0 = \frac{(E - W_0)}{e} = \frac{(3 + 2.2)}{e}\,eV \approx 0.9\,V$

38. (a) $E = \frac{12375}{5000} = 2.475\,eV \approx 4 \times 10^{-19}\,J$

So the minimum intensity to which the eye can respond

$I_{Eye} =$ (Photon flux) × (Energy of a photon)

$\Rightarrow I_{Eye} = (5 \times 10^4) \times (4 \times 10^{-19}) \simeq 2 \times 10^{-14}\,(W/m^2)$

Now as lesser the intensity required by a detector for detection, more sensitive it will be

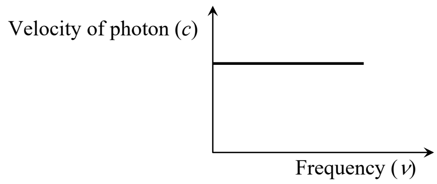
$\frac{S_{Eye}}{S_{Ear}} = \frac{I_{Ear}}{I_{Eye}} = \frac{10^{-13}}{2 \times 10^{-14}} = 5$ *i.e.* as intensity (power) detector, the eye is five times more sensitive than ear.

39. (c) Due to 10.2 *eV* photon one photon of energy 10.2 *eV* will be detected.

Due to 15 *eV* photon the electron will come out of the atom with energy (15 - 13.6) = 1.4 *eV*.

Graphical Questions

1. (a) Velocity of photon (*i.e.* light) does not depend upon frequency. Hence the graph between velocity of photon and frequency will be as follows



2. (d) De-Broglie wavelength $\lambda = \frac{h}{p} \Rightarrow \lambda \propto \frac{1}{p}$

i.e. graph will be a rectangular hyperbola.

3. (a) The stopping potential for curves a and b is same.

$\therefore \quad f_a = f_b$

Also saturation current is proportional to intensity

$\therefore \quad I_a < I_b$

4. (d) According to Einstein equation

$h\nu = h\nu_0 + K_{max} \Rightarrow K_{max} = h\nu - h\nu_0$ on comparing it with $y = mx + c$, it is clear to say that,

This is the equation of straight line having positive slope (h) and negative intercept $(h\nu_0)$ on *KE* axis.

5. (c) Comparing Einstein's equation

$K_{max} = h\nu - h\nu_0$, with $y = mx + c$, we get slope, $m = h$

6. (b) $K_{max} = h\nu - h\nu_0 \Rightarrow eV_0 = h\nu - h\nu_0 \Rightarrow V_0 = \frac{h}{e}\nu - \frac{h\nu_0}{e}$

Comparing this equation with $y = mx + c$, we get slope $m = \frac{h}{e} \Rightarrow h = m \times e$.

7. (a) Using Einstein's equation, $V_0 = \left(\frac{h}{e}\right)\nu - \frac{W_0}{e}$

Comparing this equation with $y = mx + c$

We get intercept on – V_0 axis $= \frac{W_0}{e}$

$\Rightarrow OB = \frac{W_0}{e} \Rightarrow W_0 = OB \times e$

8. (b) From the given graph it is clear that if we extend the given graph for A and B, intercept of the line A on V axis will be smaller as compared to line B means work function of A is smaller than that of B.

9. (a) Wavelength λ_k is independent of the accelerating voltage (V), while the minimum wavelength λ_c is inversely proportional to V. Therefore as V increases, λ_k remains unchanged whereas λ_c decreases or $\lambda_k - \lambda_c$ will increase.

10. (c) In X-ray spectra, depending on the accelerating voltage and the target element, we may find sharp peaks super imposed on continuous spectrum. These are at different wavelengths for different elements. They form characteristic X-ray spectrum.

11. (b) Photo current (i) directly proportional to light intensity (I) falling on a photosensitive plate. $\Rightarrow i \propto I$

12. (d) According to Einstein's equation

$h\nu = W_0 + K_{max} \Rightarrow V_0 = \left(\frac{h}{e}\right)\nu - \frac{W_0}{e}$

This is the equation of straight line having positive slope (h/e) and intercept on $-V_0$ axis, equals to $\frac{W_0}{e}$

13. (d) In photocell, at a particular negative potential (stopping potential V_0) of anode, photoelectric current is zero,

At the potential difference between cathode and anode increases current through the circuit increases but after some time constant current (saturation current) flows through the circuit even if potential difference still increasing.

14. (b) Stopping potential does not depend upon intensity of incident light (I).

15. (a) Stopping potential is that negative potential for which photo electric current is zero.

16. (d) $\because V_0 = \left(\frac{h}{e}\right)\nu - \left(\frac{W_0}{e}\right)$. From the graph $V_2 > V_1$

$\Rightarrow \frac{h\nu_2}{e} - \frac{W_0}{e} > \frac{h\nu_1}{e} - \frac{W_0}{e} \Rightarrow \nu_2 > \nu_1$

$\Rightarrow \lambda_1 > \lambda_2$ (as $\lambda \propto \frac{1}{\nu}$)

17. (d) $I \propto \frac{1}{d^2}$ and photo current $i \propto I \Rightarrow i \propto \frac{1}{d^2}$

18. (a) $h\nu = h\nu_0 + KE_{max} \Rightarrow KE_{max} = h\nu - h\nu_0$

On comparing this equation with $y = mx + c$ we get

$m = h =$ Universal constant

19. (b) $\lambda_0 = \frac{c}{\nu_0} = \frac{3\times10^8}{5\times10^{14}} = 6\times10^{-7} m = 6000 Å$

20. (c) Work function is the intercept on $K.E.$ axis *i.e.* $2eV$.

21. (b) From the graph stopping potential $|V_s| = -V$

Also $k_{max} = (|V_0|eV = 4eV$.

22. (c) By Moseley's law, $\sqrt{\nu} = a(Z-b)$ or, $\nu = a^2(Z-b)^2$

Comparing with the equation of a parabola, $y^2 = 4ax$ it conforms to graph c.

23. (a) $\lambda_{min} = \frac{hc}{eV} \Rightarrow \lambda \propto \frac{1}{V}$

$\because \lambda_2 > \lambda_1$ (see graph) $\Rightarrow V_1 > V_2$

$\sqrt{\nu} = a(Z-b)$ Moseley's law

$\nu \propto (Z-1)^2 \Rightarrow \lambda \propto \frac{1}{(Z-1)^2}$ $\left(\because \nu \propto \frac{1}{\lambda}\right)$

$\lambda_1 > \lambda_2$ (see graph for characteristic lines) $\Rightarrow Z_2 > Z_1$.

24. (a) $K_{max} = h\nu - h\nu_0 = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$ *i.e.* graph between K_{max} and $\frac{1}{\lambda}$ will be straight line having slope (hc) and intercept $\frac{hc}{\lambda_0}$ on $-KE$ axis.

25. (a) ν varies from 0 to ν_{max}.

26. (a) $\lambda_{min} = \frac{hc}{eV} \Rightarrow \log.\lambda_{min} = \log\frac{hc}{e} - \log V$

$\Rightarrow \log\lambda_{min} = -\log V + \log\frac{hc}{e}$

This is the equation of straight line having slope (–1) and intercept $\log\frac{hc}{e}$ on $+\log_e\lambda_{min}$ axis.

27. (c) For K_α line $\nu \propto (Z-1)^2 \Rightarrow \lambda \propto \frac{1}{(Z-1)^2}$

i.e. the graph between λ and z will be (c).

28. (b) Slope of $V_0 - \nu$ curve $= \frac{h}{e}$

$\Rightarrow h =$ Slope $\times e = 1.6\times10^{-19}\times 4.12\times10^{-15}$ $= 6.6\times10^{-34}$ J-sec.

29. (b) $I_1 > I_2$ (given) $\Rightarrow i_1 > i_2$ $(\because i \propto I)$
and stopping potential does not depend upon intensity. So its value will be same (V_0).

30. (c) Slope of $V_0 - \nu$ curve for all metals be same $\left(\frac{h}{e}\right)$ *i.e.* curves should be parallel.

31. (c) $\lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2m}} \cdot \frac{1}{\sqrt{E}}$. Taking log of both sides $\log \lambda = \log \frac{h}{\sqrt{2m}} + \log \frac{1}{\sqrt{E}} \Rightarrow$
$\log \lambda = \log \frac{h}{\sqrt{2m}} - \frac{1}{2} \log E$
$\Rightarrow \log \lambda = -\frac{1}{2} \log E + \log \frac{h}{\sqrt{2m}}$
This is the equation of straight line having slope (–1/2) and positive intercept on log λ axis.

32. (b) $\sqrt{\nu} \propto (Z - b)$

33. (b) Peak of K_α is greater than peak of K_β line.

34. (a) $|-4V| > |-2\ V|$

35. (a) $\because x \propto \frac{1}{v^2}$. The ion whose deflection is less, its velocity will be more. From the curve $x_1 < x_2 < x_3 < x_4$, therefore $v_1 > v_2 > v_3 > v_4$.

36. (a) All the positive ions of same specific charge moving with different velocity lie on the same parabola.

37. (b) The equation of curve between V_0 and ν is $\frac{h\nu}{e} - \frac{h\nu_0}{e} = V_0$.
This is equation of a straight line with slope $= \frac{h}{e}$.

38. (b) Stopping potential equals to maximum kinetic energy.
Since stopping potential is varying linearly with the frequency. There fore max. *KE* for both the metals also vary linearly with frequency.

Assertion and Reason

1. (a) Momentum of a photon is given by $p = \frac{h}{\lambda}$
Also the photon is a form of energy packets behaves as a particle having energy $E = \frac{hc}{\lambda}$.
So $p = \frac{E}{c}$

2. (d) Photoelectric effect demonstrates the particle nature of light. Number of emitted photoelectrons depends upon the intensity of light.

3. (b) Charge does not change with speed but mass varies with the speed as per relation $m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$. Hence specific charge *e/m* decreases with increase in speed.

4. (a) X-rays lies in electromagnetic spectrum.

5. (b) Mass of moving photon $m = \frac{h\nu}{c^2} = \frac{h}{c\lambda}$ and $E = mc^2$.

6. (d) According Einstein equation $KE = h\nu - h\nu_0$; *i.e., KE* depends upon the frequency. Photoelectron emitted only if incident frequency more than threshold frequency.

7. (e) The atomic number (number of electrons or protons) remains same in isotope. Isotope of an element can be separated on account of their different atomic weight by using mass spectrograph.

8. (b) The specific charge (e/m) of the positive rays is not universal constant because these rays may consists of ions of different element.

9. (b) Less work function means less energy is required for ejecting out the electrons.

10. (a) de-Broglie wavelength associated with gas molecules varies as $\lambda \propto \frac{1}{\sqrt{T}}$

11. (e) If electron is moving parallel to the magnetic field, then the electron is not deflected *i.e.*, if electron is not deflected we cannot be sure that there is no magnetic field in that region.

12. (d) At normal pressure positive ions and electrons liberated by ionisation of gas atoms, due to cosmic rays are very small in number and they collide constantly with the gas atoms which are present in large numbers, and hence are unable to move a

long distance under the electric field and soon get recombined *i.e.,* flow of ions in the gas does not take place.

13. (d) Light is produced in gases in the process of electric discharge at low pressure. When accelerated electrons collide with atoms of the gas, atoms get excited. The excited atoms return to their normal state and in this process light radiations are emitted.

14. (d) The discharge depends on both pressure of discharge tube and ionisation potential of gas. Since the ionisation potential of different gases are different, hence the discharge in different gases takes place at different potential.

15. (d) If electric field is used for detecting the electron beam, then very high voltage will have to be applied or very long tube will have to be taken.

16. (b) Specific charge of a positive ion corresponding to one gas is fixed but it is different for different gases.

17. (e) In Millikan's experiment oil drops should be of microscopic sizes. If much bigger oil drops are used, then a very high electric field will be required to balance it which is not possible to achieve practically.

Further, the apparent weight of the liquid $\frac{4}{3}\pi a^3 g\ (\rho_{\text{liquid}} - \sigma_{\text{air}}) = 6\pi a\eta v.$

If a is large, v will be large and the experimental errors will be high.

18. (e) Only the photoelectrons emitted from the surface of the metal have maximum kinetic energy. Those emitted from inside the metal loses part of their energy in collision with the other atoms inside the metal.

19. (d) On increasing the intensity of incident light, the current in photoelectric cell will increase. The energy of the photons $(h\nu)$ will, however not increase with increase in intensity, and hence the kinetic energy of the emitted electrons will not increase.

20. (a) When a light of single frequency falls on the electron of inner layer of metal, then this electron comes out of the metal surface after a large number of collisions with atoms of its upper layer.

21. (b) There is no emission of photoelectrons till the frequency of incident light is less than a minimum frequency, however intense light it may be. In photoelectric effect, it is a single particle collision. Intensity is $h\nu \times N,$ where $h\nu$ is the individual energy of the photon and N is the total number of photon. In the wave theory, the intensity is proportional, not only to ν^2 but also to the amplitude squared. For the same frequency, increase in intensity only increase the number of photons (in the quantum theory of Einstein).

22. (a) The photoemissive cell may be evacuated contain an inert gas at low pressure. An inert gas in the cell gives greater current but causes a time lag in the response of the cell to very rapid changes of radiation which may make it unsuitable for some purpose.

23. (c) Wavelength of X-rays is very small $(\approx \mathring{A})$. Hence they are not diffracted by means of ordinary grating. X-rays follows the Bragg's law.

24. (b) The penetrating power of X-rays depends upon the voltage applied across the tube producing X-rays. X-rays can pass through matter of lighter elements such as flesh (which is composed of oxygen, hydrogen and carbon) but cannot pass through substances made of heavier elements like bones (which are made of phosphorus and calcium).

25. (c) Intensity of X-rays (I) is proportional to the filament current and also to the square of the voltage. It is well known that intensity of X-rays depends on the number of photons emitted per second from target.

26. (b) When fast moving electrons strike the atoms of the target, then most of their kinetic energy is used in increasing the thermal agitation of the atoms of the target and only a small part is radiated in the form of X-rays. So the temperature of the target rises.

27. (e) Higher is the wavelength of X-ray, lesser is the frequency and penetration power.

28. (a) The distance between the atoms of crystals is of the order of wavelength of *X*-rays. When they fall on a crystal, they are diffracted. The diffraction pattern is helpful in the study of crystal structure.

29. (b) In photoelectric effect, the photon falling on some matter is absorbed by the matter and its energy is transferred to an electron of the matter. In *X*-ray production, photons are produced which get energy from energetic electrons ionising the inner shells of the target which in turn cause a cascade of emission lines.

30. (e) Soft and hard *X*-rays differ only in frequency. But both types of *X*-ray travel with speed of light.