4. (b) Total flux coming out from unit charge $= \vec{E}.\vec{ds} = \frac{1}{\varepsilon_0} \times 1 = \varepsilon_0^{-1}$

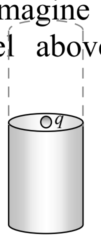
5. (c)

6. (a) As there is no charge residing inside the cube, hence net flux is zero.

7. (d) $\phi = \frac{\Sigma q}{\varepsilon_0} = 0$ *i.e.* net charge on dipole is zero.

8. (a) Electric flux coming out through a closed surface is q/ε_0.

9. (c) To apply Gauss's theorem it is essential that charge should be placed inside a closed surface. So imagine another similar cylindrical vessel above it as shown in figure (dotted).



10. (b)

11. (d) $e = \frac{\lambda}{2\pi\varepsilon_0 r} \Rightarrow E \propto \frac{1}{r}$

12. (b) Charge enclosed by cylindrical surface (length 100 *cm*) is $Q_{enc} = 100Q$. By applying Gauss's law $\phi = \frac{1}{\varepsilon_0}(Q_{enc}) = \frac{1}{\varepsilon_0}(100Q)$

13. (c) S.I. unit of electric flux is $\frac{N \times m^2}{C} = \frac{J \times m}{C} =$ *volt* $\times$ *m*.

14. (b) By using $\int \vec{E} \cdot \vec{dA} = \frac{1}{\varepsilon_0}(Q_{enc})$

15. (b)

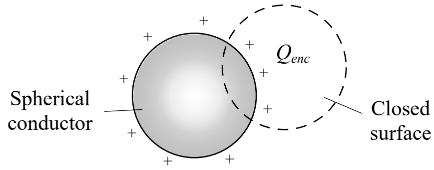
16. (d) By Gauss's law $\phi = \frac{1}{\varepsilon_0}$ $(Q_{enclosed})$

$\Rightarrow Q_{enclosed} = \phi\varepsilon_0 = (-8 \times 10^3 + 4 \times 10^3)\varepsilon_0$

$= -4 \times 10^3 \varepsilon_0$ *Coulomb*.

17. (d) Net flux through the cube $\phi_{net} = \frac{Q}{\varepsilon_0}$; so flux through one face $\phi_{face} = \frac{q}{6\varepsilon_0}$

18. (a) $\phi_{surface} = \frac{1}{\varepsilon_0}(Q_{enclosed})$



19. (b) $\phi_{net} = \frac{1}{\varepsilon_0} \times Q_{enc} \Rightarrow Q_{enc} = (\phi_2 - \phi_1)\varepsilon_0$

20. (a) $\phi_{face} = \frac{q}{6\varepsilon_0} = \frac{4\pi q}{6(4\pi\varepsilon_0)}$

21. (b) $\phi = \frac{1}{\varepsilon_0} \times Q_{enc} = \frac{1}{\varepsilon_0}(2q)$

22. (c) The electric field is due to all charges present whether inside or outside the given surface.

23. (b)

24. (c) In electric dipole, the flux coming out from positive charge is equal to the flux coming in at negative charge *i.e.* total charge on sphere = 0. From Gauss law, total flux passing through the sphere = 0.

25. (b) According to Gauss's applications.

26. (a) Flux is due to charges enclosed per ε_0

$\therefore$ Total flux = $(-14 + 78.85 - 56)nC/\varepsilon_0$

$= 8.85 \times 10^{-9} C \times \frac{4\pi}{4\pi\varepsilon_0} = 8.85 \times 10^{-9} \times 9 \times 10^9 \times 4\pi$

$= 1000.4\ Nm^2/C$ *i..e.* $1000\ Nm^2C^{-1}$

27. (c) According to Gauss law $\oint E \cdot ds = \frac{ql}{\varepsilon_0}$

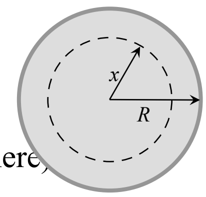
$\oint ds = 2\pi rl$; (E is constant)

$\therefore E \cdot 2\pi rl = \frac{ql}{\varepsilon_0} \Rightarrow E = \frac{q}{2\pi\varepsilon_0 r}$ *i.e.* $E \propto \frac{1}{r}$

28. (c) Let sphere has uniform chare density $\rho\left(= \frac{3Q}{4\pi R^3}\right)$ and E is the electric field at distance x from the centre of the sphere.

Applying Gauss law

$E.4\pi x^2 = \frac{q}{\varepsilon_0} = \frac{\rho V}{\varepsilon_0} = \frac{\rho}{\varepsilon_0} \times \frac{4}{3}\pi x^3$



($V =$ Volume of dotted sphere)

$\therefore E = \frac{\rho}{3\varepsilon_0} x \Rightarrow E \propto x$

Capacitance

1. (c) $V = \frac{V}{8} \Rightarrow \frac{V}{K} = \frac{V}{8} \Rightarrow K = 8$

2. (c) Battery in disconnected so Q will be constant as $C \propto K$. So with introduction of dielectric slab capacitance will increase using $Q =$

CV, V will decrease and using $U = \frac{Q^2}{2C}$, energy will decrease.

3. (a) $q = CV$ and $U = \frac{1}{2}CV^2 = \frac{q^2}{2C}$

4. (a) $U = \frac{1}{2}CV^2 = \frac{1}{2} \times 4 \times 10^{-6} \times (100)^2 = 0.02\ J$

5. (d) When $\frac{Q_1}{R_1} \neq \frac{Q_2}{R_2}$; current will flow in connecting wire so that energy decreases in the form of heat through the connecting wire.

6. (a,d)Capacitance will be increased when a dielectric is introduced in the capacitor but potential difference will remain the same because battery is still connected. So according to $q = CV$, charge will increase *i.e.* $Q > Q_0$ and $U = \frac{1}{2}QV_0, U_0 = \frac{1}{2}Q_0V_0 \Rightarrow$ $Q > Q_0$ so $U > U_0$

7. (c)

8. (b) $U = \int_0^V CV\,dV = \frac{1}{2}CV^2$

9. (b) Law of conservation of charge.

10. (c) After the connection of wire $V_1 = V_2$

$\therefore \frac{Q_1}{25} = \frac{Q_2}{20} \Rightarrow \frac{Q_1}{Q_2} = \frac{25}{20} \Rightarrow Q_1 > Q_2$

11. (c) Volume of 8 small drops = Volume of big drop

$8 \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3 \Rightarrow R = 2r$

As capacity is r, hence capacity becomes 2 times.

12. (a) $U = \frac{1}{2}CV^2 = \frac{1}{2} \times 50 \times 10^{-6} \times (10)^2 = 2.5 \times 10^{-3}\ J$

13. (b)

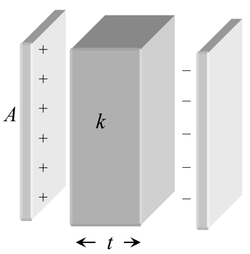
14. (d) $C_{medium} = K\,C_{air} \Rightarrow K = \frac{C_{medium}}{C_{air}} = \frac{110}{50} = 2.20$

15. (c) Potential difference between the plates $V = V_{air} + V_{medium}$

$= \frac{\sigma}{\varepsilon_0} \times (d - t) + \frac{\sigma}{K\varepsilon_0} \times t$

$\Rightarrow V = \frac{\sigma}{\varepsilon_0}(d - t + \frac{t}{K})$

$= \frac{Q}{A\varepsilon_0}(d - t + \frac{t}{K})$



Hence capacitance $C = \frac{Q}{V} = \frac{Q}{\frac{Q}{A\varepsilon_0}(d - t + \frac{t}{K})}$

$= \frac{\varepsilon_0 A}{(d - t + \frac{t}{K})} = \frac{\varepsilon_0 A}{d - t\left(1 - \frac{1}{K}\right)}$

16. (d) $C = \frac{K\varepsilon_0 A}{d}$

17. (a) Stationary charge produces electric field only.

18. (d)

19. (b) $C = \frac{\varepsilon_0 A}{d} . C = \frac{\varepsilon_0 A}{d/2} \Rightarrow C = 2C$

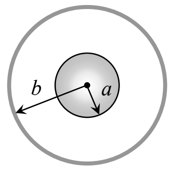
20. (b) By using $V_{big} = n^{2/3}v_{small} \Rightarrow \frac{V_{Big}}{v_{small}} = (8)^{2/3} = \frac{4}{1}$

21. (b) $V_{Big} = n^{2/3}v_{small} = (1000)^{2/3}v_{small} = 100\ v_{small}$

22. (b) $E_{medium} = \frac{E_{air}}{K} = \frac{E}{2}$

23. (d) Given : $(b - a) = 1 \times 10^{-3}\ m$ ..... (i)

and $C = 4\pi\varepsilon_0\left(\frac{ab}{b - a}\right) = 1 \times 10^{-6}$



$\Rightarrow 1 \times 10^{-6} = \frac{1}{9 \times 10^9}\left(\frac{ab}{10^{-3}}\right)$

$\Rightarrow ab = 9$ ..... (ii)

From equations (i) and (ii)

$b - \frac{9}{b} = \frac{1}{1000} \Rightarrow 1000\,b^2 - b - 9000 = 0$

$\Rightarrow b = \frac{1 \pm \sqrt{(-1)^2 - 4(1000)(-9000)}}{2 \times 1000}$

{Solving of quadratic equation}

$\Rightarrow b = \frac{1 \pm \sqrt{36 \times 10^6}}{2000} \approx \frac{\sqrt{36 \times 10^6}}{2000} = 3\,m.$

24. (a) High K means good insulating property and high x means able to withstand electric field gradient to a higher value.

25. (b) $C_{medium} = K \times C_{air}$

26. (d) By using $Q = nq \Rightarrow Q = 64\,q$

27. (c) Capacity of parallel plate capacitor $C = \frac{\varepsilon_0 A}{d}$

$\Rightarrow C \propto A$

28. (b) After connection of wire, potential becomes equal

$\therefore \frac{Q_1}{r_1} = \frac{Q_2}{r_2} \Rightarrow \frac{Q_1}{Q_2} = \frac{r_1}{r_2}$ when $r_1 > r_2$, then $Q_1 > Q_2$

29. (c)

30. (b) Because metals are good conductor of electricity.

31. (b) $C = \frac{\varepsilon_0 AK}{d} = 4\pi\varepsilon_0 r$

r = Radius of sphere of equivalent capacity

$\Rightarrow r = \frac{AK}{4\pi d} = \frac{100\times10^{-4}\times6}{1\times10^{-3}\times4\times3.14} = \frac{15}{3.14} = 4.77\ m$

32. (a) $C = 4\pi\varepsilon_0 K\left[\frac{ab}{b-a}\right] = \frac{1}{9\times10^9}.6\left[\frac{12\times9\times10^{-4}}{3\times10^{-2}}\right]$

$= 24\times10^{-11} = 240\ pF$

33. (c) $C \propto \frac{1}{d} \Rightarrow$

$\frac{C_{medium}}{C_{air}} = \frac{d}{d-t+\frac{t}{K}} = \frac{6}{6-4.5+\frac{4.5}{9}} = \frac{6}{2} = 3$

34. (d) Since charge flows from high potential to lower potential.

If positive charge is given, then $V_1 < V_2$ as $r_1 > r_2$

So positive charge flows from $Q \to P$

If negative charge is given, then $V_1 > V_2$

So negative charge flows form $P \to Q$.

Since it is not given that whether the charge given is positive or negative, hence the information is incomplete.

35. (c) $W = \frac{Q^2}{2C} \Rightarrow W = 4W$

36. (a) Potential difference across the condenser

$V = V_1 + V_2 = E_1 t_1 + E_2 t_2 = \frac{\sigma}{K_1\varepsilon_0}t_1 + \frac{\sigma}{K_2\varepsilon_0}t_2$

$\Rightarrow V = \frac{\sigma}{\varepsilon_0}\left(\frac{t_1}{K_1}+\frac{t_2}{K_2}\right) = \frac{Q}{A\varepsilon_0}\left(\frac{t_1}{K_1}+\frac{t_2}{K_2}\right)$

37. (a) For capacitor $\frac{V_1}{V_2} = \frac{d_1}{d_2} \Rightarrow$

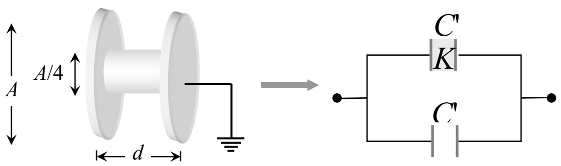
$V_2 = \frac{V_1\times d_2}{d_1} = \frac{60\times12}{4} = 180\ V$

38. (d) Area of the given metallic plate $A = \pi r^2$

Area of the dielectric plate $A' = \pi\left(\frac{r}{2}\right)^2 = \frac{A}{4}$

Uncovered area of the metallic plates $A'' = A - A'$

$= A - \frac{A}{4} = \frac{3A}{4}$



The given situation is equivalent to a parallel combination of two capacitor. One capacitor (C') is filled with a dielectric medium (K = 6) having area $\frac{A}{4}$ while the other capacitor (C'') is air filled having area $\frac{3A}{4}$

Hence $C_{eq} = C' + C'' = \frac{K\varepsilon_0(A/4)}{d} + \frac{\varepsilon_0(3A/4)}{d}$

$= \frac{\varepsilon_0 A}{d}\left(\frac{K}{4}+\frac{3}{4}\right) = \frac{\varepsilon_0 A}{d}\left(\frac{6}{4}+\frac{3}{4}\right) = \frac{9}{4}C$

$\left(\because C = \frac{\varepsilon_0 A}{d}\right)$

39. (d) If nothing is said, it is considered that battery is disconnected. Hence charge remain the same

Also $V_{air} = \frac{\sigma}{\varepsilon_0}\times d$ and $V_{medium} = \frac{\sigma}{\varepsilon_0}(d - t + \frac{t}{k})$

$\Rightarrow \frac{V_m}{V_a} = \frac{(d-t+\frac{t}{k})}{d} \Rightarrow \frac{V_m}{120} = \frac{(8-6+\frac{6}{6})}{8} \Rightarrow V_m =$ 45V

40. (c) $C = \frac{\varepsilon_0 A}{d-t+\frac{t}{K}} = \frac{1}{4\pi\times9\times10^9}\cdot\frac{\pi(0.12)^2}{\left(2+\frac{1}{2}\right)10^{-3}}$

$= \frac{2\times144\times10^{-10}}{36\times5} = 160\ pF$

41. (c) Electric field between the plates of a parallel plate capacitor $E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{A\varepsilon_0}$ *i.e.* $E \propto d^0$

42. (b) $C = \frac{\varepsilon_0 A}{d} = 1pF$ and $C = \frac{K\varepsilon_0 A}{2d} = 2pF$ $\therefore K = 4$.

43. (b) When a dielectric K is introduced in a parallel plate condenser its capacity becomes K times. Hence $C = 5C_0$. Energy stored $W_0 = \frac{q^2}{2C_0}$

$\therefore W = \frac{q^2}{2C} = \frac{q^2}{2\times5C_0} \Rightarrow W = \frac{W_0}{5}$

44. (a) Force on one plate due to another is

$F = qE = q\times\frac{\sigma}{2\varepsilon_0 K} = q\left(\frac{q}{2AK\varepsilon_0}\right) = \frac{q^2}{2AK\varepsilon_0}$

(where $\frac{\sigma}{2\varepsilon_0 K}$ is the electric field produced by one plate at the location of other).

45. (d) Extra charge $Q = (2CV - CV) = CV$ flows through potential V of the battery. Thus $W = QV = CV^2$

46. (d) If the drops are conducting, then $\frac{4}{3}\pi R^3 = N\left(\frac{4}{3}\pi r^3\right) \Rightarrow R = N^{1/3} r$. Final charge $Q = Nq$

So final potential $V = \frac{Q}{R} = \frac{Nq}{N^{1/3} r} = V \times N^{2/3}$

47. (c) Because the charges are produced due to induction and moreover the net charge of the condenser should be zero.

48. (b) $\Delta E = E_{Final} - E_{Initial} = \frac{1}{2} C(V_{Final}^2 - V_{Initial}^2)$

$= \frac{1}{2} \times 6 \times (20^2 - 10^2) \times 10^{-6}$

$= 3 \times (400 - 100) \times 10^{-6} = 3 \times 300 \times 10^{-6} = 9 \times 10^{-4}\ J$

49. (c) Since aluminum is a metal, therefore field inside this will be zero. Hence it would not affect the field in between the two plates, so capacity $= \frac{q}{V} = \frac{q}{Ed}$ remains unchanged.

50. (a) $V_{Big} = n^{2/3}.v_{small} \Rightarrow V_{Big} = (27)^{2/3}.v_{small} = 9\ v_{small}$

51. (b) In spherical capacitor $C = 4\pi\varepsilon_0 K\left(\frac{ab}{b-a}\right) \Rightarrow C \propto K$

52. (a) In air the potential difference between the plates

$V_{air} = \frac{\sigma}{\varepsilon_0}.d$ ..... (i)

In the presence of partially filled medium potential difference between the plates

$V_m = \frac{\sigma}{\varepsilon_0}(d - t + \frac{t}{K})$ ..... (ii)

Potential difference between the plates with dielectric medium and increased distance is

$V_m' = \frac{\sigma}{\varepsilon_0}\left\{(d + d') - t + \frac{t}{K}\right\}$ ..... (iii)

According to question $V_{air} = V_m'$ which gives $K = \frac{t}{t - d'}$

Hence $K = \frac{2}{2 - 1.6} = 5$

53. (b) Initially $F = qE$ and $E = \frac{\sigma}{\varepsilon_0}$ $\therefore$ $F = \frac{q\sigma}{\varepsilon_0}$

If one plate is removed, then E becomes $\frac{\sigma}{2\varepsilon_0}$

So $F = \frac{q\sigma}{2\varepsilon_0} = \frac{F}{2}$

54. (a) Common potential $V = \frac{\text{Total charge}}{\text{Total capacitance}}$

$V = \frac{150 \times 10^{-6} \times 2}{4\pi\varepsilon_0(10 \times 10^{-2} + 20 \times 10^{-2})} = 9 \times 10^6\ V$

55. (d) Because for metal $K = \infty$.

56. (c) The energy will be minimum in this case and every system tends to possess minimum energy.

57. (d) When the battery is disconnected, the charge will remain same in any case.

Capacitance of a parallel plate capacitor is given by $C = \frac{\varepsilon_0 A}{d}$

When d is increased, capacitance will decreases and because the charge remains the same, so according to $q = CV$, the voltage will increase, Hence the electrostatics energy stored in the capacitor will increase.

58. (c) New potential difference $= \frac{V}{K} = \frac{100}{10} = 10\,V$

59. (b) $4\pi\varepsilon_0 r = \frac{\varepsilon_0 A}{d} \Rightarrow d = \frac{A}{4\pi r} = \frac{\pi(20 \times 10^{-3})^2}{4\pi \times 1} = 0.1\,mm$

60. (c) When dielectric is introduced, the capacitance will increase and as the battery remains connected, so the voltage will remain constant. Hence according to $Q = CV$, the charge will increase.

61. (a) $4\pi\varepsilon_0 r = 1 \times 10^{-6} \Rightarrow r = 10^{-6} \times 9 \times 10^9 = 9\,km$

62. (b) After inserting the dielectric slab

New capacitance $C = K.C = \frac{K\varepsilon_0 A}{d}$

New potential difference $V = \frac{V}{K}$

New charge $Q = C\,V = \frac{\varepsilon_0 AV}{d}$

New electric field $E = \frac{V}{d} = \frac{V}{Kd}$

Work done (W) = Final energy – Initial energy

W $= \frac{1}{2}C\,V^2 - \frac{1}{2}CV^2 = \frac{1}{2}(KC)\left(\frac{V}{K}\right)^2 - \frac{1}{2}CV^2$

$= \frac{1}{2}CV^2\left(\frac{1}{K}-1\right) = -\frac{1}{2}CV^2\left(1-\frac{1}{K}\right)$

$= -\frac{\varepsilon_0 AV^2}{2d}\left(1-\frac{1}{K}\right)$ so $|W| = \frac{\varepsilon_0 AV^2}{2d}\left(1-\frac{1}{K}\right)$.

63. (d)

64. (b) $E = \frac{V}{d} = \frac{100}{10^{-3}} = 10{,}0000\ V/m$

65. (d) The electric field between the spheres of a charged capacitor is non-uniform and it decreases with distance from the centre as $E \propto \frac{1}{r^2}$.

66. (d) $C = \frac{\varepsilon_0 A}{d-(d/2)} = 2\frac{\varepsilon_0 A}{d}$

67. (b) In charging of capacitor half of the supplied energy is stored in the capacitor.

68. (c) In this process capacity increases, so battery supplies additional charge to capacitor.

69. (d) By using $C_{air} = \frac{\varepsilon_0 A}{d}$, $C_{medium} = \frac{\varepsilon_0 A}{d-t+\frac{t}{K}}$

For $K = \infty$ $\quad C_{medium} = \frac{\varepsilon_0 A}{d-t}$

$\Rightarrow \frac{C_m}{C_a} = \frac{d}{d-t} \Rightarrow \frac{C_m}{15} = \frac{6}{6-3} \Rightarrow C_m = 30\mu C$

70. (d) $C = \frac{\varepsilon_0 KA}{d} \Rightarrow C \propto K, Q = CV \Rightarrow Q \propto C$ ($\because V$ = constant)

71. (a) Initially when key is closed, the capacitor acts as short-circuit, so bulb will light up. But finally the capacitor becomes fully charged, so it will act as open circuit, so bulb will not glow.

72. (c) $C_1 = \varepsilon_0 \frac{A}{d_1}$ and $C_2 = K\varepsilon_0 \frac{A}{d_2}$

$\therefore \frac{C_1}{C_2} = \frac{1}{K}\times\frac{d_2}{d_1} = \frac{C}{2C} = \frac{1}{K}\times\frac{2d}{d} \Rightarrow K = 4$

73. (b) Capacity of spherical conductor of 20 *cm* diameter $C_1 = 4\pi\varepsilon_0 r = 4\pi\varepsilon_0 \times 10$

Capacity of parallel plate air capacitor

$C_2 = \frac{\varepsilon_0 A}{d} = \frac{\varepsilon_0[\pi(2)^2]}{d} = \frac{\varepsilon_0 \times 4\pi}{d}$

Hence $C_1 = C_2 \Rightarrow 40\pi\varepsilon_0 = \frac{4\pi\varepsilon_0}{d} \Rightarrow d = 10^{-3} m$

74. (c) Capacity when outer sphere is earthed

$C_1 = 4\pi\varepsilon_0 \frac{ab}{b-a}$

Capacity when inner sphere is earthed

$C_2 = 4\pi\varepsilon_0 b + \frac{4\pi\varepsilon_0 ab}{b-a} = 4\pi\varepsilon_0\left(\frac{b^2}{b-a}\right)$

Difference in capacity $= C_2 - C_1 = 4\pi\varepsilon_0 b$

75. (a)

76. (d) Electric field between the plates of parallel plate capacitor is uniform and it doesn't depend upon distance.

77. (b) $C = \frac{K\varepsilon_0 A}{d}$; $\therefore \frac{C_1}{C_2} = \frac{K_1}{K_2} \Rightarrow \frac{C}{C_2} = \frac{5}{20} \Rightarrow C_2 = 4C$

78. (c) $C \propto \frac{ab}{b-a}$; $a = R - x, b = R$ so, $C \propto \frac{R(R-x)}{x}$

79. (d) When there is no battery, charge remains same while potential difference and electric field decreases

i.e. $Q = Q_0, V = \frac{V_0 \times 3}{9} = \frac{V_0}{3}$ and $E = \frac{E_0 \times 3}{9} = \frac{E_0}{3}$

80. (a) $V = n^{2/3} v \Rightarrow V = (64)^{2/3} \times 9 \times 10^9 \times \frac{10^{-9}}{(2\times 10^{-2})}$

$= 7.2 \times 10^3\ V$

81. (d) $V = n^{2/3}\ v \Rightarrow V = (125)^{2/3} \times 50 = 1250\ V$

82. (a) $W_{ext} = \frac{1}{2}C'V'^2 - \frac{1}{2}CV^2$

$= \left(\frac{1}{2}\right)\left(\frac{C}{2}\right)(2V)^2 - \frac{1}{2}CV^2 = \frac{1}{2}CV^2$

$W_{ext} = \frac{1}{2}\times 50\times 10^{-6}\times(100)^2 = 25\times 10^{-2}\ J$

83. (c) $\Delta V = \frac{1}{2}\frac{C\times C}{(C+C)}|V-(-V)|^2 = CV^2$

84. (c) $C = \frac{\varepsilon_0 A}{\left(\frac{t_1}{k_1}+\frac{t_2}{k_2}\right)} = \frac{\varepsilon_0 A}{\frac{6\times 10^{-3}}{10}+\frac{4\times 10^{-3}}{5}} = \frac{5000}{7}\varepsilon_0 A$

85. (c) Initially charge on the capacitor $Q = 10\times 12 = 120\mu C$

Finally charge on the capacitor $Q' = (5\times 10)\times 12 = 600\mu C$

So charge supplied by the battery later $= Q' - Q = 480\mu C$

86. (a)

87. (c) Heat produced = Energy of charged capacitor $= \frac{1}{2}CV^2$

$= \frac{1}{2}\times(2\times 10^{-6})\times(100)^2 = 0.01J$

88. (a)

89. (b) Potential of both spheres will be same.

90. (d) $C_{air} = \frac{C_{medium}}{K} = \frac{C}{2}$

91. (a) We have $C = \frac{\varepsilon_0 A}{d} \Rightarrow A = \frac{Cd}{\varepsilon_0} = \frac{3 \times 5 \times 10^{-3}}{8.85 \times 10^{-12}}$

$= 1.7 \times 10^9 m^2$

92. (b) $Q = CV = \frac{\pi (0.08)^2 \varepsilon_0}{1 \times 10^{-3}} \times 100 = 1.8 \times 10^{-8} C$

93. (d) $C = \frac{A\varepsilon_0}{d} = 10 \mu F$

$C_1 = \frac{A\varepsilon_0}{d - t + \frac{t}{k}} = \frac{A\varepsilon_0}{d - \frac{d}{2} + \frac{d}{2k}} = \frac{A\varepsilon_0}{\frac{d}{2}\left(1 + \frac{1}{2}\right)} = \frac{4}{3} \cdot \frac{A\varepsilon_0}{d}$

$\therefore C_1 = \frac{4}{3} \times 10 = 13.33 \mu F$

94. (b) The energy stored $= \frac{1}{2} QV$

95. (c) $C_1 = \frac{\varepsilon_0 A}{d}$ and $C_2 = \frac{K\varepsilon_0 A}{2d}$

$\Rightarrow \frac{C_2}{C_1} = \frac{K}{2} \Rightarrow \frac{40 \times 10^{-12}}{10 \times 10^{-12}} = \frac{K}{2} \Rightarrow K = 8$

96. (c) $C = n^{1/3} C \Rightarrow C = 2^{1/3} C \Rightarrow 2C < C' > C$

97. (c) $U = \frac{1}{2} CV^2 = \frac{1}{2} \times 2 \times 10^{-6} \times (200)^2 = 4 \times 10^{-2} J$

98. (c) $C = 4\pi\varepsilon_0 R$, $R = \frac{C}{4\pi\varepsilon_0} \Rightarrow$

$R = (1/9) \times 9 \times 10^9 = 10^9 m$

99. (a)

100. (b) $C = 4\pi\varepsilon_0 R$

$R = \frac{C}{4\pi\varepsilon_0} = 9 \times 10^9 \times 10^{-12} = 9 \times 10^{-3} m$

Diameter $= 2R = 2 \times 9 \times 10^{-3} = 18 \times 10^{-3} m$

101. (b) $V = \frac{Q}{C} = \frac{Qd}{\varepsilon_0 KA} \Rightarrow V \propto d$

102. (a) $U = \frac{1}{2} CV^2 = \frac{1}{2} \times 10 \times 10^{-12} \times (50)^2 = 1.25 \times 10^{-8} J$

103. (c) $F_A = F_B$; because an uniform electric field produced between the plates.

104. (b) $K = \frac{t}{t-d} = \frac{4 \times 10^{-3}}{4 \times 10^{-3} - 3.5 \times 10^{-3}} = 8$

105. (a) $E_{medium} = \frac{E_{air}}{k}$

106. (a) Maximum potential difference

$= 19 \frac{kV}{mm} \times 0.01 mm = 0.19 kV = 190 V$

107. (b) $C' = n^{1/3} C = (64)^{1/3} C = 4C$

108. (d) $U = \frac{1}{2} CV^2 = \frac{1}{2} \times 700 \times 10^{-12} (50)^2 = 8.7 \times 10^{-7} J$

109. (d) $\Delta U = U_2 - U_1 = \frac{V^2}{2}(C_2 - C_1)$

$= \frac{(100)^2}{2}(10-2) \times 10^{-6} = 4 \times 10^{-2} J$

110. (a) $U = \frac{1}{2} CV^2 = \frac{1}{2} \times 12 \times 10^{-12} \times (50)^2 = 1.5 \times 10^{-8} J$

111. (c) $C \propto \frac{1}{d} \Rightarrow \frac{C_1}{C_2} = \frac{d_2}{d_1} \Rightarrow \frac{15}{C_2} = \frac{2}{6} \Rightarrow C_2 = 45 \mu F$

112. (d)

113. (c) $C = \frac{\varepsilon_0 A}{d}$ and $C = \frac{\varepsilon_0 A}{\left(d - t + \frac{t}{K}\right)} \Rightarrow \frac{C}{C} = \frac{\left(d - t + \frac{t}{K}\right)}{d}$

$\Rightarrow \frac{20}{C} = \frac{\left(2 \times 10^{-3} - 1 \times 10^{-3} + \frac{1 \times 10^{-3}}{2}\right)}{2 \times 10^{-3}} \Rightarrow$

$C = 26.6 \mu F$

114. (a, b)

115. (a) $C = \frac{\varepsilon_0 KA}{d} \Rightarrow \frac{C_1}{C_2} = \frac{K_1}{K_2} \times \frac{d_2}{d_1}$

$\frac{2}{C_2} = \frac{1}{2.8} \times \frac{(0.4/2)}{(0.4)} \Rightarrow C_2 = 11.2 \mu F$

116. (c) $\Delta U = \frac{1}{2} \frac{C_1 C_2 (V_2 - V_1)^2}{(C_1 + C_2)} = \frac{(3 \times 5) \times 10^{-12} \times (500 - 300)^2}{(3+5) \times 10^{-6}}$

$= \frac{15 \times 10^{-12} \times 4 \times 10^4}{8 \times 10^{-6}} = 0.0375 J$

117. (b) Charge on smaller sphere

= Total charge $\left(\frac{r_1}{r_1 + r_2}\right) = 30\left(\frac{5}{5+10}\right) = 10 \mu C$

118. (d) $C = \frac{\varepsilon_0 A}{d}$ and $C = \frac{\varepsilon_0 A}{\left\{d - \frac{d}{2} + \frac{(d/2)}{\infty}\right\}} = \frac{2\varepsilon_0 A}{d}$

$\Rightarrow C = 2C$

119. (b) By inserting the dielectric slab. Capacitance (*i.e.* ability to hold the charge) increases. In the presence of battery more charge is supplied from battery.

120. (a) Initial energy of body of capacitance 4 μF is

$U_i = \frac{1}{2} \times (4 \times 10^{-6})(80)^2 = 0.0128 J$

Final potential on this body after connection is $V = \frac{4 \times 80 + 6 \times 30}{4 + 6} = 50 V$. So final energy on it

$U_f = \frac{1}{2} \times 4 \times 10^{-6} (50)^2 = 0.005 J$

Energy lost by this body $= U_i - U_f = 7.8 mJ$

121. (d)

122. (d) Capacitance of the given assembly

$C = 4\pi\varepsilon_0\left(\frac{R_1R_2}{R_2 - R_1}\right) \Rightarrow C \propto \frac{R_1R_2}{(R_2 - R_1)}$

123. (d)

124. (c) $C \propto \frac{1}{d} \Rightarrow \frac{C_1}{C_2} = \frac{d_2}{d_1}$ so $\frac{C_2}{10} = \frac{8}{4} \Rightarrow C_2 = 20\mu F$

125. (a) $U = \frac{1}{2}CV^2$ so $24 \times 60 \times 60 = \frac{1}{2}C(1200)^2 \Rightarrow$ C=120 mF

126. (a) Energy density

$= \frac{1}{2}\varepsilon_0 E^2 = \frac{1}{2}\varepsilon_0\left(\frac{\sigma}{\varepsilon_0}\right)^2 = \frac{\sigma^2}{2\varepsilon_0} = \frac{q^2}{2\varepsilon_0 A^2}$

127. (b) $U = \frac{Q^2}{2C} = \frac{(40 \times 10^{-6})^2}{2 \times 10^{-6} \times 10} = \frac{16 \times 10^{-10}}{2 \times 10^{-5}} = 8 \times 10^{-5}\, J$

$= 8 \times 10^{-5} \times 10^7 = 800\, erg$

128. (c)

129. (b) $F = \frac{CV^2}{2d} = \frac{Q \times E}{2} = \frac{10^{-6} \times 10^5}{2} = 0.05\, N$

130. (d) Work done $W = U_f - U_i$

$U_i = \frac{1}{2}CV_0^2$ and $U_f = \frac{1}{2}\frac{(C)}{3}.(3V_0)^2 = 3 \times \frac{1}{2}CV_0^2$

So $W = \frac{\varepsilon_0 A V_0^2}{d}$

131. (b) In the presence of battery potential difference remains constant. Also $E = \frac{V}{d}$, so E remains same.

132. (c) Capacitance with dielectric $C_{medium} = \frac{K\varepsilon_0 A}{d}$

$\Rightarrow C_{medium} \propto \frac{K}{d}$

133. (a)

134. (a) Thin metal plates doesn't affect the capacitance.

135. (b) $U = \frac{1}{2}C_{eq}V^2 = \frac{1}{2}(nC)V^2$

136. (c) $U_{Big} = n^{5/3}\, u_{small}$

137. (c) After redistribution new charges on spheres are $Q_1 = \left(\frac{10}{10+20}\right) \times 10 = \frac{10}{3}\mu C$

and $Q_2 = \left(\frac{20}{10+20}\right) \times 10 = \frac{20}{3}\mu C$

Ratio of charge densities $\frac{\sigma_1}{\sigma_2} = \frac{Q_1'}{Q_2'} \times \frac{r_2^2}{r_1^2}$

$= \frac{10/3}{20/3} \times \left(\frac{20}{10}\right)^2 = \frac{2}{1}$ $\left\{\sigma = \frac{Q}{4\pi r^2}\right\}$

138. (d) $\frac{\sigma_{small}}{\sigma_{Big}} = \frac{q}{Q} \times \frac{R^2}{r^2} = \frac{q}{(nq)} \times \frac{(n^{1/3}r)^2}{r^2} = n^{-1/3} = (64)^{-1/3} = \frac{1}{4}$

139. (a) $C = 4\pi \epsilon_0 R = \frac{1}{9 \times 10^9} \times 1 = 1.1 \times 10^{-10}\, F$

140. (d) $U = \frac{1}{2}CV^2 = \frac{1}{2} \times 2 \times 10^{-6} \times (50)^2 = 25 \times 10^{-4}\, J$

$= 25 \times 10^3\, erg$

141. (d) $U = \frac{1}{2}CV^2 = \frac{1}{2}5 \times 10^{-6} \times (20 \times 10^3)^2 = 1kJ$

142. (d) $C = \frac{\varepsilon_0 A}{d}$ As $A \to \frac{1}{2}$ times and $d \to 2$ times

So $C \to \frac{1}{4}$ times *i.e.* $C = \frac{1}{4}C = \frac{12}{4} = 3\,\mu F$

143. (c) $U = \frac{1}{2}CV^2 = \frac{1}{2} \times 6 \times 10^{-6}(100)^2 = 0.03 J$

144. (c) Because there is no source of charge.

145. (d) $C_{air} = \frac{\varepsilon_0 A}{d}$, with dielectric slab $C' = \frac{\varepsilon_0 A}{\left(d - t + \frac{t}{K}\right)}$

Given $C = \frac{4}{3}C \Rightarrow \frac{\varepsilon_0 A}{\left(d - t + \frac{t}{K}\right)} = \frac{4}{3} \times \frac{\varepsilon_0 A}{d}$

$\Rightarrow K = \frac{4t}{4t - d} = \frac{4(d/2)}{4[(d/2) - d]} = 2$

146. (d) $U = \frac{1}{2}CV^2 = \frac{1}{2} \times 10 \times 10^{-6} \times (500)^2 = 1.25 J$

147. (c) $C = \frac{\varepsilon_0 A}{d} \Rightarrow \varepsilon_0 = \frac{Cd}{A} \Rightarrow \varepsilon_0 \to \frac{Farad \times m}{m^2} \to \frac{F}{m}$

148. (a) $W = \frac{Q^2}{2C} = \frac{(8 \times 10^{-18})^2}{2 \times 100 \times 10^{-6}} = 32 \times 10^{-32}\, J$

149. (a) $V = n^{2/3}v = (64)^{2/3} \times 10 = 160\, volt$

150. (d) $V = n^{2/3}v \Rightarrow 2.5 = (125)^{2/3}v \Rightarrow V = \frac{2.5}{25} = 0.1\, volt$

151. (a) Let $E = \frac{1}{2}C_0V_0^2$ then $E_1 = 2E$ and $E_2 = \frac{E}{2}$

So $\frac{E_1}{E_2} = \frac{4}{1}$

152. (c) Work done appears in the form of energy which is given by $\frac{q^2}{2C}$

153. (b) Some energy lost in the form of heat in resistance also.

154. (c) Given $\Rightarrow$ $V = 200\,volt,\ \ Q = 0.1\,C$

As energy $U = \frac{QV}{2},\ U = \frac{0.1\times 200}{2} = 10\ Joule$

155. (b) $V = n^{2/3}v = (8)^{2/3}v = 4v$ *i.e.* 4 times.

156. (b) $U = \frac{Q^2}{2C}$; in given case C increases so U will decrease.

157. (b) Power $= \frac{\frac{1}{2}CV^2}{t} = \frac{1\times 40\times 10^{-6}\times(3000)^2}{2\times 2\times 10^{-3}} = 90\ kW$

158. (c) Using $C = n^{1/3}c \Rightarrow c = \frac{C}{n^{1/3}} = \frac{C}{(8)^{1/3}} = \frac{C}{2} = \frac{1}{2}\mu F$

159. (d) $C = \frac{\varepsilon_0 A}{d}$ ......(i)

$C = \frac{\varepsilon_0 KA}{2d}$ ......(ii)

From equation (i) and (ii) $\frac{C}{C} = \frac{K}{2} \Rightarrow$

$2 = \frac{K}{2} \Rightarrow K = 4$

160. (a) Energy $U = \frac{1}{2}\frac{Q^2}{C}$ for a charged capacitor charge Q is constant and with the increase in separation C will decrease $\left(C \propto \frac{1}{d}\right)$, So overall U will increase.

161. (b)

162. (b) In general electric field between the plates of a charged parallel plate capacitor is given by $E = \frac{\sigma}{\varepsilon_0 K}$

163. (a) When a lamp is connected to D.C. line with a capacitor. If will form an open circuit. Hence, the lamp will not glow.

164. (b) The increase in energy of the capacitor

$\Delta U = \frac{1}{2}C(V_2^2 - V_1^2) = \frac{1}{2}(6\times 10^{-6})(20^2 - 10^2)$

$= 3\times 10^{-6}\times 300 = 9\times 10^{-4}\,J$

165. (b) $U = \frac{1}{2}CV^2 = \frac{1}{2}\times 4\times 10^{-6}\times(400)^2 = 0.32\,J$

166. (b) The energy density of parallel plate capacitor is given by $U = \frac{1}{2}\varepsilon_0 E^2 = \frac{1}{2}\varepsilon_0\left(\frac{V}{d}\right)^2$

$= \frac{1}{2}\times 8.85\times 10^{-12}\,C^2/Nm^2\times\left(\frac{300\ volt}{2\times 10^{-3}m}\right)^2 = 0.1\,J/m^3$

167. (d) Dielectric constant of medium

$K = \frac{\text{Capacity of condenser with medium}}{\text{Capacity of condenser}} = \frac{12}{2.0} = 6$

168. (b) $C = \frac{K\varepsilon_0 A}{d} \propto \frac{K}{d}$

Hence, $\frac{C_1}{C_2} = \frac{K_1}{K_2}\times\frac{d_2}{d_1} = \frac{K}{2K}\times\frac{d/2}{d} = \frac{1}{4}$

Therefore, $C_2 = 4C_1$

169. (d) $Q_1 = 10^{-2}C,\ Q_2 = 5\times 10^{-2}C$

Total charge of the system $Q = 6\times 10^{-6}\,C$

Charge on small sphere

$Q_1 = \frac{Qr_1}{r_1 + r_2} = \frac{6\times 10^{-2}\times 1}{1+2} = 2\times 10^{-2}C$

170. (a) The potential difference across the parallel plate capacitor is $10\,V - (-10\,V) = 20\,V$.

Capacitance $= \frac{Q}{V} = \frac{40}{20} = 2F$.

171. (c) $V = Q/C$

Q = the amount of charge

C = capacitance which depends on geometry and size of conductor.

Grouping of Capacitors

1. (d) $Q_1 = CV$ and $Q_2 = CV$

Applying charge conservation

$CV_1 + CV_2 = Q_1 + Q_2$

$CV_1 + CV_2 = 2CV \Rightarrow V_1 + V_2 = 2V$

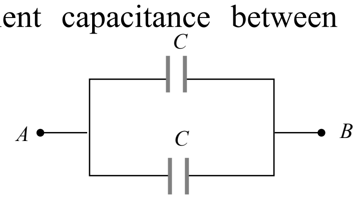
2. (a)

3. (c) The given arrangement becomes an arrangement of $(n-1)$ capacitors connected in parallel. So $C_R = (n-1)C$

4. (a)

5. (a) The given circuit is equivalent to a parallel combination two identical capacitors

Hence equivalent capacitance between A and B is



$C = \frac{\varepsilon_0 A}{d} + \frac{\varepsilon_0 A}{d}$

$= \frac{2\varepsilon_0 A}{d}$

6. (c) $C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = 2.4\mu F.$

Charge flown = 2.4 × 500 × 10^{-6} C =1200 μC.

7. (c) $C_R = C_1 + C_2 = \frac{k_1 \varepsilon_0 A_1}{d} + \frac{k_2 \varepsilon_0 A_2}{d}$

$= \frac{2 \times \varepsilon_0 \frac{A}{2}}{d} + \frac{4 \times \varepsilon_0 \frac{A}{2}}{d} = 2 \times \frac{10}{2} + 4 \times \frac{10}{2} = 30\mu F$

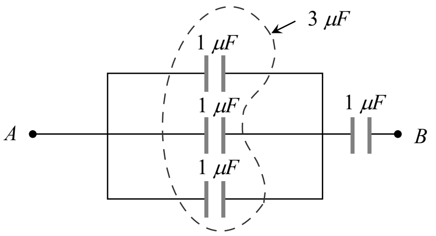
8. (d) In series combination, charge is same on each capacitor.

9. (b) According to energy conservation, energy remains the same

$\Rightarrow U_{parallel} = U_{series} \Rightarrow \frac{1}{2}(nC)V^2 = \frac{1}{2}\left(\frac{C}{n}\right)V'^2 \Rightarrow V' = nV$

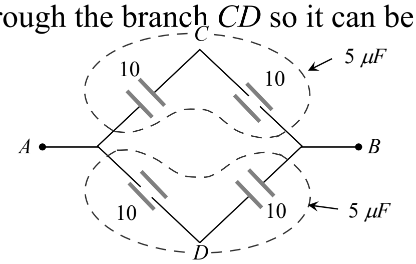
(V = potential difference across series combination)

10. (d) The circuit can be drawn as follows



$\Rightarrow C_{AB} = \frac{3 \times 1}{3 + 1} = \frac{3}{4}\mu F$

11. (d) In the given system, no current will flow through the branch CD so it can be removed



Effective capacitance of the system $= 5 + 5 = 10\mu F$

12. (a) $\frac{1}{C_s} = \frac{1}{3} + \frac{1}{9} + \frac{1}{18} = \frac{1}{2} \Rightarrow C_s = 2\mu F$

$C_p = 3 + 9 + 18 = 30\mu F \Rightarrow \frac{C_s}{C_p} = \frac{2}{30} = \frac{1}{15}$

13. (b) Total capacitance of given system $C_{eq} = \frac{8}{5}\mu F$

$U = \frac{1}{2}C_{eq}V^2 = \frac{1}{2} \times \frac{8}{5} \times 10^{-6} \times 225 = 180 \times 10^{-6} J$

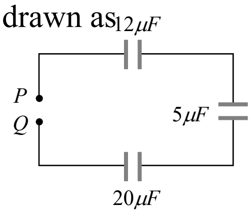
$= 180 \times 10^{-6} \times 10^7 \, erg = 1800 \, erg$

14. (c) $U = \frac{1}{2}CV^2 = \frac{1}{2} \times 2 \times (200)^2 \times 10^{-6} = 0.04 J$

15. (c) $Q_1 = Q_2 + Q_3$ because in series combination charge is same on both the condenser and $V = V_1 + V_2$ because in parallel combination $V_2 = V_3$.

Hence $V = V_1 + V_2$

16. (b) The given circuit can be drawn as



where $C = (3 + 2)\mu F = 5\mu F$

$\frac{1}{C_{PQ}} = \frac{1}{5} + \frac{1}{20} + \frac{1}{12} = \frac{20}{60} = \frac{1}{3}$

$\Rightarrow C_{PQ} = 3\mu F$

17. (b) In series combination Q is constant, hence according to

$U = \frac{Q^2}{2C} \Rightarrow U \propto \frac{1}{C} \Rightarrow \frac{U_1}{U_2} = \frac{C_2}{C_1} = \frac{0.6}{0.3} = \frac{2}{1}$

18. (b) Potential difference across $4\mu F$ capacitor

$V = \left(\frac{6}{4+6}\right) \times 500 = 300 \, volt$

19. (c) Charge flowing $= \frac{C_1 C_2}{C_1 + C_2}V$. So potential difference across $C_1 = \frac{C_1 C_2 V}{C_1 + C_2} \times \frac{1}{C_1} = \frac{C_2 V}{C_1 + C_2}$

20. (c) In parallel, $C = C_1 + C_2 + C_3 = 20\mu F$

21. (c) $\frac{1}{C_R} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \Rightarrow C_R = (C_1^{-1} + C_2^{-1} + C_3^{-1})^{-1}$

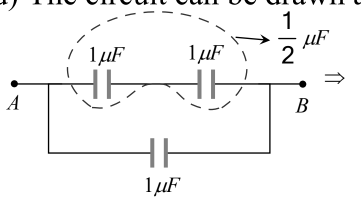
22. (c) $C_1 = 2C$ and $C_2 = C/2$, so $C_1 / C_2 = 4:1$

23. (a) In parallel combination $V_1 = V_2$

or $\frac{q_1}{C_1} = \frac{q_2}{C_2} \Rightarrow \frac{q_1}{q_2} = \frac{C_1}{C_2}$

24. (c)

25. (d) The circuit can be drawn as follows



$\Rightarrow$ Equivalent capacitance $C_{eq} = \frac{1}{2} + 1 = \frac{3}{2}\mu F$

26. (a) Energy (U) $=\frac{q^2}{2C}$. q remains same so $U \propto \frac{1}{C}$

$\Rightarrow \frac{U_{Before}}{U_{After}} = \frac{C_1 + C_2}{C_1}$

27. (a) $C_{AB} = 3+\frac{3}{3} = 4, \mu F$ $C_{AC} = \frac{3}{2}+\frac{3}{2} = 3\mu F$

$\therefore C_{AB} : C_{AC} = 4:3$

28. (c) Initial energy $U_i = \frac{1}{2}C_1V_1^2 + \frac{1}{2}C_2V_2^2$, Final energy $U_f = \frac{1}{2}(C_1 + C_2)V^2$ (where $V = \frac{C_1V_1 + C_2V_2}{C_1C_2}$)

Hence energy loss $\Delta U = U_i - U_f = \frac{C_1C_2}{2(C_1 + C_2)}(V_1 - V_2)^2$

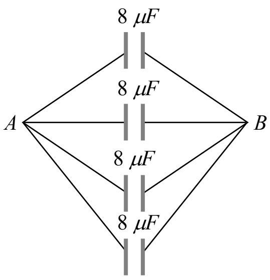
29. (b) The two capacitors are in parallel so $C = \frac{\varepsilon_0 A}{t \times 2}(k_1 + k_2)$

30. (c) $\frac{1}{C} = \frac{1}{2}+\frac{1}{2}+\frac{1}{2}$ $\Rightarrow C = \frac{2}{3}F$

31. (c) Charges developed are same so $C_1V_1 = C_2V_2$ $\Rightarrow \frac{V_1}{V_2} = 2$

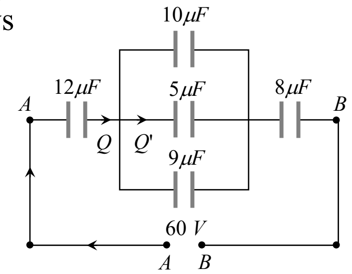
$V_1 + V_2 = 120 \Rightarrow V_1 = 80\ volts$

32. (a) Given circuit can be drawn as



Equivalent capacitance = 4 × 8 = 32μF

33. (d) The given circuit can be redrawn ass follows

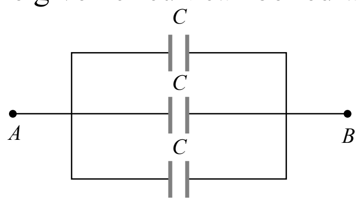


Equivalent capacitance of the circuit $C_{AB} = 4\mu F$

Charge given by the battery $Q = C_{eq}V = 4 \times 60 = 240\mu C$

Charge in 5μF capacitor $Q = \frac{5}{(10+5+9)} \times 240 = 50\mu C$

34. (b) The given circuit can be redrawn as follows



$\Rightarrow C_{AB} =$

35. (b) The given arrangement is equivalent to the parallel combination of three identical capacitors. Hence equivalent capacitance $= 3C = 3\frac{\varepsilon_0 A}{d}$

36. (d) Total capacitance $\frac{1}{C} = \frac{1}{20}+\frac{1}{8}+\frac{1}{12}$ $\Rightarrow$ $C = \frac{120}{31}\mu F$

Total charge $Q = CV = \frac{120}{31} \times 300 = 1161\mu C$

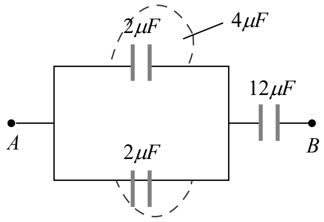
Charge, through 4 μF condenser $= \frac{1161}{2} = 580\mu C$

and potential difference across it $= \frac{580}{4} = 145V$

37. (c) $U = \frac{1}{2}CV^2$

Now if V is constant, then U is greatest when 'C_{eq}' is maximum. This is when all the three are in parallel.

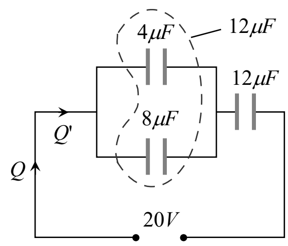
38. (d)



$\Rightarrow C_{AB} = \frac{4 \times 12}{4+12} = 3\mu F$

39. (b) Equivalent capacitance of the circuit $C_{eq} = 6\mu F$

Charge supplied from source Q = 6 × 20 =120 μC

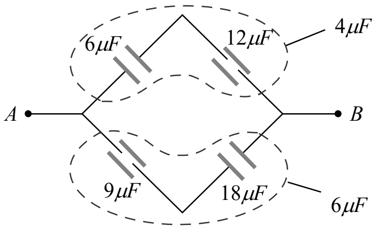


Hence charge on the plates of 4 μF capacitor

$= Q = \frac{4}{(4+8)} \times 120 = 40\mu C$

40. (b) Charge flows to second capacitor until the potential is same *i.e.* $V/2$. So new charge = $CV/2$

41. (d) Given circuit can be drawn as follows. It is a balance whetstone bridge type network, hence 24 μF capacitor can be neglected

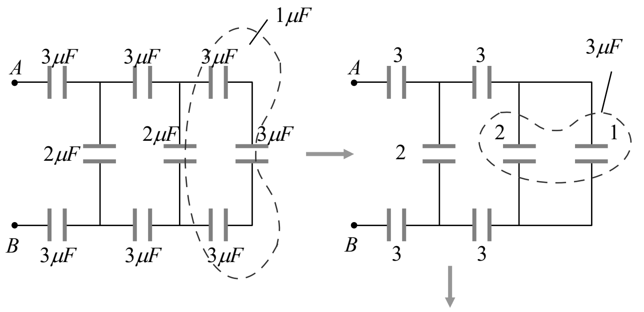


Equivalent capacitance between A and $B = 4 + 6 = 10\mu F$.

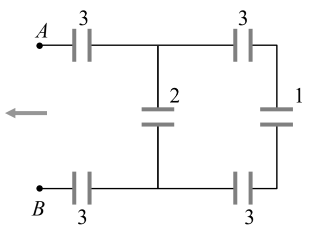
42. (c) By using, common potential $V = \frac{C_1 V_1 + C_2 V_2}{C_1 + C_2}$

$\Rightarrow 20 = \frac{2 \times 200 + C_2 \times 0}{2 + C_2} \Rightarrow C_2 = 18\mu F$

43. (a) The given circuit can be redrawn as follows



On further solving the network in similar manner equivalent



capacitance obtained between A and B will be 1 μF.

44. (d) 12 μF and 6μF are in series and again are in parallel with 4μF.

Therefore, resultant of these three will be

$= \frac{12 \times 6}{12 + 6} + 4 = 4 + 4 = 8\mu F$

This equivalent system is in series with 1 μF.

Its equivalent capacitance $= \frac{8 \times 1}{8 + 1} = \frac{8}{9}\mu F$ ....(i)

Equivalent of 8μF, 2μF and 2μF

$= \frac{4 \times 8}{4 + 8} = \frac{32}{12} = \frac{8}{3}\mu F$

.....(ii)

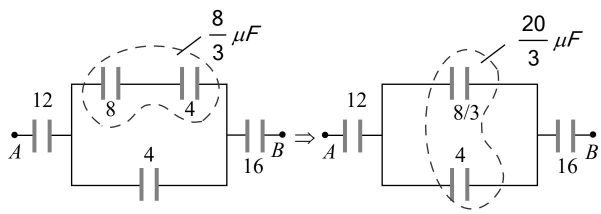
(i) and (ii) are in parallel and are in series with C

$\therefore \quad \frac{8}{9} + \frac{8}{3} = \frac{32}{9}$ and $C_{eq} = 1 = \frac{\frac{32}{9} \times C}{\frac{32}{9} + C} \Rightarrow$

$C = \frac{32}{23}\mu F$

45. (d) The two capacitors formed by the slabs may assumed to be in series combination.

46. (d) The given circuit can be simplified as follows



Hence equivalent capacitance between A and B

$\frac{1}{C_{AB}} = \frac{1}{12} + \frac{1}{20/3} + \frac{1}{16} \Rightarrow C_{AB} = \frac{240}{71} F$

47. (c) Let q_1, q_2 be the charges on two condensers

$\therefore \; V = \frac{q_1}{6} = \frac{q_2}{14} \Rightarrow \frac{q_1}{q_2} = \frac{6}{14} = \frac{3}{7}$

Also $\quad q_1 + q_2 = 600 \Rightarrow \quad q_1 + \frac{14}{6} q_1 = 600 \Rightarrow$

$q_1 = \frac{600}{20} \times 6$

$\therefore \; V = \frac{q_1}{6} = \frac{600}{20} = 30 \; volt$

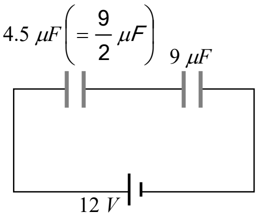
48. (a) By using charge conservation $0.2 \times 600 = (0.2 + 1)V$

$\Rightarrow V = \frac{0.2 \times 600}{1.2} = 100 \; V$

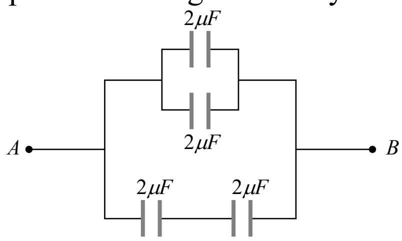
49. (d) The given circuit can be redrawn as follows potential difference across 4.5 μF capacitor

$V = \dfrac{9}{\left(\dfrac{9}{2}+9\right)} \times 12$

$= 8\ V$



50. (b) The possible arrangement may be



51. (a) By using $V = \dfrac{C_1V_1 + C_2V_2}{C_1 + C_2}$

$\Rightarrow 40 = \dfrac{10\times 100 + C_2 \times 0}{10 + C_2} \Rightarrow C_2 = 15\mu F$

52. (a) The total energy before connection

$= \dfrac{1}{2}\times 4\times 10^{-6}\times (50)^2 + \dfrac{1}{2}\times 2\times 10^{-6}\times (100)^2$

$= 1.5\times 10^{-2}\ J$

When connected in parallel

$4\times 50 + 2\times 100 = 6\times V \Rightarrow V = \dfrac{200}{3}$

Total energy after connection

$= \dfrac{1}{2}\times 6\times 10^{-6}\times \left(\dfrac{200}{3}\right)^2 = 1.33\times 10^{-2}\ J$

53. (b) $\dfrac{1}{C} = \dfrac{1}{3} + \dfrac{1}{6} \Rightarrow C = 2\ pF$

Total charge $= 2\times 10^{-12}\times 5000 = 10^{-8}\ C$

The new potential when the capacitors are connected in parallel is

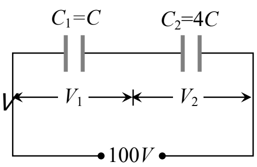
$V = \dfrac{2\times 10^{-8}}{(3+6)\times 10^{-12}} = 2222\ V$

54. (b) $C_{eq} = \dfrac{C\times 4C}{(C + 4C)} = \dfrac{4C}{5}$

$Q = C_{eq}.V = \dfrac{4C}{5}\times 100 = 80C$

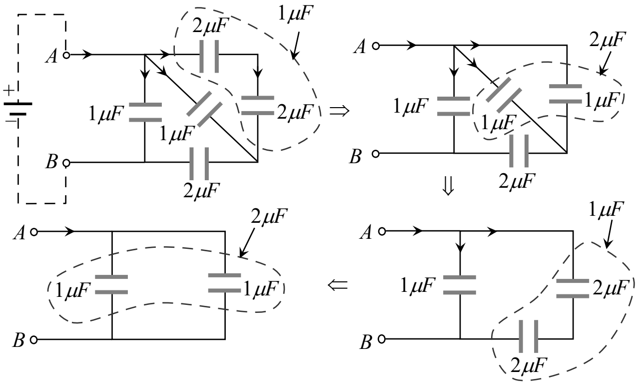
Hence $V_1 = \dfrac{Q}{C_1} = \dfrac{80C}{C_1} = 80\ V$

and $V_2 = \dfrac{80C}{4C} = 20\ V$



55. (d) $C_{PQ} = \dfrac{1}{3}\mu F + 1\mu F = \dfrac{4}{3}\mu F$

56. (b) The given circuit can be simplified as follows



Hence equivalent capacitance between A and B is $2\mu F$.

57. (a) From the given figure, total capacitance is

$\dfrac{1}{1} = \dfrac{1}{C} + \dfrac{1}{(1+2.5)} \Rightarrow 1 = \dfrac{1}{C} + \dfrac{1}{3.5} \Rightarrow$

$C = \dfrac{3.5}{2.5} = 1.4\ \mu F$

58. (a) Loss of energy during sharing $= \dfrac{C_1C_2(V_1 - V_2)^2}{2(C_1 + C_2)}$

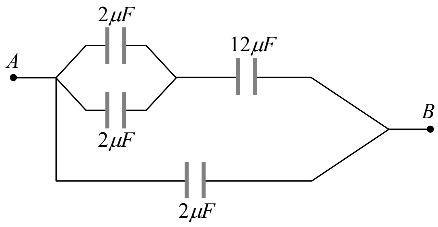
In the equation, put $V_2 = 0,\ V_1 = V_0$

$\therefore$ Loss of energy $= \dfrac{C_1C_2V_0^2}{2(C_1 + C_2)}$

$= \dfrac{C_2U_0}{C_1 + C_2}\quad \left[\because U_0 = \dfrac{1}{2}C_1V_0^2\right]$

59. (d) Minimum when connected in series and maximum when connected in parallel.

60. (c) The circuit can be rearranged as



Net capacitance between $AB = \dfrac{4\times 12}{4+12} + 2 = 5\ \mu F$

61. (c) Energy stored in the capacitor $= \dfrac{1}{2}CV^2\times 100$

$= \dfrac{1}{2}\times 10\times 10^{-6}\times (100\times 10^3)^2\times 100 = 5\times 10^6\ J$

Electric energy costs $= 108\ Paise\,per\,kWH$

$= \dfrac{108\ Paise}{3.6\times 10^6\ J}$

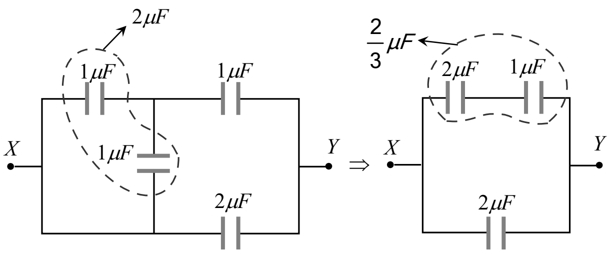
$\therefore$ Total cost of charging $= \dfrac{5\times10^6\times108}{3.6\times10^6} = 150\ Paise$

62. (b) Net capacitance $= \dfrac{1}{\left(\dfrac{1}{2}+\dfrac{1}{3}+\dfrac{1}{6}\right)} = 1\,\mu F$

Total charge $= CV = 1\,\mu F \times 10\ V = 10\,\mu C$

Total charge on every capacitor in series system is same. So charge on 3 μF is 10 μC.

63. (c) The given circuit can be simplified as follows



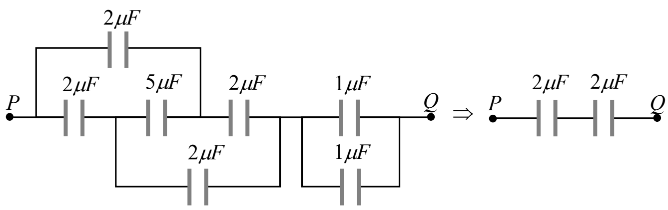
$\Rightarrow C_{xy} = \dfrac{2}{3} + 2 = \dfrac{8}{3}\,\mu F$

64. (c) Common potential $V = \dfrac{6\times20+3\times0}{(6+3)} = \dfrac{120}{9}\ Volt$

So, charge on $3\,\mu F$ capacitor

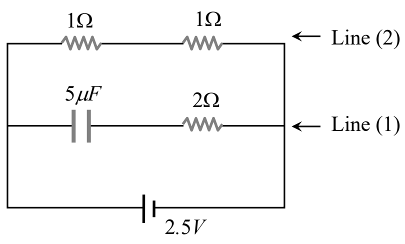
$Q_2 = 3\times10^{-6}\times\dfrac{120}{9} = 40\,\mu C$

65. (b) The given circuit can be redrawn as follows



$\Rightarrow C_{PQ} = 1\,\mu F$

66. (c) In steady state condition. No current flows through line (1). Hence total current $i = \dfrac{2.5}{(1+1+0.5)} = 1\ A$



Potential difference a cross line (2) = potential difference a cross capacitor $= 1\times2 = 2\ Volt$

So, charge on capacitor = 5 × 2 = 10 μC

67. (d)

68. (b) Initially potential difference a cross each capacitor

$V_1 = \dfrac{20}{(10+20)}\times200 = \dfrac{400}{3}\ V$

and $V_2 = \dfrac{10}{(10+20)}\times200 = \dfrac{200}{3}\ V$

Finally common potential $V = \dfrac{C_1V_1 + C_2V_2}{C_1+C_2}$

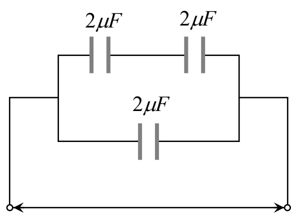
$$V = \dfrac{10\times\dfrac{400}{3} + 20\times\dfrac{200}{3}}{(10+20)} = \dfrac{800}{9}\ V$$

69. (c) Charge on C_1 = charge on C_2

$\Rightarrow C_1(V_A - V_D) = C_2(V_D - V_B)$

$\Rightarrow C_1(V_1 - V_D) = C_2(V_D - V_2) \Rightarrow V_D = \dfrac{C_1V_1 + C_2V_2}{C_1 + C_2}$

70. (c) $C = \dfrac{2\times2}{2+2} + 2 = 3\,\mu F$



71. (d) $V = \dfrac{C_1V_1 + C_2V_2}{C_1+C_2} \Rightarrow 20 = \dfrac{10\times50 + C_2\times0}{10 + C_2}$

$\Rightarrow 200 + 20C_2 = 500 \Rightarrow C_2 = 15\,\mu F$

72. (d) The given figure is equivalent to a balanced Wheatstone's bridge, hence $C_{eq} = 6\,\mu F$

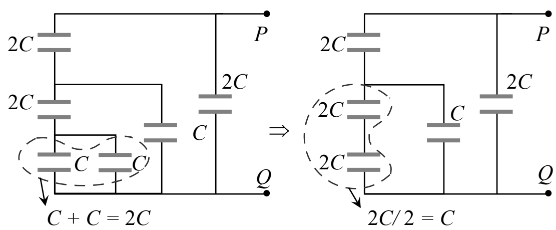
73. (a) $C_p = 4C_s \Rightarrow (C_1 + C_2) = 4\dfrac{C_1C_2}{(C_1+C_2)}$

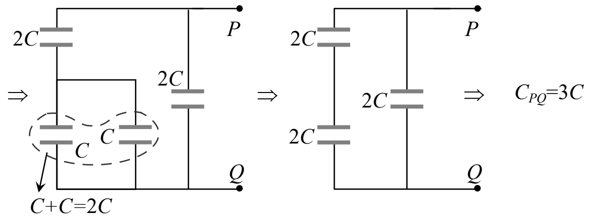
$\Rightarrow (C_1 - C_2)^2 = 0 \Rightarrow C_1 = C_2$

74. (a) In steady state potential difference a cross capacitor $= 2V$.

So charge on capacitor $Q = 10\times2 = 20\,\mu C$

75. (a)





76. (b) There are two capacitors parallel to each other.

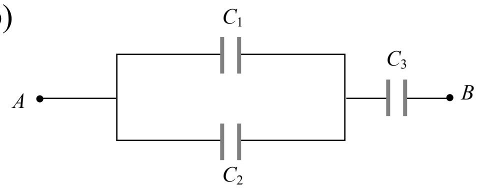
$\therefore$ Total capacitance $= \dfrac{2\varepsilon_0 A}{d}$

$\therefore$ Energy stored $= \dfrac{1}{2}\left(\dfrac{2\varepsilon_0 A}{d}\right)V^2$

$= \dfrac{8.86\times10^{-12}\times50\times10^{-4}\times12^2}{3\times10^{-3}} = 2.1\times10^{-9}\,J$

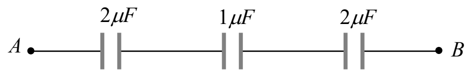
77. (c) $V = \dfrac{V_1C_1+V_2C_2}{C_1+C_2} = \dfrac{500\times20+200\times10}{20+10} = 400\,V$

78. (b)



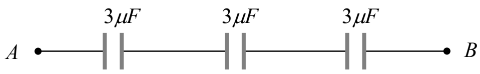
$C = \dfrac{(C_1+C_2)\times C_3}{(C_1+C_2)+C_3} = \dfrac{(5+10)\times4}{5+10+4} = \dfrac{60}{19} = 3.2\,\mu F$

79. (d)



$\dfrac{1}{C} = \dfrac{1}{2}+\dfrac{1}{1}+\dfrac{1}{2} = \dfrac{1+2+1}{2} = \dfrac{4}{2} = 2 \Rightarrow C_{AB} = 0.5\,\mu F$

80. (a)



$\dfrac{1}{C_{AB}} = \dfrac{1}{3}+\dfrac{1}{3}+\dfrac{1}{3} = 1 \Rightarrow C_{AB} = 1\,\mu F$

81. (d) $C_1 + C_2 + C_3 = 12$ ....(i)

$C_1C_2C_3 = 48$ ....(ii)

$C_1 + C_2 = 6$ ....(iii)

From equation (i) and (iii)

$C_3 = 6$ ....(iv)

From equation (ii) and (iv) $C_1C_2 = 8$

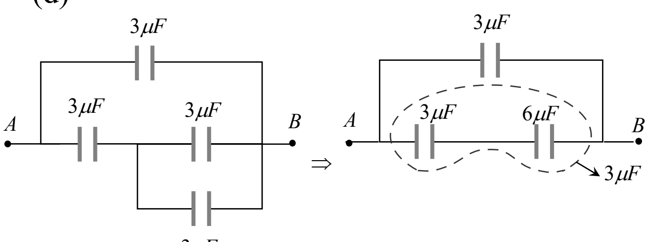
Also $(C_1 - C_2)^2 = (C_1 + C_2)^2 - 4C_1C_2$

$(C_1 - C_2)^2 = (6)^2 - 4\times8 = 4$

$\Rightarrow C_1 - C_2 = 2$ .....(v)

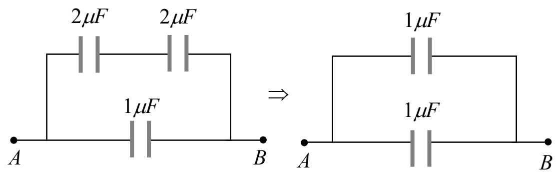
On solving (iii) and (v) $C_1 = 4,\ C_2 = 2$

82. (d)



$\Rightarrow C_{AB} = 5\mu F$

83. (b) The given circuit can be redrawn as shown below



$\Rightarrow C_{AB} = 2\mu F$

84. (b) In series combination charge Q is same. So charge on $2\mu F$ capacitor is

$Q = C_{eq}V = \left(\dfrac{2\times8}{2+8}\right)\times300\times10^{-6} = 4.8\times10^{-4}\,C$

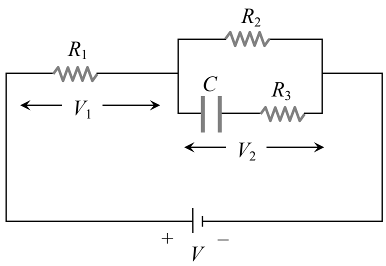
85. (b) In series $V' = nV = 10\ V$

86. (b) In steady state potential difference across capacitor

V_2=potential difference across resistance

$R_2 = \left(\dfrac{R_2}{R_1+R_2}\right)V$

Hence V_2 depends upon R_2 and R_1



87. (b) $C_1 = \dfrac{K_1\varepsilon_0 \frac{A}{2}}{\left(\frac{d}{2}\right)} = \dfrac{K_1\varepsilon_0 A}{d}$

$C_2 = \dfrac{K_2\varepsilon_0 \frac{A}{2}}{\left(\frac{d}{2}\right)} = \dfrac{K_2\varepsilon_0 A}{d}$ and $C_3 = \dfrac{K_3\varepsilon_0 A}{\left(\frac{d}{2}\right)} = \dfrac{2K_3\varepsilon_0 A}{d}$

$\dfrac{1}{C_{eq}} = \dfrac{1}{C_1+C_2}+\dfrac{1}{C_3} = \dfrac{1}{\frac{\varepsilon_0 A}{d}(K_1+K_2)}+\dfrac{1}{\frac{\varepsilon_0}{d}\times2K_3}$

$$\frac{1}{C_{eq}} = \frac{d}{\varepsilon_0 A}\left[\frac{1}{K_1 + K_2} + \frac{1}{2K_3}\right]$$

$$C_{eq} = \left[\frac{1}{K_1 + K_2} + \frac{1}{2K_3}\right]^{-1} \cdot \frac{\varepsilon_0 A}{d}$$

So $K_{eq} = \left[\frac{1}{K_1 + K_2} + \frac{1}{2K_3}\right]^{-1}$

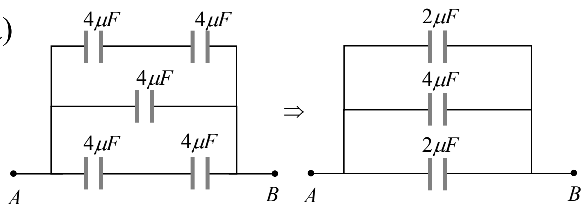
88. (b) In series combination of capacitors, voltage distributes on them, in the reverse ratio of their capacitance *i.e.* $\frac{V_A}{V_B} = \frac{3}{2}$ ......(i)

Also $V_A + V_B = 10$ ....(ii)

On solving (i) and (ii) $V_A = 6V$, $V_B = 4V$

89. (d) $C' = C/n = \frac{6 \times 10^{-12}}{3} = 2 \times 10^{-12} F$

90. (a)



$\Rightarrow C_{AB} = 8\ \mu F$

91. (d) In series combination of capacitor charge on each capacitor is same $Q_1 = Q_2 = Q = C_{eq}V$

$$C_{eq}V = \left(\frac{10 \times 20}{10 + 20}\right) \times 30 = \frac{200}{30} \times 30 = 200\ \mu C$$

92. (d) $C_1 = \frac{K_1\varepsilon_0 \frac{A}{2}}{\left(\frac{d}{2}\right)} = \frac{K_1\varepsilon_0 A}{d}$

$C_2 = \frac{K_2\varepsilon_0\left(\frac{A}{2}\right)}{\left(\frac{d}{2}\right)} = \frac{K_2\varepsilon_0 A}{d}$ and $C_3 = \frac{K_3\varepsilon_0 A}{2d} = \frac{K_3\varepsilon_0 A}{2d}$

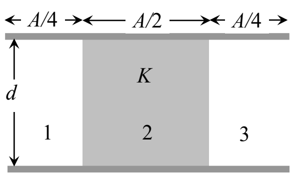
Now, $C_{eq} = C_3 + \frac{C_1C_2}{C_1 + C_2} = \left(\frac{K_3}{2} + \frac{K_1K_2}{K_1 + K_2}\right) \cdot \frac{\varepsilon_0 A}{d}$

93. (c) $\frac{1}{C_{eq}} = \frac{1}{3} + \frac{1}{10} + \frac{1}{15} \Rightarrow C_{eq} = 2\mu F$

Charge on each capacitor

$Q = C_{eq} \times V \Rightarrow 2 \times 100 = 200\mu C$

94. (a) $C_1 = \frac{\varepsilon_0\left(\frac{A}{4}\right)}{d}, C_2 = \frac{K\varepsilon_0\left(\frac{A}{2}\right)}{d}, C_3 = \frac{\varepsilon_0\left(\frac{A}{4}\right)}{d}$



$$C_{eq} = C_1 + C_2 + C_3 = \left(\frac{K+1}{2}\right)\frac{\varepsilon_0 A}{d} = \left(\frac{4+1}{2}\right) \times 10 = 25\mu F$$

95. (b)

96. (b) $C_{eq} = \frac{C_1C_2}{C_1 + C_2} + C_3 = \frac{2 \times 6}{2 + 6} + 4 = 5.5\ \mu F$

Energy supplied $(E) = QV = CV^2 = 22 \times 10^{-6}\ J$

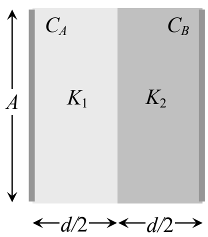
P.E. stored

$(U) = \frac{1}{2}C_{eq}V^2 = \frac{1}{2} \times 5.5 \times (2)^2 = 11 \times 10^{-6}\ J$

$\Rightarrow$ Energy lost $= E - U = 11 \times 10^{-6}\ J$

97. (d) $\Delta U = \frac{C_1C_2}{2(C_1 + C_2)}(V_1 - V_2)^2 = \frac{20 \times 30}{2(20 + 30)}(5 - 0)^2 = 150 J$

98. (d) $C_A = \frac{K_1\varepsilon_0 A}{d/2}, C_B = \frac{K_2\varepsilon_0 A}{d/2}$



$\therefore\ C_{eq} = \frac{C_1}{C_2} = \frac{2K_1K_2}{K_1 + K_2}$

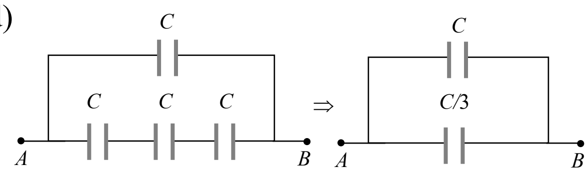
$= \frac{C_AC_B}{C_A + C_B} = \left(\frac{2K_1K_2}{K_1 + K_2}\right)\frac{\varepsilon_0 A}{d}$

$\left(\because\ C = \frac{\varepsilon_0 A}{d}\right)$

99. (c) All capacitors are in parallel

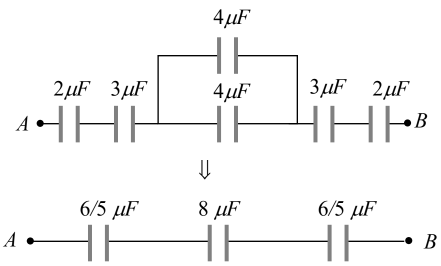
So, $C_{eq} = 1\mu F + 1\mu F + 1\mu F = 3\mu F$

100. (d)



$\Rightarrow C_{eq} = \frac{C}{3} + C = \frac{4C}{3}$

101. (b)



$$\frac{1}{C_{eq}} = \frac{5}{6} + \frac{1}{8} + \frac{5}{6} = \frac{20 + 3 + 20}{24} \Rightarrow C_{eq} = \frac{24}{43}\mu F$$

102. (b) Given circuit is a balanced Whetstone bridge.

103. (b) In steady state charge on C_1 is

$$Q_1 = \left(\frac{C_1}{C_1 + C_2}\right) \times Q = \frac{Q}{3}$$

and charge on C_2 is $Q_2 = \left(\frac{C_2}{C_1 + C_2}\right).Q = \frac{2}{3}Q$

104. (a) $\frac{1}{C_{eq}} = \frac{1}{2} + \frac{1}{3} + \frac{1}{6} \Rightarrow C_{eq} = 1\,\mu F$

Total charge $Q = C_{eq}.V = 1 \times 24 = 24\ \mu C$

So p.d. across 6 μF capacitor = $\frac{24}{6} = 4\ volt$

105. (b) $V = \frac{C_1V_1 - C_2V_2}{C_1 + C_2} = \frac{6 \times 12 - 3 \times 12}{3 + 6} = 4\ volt$

106. (c) Initial energy of the system

$$U_i = \frac{1}{2}CV_1^2 + \frac{1}{2}CV_2^2$$

When the capacitors are joined, common potential $V = \frac{CV_1 + CV_2}{2C} = \frac{V_1 + V_2}{2}$

Final energy of the system

$$U_f = \frac{1}{2}(2C)V^2 = \frac{1}{2}2C\left(\frac{V_1 + V_2}{2}\right)^2 = \frac{1}{4}C(V_1 + V_2)^2$$

Decrease in energy = $U_i - U_f = \frac{1}{4}C(V_1 - V_2)^2$

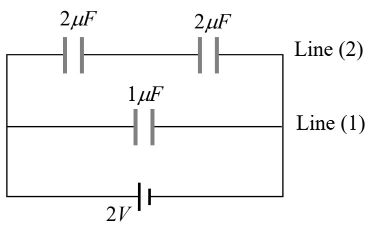
107. (d) $V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2} = \frac{10 \times 250 + 5 \times 100}{10 + 5} = 200\ volt$

108. (b) $\frac{1}{C_{eq}} = \frac{1}{1} + \frac{1}{2} \Rightarrow C_{eq} = \frac{2}{3}\mu F$

109. (d) Potential difference across both the lines is same i.e. 2 V. Hence charge flowing in line 2

$$Q = \left(\frac{2}{2}\right) \times 2 = 2\,\mu C$$

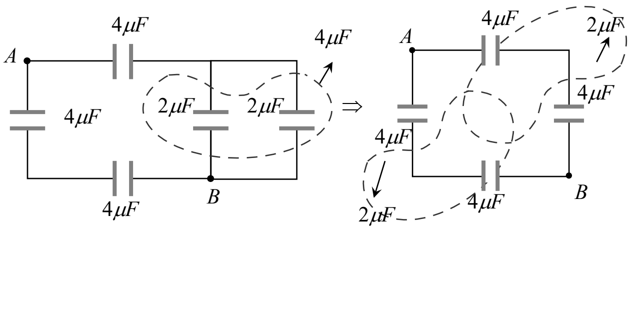
So charge on each capacitor in line (2) is 2 μC



110. (a) In series $C = C'/n$ *i.e.* $C' = nC = 2 \times 3 = 6\ \mu F$

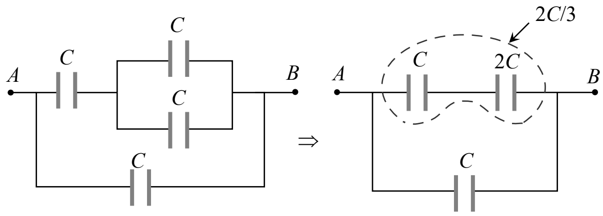
In parallel $C' = nC$ *i.e.* $C' = \frac{C}{n} = \frac{12}{2} = 6\ \mu F$

111. (c) The given circuit can be simplified as follows



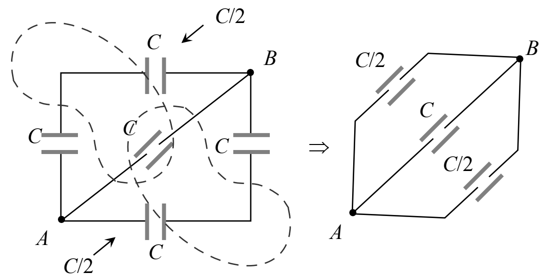
Equivalent capacitance between A and B is $C_{AB} = 4\ \mu F$

112. (c) The given circuit can be simplified as follows



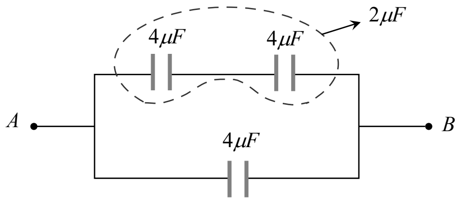
Equivalent capacitance between A and B is $C_{AB} = \frac{5}{3}C$

113. (a) The given circuit can be simplified as follows



Equivalent capacitance between A and B is $C_{AB} = 2\ C$

114. (b) The given circuit can be drawn as follows



$\Rightarrow C_{AB} = 2 + 4 = 6\mu F$

115. (a) $C_{max} = nC = 3 \times 3 = 9\mu F$, $C_{min} = \frac{C}{n} = \frac{3}{3} = 1\,\mu F$

116. (c) Common potential $V = \frac{C_1V + C_2 \times 0}{C_1 + C_2} = \frac{C_1}{C_1 + C_2}.V$

117. (c) $\frac{1}{C_{eq}} = \frac{1}{1} + \frac{1}{2} + \frac{1}{8} \Rightarrow C_{eq} = \frac{8}{13}\mu F$

Total charge $Q = C_{eq}V = \frac{8}{13} \times 13 = 8\mu C$

Potential difference across $2\mu F$ capacitor $= \frac{8}{2} = 4\,V$

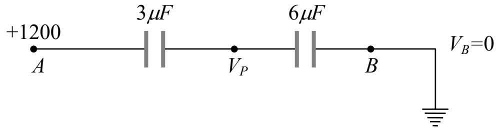
118. (d) Equivalent capacitance $= \frac{2\times 3}{2+3} = \frac{6}{5}\mu F$

Total charge by $Q = CV = \frac{6}{5}\times 1000 = 1200\mu C$

Potential (V) across $2\mu F$ is $V = \frac{Q}{C} = \frac{1200}{2} = 600\,volt$

$\therefore$ Potential on internal plates $= 1000 - 600 = 400\,V$

119. (c) Given circuit can be reduced as follows



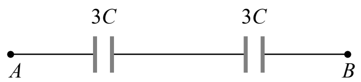
In series combination charge on each capacitor remain same. So using $Q = CV$

$\Rightarrow C_1V_1 = C_2V_2 \Rightarrow 3(1200 - V_p) = 6(V_P - V_B)$

$\Rightarrow 1200 - V_p = 2V_p \quad (\because V_B = 0)$

$\Rightarrow 3V_p = 1200 \Rightarrow V_p = 400\,volt$

120. (b) Given circuit can be reduced as follows

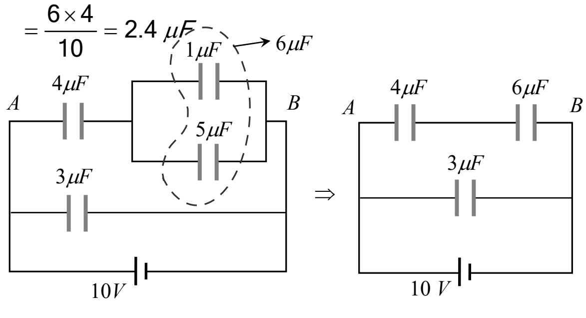


(C = capacitance of each capacitor)

The capacitor $3C$, $3C$ shown in figure can with stand maximum 200 V.

$\therefore$ So maximum voltage that can be applied across A and B equally shared. Hence maximum voltage applied cross A and B be equally shared. Hence max. voltage applied across A and B will be (200 + 200) = 400 *volt*.

121. (b) Equivalent capacity between A and B $= \frac{6\times 4}{10} = 2.4\,\mu F$



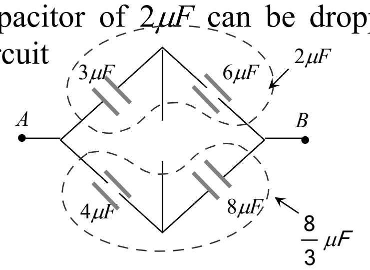
Hence charge across $4\mu F$ (Since in series combination charge remains constant) or 6 $\mu F = 2.4 \times 10 = 24\,\mu C$

122. (d) The given circuit is equivalent to parallel combination of two identical capacitors, each having capacitance $C = \frac{\varepsilon_0 A}{d}$. Hence

$C_{eq} = 2C = \frac{2\varepsilon_0 A}{d}$

123. (b) $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} = \frac{1}{2} + \frac{1}{3} + \frac{1}{6} = \frac{3+2+1}{6} = \frac{6}{6} = 1\mu F$

124. (d) Given circuit is balanced Whetstone bridge. So capacitor of $2\mu F$ can be dropped from the circuit



$\Rightarrow C_{AB} = 2 + \frac{8}{3} = \frac{14}{3}\mu F$

125. (d) Equivalent capacitance $\frac{1}{C_{eq}} = \frac{1}{1} + \frac{1}{2} + \frac{1}{3}$

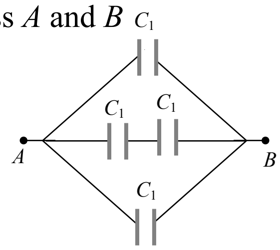
$\Rightarrow C_{eq} = \frac{6}{11}\mu F$

Charge supplied from battery $Q = \frac{6}{11}\times 11 = 6\mu C$

Hence potential difference across $1\mu F$ capacitor $= \frac{6}{1} = 6\,V$

126. (d) The capacitance across A and B

$= \frac{C_1}{2} + C_1 + C_1 = \frac{5}{2}C_1$



As $Q = CV$,

$1.5\mu C = \frac{5}{2}C_1 \times 6$

$\Rightarrow C_1 = \frac{1.5}{15}\times 10^{-6} = 0.1\times 10^{-6}\,F = 0.1\mu F.$

127. (c) After charging, total charge on the capacitor $Q = CV$

$= 10 \times 10^{-6}\,F \times 1000\,V = 10^{-2}\,C.$

Common potential $V = \frac{C_1V_1}{C_1 + C_2} = \frac{10^{-2}}{16\times 10^{-6}} =$ 625V.