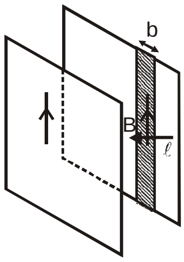
PHYSICS

1. Magnetic field due to one of the sheet

$B = \frac{\mu_0 K}{2}$ Parallel to second sheet



Force on section of width b

$F = bK\ell \frac{\mu_0 K}{2}$

Force per unit area

$P = \frac{B}{\ell b} = \frac{\mu_0 K^2}{2}$

$P = 4\pi \times 10^{-7} \frac{1}{2\pi}$

2. Magnetic field due to circular current carrying loop on axis of loop is :

$B = \frac{\mu_0}{4\pi} \frac{2I\pi R^2}{(R^2 + x^2)^{3/2}}$, I = Qf

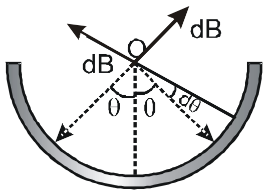
$B_1 + B_2 = 0$

$\frac{Q_1 R^2}{(R^2 + R^2)^{3/2}} + \frac{Q_2 4R^2}{(4R^2 + R^2)^{3/2}} = 0$

$\frac{Q_1}{2\sqrt{2}} + \frac{Q_2 4}{5\sqrt{5}} = 0$

$\frac{Q_1}{Q_2} = -\frac{8\sqrt{2}}{5\sqrt{5}}$

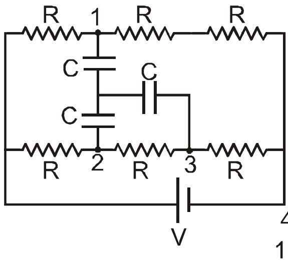
3.



$dB = \frac{\mu_0 d\iota}{2\pi R} = \frac{\mu_0 \times \frac{\varepsilon}{\ell}(\sigma_0 \cos\theta) R d\theta \times t}{2\pi R}$

$B = \int_0^{\pi/2} 2 dB \cos\theta = \frac{\mu_0 \sigma_0 \varepsilon t}{4\ell}$

4. No current passes through capacitors in steady state. Assume potential at point '4' to be zero.

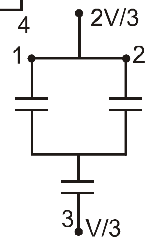


Then points '1' and '2' are at same potential $\frac{2V}{3}$.

Hence C_1 and C_2 can be taken in parallel.

The potential at point 3 is $\frac{V}{3}$.

$\therefore$ Equivalent circuit of all three capacitors is shown



Hence potential difference across capacitor C_3 is

$$= \frac{2C}{2C+C} \times \left(\frac{2V}{3} - \frac{V}{3}\right) = \frac{2V}{9}$$

5. $P_{B_1 + B_2} = 30\ W$

$P_{B_3} = 60\ W$, $P_{B_4} = 60\ W$

$$P_{B_5} = \frac{(200)^2}{\frac{400^2}{120}} = \frac{120}{4} = 30W$$

$P_{total} = 180W$

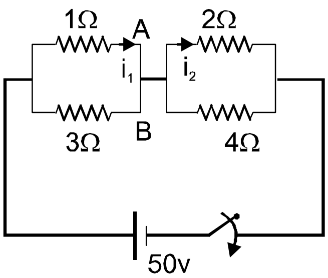
6. Since the cell gives out a power of 10W, a current 2A must flow through the cell towards left.

$\therefore$ Power consumed in 2Ω resistor = $2^2 \times 2$ = 8W

Total current flowing in 1Ω = 7Amp.

$\therefore$ Power consumed by 1Ω = $7^2 \times 1$ = 49 W

7.



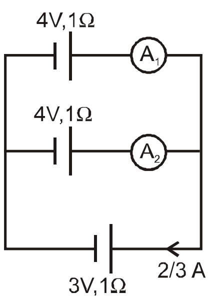
$$R_{eq} = \frac{3}{4} + \frac{8}{6} = \frac{25}{12} \Rightarrow \quad i_0 = \frac{V}{R_{eq}} = 24\ \text{Amp.}$$

$i_1 = \frac{3}{4} \times 24 = 18$ Amp., $i_2 = \frac{4}{6} \times 24 = 32$ Amp.

Current in the branch AB

$\Delta i = 2$ Amp.

8.



9. $\tau = RC = \frac{3}{20}$ s

voltage in capacitor rises to 63% of maximum value.

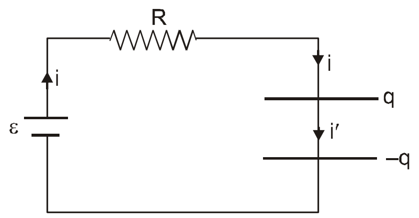
$0.63 = (1 - e^{-t/\tau})$

t = 0.15 s

10. Potential on AB wire is 9V.

Hence ε greater then 9v cannot be measured.

11. **(i)** At t > 0



i′ = current through dielectric

$= \frac{q}{C.R.}$ ...(i)

By K.V.L. $\varepsilon - iR - \frac{q}{C} = 0$ ...(2)

$i = i' + \frac{dq}{dt} = \frac{q}{RC} + \frac{dq}{dt}$ ...(3)

By (2) and $\varepsilon - \left(\frac{q}{RC} + \frac{dq}{dt}\right) R - \frac{q}{C} = 0$

$\Rightarrow \quad \varepsilon C - 2q - RC\frac{dq}{dt} = 0$

$\Rightarrow \quad \varepsilon C - 2q = RC\frac{dq}{dt} \Rightarrow \int_0^q \frac{dq}{\varepsilon C - 2q} = \int_0^t \frac{dt}{RC}$

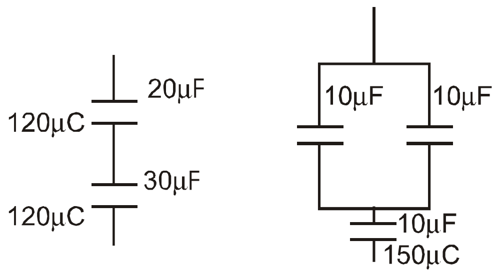
$\Rightarrow \quad -\frac{1}{2}\ell n\frac{\varepsilon C - 2q}{\varepsilon C} = \frac{t}{RC} \Rightarrow \quad q = \frac{\varepsilon C}{2}\left(1 - e^{-\frac{2t}{RC}}\right)$

(ii) $q_{max} = \frac{\varepsilon C}{2}$ as $t \to \infty$

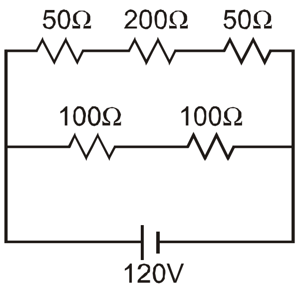
and by (2) $\varepsilon - iR - \frac{\varepsilon}{2} = 0$

$\Rightarrow \quad i = \frac{\varepsilon}{2R}$ at that time.

12.



13.



14. Magnetic field is non zero only in the region between the two solenoids , where $B = \mu_0 n_2 i_2$

$\therefore$ energy stored per unit volume = $\dfrac{B^2}{2\mu_0} = \dfrac{\mu_0 n_2^2 i_2^2}{2}$

The energy per unit length. = energy per unit volume × area of cross section where $B \neq 0$

$= \dfrac{\mu_0 n_2^2 i_2^2}{2}\,[\pi (r_2^2 - r_1^2)]$ $\qquad = \dfrac{\mu_0 n_1^2 i_1^2}{2}\,[\pi(r_2^2 - r_1^2)$, since $n_1 i_1 = n_2 i_2$

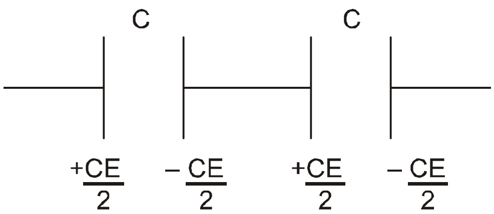
15. $\varepsilon_1 = 300\,\alpha$ ....(i)

$-\varepsilon_2 + \varepsilon_1 = 100\,\alpha$ ....(ii)

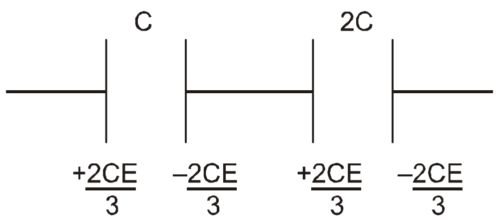
where, α is the potential gradient

$\therefore \quad \dfrac{\varepsilon_2}{\varepsilon_1} = \dfrac{2}{3}$.

16. Initial



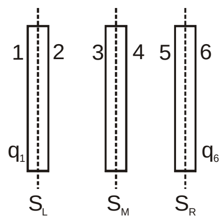
Final



17. Since electric field on plate at surface S_L is zero, net charge on left side of S_L is equal to net charge on right side of S_L. Further net charge between any two dotted surfaces (out of S_L, S_M and S_R) is zero from Gauss theorem.

$\therefore$ Charge on left most surface q_1 is equal to charge on right most surface q_6, that is, $q_1 = q_6$

Hence all statements are true.



18. For given condition :

Magnitude of $B_{solienoid}$ = Magnitude of B_{loop}

$$\mu_0 ni = \frac{\mu_0 I}{2R} \qquad \text{here } n = \frac{\text{Total no. of turn}}{\text{Total length}} = \frac{1300}{0.65}$$

$$i = \frac{I}{2R} \times \frac{1}{n} \qquad = \frac{8 \times 0.65}{2 \times 0.02 \times 1300} \qquad = \qquad 100 \text{ mA.}$$

For given condition :

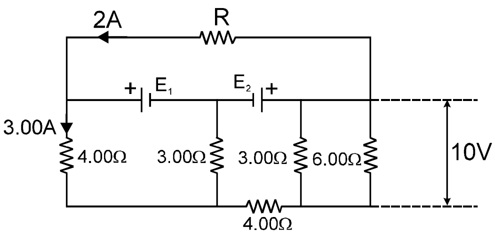
Total magnetic field at the centre of loop

$$= \quad |B_{loop}| + |B_{solenoid}| \qquad \because \qquad |B_{loop}| = ||B_{solenoid}|$$

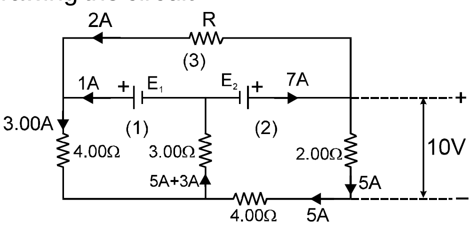
$$= \quad 2|B_{loop}| \qquad = \quad 2 \times \frac{\mu_0 I}{2R}$$

$$= \frac{2 \times 4\pi \times 10^{-7} \times 8}{2 \times 0.02} = 16\,\pi \times 10^{-5} \text{ T.}$$

19.



after redrawing the circuit



(a) $I_4 = 5A$

(b) From loop (1) to (1)

$-8(3) + E_1 - 4(3) = 0 \quad \Rightarrow \quad E_1 = 36$ volt

from loop (2) to (2)

$+4(5) + 5(2) - E_2 + 8(3) = 0$

$E_2 = 54$ volt

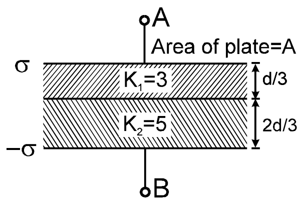
(c) from loop (3) to (3)

$-2R - E_1 + E_2 = 0$

$$R = \frac{E_2 - E_1}{2} = \frac{54}{2} - 36 = 9\ \Omega$$

Ans. (a) 5.00 A (b) 36.0 V, 54.0 V (c) 9.00 Ω

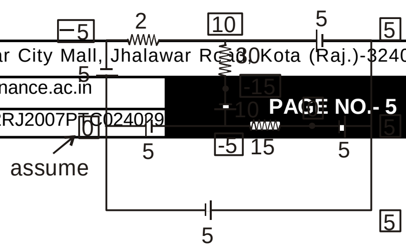
20.



(i) $$\frac{e_1}{e_2} = \frac{\in_1 E_1^2}{\in_2 E_2^2} = \frac{k_1 E_1^2}{k_2 E_2^2} = \left(\frac{k_1}{k_2}\right)\left(\frac{k_2}{k_1}\right)^2 = \frac{k_2}{k_1} = \frac{5}{3}$$

(ii) $$\sigma_B = \sigma\left(1 - \frac{1}{k_1}\right) - \sigma\left(1 - \frac{1}{k_2}\right) = \sigma\left(\frac{1}{k_2} - \frac{1}{k_1}\right) = -\frac{2\sigma}{15}$$

21. Potentials are indicated in figure



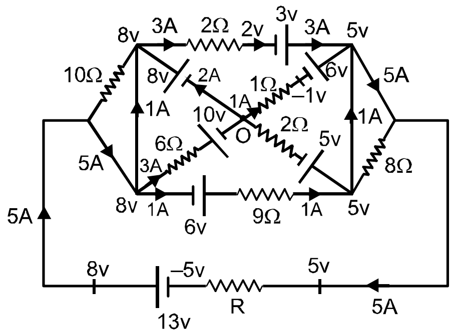
Current in 2Ω $= \frac{10-(-5)}{2} = \frac{15}{2}$ = **7.5 A, leftwards**

Current in 30 Ω $= \frac{10-(-15)}{30} = \frac{25}{30} = \frac{5}{6}$ **A, downwards**

$\frac{i_1}{i_2}$ **= 9**

22. Let the junction located at the center of rectangular portion of circuit be at zero potential .Then potentials of many other points can be shown as in figure . Now current can be written in every branch satisfying KCL.

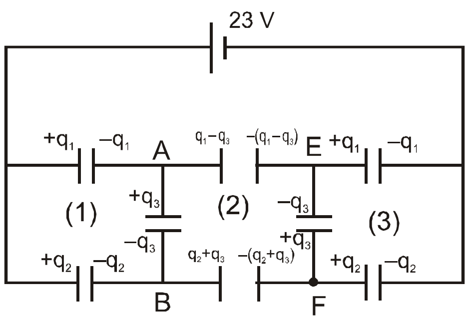
So, $R = \frac{5-(-5)}{5} = 2\Omega$ **Ans.**



Reading of A_1 = 0 **Ans**

& reading A_2 = 5 A **Ans.**

23.



The distribution of charge is shown in figure $\frac{-q_2}{5} + \frac{q_3}{0.75} + \frac{q_1}{15} = 0$

⇒ $q_1 - 3q_2 + 20q_3 = 0$ ....(i)

$-\left(\frac{q_2+q_3}{15}\right) - \frac{q_3}{0.75} + \frac{q_1-q_3}{5} - \frac{q_3}{0.75} = 0$

⇒ $3q_1 - q_2 - 44q_3 = 0$ ....(ii)

$23 - \frac{q_2}{5} - \left(\frac{q_2+q_3}{15}\right) - \frac{q_2}{5} = 0$

$345 = 7q_2 + q_3$ ....(iii)

From eq.(i), (ii), (iii)

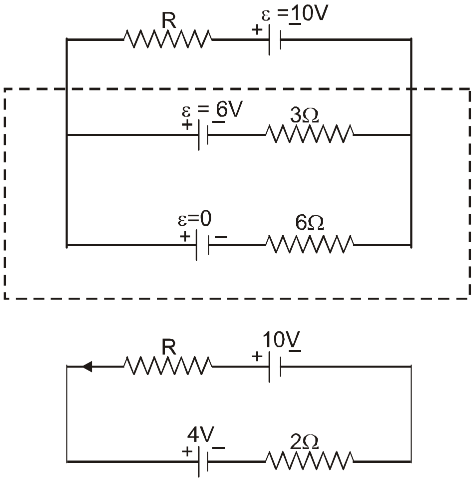
$q_1 = \frac{19 \times 345}{92}$, $q_2 = \frac{13 \times 345}{92}$, $q_3 = \frac{345}{92}$

Potential difference between A and B = $\frac{q_3}{0.75}$ = 5V **...Ans.**

24. Given circuit can be simplified as dotted part can be replaced as

$$\varepsilon_{eq} = \frac{\frac{6}{3}+\frac{0}{6}}{\frac{1}{3}+\frac{1}{6}} = 4V$$

$$\frac{1}{r_{eq}} = \frac{1}{3}+\frac{1}{6} \quad \Rightarrow \quad r_{eq} = 2\Omega$$



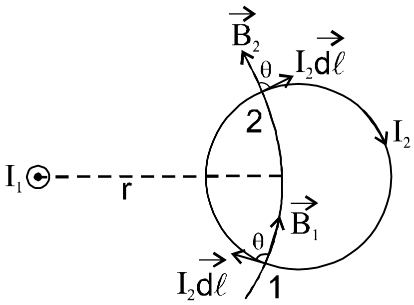
then current $I = \frac{10-4}{2+R} = \frac{6}{2+R}$

Power in R, $P = \left(\frac{6}{2+R}\right)^2 R = \frac{36R}{(2+R)^2}$,

for P to be maximum $\frac{dP}{dR} = 0$

on solving $R = 2\Omega$

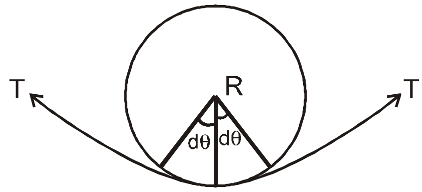
25.



The force on current elements 1 and 2 is equal in magnitude and opposite in direction

$\Rightarrow \quad F_{net} = 0$

26. B at end = $\frac{1}{2}$ B at interior = $\frac{1}{2}$ B



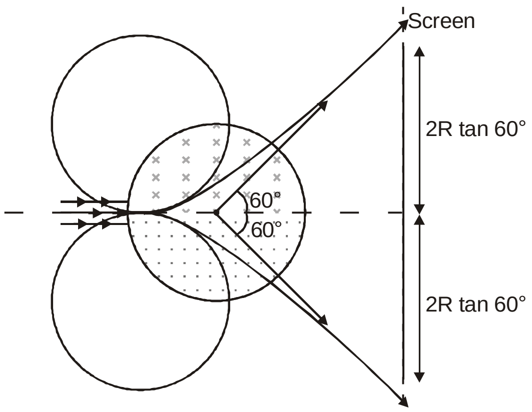
$IdL\left(\frac{B}{2}\right) = 2T \sin d\theta$

$dL = R(2d\theta)$

$I\,R.2d\theta\,\frac{B}{2} = 2T\,d\theta$

$T = \frac{BIR}{2}$

27.



Required d = 4R tan 60° = $4(\sqrt{3})\sqrt{3} = 12$

28. $R_{AC} = R_{CB} = \frac{2\pi\times 20}{3} \times \frac{3}{\pi} = 40\ \Omega$

& $R_{AD} = R_{BD} = \frac{2\pi\times 20}{3} \times \frac{6}{\pi} = 80\ \Omega$

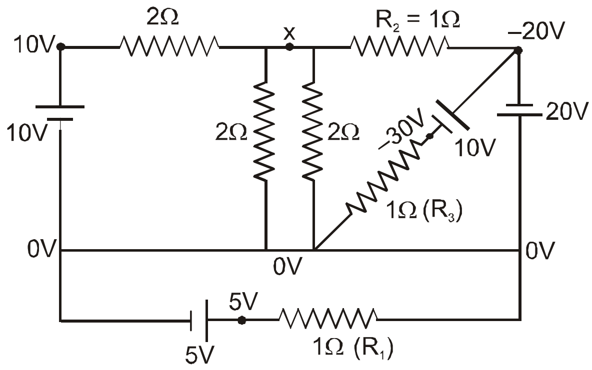
$\Rightarrow$ Balanced W.S.B $\Rightarrow$ $R_{CD} = \frac{120}{2} = 60\ \Omega$

$\varepsilon \times \left(\frac{60}{60+5}\right) = 48\ x$

& $\varepsilon = x\ \ell$

$\Rightarrow$ $\ell \times \frac{60}{65} = 48$ $\Rightarrow$ $\ell = 52$ cm

29.



Potential of different points are shown.

(i) current in R_1

$I_1 = \frac{\Delta V}{R_1} = \frac{5-0}{1}$ A = 5A from left to right.

(ii) current in R_3

$I_3 = \frac{\Delta V}{R_3} = \frac{30}{1}$ A = 30 A from lower to higher.

(iii) For current in R_2
using KCL

$$\frac{10-x}{2} + \frac{0-x}{2} + \frac{0-x}{2} + \frac{-20-x}{1} = 0$$

$\Rightarrow$ $\frac{10}{2} - 20 = \frac{3x}{2} + x \Rightarrow$ $x = -6V$

$\therefore$ $I_2 = \frac{20-6}{1}$ A = 14 A.

30. $E < 10^6$ $\Rightarrow$ $\frac{10^3}{d} < 10^6$

$d > 10^{-3}$ m $\Rightarrow$ $C = \frac{k\varepsilon_0 A}{d}$

$d = \frac{k\varepsilon_0 A}{C} > 10^{-3}$

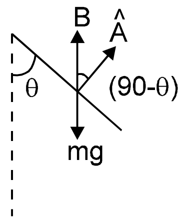
$A > \frac{10^{-3}\ x\ C}{k\varepsilon_0}$ $\Rightarrow$ $A > \frac{10^{-3}\ x\ 50\ x\ 10^{-12}}{(6\pi)\ x \left(\frac{1}{36\pi} x 10^{-9}\right)} = 300\ mm^2$

31. Applying Energy conservation, initially kinetic energy = 0
gravitational P.E. = 0 (say) & Magnetic P.E. = μB

where, μ = magnetic moment of the loop = i. $\left(\frac{\sqrt{3}a^2}{4}\right)$

Finally when the loop becomes horizontal, Kinetic energy = 0

gravitational P.E.=mg$\left(\frac{a}{\sqrt{3}}\right)$ (because mg acts on the centre of mass)



magnetic P.E. = 0

$\Rightarrow \quad 0 + 0 + \mu B = 0 + \frac{mga}{\sqrt{3}} + 0 \Rightarrow \quad B = \frac{mga}{\sqrt{3}\mu} = \frac{4mg}{3ia}$

using values, B = 400 mT

32. Since $\vec{M} \parallel^r \text{ to } \vec{B}$

$\therefore$ torque zero.

33. at C direction must be along $t\hat{k}$ direction.

34. The emf is the difference between emf across straight segment OA and OC.

36. $V_P = x$

$\frac{3-x}{1} = \frac{x-4}{2} + \frac{x+10}{6}$

Solve

q = 2 × 4 = 8μc

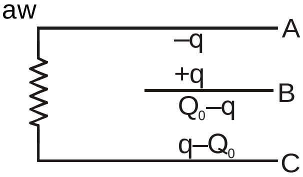
38. The current through the galvanometer is ~ $\frac{1}{1000}$ of total current, the S << G.

39. Potential difference across galvanometer = Potential difference across S.

$\Rightarrow \quad i_g \cdot G = (I - i_g) \cdot S$

$\Rightarrow \quad 10 \times 10^{-3} \cdot 10 = (1 - 10 \times 10^{-3}) \cdot S \quad \Rightarrow \quad R_S = \frac{10^{-1}}{1-10^{-2}} = \frac{10}{99}\,\Omega$

40. At any time t, the charge on right capacitor be q. Applying Kirchoff's law

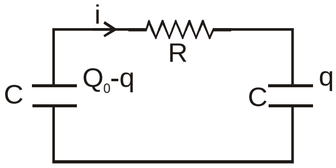


$\frac{Q_0 - q}{C} = iR + \frac{q}{C} \qquad \therefore \quad \frac{Q_0 - 2q}{2CR} = \frac{dq}{dt}$

integrating and evaluating the constant we get

Hence $q = \frac{Q_0}{2}(1 - e^{-\frac{2t}{RC}})$

or $i = \frac{dq}{dt} = \frac{Q_0}{RC} e^{-\frac{2t}{RC}}$



41. At steady state charges on both the capacitor will be equal. Hence charge on plate A is $-Q_0/2$.

42. Finally the charge on either capacitor is $Q_0/2$. Hence heat produced is = initial P.E. – final P.E.

$= \frac{Q_0^2}{2C} - \frac{(Q_0/2)^2}{2C} - \frac{(Q_0/2)^2}{2C} = \frac{Q_0^2 b}{4S\varepsilon_0}$

43. (A) At constant charge, the electric field within the capacitor remains same when plate separation is changed. The electric field in capacitor is $E = \frac{V}{d}$. Hence at constant potential difference the electric field decreases with increase in d.

(B) $U = \frac{1}{2}\frac{Q^2}{C}$. Hence at constant charge U increases with decrease in C.

$U = \frac{1}{2}CV^2$. Hence at constant potential difference U decreases with decrease in C.

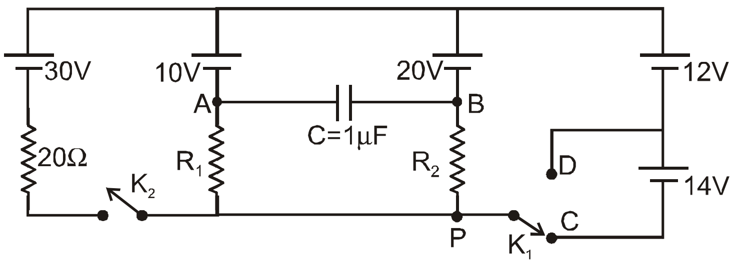
(C) Capacitance increases on insertion of dielectric.

(D) As a result of insertion of dielectric the capacitance increases

$U = \frac{1}{2}\frac{Q^2}{C}$. Hence at constant charge U decreases with increase in C.

$U = \frac{1}{2}CV^2$. Hence at constant potential difference U increases with increase in C.

44. The state of key K_2 has no effect on current through R_1 and R_2 as well has no effect on charge in the capacitor. Also position of key K_1 has no effect on potential difference between points A and B, that is $V_A – V_B$ =10 volts under all conditions. Hence charge on capacitor under all cases is 10μC.



Assume the potential at point P to be zero,

When Key K_1 is in position C: V_A = 16 Volt and V_B = 6 volts. Hence current in both R_1 and R_2 will flow downwards.

When Key K_1 is in position D: V_A = 2 Volt and V_B = – 8 volts. Hence current through R_1 will flow downwards and through R_2 will flow upwards.