Phy 112

Name : Udoy Saha

ID : 21301095

Section : 10

Chapter 25 Problem 53

Here, plate area, $A = 0.12\ m^2$

Separation distance, $d = 1.2cm = 0.012\ m$

Potential difference, $V = 120\ V$

Thickness of dielectric slab, $b = 4mm = 4\times10^{-3}\ m$

Dielectric constant, $k = 4.8$

[a] Capacitance before the slab is inserted,

$$C_0 = \frac{\varepsilon_0 A}{d} = \frac{8.854\times10^{-12}\times 0.12}{0.012}$$

$$= 8.854\times10^{-11}\ F$$

(Ans)

[b] Capacitance with the slab in place,

$$C = \frac{\varepsilon_0 A}{d-b+\frac{b}{k}} = \frac{8.854\times10^{-12}\times0.12}{0.012-(4\times10^{-3})+\frac{4\times10^{-3}}{4.8}}$$

$$= 1.2\times10^{-10}\ F$$

(Ans)

[c] Free ~~\$~~ charge before slab inserted,

$$q_0 = C_0 V = 8.854\times10^{-11}\times120$$

$$= 1.06248\times10^{-8}\ C$$

(Ans)

[d] Free charge after the slab inserted,

$$q = q_0 = 1.06248 \times 10^{-8} \, C$$ (Ans)

Because, the battery is disconnected.

[e] Magnitude of the electric field in the space between the plates and the dielectric,

$$E_0 = \frac{q_0}{\varepsilon_0 \cdot A} = \frac{1.06248 \times 10^{-8}}{8.854 \times 10^{-12} \times 0.12} = 10^4 \ V m^{-1}$$ (Ans)

[f] Magnitude of the electric field in the dielectric,

$$E = \frac{E_0}{K} = \frac{10^4}{4.8} = 2083.33 \ V m^{-1}$$ (Ans)

[g] Potential difference across the plates,

$$V = E_0 (d - b) + E b$$

$$= 10^4 (0.012 - 4 \times 10^{-3}) + 2083.33 \times 4 \times 10^{-3}$$

$$= 88.33 \ V$$

(Ans)

(A.1) External work done to insert the slab,

$$W_{ext} = \Delta U = U_f - U_i = \frac{q^2}{2C} - \frac{q_0^2}{2C_0}$$

$$= \frac{q^2}{2}\left(\frac{1}{C} - \frac{1}{C_0}\right)$$

$$= \frac{(1.06248 \times 10^{-8})^2}{2}\left(\frac{1}{1.2 \times 10^{-10}} - \frac{1}{8.854 \times 10^{-11}}\right)$$

$$= -1.67 \times 10^{-7}\ \text{J}$$

(Ans)

Chapter 26 : Problem 16

Here,

$I = 60$ A

$$\frac{R}{L} = 0.150 \frac{\Omega}{\text{km}} = \frac{\sigma}{A}$$

(a) For copper cable, $J = \frac{I}{A} = \frac{I \times (0.150 \div 1000)}{\sigma}$

$$= \frac{60 \times (0.150 \div 1000)}{1.77 \times 10^{-8}}$$

$$\cancel{= 508.475 \times 10^{6}\ \text{A m}^{-2}}$$

Ans

$$= 508.475 \times 10^3 \ A m^{-2}$$

(Ans)

b For copper, mass per unit length,

$$\lambda = \frac{m}{L} = \rho A = \rho \cdot \frac{\sigma}{(0.150 \div 1000)}$$

$$= 8960 \times \frac{1.77 \times 10^{-8}}{(0.150 \div 1000)}$$

$$= 1.05728 \ kg \ m^{-1}$$

(Ans)

c For Aluminum cable,

$$J = \frac{I}{A} = \frac{I \times (0.150 \div 1000)}{\sigma} = \frac{60 \times 0.15 \times 10^{-3}}{2.65 \times 10^{-8}}$$

$$= 339.623 \times 10^3 \ A m^{-2}$$

(Ans)

d For Aluminum, $\lambda = \frac{m}{L} = \rho A = \rho \cdot \frac{\sigma}{(0.15 \times 10^{-3})}$

$$= 2600 \times \frac{2.65 \times 10^{-8}}{0.15 \times 10^{-3}}$$

$$= 0.4593 \ kg \ m^{-1}$$

(Ans)

— o — x — o —

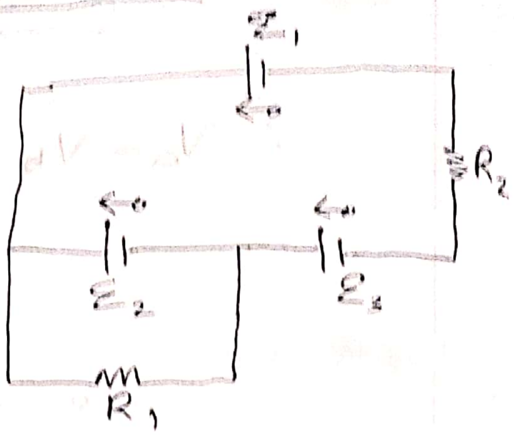
Here, $R_1 = 100\ \Omega$

$R_2 = 50\ \Omega$

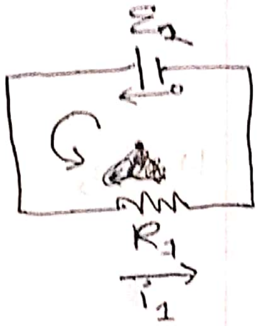
$\mathcal{E}_1 = 6\ V$

$\mathcal{E}_2 = 5\ V$

$\mathcal{E}_3 = 4\ V$



[a] For the lower loop, let the electron flow for R_1 be from left to right.



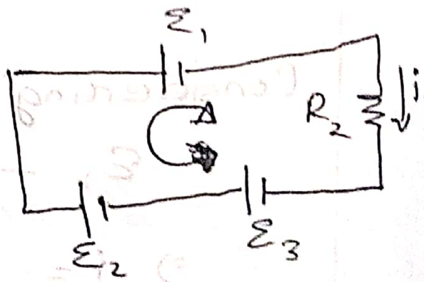
$\therefore$ According to KVL,

$$\mathcal{E}_2 - i_1 R_1 = 0$$

$$\Rightarrow i_1 = \frac{\mathcal{E}_2}{R_1} = \frac{5}{100} = 0{\cdot}05\ A$$

(Ans)

[b] For the upper loop, let the current flow for R_2 be from top to bottom.



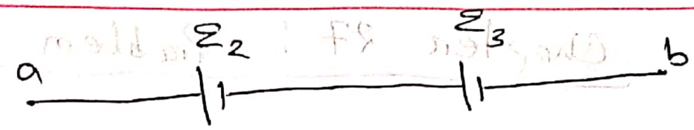
$\therefore$ According to KVL,

$$-\mathcal{E}_1 - i_2 R_2 + \mathcal{E}_3 + \mathcal{E}_2 = 0$$

$$\therefore i_2 = \frac{-\mathcal{E}_1 + \mathcal{E}_2 + \mathcal{E}_3}{R_2} = \frac{-6+5+4}{50}$$

$$= 0{\cdot}06\ A$$

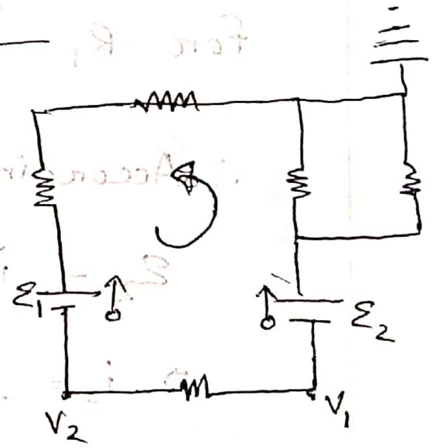
(c)



$$\therefore V_a - V_b = \mathcal{E}_3 + \mathcal{E}_2 = 4+5$$
$$= 9\ V$$

(Ans)

Chap 27 ; Problem 31



Here, $\mathcal{E}_1 = 5V$

$\mathcal{E}_2 = 12\ V$

Each resistor has, $R = 2\Omega$

$$\therefore R_{eq} = R + R + \left(\frac{1}{R}+\frac{1}{R}\right)^{-1} + R$$
$$= 3R + \frac{R}{2} = 3\times 2 + \frac{2}{2} = 7\ \Omega$$

Considering the current flow to be clockwise,

$$\mathcal{E}_1 - iR_{eq} - \mathcal{E}_2 = 0$$
$$\Rightarrow i = \frac{\mathcal{E}_1 - \mathcal{E}_2}{R_{eq}} = \frac{5-12}{7} = -1\ A$$

$\therefore |i| = 1\ A$, which flows anti-clockwise

a Here, resistance of only the parallel connection,

$$R_p = \left(\frac{1}{R} + \frac{1}{R}\right)^{-1} = 1\ \Omega$$

$$\therefore V_p = i R_p$$

$$= 1 \times 1 = 1\ V$$

$\therefore$ Potential difference between Ground and V_1,

$$V_G - V_1 = \mathcal{E}_2 - V_p$$

$$\Rightarrow 0 - V_1 = 12 - 1$$

$$\therefore V_1 = -11\ V$$

(Ans)

b Potential difference between Ground and V_2,

$$V_2 - V_G = -iR - iR - \mathcal{E}_1$$

$$\Rightarrow V_2 - 0 = -2 \times 1 \times 2 - 5$$

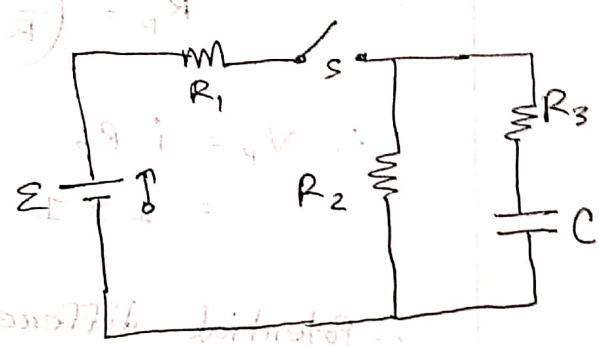
$$\therefore V_2 = -9\ V$$

(Ans)

Chapter 27 : Problem 63

Here, $\mathcal{E} = 1.2$ kV

$= 1.2 \times 10^3$ V



$C = 6.5\ \mu F$

$= 6.5 \times 10^{-6}$ F

$R_1 = R_2 = R_3 = 0.73\ M\Omega$

$= 0.73 \times 10^6\ \Omega$

At, $t = 0s$, the capacitor will be uncharged and we can take the equivalent resistance from the circuit ignoring the capacitor.

$$\therefore R_{eq} = R_1 + \left(\frac{1}{R_2} + \frac{1}{R_3}\right)^{-1} = 1.095 \times 10^6\ \Omega$$

(a) At $t = 0s$, $i_1 = \dfrac{\mathcal{E}}{R_{eq}} = 1.096 \times 10^{-3}$ A (Ans)

(b) Here, $i_p = i_1 = 1.096 \times 10^{-3}$ A

$$\therefore V_p = i_p \times R_p = i_p \times \left(\frac{1}{R_2} + \frac{1}{R_3}\right)^{-1} = 400\ V$$

Therefore, $i_2 = \dfrac{V_p}{R_2} = 5.479 \times 10^{-4}$ A

(Ans)

$\boxed{c}$ $i_3 = \frac{V_P}{R_3} = \frac{V_P}{R_2} = i_2 = 5.479 \times 10^{-4}$ A (Ans)

Now, at $t = \infty$, the capacitor will be fully charged. So, no current will pass through R_3 and C.

$\boxed{d}$ When $t = \infty$ s,

$$i_1 = \frac{\mathcal{E}}{R_5} = \frac{1.2\times10^{3}}{2(0.73\times10^{6})} = \cancel{1.64\times10^{-3}\,A}$$

$$= 8.219 \times 10^{-4} \text{ A}$$ (Ans)

$\boxed{e}$ $i_2 = \frac{\mathcal{E}}{R_5} = i_1 = 8.219 \times 10^{-4}$ A (Ans)

$\boxed{f}$ As no current will pass through R_3,

$i_3 = 0$ A (Ans)

~~At any time t, for the left loop,~~ $\cancel{\mathcal{E} - i_1R_1 - i_2R_2 = 0}$

~~for the right loop,~~ $\cancel{-i_3R_3 - V_c + i_2R_2 = 0}$

(g) At $t = 0\,s$,

$i_2 = 5.479 \times 10^{-4}\ A$

$\therefore V_2$ at $t = 0\,s$ is, $V_2 = i_2 R_2$

$= 400\ V$

(Ans)

(h) At $t = \infty\,s$,

$i_2 = 8.219 \times 10^{-4}\ A$

$\therefore V_2$ at $t = \infty\,s$ is, $V_2 = i_2 R_2$

$= 600\ V$

(Ans)

(i)

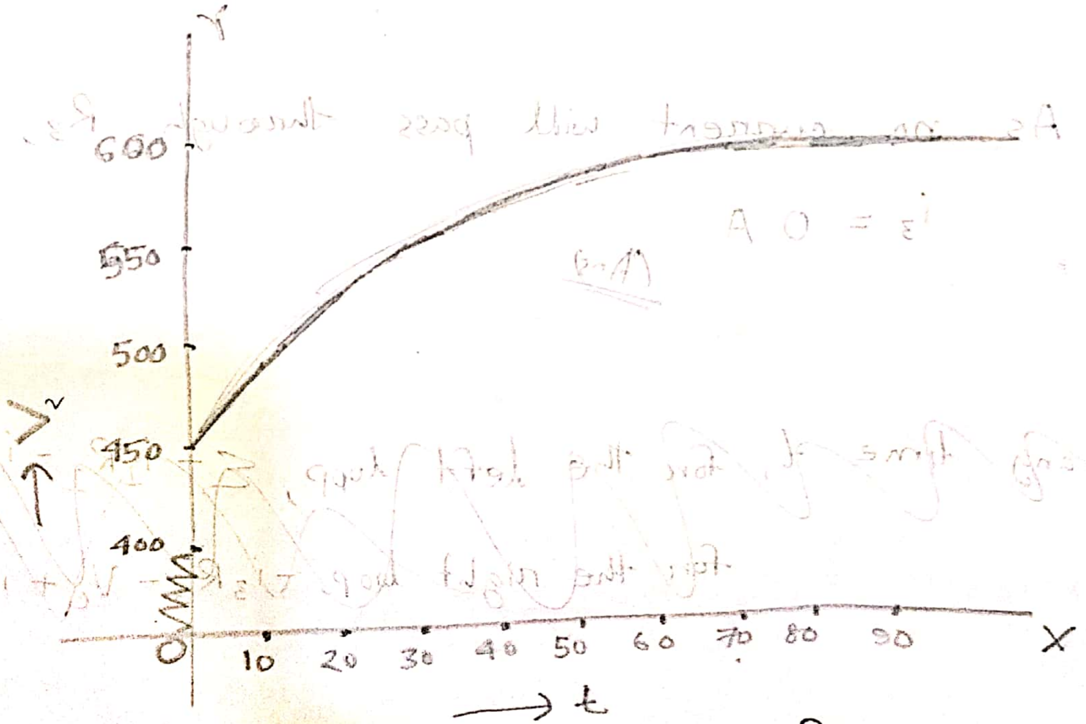


Fig:- V_2 vs t graph for R_2