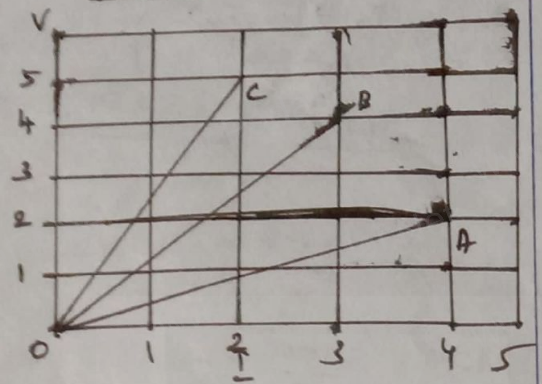
XII

UNIT-2 [Current Electricity]

Exercise problems

1. Figure 1: (Graph 1)



According to ohm's law

$V = IR$

$R = V/I$

For A

$R_A = \frac{\Delta V}{\Delta I} = \frac{2-0}{4-0} = \frac{2}{4} = 0.5\Omega$

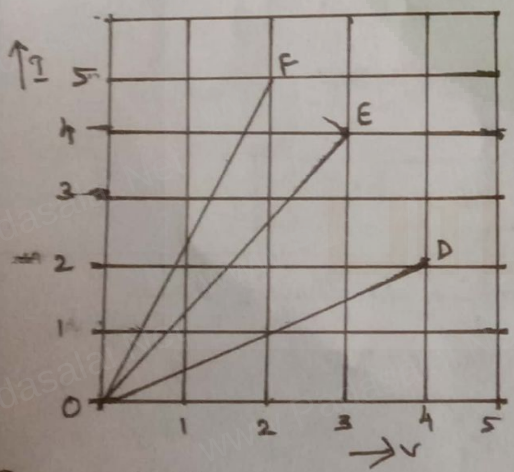
For B

$R_B = \frac{\Delta V}{\Delta I} = \frac{4-0}{3-0} = \frac{4}{3} = 1.33\Omega$

For C

$R_C = \frac{\Delta V}{\Delta I} = \frac{5-0}{2-0} = \frac{5}{2} = 2.5\Omega$

Graph 2:



In graph 2

Slope $= \frac{\Delta I}{\Delta V}$

$R = \frac{1}{\text{slope}} = \frac{\Delta V}{\Delta I}$

For D

$R_D = \frac{\Delta V}{\Delta I} = \frac{4-0}{2-0} = \frac{4}{2} = 2\Omega$

For E:

$R_E = \frac{\Delta V}{\Delta I} = \frac{3-0}{4-0} = \frac{3}{4} = 0.75\Omega$

For F:

$R_F = \frac{\Delta V}{\Delta I} = \frac{2-0}{5-0} = \frac{2}{5} = 0.4\Omega$

From A, B, C, D, E and F

R_F has minimum resistance
R_C has maximum resistance

2. $W = 10^9 J$; $V = 5\times10^7 V$

$t = 0.2 s$

a) total amount of charge transfered

$W = Vq$

$q = \frac{W}{V} = \frac{10^9}{5\times10^7}$

$= 0.2\times10^2$

$\boxed{q = 20\,C}$

b) the current in the lightning bolt

$I = \frac{q}{t} = \frac{20}{0.2} = \frac{20}{2\times10^{-1}}$

$\boxed{I = 100\,A}$

c) the power delivered in 0.2 S

$P = VI$

$= 5\times10^7 \times 100$

$= 5\times10^9$

$\boxed{P = 5\,GW}$

3. $A = 10^{-6} m^2$; $I = 2A$

$n = 8\times10^{28}$

$J = ?$ $V_d = ?$

$$J = \frac{I}{A}$$

$$= \frac{2}{10^{-6}}$$

$$\boxed{J = 2\times10^{6}\ A\,m^{-2}}$$

$$J = n e v_d$$

$$v_d = \frac{J}{ne} = \frac{2\times10^{6}}{8\times10^{28}\times1.6\times10^{-19}}$$

$$= 0.156\times10^{-3}$$

$$\boxed{v_d = 15.6\times10^{-5}\ m s^{-1}}$$

(4) $R_0 = 10\,\Omega$; $\alpha = 0.004/°C$

$R_{100} = ?$ $T = 100°C$; $T_0 = 0°C$

$$R_T = R_0(1+\alpha(T-T_0))$$

$$R_{100} = 10(1+0.004(100))$$

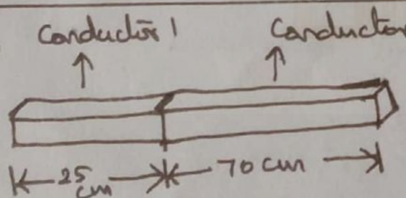
$$= 10(1+0.4)$$

$$= 10(1.4)$$

$$\boxed{R_{100} = 14\,\Omega}$$

As the temperature increases the resistance of the wire also increases

(5)



$\rho_1 = 4\times10^{-3}\,\Omega m$; $l_1 = 25\times10^{-2}\,m$

Area = multiplication of length of 2 sides

$$= 3\times10^{-3}\times3\times10^{-3}$$

$$\boxed{A = 9\times10^{-6}\,m^2}$$

$\rho_2 = 5\times10^{-3}\,\Omega m$; $l_2 = 70\times10^{-2}\,m$

$R = ?$ (between the rods)

$$R_s = R_1 + R_2$$

$$R_1 = \frac{\rho_1 l_1}{A}$$

$$= \frac{4\times10^{-3}\times25\times10^{-2}}{9\times10^{-6}}$$

$$= \frac{100\times10^{-5}}{9\times10^{-6}}$$

$$\boxed{R_1 = \frac{1000}{9}\,\Omega}$$

$$R_2 = \frac{\rho_2 l_2}{A}$$

$$= \frac{5\times10^{-3}\times70\times10^{-2}}{9\times10^{-6}}$$

$$= \frac{350\times10^{-5}\times10^{6}}{9}$$

$$\boxed{R_2 = \frac{3500}{9}\,\Omega}$$

$$R_s = R_1 + R_2$$

$$= \frac{1000}{9} + \frac{3500}{9}$$

$$= \frac{4500}{9}$$

$$\boxed{R_s = 500\,\Omega}$$

(6) According to ohm's law

a) $V = IR$

$V = \xi$

$R_1 = R_2 = R_3 = R$

Three bulbs are connected in series combination

$$R_s = R_1 + R_2 + R_3$$

$$R_s = R+R+R = 3R$$

When Switch open.

$$\boxed{I = \frac{V}{R_s} = \frac{\xi_r}{3R}}$$

When Switch closed.

$$I = \frac{V}{RR} = \frac{\xi_r}{R+R}$$

$$\boxed{I = \frac{\xi_r}{2R}}$$

When "S" closed no current flows through c bulb.

b) When switch open

three bulbs are in series combination so there is no change in intensities.

So all the ~~bulb~~ bulbs having equal intensities.

When switch closed.

Two bulbs A and B are only in series combination so the intensities across two bulbs (A and B) increases and both having equal intensities.

The bulb "c" is in parallel combination, hence no current flows through c bulb, so it will not glow.

c) Voltage.

Switch is open:

In series combination the current will same.

So

$V_A = IR$

$= \frac{\xi_r}{3R} \cdot R$

$$\boxed{V_A = \frac{\xi_r}{3}}$$

$V_B = IR$

$= \frac{\xi_r}{3R} \cdot R$

$$\boxed{V_B = \frac{\xi_r}{3}}$$

$V_C = IR$

$= \frac{\xi_r}{3R} \cdot R$

$$\boxed{V_C = \frac{\xi_r}{3}}$$

Switch closed.

both A and B are in series combination. bulb c in parallel so no current flows through c so $I = 0$

$V_A = IR$

$= \frac{\xi_r}{2R} \cdot R$

$$\boxed{V_A = \frac{\xi_r}{2}}$$

$V_B = IR$

$= \frac{\xi_r}{2R} \cdot R$

$$\boxed{V_B = \frac{\xi_r}{2}}$$

$V_C = IR$

$= 0 \times R$

$$\boxed{V_C = 0}$$

d) Power: Switch open:

$P_A = V_A I_A$

$= \frac{\xi_r}{3} \times \frac{\xi_r}{3R}$

$$\boxed{P_A = \frac{\xi_r^2}{9R}}$$

$P_B = V_B I_B$

$P_B = \frac{\xi_r}{3} \times \frac{\xi_r}{3R} = \frac{\xi_r^2}{9R}$

$P_C = V_C I_C$

$= \frac{\xi}{3} \times \frac{\xi}{3R}$

$$\boxed{P_C = \frac{\xi^2}{9R}}$$

Switch closed.

$P_A = V_A I_A$

$= \frac{\xi}{2} \times \frac{\xi}{2R}$

$$\boxed{P_A = \frac{\xi^2}{4R^2}}$$

$P_B = V_B I_B$

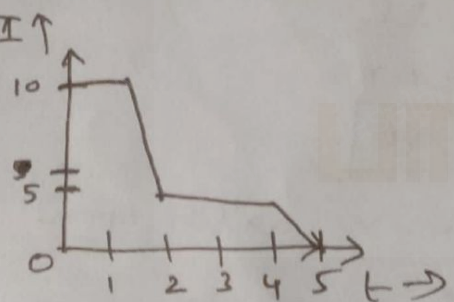
$= \xi/2 \times \frac{\xi}{2R}$

$$\boxed{P_B = \frac{\xi^2}{4R^2}}$$

$P_C = V_C I_C$

$\boxed{P_C = 0}$ //

(7)



At $t = 0s$

$I = dq/dt$

$dq = I \times dt$

$\boxed{dq = 0s}$

$t = 2s$

$I = dq/dt$

$dq = I \times dt$

$= 5 \times 2$

$\boxed{dq = 10C}$

At $t = 5s$

$I = \frac{dq}{dt} \Rightarrow dq = I \times dt$

$\boxed{dq = 0 \times 5 = 0s}$ //

(8) resistance of required $\}$ $= 150\Omega$

$R_1 = 220\Omega$; $R_2 = 79\Omega$; $R_3 = 92\Omega$

For ~~gee~~ getting 150Ω resistance as resultant, two of the resistance should be connected in parallel and 1 connected with series.

$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{220} + \frac{1}{79}$

$R_P = \frac{220 \times 79}{220 + 79} = \frac{17380}{299}$

$= 58.1$

$\boxed{R_P \simeq 58\Omega}$

$R_S = R_P + R_3$

$= 58 + 92$

$\boxed{R_S = 150\Omega}$ //

(9) $I_1 = 0.9A$; $R_1 = 2\Omega$

$I_2 = 0.3A$; $R_2 = 7\Omega$

ξ $r = ?$

$I_1 = \frac{\xi}{R_1 + r}$

$\xi = I_1(R_1 + r)$ — (1)

$\xi = I_2(R_2 + r)$ — (2)

$I_1(R_1 + r) = I_2(R_2 + r)$

$I_1 R_1 + I_1 r = I_2 R_2 + I_2 r$

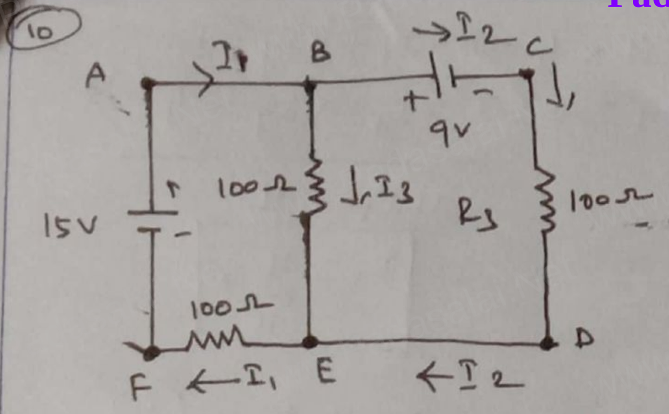
$I_1 R_1 - I_2 R_2 = I_2 r - I_1 r$

$r = \frac{I_1 R_1 - I_2 R_2}{I_2 - I_1}$

$= \frac{(0.9 \times 2) - (0.3 \times 7)}{0.3 - 0.9}$

$r = \frac{1.8 - 2.1}{-0.6} = \frac{-0.3}{-0.6} = \frac{3}{6} = 0.5\Omega$ //

10



Kirchoff's law (1st law) at junction B

$$I_1 - I_2 - I_3 = 0$$

$$\boxed{I_3 = I_1 - I_2} \quad \text{— (1)}$$

Kirchoff's II law in ABEFA

$$100 I_3 + 100 I_1 = 15\,V$$

$$100(I_1 - I_2) + 100 I_1 = 15\,V$$

$$100 I_1 - 100 I_2 + 100 I_1 = 15$$

$$\boxed{200 I_1 - 100 I_2 = 15} \quad \text{— (2)}$$

Kirchoff's II law to BCDEB

$$100 I_3 - 100 I_2 = 9$$

$$100(I_1 - I_2) - 100 I_2 = 9$$

$$100 I_1 - 100 I_2 - 100 I_2 = 9$$

$$\boxed{100 I_1 - 200 I_2 = 9} \quad \text{— (3)}$$

(3) × 2 $\Rightarrow 200 I_1 - 400 I_2 = 18$

(2) (−) $\Rightarrow 200 I_1 - 100 I_2 = 15$

$$-300 I_2 = +3$$

$$I_2 = -\frac{3}{300}$$

$$\boxed{I_2 = -0.01\,A}$$

Substitute I_2 in eqn. No. (2)

$$200 I_1 - 100(-0.01) = 15$$

$$200 I_1 + 1 = 15$$

$$200 I_1 = 14$$

$$I_1 = \frac{14}{200} = \frac{7}{100}$$

$$\boxed{I_1 = 0.07\,A}$$

Substitute I_1 & I_2 in eqn. (1)

$$I_3 = 0.07 - (-0.01)$$

$$\boxed{I_3 = 0.08\,A}$$

11 $r = 20\,\Omega$; $l = 4\,m$.

$\xi = 4\,V$; $r' = 2980\,\Omega$

Effective resistance of two resistors in series combination

$$R = r + r'$$

$$= 20 + 2980$$

$$\boxed{R = 3000\,\Omega}$$

$$I = \xi / R = \frac{4}{3000}\,A$$

Potential drop across the wire

$$V = I \times r$$

$$= \frac{4}{3000} \times 20$$

$$\boxed{V = \frac{80}{3000}\,V} \Rightarrow \boxed{V = \frac{8}{300}\,V}$$

Potential gradient

$$(E) = V/l.$$

$$= \frac{80}{3000} \times \frac{1}{4}$$

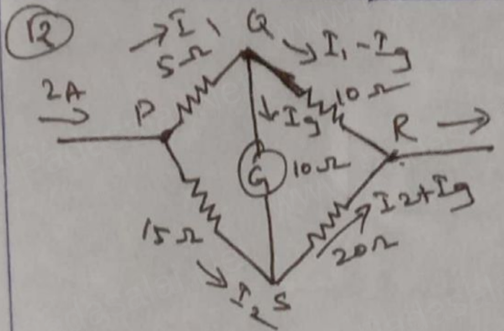
$$= \frac{2}{3000}$$

$$= \cancel{0.00066}$$

$$E = 0.0066$$

$$\boxed{E = 0.66 \times 10^{-2}\,Vm^{-1}}$$

(12)



$I = 2A$

$I_2 = I - I_1$

Applying Kirchoff's II law at PQSP

$5I_1 + 10I_g - 15I_2 = 0$

$5I_1 + 10I_g - 15(I - I_1) = 0$

$5I_1 + 10I_g - 15I + 15I_1 = 0$

$20I_1 - 15I + 10I_g = 0$

$20I_1 - 30 + 10I_g = 0$

$20I_1 + 10I_g = 30$

$\boxed{2I_1 + I_g = 3}$ —(1)

Applying Kirchoff's II law at QRSQ

$10(I_1 - I_g) - 20(I_2 + I_g) - 10I_g = 0$

$10I_1 - 10I_g - 20I_2 - 20I_g - 10I_g = 0$

$10I_1 - 40I_g - 20I_2 = 0$

$10I_1 - 40I_g - 20(I - I_1) = 0$

$10I_1 - 40I_g - 20I + 20I_1 = 0$

$30I_1 - 40I_g - 20(2) = 0$

$30I_1 - 40I_g - 40 = 0$

$30I_1 - 40I_g = 40$

$\boxed{3I_1 - 4I_g = 4}$ —(2)

(1) × 4 ⇒ $8I_1 + 4I_g = 12$

(2) ⇒ $3I_1 - 4I_g = 4$ (+)

$11I_1 = 16$

$\boxed{I_1 = \frac{16}{11} A}$

I_1 value substitute in (1)

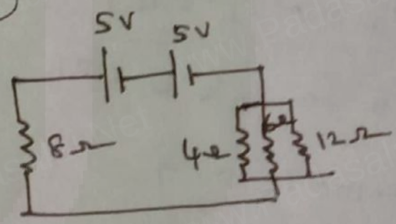
$2 \times \left(\frac{16}{11}\right) + I_g = 3$

$32 + 11I_g = 33$

$11I_g = 33 - 32$

$\boxed{I_g = \frac{1}{11} A}$

(13)



$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$\frac{1}{R_p} = \frac{1}{4} + \frac{1}{6} + \frac{1}{12}$

$1/R_p = \frac{6+4+2}{24} = \frac{12}{24} = \frac{1}{2}$

$\boxed{R_p = 2\Omega}$

$R_s = R_p + R = 2 + 8$

$\boxed{R_s = 10\Omega}$

$\xi = \xi_1 + \xi_2$

$= 5 + 5$

$\boxed{\xi = 10V}$

i) Current drawn from the cell

$I = \frac{\xi}{R} = \frac{10}{10}$

$\boxed{I = 1A}$

ii) Current through each resistor

Potential through 8Ω resistor

$\boxed{V = IR = 8 \times 1 = 8V}$

Potential ~~Current~~ through (Parallel network) 2Ω resistor.

$V = IR = 1 \times 2$

$\boxed{V = 2V}$

i) ~~Potential~~ Current across 4Ω $I = \frac{V}{R} = \frac{2}{4}$

$\boxed{I = 0.5A}$

ii) across 6Ω $I = \frac{V}{R} = \frac{2}{6}$

$\boxed{I = 0.33A}$

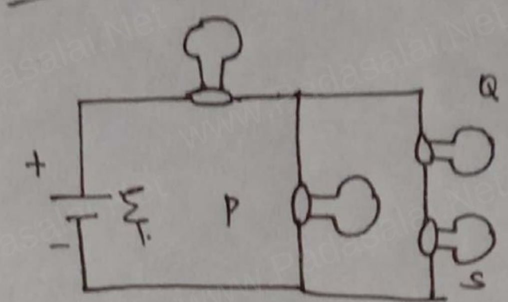
iii) across 12Ω $I = \frac{V}{R} = \frac{2}{12}$

$\boxed{I = 0.17A}$

14

	P	Q	R	S
P removed	*	on	on	on.
Q removed	on	*	on	off
R removed	off	off	*	off
S removed	on	off	on	*

Ans:



15 $\xi_1 = 1.25V$ $l_1 = 35cm$

$\xi_2 = ?$ $l_2 = 63cm$

$\boxed{\xi \propto l}$

$\frac{\xi_1}{\xi_2} = \frac{l_1}{l_2}$

$\frac{\xi_2}{\xi_1} = \frac{l_2}{l_1}$

$\xi_2 = \xi_1 \frac{l_2}{l_1}$

$= 1.25 \times \frac{63 \times 10^{-2}}{35 \times 10^{-2}}$

$= 125 \times 10^{-2} \times \frac{63}{35}$

$= 125 \times 10^{-2} \times \frac{9}{5}$

$= 25 \times 9 \times 10^{-2}$

$= 225 \times 10^{-2}$

$\boxed{\xi_2 = 2.25V}$