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Current Electricity

(3.1) emf $(\mathcal{E}) = 12V$ $r = 0.4\,\Omega$ $I_{max} = \frac{\mathcal{E}}{r} = \frac{12}{0.4} = \boxed{30A}$ Ans

Current draw from the battery will be max when ext $R = 0$.

(3.2) emf $= 10V$ $r = 3\,\Omega$ $I = 0.5A$

$I = \frac{\mathcal{E}}{R+r} \Rightarrow R + r = \frac{\mathcal{E}}{I} \Rightarrow R = \frac{10}{0.5} - 3 = \boxed{17\,\Omega}$

Terminal Voltage $= V = IR = \frac{5}{10} \times 17 = 8.5V$

(3.3) $R_1 = 1\,\Omega$ $R_2 = 2\,\Omega$ $R_3 = 3\,\Omega$

i) $R_S = R_1 + R_2 + R_3 = \boxed{6\,\Omega}$

ii) emf $(\mathcal{E}) = 12V$ $V_1 = IR_1 = 2 \times 1 = \boxed{2V}$

current $= \frac{V}{R_{eq}} = \frac{12}{6} = 2A$ $V_2 = 2 \times 2 = \boxed{4V}$

$V_3 = 2 \times 3 = \boxed{6V}$

(3.4) i) $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{2} + \frac{1}{4} + \frac{1}{5} = \frac{10+5+4}{20} = \frac{19}{20}$

$\boxed{R_P = \frac{20}{19}\,\Omega}$

ii) emf $= 20V$ $I_1 = \frac{\mathcal{E}}{R_1} = \frac{20}{2} = 10A$ $I_2 = \frac{20}{4} = 5A$ $I_3 = \frac{20}{5} = 4A$

Total current $= I_1 + I_2 + I_3 = 10 + 5 + 4 = \boxed{19A}$

(3.5) $R_1 = 100\,\Omega$ $R_2 = 117\,\Omega$ $t_1 = 27°C$. $\alpha = 1.7 \times 10^{-4}\,°C^{-1}$

$\alpha = \frac{R_2 - R_1}{R_1(t_2 - t_1)}$ $t_2 - t_1 = \frac{R_2 - R_1}{R_1 \alpha} = \frac{17 \times 10}{100 \times 17 \times 10^{-4}} = 10^3 = 1000$

$t_2 = 1000 + 27 = \boxed{1027°C}$

(3.6)

$l = 15m$ $A = 6 \times 10^{-7}\,m^2$ $R = 5\,\Omega$

$\rho = \frac{RA}{l} = \frac{5 \times 6 \times 10^{-7}}{15} = \boxed{2 \times 10^{-7}\,\Omega m}$

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(3.7) $R_1 = 2.1\ \Omega$ $t_1 = 27.5°C$

$R_2 = 2.7\ \Omega$ $t_2 = 100°C$

$$\alpha = \frac{R_2 - R_1}{R_1(t_2 - t_1)} = \frac{0.6}{2.1(72.52)}$$

$$= \frac{6}{2(72.52)} = \boxed{0.00394°C^{-1}}$$ Ans

(3.8) $V = 230V$ $I_1 = 3.2A$ $I_2 = 2.8A$ $\alpha = 1.70 \times 10^{-4}\ °C^{-1}$

$V = I_1 R_1$ $V = I_2 R_2$ $t_1 = 27°C$

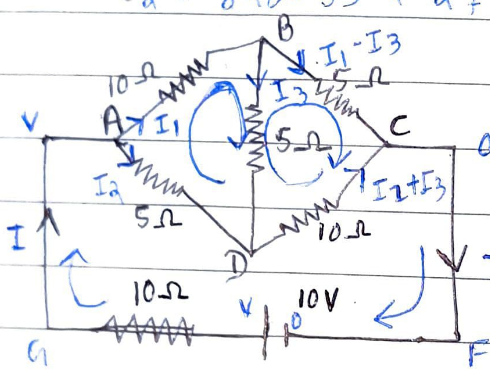
$R_1 = \frac{2300}{32} = 71.875\ \Omega$ $R_2 = \frac{V}{I_2} = \frac{2300}{28} = 82.143\ \Omega$

$$\alpha = \frac{R_2 - R_1}{R_1(t_2 - t_1)} \qquad t_2 - t_1 = \frac{R_2 - R_1}{R_1 \alpha} = \frac{10.268 \times 10^4}{71.875 \times 1.7}$$

$$= 840.35°C$$

$\therefore t_2 = 840.35 + 27 = \boxed{867.35°C}$ Ans

(3.9)



In Loop ABCDA

$10I_1 + 5I_3 - 5I_2 = 0$

In Loop BCDB

$5(I_1 - I_3) - 10(I_2 + I_3) - 5I_3 = 0$

In ADCFGA

$5I_2 + 10(I_2 + I_3) + 10(I_1 + I_2) ~~-10~~ = 10$

$5I_2 + 10(I_2 + I_3) + 10I = 10$ $I = I_1 - I_3 + I_2 + I_3$

$5I_2 + 10(I_2 + I_3) + 10(I_1 + I_2) = 10$ $= I_1 + I_2$

$10I_1 - 5I_2 + 5I_3 = 0$ —— (i) $I_1 = \frac{4}{17}A$ $I_2 = \frac{6}{17}A$

$5I_1 - 10I_2 - 20I_3 = 0$ —— (ii)

$10I_1 + 25I_2 + 10I_3 = 10$ —— (iii) $I_3 = -\frac{2}{17}A$

$I_{AB} = I_1 = \boxed{\frac{4}{17}A}$ $I_{BC} = I_1 - I_3 = \boxed{\frac{6}{17}A}$

$I_{DC} = \boxed{\frac{4}{17}A}$ $I_{AD} = \boxed{\frac{6}{17}A}$ $I_{BD} = \boxed{\frac{-2}{17}A}$

Total current $= \boxed{\frac{10}{17}A}$

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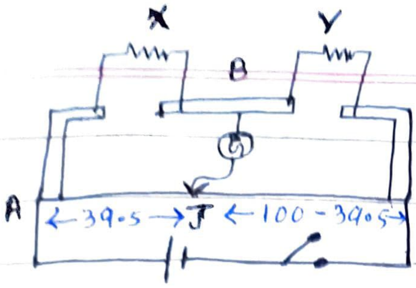
(3.10)



i) $l = 39.5\,cm$ $R_Y = 12.5\,\Omega$

$R_X = ?$

$$\frac{R_X}{39.5} = \frac{12.5}{(100-39.5)} \quad ; \quad R_X = \frac{12.5 \times 39.5}{60.5}$$

$$= \boxed{8.16\,\Omega} \text{ Ans}$$

Connections are made by thick copper strips to minimise the resistance of connection.

ii) $R = Y = 12.5\,\Omega$ $S = X = 8.16\,\Omega$ $l = ?$

$$\frac{12.5}{l} = \frac{8.16}{100-l} \Rightarrow 1250 - 12.5l = 8.16l$$

$$\Rightarrow 12.5l + 8.16l = 1250$$

$$\Rightarrow l = \frac{1250}{20.66} = \boxed{60.5\,\Omega} \text{ Ans}$$

iii) Then the conditions of the balanced bridge still remains satisfied and so again the glvanometer will not show any current.

(11) $emf(\mathcal{E}) = 8V$ $r = 0.5\,\Omega$ $V = \mathcal{E} + Ir$ $R = 15.5\,\Omega$

$\mathcal{E}'_{net} = 120 - 8.0 = 112V$

$$I = \frac{\mathcal{E}'}{R+r} = \frac{112}{15.5+0.5} = \frac{112}{16} = 7A.$$

$$V = \mathcal{E} + Ir = 8 + 7 \times \frac{5}{10} = 8 + 3.5 = \boxed{11.5V} \text{ Ans}$$

(12) $emf_1 = 1.25V$ $l_1 = 35cm$ $l_2 = 63cm$ $emf_2 = ?$

$$\text{As } \frac{\mathcal{E}_2}{\mathcal{E}_1} = \frac{l_2}{l_1} \quad \mathcal{E}_2 = \frac{l_2}{l_1} \times \mathcal{E}_1 = \frac{63}{35} \times \frac{125}{100} = \boxed{2.25V} \text{ Ans}$$

(13) $n = 8.5 \times 10^{28}\,m^{-3}$ $l = 3m$ $a = 2 \times 10^{-6}\,m^2$

$I = 3A$

$$I = v_d enA \qquad v_d = \frac{I}{enA} = \frac{3 \times 10^{-28} \times 10^{19}}{1.6 \times 8.5 \times 2 \times 10^{-6}}$$

$$= \frac{3}{16 \times 85 \times 2 \times 10}$$

$$= 1.1 \times 10^{-4}\,ms^{-1}$$

$$t = \frac{l}{v_d} = \frac{3 \times 10^4}{1.1} = 2.73 \times 10^4 s \approx \boxed{7.57\,hr}$$

(14) $\sigma = 10^{-9} C m^{-2}$ $V = 400 KV$ $I = 1800 A$

$R = 6.37 \times 10^{6} m$

Total charge q = Surface area $\times \sigma = 4\pi R^2 \sigma$

$= 4 \times 3.14 \times (6.37 \times 10^{6})^2 \times 10^{-9}$

$= 509.65 \times 10^{3} C$

$t = \frac{q}{I} = \frac{509 \times 10^{3}}{1800} = \boxed{283 sec}$ Ans

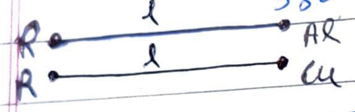
(15) a) emf = 2 V $n = 6$ $r = 0.015 \Omega$ $R = 8.5 \Omega$ Series

$I = \frac{nE}{R + rn} = \frac{6 \times 2}{8.5 + 6 \times 0.015} = \frac{12}{8.59} \approx \boxed{1.4 A}$

$V = 1.4 \times 8.5 = \boxed{11.9 V}$

b) Emf = 1.9 V $r = 380 \Omega$

$I = \frac{1.9}{380} = \frac{19}{3800} = \boxed{0.005 A}$ cannot drive the starting of car as it req 100A.

(16) 

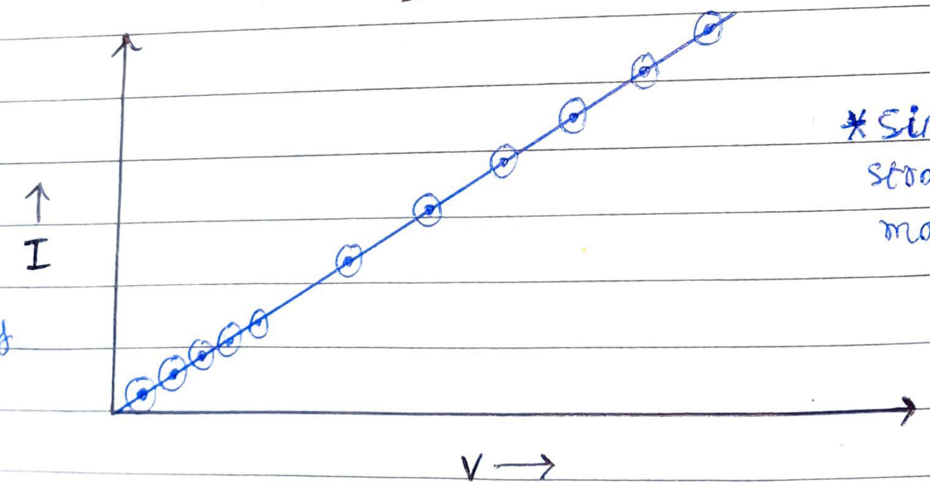
$\rho_{Al} = 2.63 \times 10^{-8} \Omega m$ $\rho_{cu} = 1.72 \times 10^{-8} \Omega m$

$RD_{Al} = 2.7$ $R.D = 8.9$

mass = Vol x density = $A l \times d$ $\frac{m_{cu}}{m_{Al}} = \frac{\rho_{cu} d_{cu}}{\rho_{Al} d_{Al}} = \frac{1.72 \times 10^{-8} \times 8.9}{2.63 \times 10^{-8} \times 2.7} = 2.2$

$R = \frac{\rho l}{A}$ $\frac{\rho l}{R} l d = \frac{\rho l d}{R}$

[cu wire is 2.2 times heavier than Al so Al is lighter and do not sag down.]

(17) 

* Temp coefficient of resistivity of manganin is negligibly small.

* Since V-I graph is straight line so manganin is an [ohmic resistor.]

(18) a) Only current is constant. Other quantity vary inversely with area of cross section.

b) NO, Non-ohmic conductors like, semiconductor diode, thyristor, vaccume diode

c) $I_{max} = \frac{\varepsilon}{r}$ $\quad I \propto \frac{1}{r}$ so, I_{max} is large if r is small

d) If the internal resistance is not very high, then the current will exceed the safety limit in case the circuit is short-circuited accidentally.

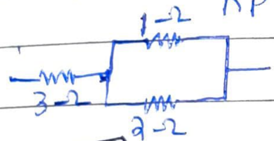
(19) a) greater
b) lower
c) nearly independent of
d) 10^{22}

(20) a) For max effective resistance all the n resistors must be connected in series $R_S = nR$

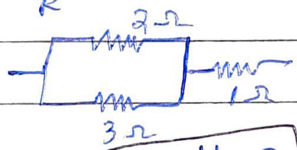
For minimum effective resistance all n resistors must be connected in parallel $\frac{1}{R_P} = \frac{1}{R} + \frac{1}{R} + \dots + n = \frac{n}{R}$ $\quad R_P = R/n$

Ratio $= \frac{nR \times n}{R} = n^2 : 1$

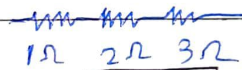
b)



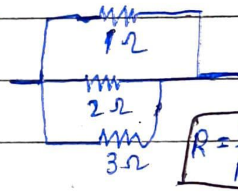
$R = \frac{11}{3}\,\Omega$



$R = \frac{11}{5}\,\Omega$

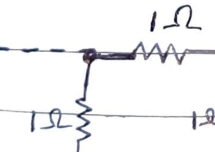


$R = 6\Omega$



$R = \frac{6}{11}\Omega$

c)

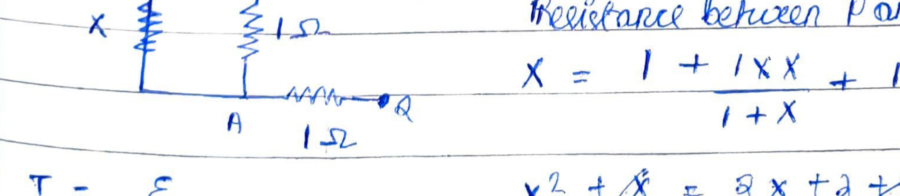


$R = \frac{4}{3}\,\Omega$ $\quad R = 4 \times \frac{4}{3} = \frac{16}{3}\,\Omega$

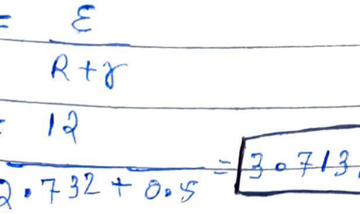
d) Equivalent Resistance R

$E_{eq} = 5R$

(21)



$r = 0.5\,\Omega$



Resistance between P and Q

$X = 1 + \frac{1 \times X}{1 + X} + 1 = 2 + \frac{X}{X+1}$

$X^2 + \cancel{X} = 2X + 2 + \cancel{X}$

$X^2 - 2X - 2 = 0$

$X = 1 \pm \sqrt{3}$ $\quad X = 1 + \sqrt{3}$

$X = 2.732\,\Omega$

$I = \frac{\varepsilon}{R + r}$

$= \frac{12}{2.732 + 0.5} = 3.713\,A$ Ans

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(22) a) $\mathcal{E}_1 = 1.02V$ $V = 2V$ $r = 0.4\Omega$ $l_1 = 67.3cm$

$\mathcal{E}_2 = \mathcal{E}$ $\frac{\mathcal{E}}{1.02} = \frac{82.3}{67.3}$ $l_2 = 82.3$ cm

$\mathcal{E} = \frac{823}{673} \times \frac{102}{100} = \boxed{1.25V}$ Ans

b) Protects the glvanometer for positions far away from the balance point, by decreasing current through it.

c) ~~No~~ balance point is not affected, as no current flows through the standar cell at the balance point.

d) Yes, it changes the potential gradiant and affects the balance point.

e) NO, If $\mathcal{E}_0$ > emf there will be no balance point on the wire AB.

f) Unsuitable, becoz the balance point will be very close to the end A and the % error measured is very large.
Modified by putting R in series so that V drop is slightely greater than the emf measured.

(23)

$R = 10\Omega$ $l_1 = 58.3$ cm X $l_2 = 68.5$cm

$\boxed{\frac{\mathcal{E}_2}{\mathcal{E}_1} = \frac{l_2}{l_1}}$ $\frac{X}{R} = \frac{l_2}{l_1}$ $X = \frac{l_2}{l_1} \times R = \frac{68.5}{58.3} \times 10 = \boxed{11.75\Omega}$

we should reduce current in the outside circuit suitably by putting a series resistor.

(24)

$r = ?$ $V = 1.5V$ $l_1 = 76.3$cm $l_2 = 64.8$

$R = 9.5\Omega$

$\boxed{r = R\left(\frac{l_1 - l_2}{l_2}\right)} = \left(\frac{76.3 - 64.8}{64.8}\right) \times \frac{95}{10}$

$= \frac{9.5 \times 11.5}{64.8}$

$\approx \boxed{1.7\Omega}$