Electric Current → NCERT

3.1) ~~V = IR~~ We know, $I = \frac{\varepsilon}{R+r}$ [R → external Resistance, r → internal "]

$\therefore I_{max} = \frac{\varepsilon}{R+r}$ (when R = 0)

$= \frac{\varepsilon}{r} = \frac{12}{0.4} A = 30 A$

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

$\Rightarrow 0.5 = \frac{10}{R+3}$

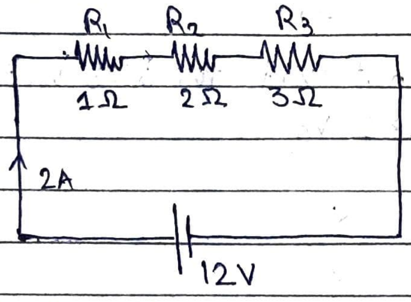
$\Rightarrow 0.5R + 1.5 = 10$

$\Rightarrow 0.5R = ~~9.5~~ ~~10~~ 8.5$

$\Rightarrow R = 17\,\Omega$

3.3) a) $R_{eq} = 1\Omega + 2\Omega + 3\Omega = 6\,\Omega$

b)



$I = \frac{V}{R} = \frac{12}{6} = 2A$

$R_1: V_1 = IR_1 = 2 \times 1 = 2V$

$R_2: V_2 = IR_2 = 2 \times 2 = 4V$

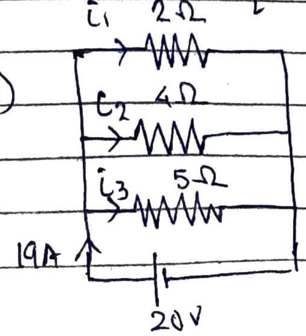
$R_3: V_3 = IR_3 = 2 \times 3 = 6V$

3.4) a) ~~Req =~~ $\frac{1}{R_{eq}} = \frac{1}{2} + \frac{1}{4} + \frac{1}{5}$

$\Rightarrow 1/R_{eq} = 3/4 + 1/5 \Rightarrow 1/R_{eq} = (15+4)/20$

$\Rightarrow R_{eq} = \frac{20}{19}\,\Omega$

b)



Total current drawn (I) $= \frac{20}{20} \times 19 = 19A$

$i_1 = \frac{20}{2} = 10\,A$; $i_2 = \frac{20}{4} = 5\,A$; $i_3 = \frac{20}{5} = 4\,A$

3.5) We know, ~~$R \propto T$~~

∴ ~~$R = KT$~~ $\alpha = 1.7 \times 10^{-4}\ ^\circ C^{-1}$

~~$\Rightarrow 27 \cdot 100 = 1.7 \times 10^{-4} \times 27$~~

$\alpha = \frac{R_1 - R}{R(T_1 - T)}$

$\Rightarrow T_1 - T = \frac{R_1 - R}{R(T_1 - T)}$

$\Rightarrow T_1 - T = \frac{R_1 - R}{R\alpha}$ $\Rightarrow T - 27 = \frac{117 - 100}{100(1.7 \times 10^{-4})}$

$\Rightarrow T_1 - 27 = 1000$ $\Rightarrow T_1 = 1027\,^\circ C$

3.6) $R = \frac{\rho l}{A}$ [ρ = Resistivity]

$\Rightarrow 5 = \frac{\rho \times 15}{6 \times 10^{-7}}$

$\Rightarrow \frac{5 \times 6 \times 10^{-7}}{15} = \rho \Rightarrow \rho = 2 \times 10^{-7}$

3.7) $R_2 = R_1[1 + \alpha(T_2 - T_1)]$

$\Rightarrow 2.7 = 2.1\left[1 + \alpha(100 - 27.5)\right]$

$\Rightarrow \frac{2.7}{2.1} = [1 + \alpha(72.5)]$

$\Rightarrow \frac{27}{21} = 1 + \alpha(72.5) \Rightarrow \frac{6}{21} = 72.5\,\alpha$

$\Rightarrow \alpha = \frac{2 \times 10^2}{7 \times 725} = \frac{4}{7 \times 145}$

$= 0.00394\,^\circ C^{-1}$

3.8) ~~$H_1 = I^2RT$~~ $\quad R_2 = R_1[1+\alpha(T_2-T_1)]$

~~$= IVT$~~

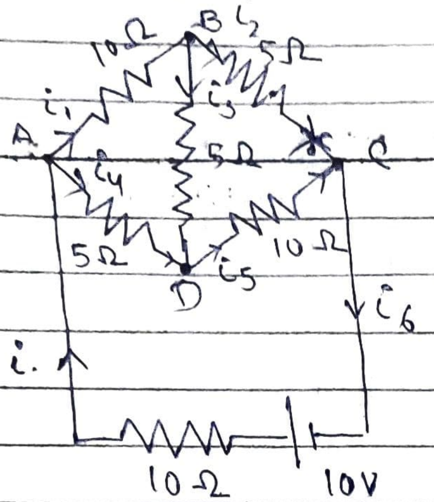
~~$= 3.2 \times 230 \times 300$~~ $\Rightarrow \frac{230}{2.8} = \frac{230}{3.2}[1+\alpha(T_2-27)]$

$\Rightarrow \frac{32}{28}\frac{8}{7} = 1+(1.7\times10^{-4})(T_2-27)$

$\Rightarrow \frac{1}{7} = 1.7\times10^{-4}(T_2-27)$

$\Rightarrow T_2 = 867°C$

3.9)



$i = \frac{V}{R} = \frac{10}{10} = 1A$

$i_2 = i_1 - i_3$

$i_5 = i_3 + i_4$

$i_6 = i_3 + i_4 + i_1 - i_3$

$\Rightarrow i = i_1 + i_4$

In closed circuits Potential is zero.

$i_1 \times 10 + i_3 \times 5 - i_4 \times 5 = 0$

$\Rightarrow 10i_1 + 5i_3 - 5i_4 = 0$

$\Rightarrow 2i_1 + i_3 - i_4 = 0$

$\Rightarrow 2i_1 + i_3 = i_4$

$2i_1 + i_3 = i_4$

$2i_1 - 8i_3 = 4i_4$

$9i_3 = -3i_4$

$-3i_3 = i_4$

$(i_1 - i_3)5 - 10(i_3 + i_4) - 5(i_3) = 0$

$\Rightarrow 5i_1 - 5i_3 - 2i_3 - 2i_4 - i_3 = 0$

$\Rightarrow i_1 - 4i_3 - 2i_4 = 0$

$\Rightarrow i_1 - 4i_3 = 2i_4$

$-10 + 10i + 10(i_1) + 5(i_1 - i_3) = 0$

$\Rightarrow -10 + 15i_1 + 10i - 5i_3 = 0$

$\Rightarrow 3i_1 + 2i - i_3 = 2$

$\rightarrow -3i_3 = i_2$

$i_2 = 2i_1 + i_3$ Also, $i = i_1 + i_2$

$\Rightarrow 4i_3 = 2i_2$

$\therefore i_3 = \frac{-2}{17}$ A $\quad i_2 = -3(i_3) = \frac{6}{17}$ A

$i_1 = -2(i_3) = \frac{4}{17}$ A

$AB = \frac{4}{17}$ A $\quad BC = \frac{6}{17}$ A $\quad CD = \frac{-4}{17}$ A

$AD = \frac{6}{17}$ A $\quad BD = \frac{-2}{17}$ A

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

3.10) a) Balance pt. from A, $l_1 = 39.5$ cm
Resistance of the resistor $Y = 12.5\ \Omega$
Condition for the balance is given as

$$\frac{X}{Y} = \frac{100 - l_1}{l_1}$$

$\Rightarrow X = 8.2\ \Omega$

The connections betwn resistors is made up of copper strips to minize resistance.

b) If X & Y are interchanged, then l_1 & $100 - l_1$ get interchanged, then l_1 and $100 - l_1$ get interchanged. The balance pt. of the bridge will be $100 - l_1$ from A
$100 - l_1 = 100 - 39.5 = 60.5$ cm

c) When the galvanometer & cell are interchanged at the balance point of the bridge, the galvanometer will show no deflection. Thus no current flows through galvanometer.

3.11) $V_{eff} = V - E$
$= 120 - 8 = 112$ V

$I = \frac{V_{eff}}{R+r}$

$= \frac{112}{15.5+5} = \frac{112}{16} = 7A$

Voltage across resistor R :⇒ $V = 7 \times 15.5 = 108.5V$

Terminal volage = $120 - 108.5 = 11.5V$

3.12 A series resistor in a charging circuit limits the current drawn from the external source.

3.12) $E_1 = 1.25V$ $\quad l_2 = 63 cm$

$l_1 = 35 cm$ $\quad E_2 = ?$

$\frac{E_1}{E_2} = \frac{l_1}{l_2}$

$\Rightarrow E_2 = 1.25 \times \frac{63}{35} = 2.25V$

3.13) $I = nAeV_d$

$= nA(1.6\times10^{-19})\frac{l}{t}$

$\Rightarrow t = \frac{nA(1.6\times10^{-19})l}{I}$

$= \frac{8.5\times10^{28}\times 1.6\times10^{-19}\times 2\times10^{-6}\times 3}{3}$

$= 2.7\times10^{4}$ s

3.14) $\sigma = 10^{-9}\ C\,m^{-2}$

$I = 1800A$

$r = 6.37\times10^{6}m$

$A = 4\pi r^2$

$= 4\pi(6.37\times10^{6})^2 = 5.09\times10^{14}m^2$

$q = \sigma \times A$

$= 10^{-9}\times 5.09\times10^{14}$

$= 5.09\times10^{5}C$

$I = \frac{q}{t}$ $\Rightarrow t = \frac{q}{I} = 282.7s$

3.15) a) $I = \frac{2 \times 6}{(6 \times 0.015 + 8.5)}$ A

$= 1.39$ A

b) $V = IR = 1.39 \times 8.5 = 11.87$ V

b) $I_{max} = \frac{E}{r} = \frac{1.9}{380} = 0.005$ A

Since a large current is reqd. to start the motor of a car, the cell cannot be used to start a motor.

3.16) $R_1 = \rho_1 \frac{l_1}{A_1}$ & $R_2 = \rho_2 \frac{l_2}{A_2}$

$R_1 = R_2$

$\rho_1 \frac{l_1}{A_1} = \rho_2 \frac{l_2}{A_2}$

& $l_1 = l_2$

$\therefore \frac{\rho_1}{A_1} = \frac{\rho_2}{A_2}$

$\Rightarrow \frac{A_1}{A_2} = \frac{\rho_1}{\rho_2} = \frac{2.63}{1.72}$

$m_1 = \text{vol} \times \text{density}$

$= A_1 l_1 \times d_1$

$m_2 = A_2 l_2 \times d_2$

$\therefore \frac{m_1}{m_2} = \frac{2.63}{1.72}$

$= 0.46$

$\therefore$ Aluminium of lighter.

3.17) The ratio of voltage & current is a const 19.7. Hence maganin is an ohmic conductor.

3.18) a) When a steady current flows in a metallic conductor of non-uniform cross-section, the current flowing through the conductor is const. Current density, electric field and drift speed are inversely proportional to the area of ~~a~~ cross-section. Therefore, they are not constant.

b) No, ohm's law is not universally applicable for all conducting elements. Vaccum diode semi conductor is a non-ohmic conductor. Ohm's law is not valid for it.

c) According to Ohm's law the relation for potential is $V = IR$. voltage (V) α current (I)
$I = V/R$
If V is low then R must be low so that high current can be drawn from the source.

d) In order to prohibit the current from exceeding the safety limit, a high tension supply must have a very large internal resistance. If the internal resistance is not large, then the current drawn can exceed the safety limits in case of a short circuit

3.19 a) Alloys of metals usually have greater ~~resistance~~ resistivity than that of ~~a metal by a~~ their constituent metals.

b) Alloys usually have lower temperature coefficient of resistance than pure metals.

c) The resistivity of the alloy, manganin, is nearly independent of increase of temperature.

d) The resistivity of a typical insulator is greater than that of a metal by a factor of the order 10^{22}.

3.20 a) Total resistors = n, each of resistance = R

i) When n resistors are connected in series, effective resistance R_1 is the maximum, given by the product nR

Hence, max Resistance of combination $R_1 = nR$

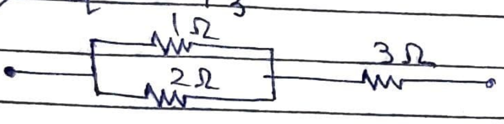
ii) When n resistors are connected in parallel the effective resistance (R_2) is the minimum given by R/n.

Hence, min Resistance of combination $R_2 = R/n$

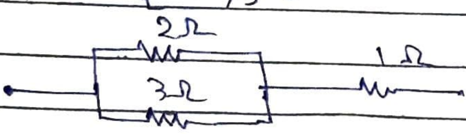
iii) $\frac{R_1}{R_2} = \frac{nR}{R/n} = n^2$

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

i) $R_{eq} = 11/3$

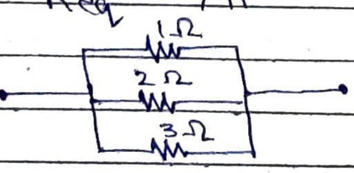


ii) $R_{eq} = 11/5\,\Omega$

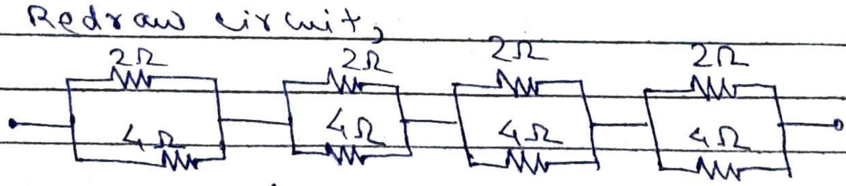


iii) $R_{eq} = 6\,\Omega$

iv) $R_{eq} = 6/11\,\Omega$



c) a) Redraw circuit,



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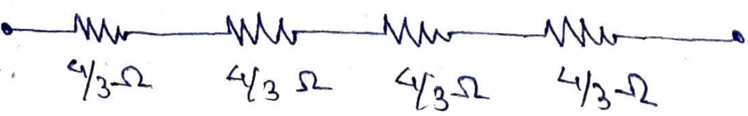

$\therefore R_{eq} = \frac{4}{3} \times 4 = \frac{16}{3}\,\Omega$

b) All are in series thus $R_{eq} = 5R$ $= 8\Omega$

3.21

$$R_{eq} = 2 + \frac{R_{eq}}{R_{eq}+1}$$

$\Rightarrow (R_{eq})^2 - 2R_{eq} - 2 = 0$

$\Rightarrow R_{eq} = \frac{2 \pm \sqrt{12}}{2} = 1 \pm \sqrt{3}$

$R_{eq} = 1 + \sqrt{3} = 2.73\ \Omega$

$r = 0.5\ \Omega$

Total $R = 3.23\ \Omega$

Current drawn $(I) = \frac{12}{3.23} \approx 3.72$ A

3.22 a) Const. emf of the given standard cell, $E_1 = 1.02$ V

Balance point on the wire, $l_1 = 67.3$ cm

$\therefore$ new balance pt. $l = 82.3$ cm

The relation connecting emf and balance pt. is,

$$\frac{E_1}{l_1} = \frac{\varepsilon}{l}$$

$$\varepsilon = \frac{l}{l_1} \times E_1$$

$$= \frac{82.3}{67.3} \times 1.02 = 1.247\ V$$

b) The purpose of using the high resistance 600 kΩ to reduce the current through the galvanometer when the movable contact is far from the balance pt.

c) The balance pt. is not affected by the presence of high resistance.

d) The pt. is not affected by the internal resistance of the driver cell.

e) The method would not work if the driver cell of the potentiometer had an emf of 1V instead of 2V. This is because if the emf of the driver cell of the potentiometer is less than the emf of the other cell, then there would be no balance pt. on the wire.

f) The circuit would not work well for determing an extremely small emf. As the circuit would be unstable, the balance pt. would be close to end A. Hence there would be a large percentage of error.
The given circuit can be modified if a series resistance is connected with the wire AB. The potential drop across AB is slightly greater than the emf measured. The percentage error would be small.

3.23

$R = 10\,\Omega$, $l_1 = 58.3$

$E_1 = iR$, $l_2 = 68.5$ cm, $E_2 = iX$

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

$$\Rightarrow X = \frac{l_1}{l_2} \times R = \frac{68.5}{58.3} \times 10 = 11.749\,\Omega$$

If we fail the potential drop across R & X must be reduced by putting resistance in series with it.

3.24

We, know $r = \left(\frac{l_1 - l_2}{l_2}\right) R$

$$= \frac{76.3 - 64.8}{64.8} \times 9.5 = 1.68\,\Omega$$