CURRENT ELECTRICITY

CHIRANJIB DASH, XII-DB, 9882

3.1) Emf of battery = 12V.

$r = 0.4\ \Omega$

Maximum current = I

According to Ohm's law

$E = Ir$

$I = \frac{E}{r} = \frac{12}{0.4} = 30A$

3.2) Emf $E = 10V$

$r = 3\ \Omega$

$I = 0.5A$

Resistance of resistor = R

From Ohm's law

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

$R + r = \frac{E}{I} = \frac{10}{0.5} = 20\ \Omega$

$R = 20 - 3 = 17\ \Omega$

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

b) $I = \frac{E}{R} = \frac{12}{6} = 2A$

from ohm's law

$V_1 = 2 \times 1 = 2V$ (i)

$V_2 = 2 \times 2 = 4V$ — (ii)

$V_3 = 2 \times 3 = 6V$ — (iii)

Therefore the potential drop across $1\ \Omega$, $2\ \Omega$ and $3\ \Omega$ are 2V, 4V, 6V.

3.4) a) $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$.

$= \frac{1}{2} + \frac{1}{4} + \frac{1}{5} = \frac{19}{20}$

$R = \frac{19}{20}\ \Omega$

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b) $V = 20V$

$I_1 = \frac{V}{R_1} = \frac{20}{2} = 10A$

$I_2 = \frac{V}{R_2}$

$= \frac{20}{4} = 5A$

$I_3 = \frac{V}{R_3} = \frac{20}{5} = 4A$

Total current $= I_1 + I_2 + I_3 = 10 + 5 + 4 = 19A$

3.5) $T = 27°C$

$R = 100\,\Omega$

$R_1 = 117\,\Omega$

$\alpha = 1.70 \times 10^{-4}\,°C^{-1}$

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

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

$T_1 - 27 = \frac{117 - 100}{100(1.7 \times 10^{-4})}$

$T_1 = 1027°C$

3.6) $l = 15\,cm$

$a = 6 \times 10^{-7}\,m^2$

$R = 5\,\Omega$

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

$\rho = \frac{RA}{l}$

$= \frac{5 \times 6 \times 10^{-7}}{15} = 2 \times 10^{-7}\,\Omega m.$

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3.7) $T_1 = 27.5°C$

$R_1 = 2.1\ \Omega$

$T_2 = 100°C$

$R_2 = 2.7\ \Omega$

$$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$$

$$= \frac{2.7 - 2.1}{2.1(100 - 27.5)} = 0.0039°C^{-1}$$

3.8) $V = 230\ V$

$I_1 = 3.2\ A$

$$R_1 = \frac{V}{I_1} = \frac{230}{3.2} = 71.87\ \Omega$$

$I_2 = 2.8\ A$

$$R_2 = \frac{V}{I_2} = \frac{230}{2.8} = 82.14\ \Omega$$

$\alpha = 1.70 \times 10^{-4}\ °C^{-1}$

$T_1 = 27°C$

$$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$$

$$T_2 - 27°C = \frac{82.14 - 71.87}{71.87 \times 1.7 \times 10^{-4}} = 840.5$$

$T_2 = 867.5°C$

3.10) Balance point from end A, $l_1 = 39.5$ cm.

Resistance of the resistor $Y = 12.5\ \Omega$

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

$$X = \frac{100 - 39.5}{39.5} \times 12.5 = 8.2\ \Omega$$

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b) If X and Y are interchanged, then l_1 and $100 - l_1$ get interchanged

$100 - l_1 = 100 - 39.5 = 60.5$ cm. (Balance point from A)

c) When the galvanometer and cell are interchanged at the balanced point of the bridge, the galvanometer will show no deflection.

3.11) $E = 8V$

$r = 0.5\Omega$

$V = 120V$

$R = 15.5\Omega$

$V' = V - E$

$= 120 - 8 = 112$ V (effective voltage)

$I = \frac{V'}{R+r} = \frac{112}{16} = 7A$

Voltage across R $V = IR = 7 \times 15.5 = 108.5$ V

Terminal voltage $= 120 - 108.5 = 11.5$ V

3.12) $E_1 = 1.25V$

$l_1 = 35$cm.

$l_2 = 63$ cm

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

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

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

∴ Emf of second cell is 2.25 V

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3.13) $n = 8.5 \times 10^{28}\ m^{-3}$ $e = 1.6 \times 10^{-19} C$

$l = 3\ cm$ $v_d = \frac{l}{t}$ (drift velocity)

$A = 2.0 \times 10^{-6}\ m^2$

$I = 3A$

$I = neAv_d$

$I = neA\frac{l}{t}$

$t = \frac{nAel}{I} = \frac{3 \times 8.5 \times 10^{28} \times 2 \times 10^{-6} \times 1.6 \times 10^{-19}}{3}$

$= 2.7 \times 10^{4}\ s.$

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

$I = 1800\ A$

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

$A = 4\pi r^2$

$= 4\pi \times (6.37 \times 10^{6})^2$

$= 5.09 \times 10^{14}\ m^2$

$q = \sigma \times A$

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

$= 5.09 \times 10^{5}\ C$

Time taken to neutralise the earth surface $= t$

$I = \frac{q}{t}$

$t = \frac{q}{I} = 282.77\ s.$

3.15) a) $n = 6$

$E = 2.0V$

$r = 0.015\ \Omega$

$R = 8.5\ \Omega$

$I = \frac{nE}{R + nr} = \frac{6 \times 2}{8.5 + 6 \times 0.015} = 1.39\ A$

Terminal voltage $V = IR = 1.39 \times 8.5 = 11.87 A$

b) $E = 1.9 V$

$R = 380 \Omega$

$$I_{max} = \frac{E}{R} = \frac{1.9}{380} = 0.005 A$$

3.16) $\rho_{Al} = 2.63 \times 10^{-8} \Omega m$

$d_1 = 2.7$

Let l_1 be the length of aluminium wire and m_1 be its mass

Resistance of wire $= R_1$

Area $= A$

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

$d_2 = 8.9$

l_2 be length of copper wire and m_2 be its mass

Resistance of copper wire $= R_2$

Area of cross-section of the copper wire $= A_2$

The two relation can be written as

$$R_1 = \rho_1 \frac{l_1}{A_1} \quad \text{—— (i)}$$

$$R_2 = \rho_2 \frac{l_2}{A_2} \quad \text{—— (ii)}$$

It is given that

$R_1 = R_2$

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

And

$l_1 = l_2$

$$\text{i.e. } \frac{\rho_1}{A_1} = \frac{\rho_2}{A_2}$$

$$\frac{A_1}{A_2} = \frac{\rho_1}{\rho_2} = \frac{2.63 \times 10^{-8}}{1.72 \times 10^{-8}} = \frac{2.63}{1.72}$$

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3.17) It can be inferred from the given table that the ratio of voltage with current is a constant which is equal to 19.7. Hence manganin is an ohmic conductor i.e the alloy obeys Ohm's law
According to Ohm's law the ratio of voltage with current is the resistance of the conductor

3.18) a) When a steady current flows in a metallic conductor of non uniform cross section, which of these quantities is constant along the conductor: current, current density, electric field. the current flowing through it is constant

b) No Ohm's law is not universally applicable for all conducting elements. Vaccum diode semi conductor is non ohmic conductor

c) According to Ohm's law, the relation for potential is V = IR

$I = \frac{V}{R}$

If V is low, then R must be very 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

can exceed the safety limit in case of a short circuit.

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

a) Alloys of metal usually have great resistivity than that of their constiticent metals.

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

3.20) a) Total no of resistor = n

Resistance of each resistor = R

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

ii) When n resistors are connected in parallel, the effective resistance is the minimum, given by ratio $\frac{R}{n}$

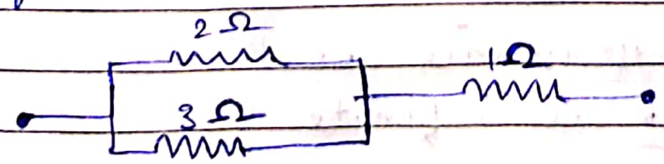
iii) The ratio of the maximum to the minimum resistance is

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

b) i) The resistance of the given resistors is $R_1 = 1\,\Omega$ $R_2 = 2\,\Omega$, $R_3 = 3\,\Omega$

Equivalence resistance = $R' = \frac{11}{3}\,\Omega$

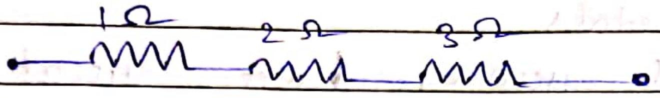
ii)



Equivalent resistance of the circuit is given by

$R' = \frac{2\times3}{2+3} + 1 = \frac{6}{15} + 1 = \frac{11}{5}\ \Omega$

iii) Equivalence resistance, $R' = 6\Omega$



Equivalence resistance of the circuit is given by the sum.

$R' = 1+2+3 = 6\ \Omega$

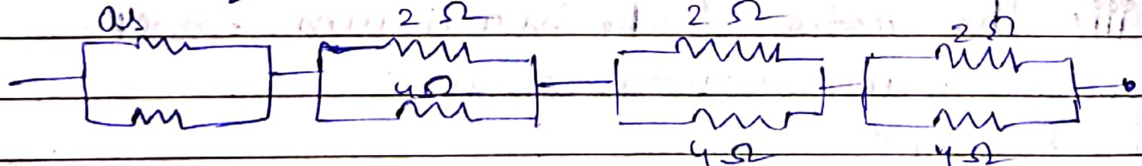
c) It can be observed from the given circuit that in the first small loop, two resistors of resistance 1Ω each are connected in series

Equivalence resistance $= (1+1) = 2\Omega$

It can be also observed that two resistors of resistance 2Ω each are connected in series.

$2+2 = 4\ \Omega$

Therefore the circuit can be redrawn as



$R' = \frac{2\times4}{2+4} = \frac{8}{6} = \frac{4}{3}\ \Omega$

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

21) $R = 1\ \Omega$

Let equivalence resistance be R'

The network is infinite.

Hence equivalent resistance is given by the relation

$$\therefore R' = 2 + \frac{R'}{(R'+1)}$$

$$(R')^2 - 2R - 2 = 0$$

$$R' = \frac{2 \pm \sqrt{4+8}}{2}$$

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

negative value of R cannot be accepted.

So $R' = (1+\sqrt{3}) = 1 + 1.73 = 2.73\,\Omega$

$r = 0.5\,\Omega$

$R_{total} = 2.73 + 0.5 = 3.23\,\Omega$

Supply voltage $V = 12V$

According to ohm's law $\frac{12}{3.23} = 3.72\,A$ (current)

3.22) Constant emf of the given standard standard cell $E_1 = 1.02\,V$

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

A cell of unknown emf ϵ replaced the standard cell.

$l_2 = 82.3$ cm.

The relation connecting emf and balance point is

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

$$\epsilon = \frac{l_2}{l_1} \times E_1 = \frac{82.3}{67.3} \times 1.02 = 1.247\,V$$

The value of unknown emf is $1.247\,V$.