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

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

$\therefore R = \frac{\varepsilon}{I} - r = \frac{10}{0.5} - 3 = 17\,\Omega$

Terminal voltage,

$V = IR = 0.5 \times 17 = 8.5\ V$

$R_s = R_1 + R_2 + R_3 = 6\,\Omega$

Current in the circuit, $I = \frac{\varepsilon}{R} = \frac{12}{6} = 2A$.

$\therefore$ Potential drops across different resistors are

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

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

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

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

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

$= \frac{19}{20}$

$\therefore R_p = \frac{20}{19}\,\Omega$

Currents drawn through different resistors are

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

$I_2 = \frac{\varepsilon}{R_2} = \frac{20}{4} = 5\ A.$

... current drawn from the battery.
$I = I_1 + I_2 + I_3 = 10 + 5 + 4 = 19A.$

Here, $R_1 = 100\Omega$
$R_2 = 117\Omega$
$t_1 = 27^\circ c$
$\alpha = 1.70 \times 10^{-4}\,{}^\circ c^{-1}$

As $\alpha = \frac{R_2 - R_1}{R_1(t_2 - t_1)}$

$\therefore t_2 - t_1 = \frac{R_2 - R_1}{R_1 \alpha} = \frac{117 - 100}{100 \times 1.70 \times 10^{-4}} = 1000$

$\therefore t_2 = 1000 + t_1 = 1000 + 27 = 1027^\circ c.$

Here, $l = 15m$
$A = 6.0 \times 10^{-7} m^2$
$R = 5.0\ \Omega$

Resistivity $\rho = \frac{RA}{l} = \frac{5.0 \times 6.0 \times 10^{-7}}{15}$
$= 2.0 \times 10^{-7}\ \Omega m.$

Here, $R_1 = 2.1\Omega$
$t_1 = 27.5^\circ C$
$R_2 = 2.7\Omega$
$t_2 = 100^\circ C$

$$= \frac{0.6}{2.1 \times 72.5}$$

$$= 0.00394 \,°C^{-1}.$$

Here, $V = 230\ V$

$I_1 = 3.2\ A$

$I_2 = 2.8\ A$

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

Resistance at room temperature,

$$R_1 = \frac{V}{I_1} = \frac{230}{3.2} = 71.875\ \Omega$$

Resistance at steady temperature

$$R_2 = \frac{V}{I_2} = \frac{230}{2.8} = 82.143\ \Omega$$

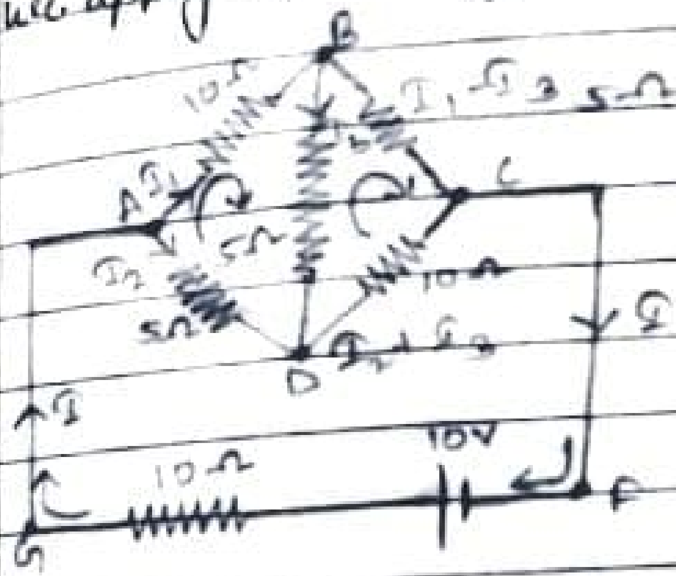
Now,

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

$$\therefore t_2 - t_1 = \frac{R_2 - R_1}{R_1 \alpha}.$$

Let I ...

we apply Kirchhoff's second rule to different loops.



For loop ABDA,

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

For loop BCDB,

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

For loop ADCFGA,

$$5I_2 + 10(I_2 + I_3) + 10(I_1 + I_2) = 10 \qquad (\because I_1 + I_2 = I)$$

$$10I_1 - 5I_2 + 5I_3 = 0 \quad \text{—— (1)}$$

$$5I_1 - 10I_2 - 20I_3 = 0 \quad \text{—— (2)}$$

$$10I_1 + 25I_2 + 10I_3 = 0 \quad \text{—— (3)}$$

Solving equations (1), (2) and (3), we get

$I_1 = \frac{4}{17}$ A, $I_2 = \frac{6}{17}$ A, $I_3 = \frac{-2}{17}$ A

Currents in different branches are

$$I_{BA} = I_1 = \frac{4}{17} \text{ A}$$

$$I_{BC} = I_1 - I_3 = \frac{6}{17} \text{ A}$$

$$I_{DC} = I_2 + I_3 = \frac{4}{17} \text{ A}$$

$$I_{AD} = I_2 = \frac{6}{17} \text{ A}.$$

$$I_{AD} = I_3 = \frac{-2}{17} \text{ A}.$$

Total current,

$$I = I_1 + I_2 = \frac{10}{17} \text{ A}.$$

Here, $l = 35.9$ cm

$R = x = ?$

$S = Y = 12.5\,\Omega$

As $S = \frac{100 - l}{l} \times R$

$\therefore 12.5 = \frac{100 - 39.5}{39.5} \times R$

$R = \frac{12.5 \times 39.5}{60.5} = 8.16\,\Omega$

connections are made by thick copper strips to minimise the resistances of connections which are not counted for in the above formula.

When X and Y are interchanged,

$R = Y = 12.5\,\Omega$

$S = X = 8.16\,\Omega$

$l = ?$

As $S = \frac{100-l}{l} \times R$

$\therefore 8.16 = \frac{100-l}{l} \times 12.5$

$8.16\,l = 1250 - 12.5\,l$

$l = \frac{1250}{20.66} = 60.5\,\Omega$ from the end A.

When the galvanometer and cell are interchanged at the balance point, the conditions of the balanced bridge are still satisfied and so again the galvanometer will not show any current.

When the storage battery of 8.0 volt is charged with a d.c supply of 120 V, the net emf in the circuit will be

$\varepsilon' = 120 - 8.0 = 112\,V$

Current in the circuit during charging

$I = \frac{\varepsilon'}{R+r} = \frac{112}{15.5+0.5} = 7\,A$

The terminal voltage of the battery during charging.

$V = \varepsilon + Ir = 8.0 + 7 \times 0.5 = 11.5\,V$

The rheostat resistance limits the current drawn from the external source. In its absence, the current will be dangerously high.

Here, $\varepsilon_1 = 1.25\,V$

$l_1 = 35.0\,cm$

$l_2 = 63.0\,cm$

$\varepsilon_2 = ?$

As $\frac{\varepsilon_2}{\varepsilon_1} = \frac{l_2}{l_1}$

$\therefore \varepsilon_2 = \frac{l_2}{l_1} \times \varepsilon_1 = \frac{63 \times 1.25}{35} = 2.25\,V$

Here,

$n = 8.5 \times 10^{28}\,m^{-3}$

$l = 3m$

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

$e = 1.6 \times 10^{-19}\,C$

$I = 3.0\,A$

Drift speed,

$v_d = \frac{I}{enA}$

$= \frac{3}{1.6 \times 10^{-19} \times 8.5 \times 10^{28} \times 2 \times 10^{-6}}\,m/s$

$= \frac{3}{16 \times 85 \times 2 \times 10}\,m/s = 1.1 \times 10^{-4}\,m/s$

Required time,

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

$= \frac{3}{1.1 \times 10^{-4}}$ s

$= 2.73 \times 10^{4}$ s $\simeq 7.57$ h.

14) Surface Charge density $\sigma = 10^{-9}\,cm^{-2}$

Radius of earth $= R = 6.37 \times 10^{6}\,m$

Current $= I = 1800\,A$

Total charge of the globe.

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

$= 4 \cdot 3.14 \times (6.37 \times 10^{6})^2 \times 10^{-9} = 509.65 \times 10^{3}\,C$

Required time

$t = \frac{q}{I} = \frac{509.65 \times 10^{3}}{1800} = 283.13s \simeq 283\,s$

15) Here $\varepsilon = 2V$, $r = 0.015\,\Omega$, $R = 8.5\,\Omega$, $n = 6$

When the cells joined in series the current is

$I = \frac{n\varepsilon}{R + nr} = \frac{6 \times 2}{8.5 + 6 \times 0.015} = \frac{12}{8.59}\,A \simeq 1.4\,A$

Terminal voltage.

$V = IR = 1.4 \times 8.5 = 11.9\,V$

b) Here $\varepsilon = 1.9V$, $r = 380\,\Omega$

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

This secondary cell cannot drive the starting motor of car because that requires a large current of about 100 A for few second.

16) Given,

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

relative density of Al $= 2.7$ and that of Cu $= 8.9$

Mass = volume $\times$ density $= Ald$

$= \frac{\rho l}{R} \cdot ld = \frac{\rho d l^2}{R}$ $\left[\because R = \rho \frac{l}{A}\right]$

As the two wires are of equal length and have the same resistance, their mass ratio will be

$\frac{m_{cu}}{m_{Al}} = \frac{\rho_{cu}\, d_{cu}}{\rho_{Al}\, d_{Al}} = \frac{1.72 \times 10^{-8} \times 8.9}{2.63 \times 10^{-8} \times 2.7} = 2.156 \simeq 2.2$

18) a) Only current is constant because it is given to be steady. Other quantities : current density, electric field and drift speed vary inversely with area of cross section.

b) No Ohm's law is not universally applicable for all conducting elements. Examples of non ~~ohmic~~ ohmic elements are vacuum diode, transistor, gas discharge tube, electrolytic soln etc.

c) The maxm current that can be drawn from a voltage supply is given by

$$I_{max} = \frac{\varepsilon}{r}$$

clearly I_{max} will be large if r is small

d) If the internal resistance is not very large ; then the current will exceed the safety limits in case the circuit is short circuited accidentally.

19 a) Alloys of metal usually have greater resistivity than that of their constituents

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

c) The resistivity of alloy manganin is nearly independent of rapidly with increase of temp.

d) The resistivity of a typical insulator is greater than that of a metal ~~with increase of temperature~~ by a factor of order of 10^{22}

20 a) For maximum effective resistance, all the n resistors must be connected in series.

∴ maximum effective resistance

$$R_s = nR$$

For minimum resistance, n resistors should be in parallel connection

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

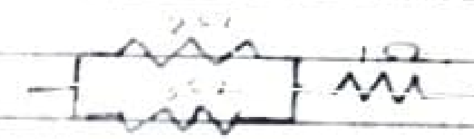
i) When parallel combination of 1Ω and 2Ω resistors are connected in series with 3Ω resistors

$$R = R_p + R_3 = \frac{R_1 R_2}{R_1 + R_2} + R_3 = \frac{1\times 2}{1+2} + 3 = \frac{11}{3}\,\Omega$$

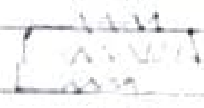
ii) When parallel combination of 2Ω and 3Ω resistors is connected in series with 1Ω resistors the equivalent resistance is

$$R = \frac{R_2 R_3}{R_2 + R_3} + R_1 = \frac{2\times 3}{2+3} + 1 = \frac{6}{5} + 1 = \frac{11}{5}\,\Omega$$

a) 

ii) 

c) 

d) 

iii) When three resistances are connected in series the equivalent resistance is

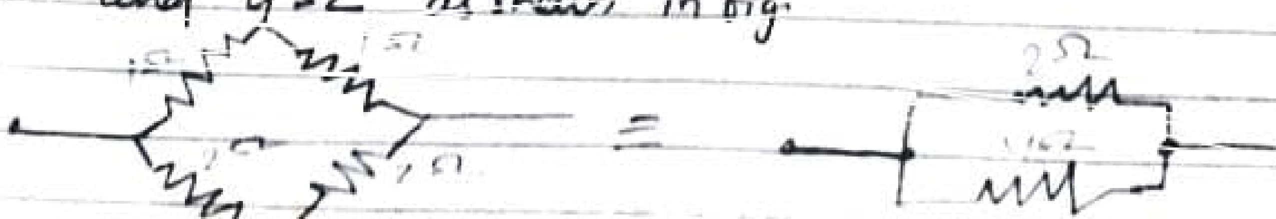
$$R = R_1 + R_2 + R_3 = (1+2+3)\,\Omega = 6\,\Omega$$

iv) When all resistances are connected in parallel

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{1} + \frac{1}{2} + \frac{1}{3} = \frac{11}{6}$$

Equivalent resistence $= \frac{6}{11}\,\Omega$

c) The network shown in fig is a series combination of four identical units. One such unit is shown in figure and it is equivalent to parallel combination of resistances of 2Ω and 4Ω as shown in fig.



Resistance R of one such unit is given by

$$\frac{1}{R} = \frac{1}{2} + \frac{1}{4} = \frac{2+1}{4} = \frac{3}{4}$$

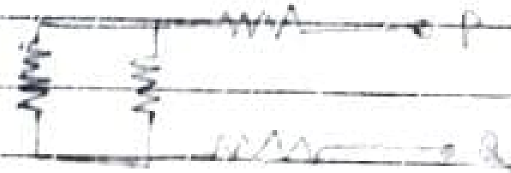
$$R = \frac{4}{3}\ \Omega$$

Resistance of total network $= 4 \times \frac{4}{3} = \frac{16}{3}\ \Omega$

ii) The network shown in fig is a series combination of 5 resistors each of resistance R

$\therefore$ Equivalent resistance $= \cancel{4 \times \frac{4}{3}} = \cancel{\frac{16}{3}}\ 5R$

21) Let the equivalent resistance of infinite network be x. The network consists of infinite units of three resistors of 1Ω and 1Ω. Addition of 1 more resistor such unit across will not affect the total resistance. The network obtained by adding one more unit would appear

22) 

Resistance between A and B

= Resistance equivalent to parallel combination of x and 1 Ω

$= \frac{x \cdot 1}{x+1} = \frac{x}{x+1}$

Resistance between P and Q $= 1 + \frac{x}{x+1} + 1 = 2 + \frac{x}{x+1}$

This must be equal to original resistance x

$x = 2 + \frac{x}{1+x}$

$x^2 - 2x - 2 = 0$

$x = 1 \pm \sqrt{3}$

As the value of resistance cannot be negative so $x = 1 + \sqrt{3} = 2.73$

Current $I = \frac{\text{Emf}}{\text{total resistance}} = \frac{E}{x+r} = \frac{12}{2.732+0.5} = 3.713A$

22 a) $E = 1.02V$, $l_1 = 67.2cm$, $E_2 = E = ?$, $l_2 = 82.3cm$

Formula for the comparision of emf by ~~potential~~ Potentiometer is

$\frac{E_2}{E_1} = \frac{l_2}{l_1}$ $\therefore$ $\frac{E_2}{1.02} = 1.25V$

b) High resistance of 500 ~~kΩ~~ Ω protects the galvanometer for position far away from balance point

c) No balance point is not affected by high resistance because no current flows through standard cell at balance point.

d) Yes, the balance point is affected by the internal resistance affects the current through the potentiometer wire, so change ~~the potential~~ i.e potential gradient and hence affects the ~~current through~~ balance point.

e) No, the arrangement will not work. If E is greater then emf of the driver cell of potentiometer there will be no balance point on wire AB.

23) Here, $R = 10\Omega$, $l_1 = 58.3cm$, $x = ?$, $l_2 = 68.5cm$

Let E_1 and E_2 be potential drops across R and x respectively and I be the current in potentiometer wire

Then $\frac{E_2}{E_1} = \frac{Ix}{IR} = \frac{x}{R}$

But $\frac{E_2}{E_1} = \frac{l_2}{l_1}$ $\therefore$ $\frac{x}{R} = \frac{l_2}{l_1}$

$x = \frac{l_2}{l_1} R = \frac{68.5}{58.3} \times 10 = 11.75\Omega$

24) Here, $l_1 = 76.3cm$, $l_2 = 64.8cm$, $R = 9.5\Omega$

The formula for internal resistance of a cell by potentiometer method

$$r = R\left(\frac{l_1 - l_2}{l_2}\right) = 9.5\left(\frac{76.3 - 64.8}{64.8}\right) = \frac{9.5 \times 11.5}{64.8} \simeq 1.7\Omega$$