UNIT – 2 CURRENT ELECTRICITY

I.One marks

1. Resistance of a metal wire of length 10cm is 2 Ω. If the wire is stretched uniformly to 50 cm ,resistance is

a) 25 Ω b) 10 Ω c) 5 Ω d) 50 Ω

2. The colour code on a carbon resistor is red – red – black. The resistance of the resistor is

a) 2.2 Ω b) 22 Ω c) 220 Ω d) 2.2 kΩ

3. The brown ring at one end of a carbon resistor indicates a tolerance of

a) 1% b) 2% c) 5% d) 10%

4. The unit of conductivity is

a) mho b) ohm c) ohm – m d)mho – m^{-1}

5. The material through which electric charge can flow easily is

a) quartz b) mica c) germanium d) copper

6. In the case of insulators, as the temperature decreases, the resistivity

a) decreases b) increases c) remains constant d) becomes zero

7. If the length of a copper wire has a certain resistance R, then on doubling the length its specific resistance

a) will be doubled b) will be 1/4th

c) will become four times d) will remain the same

8. When two 2 Ω resistances are in parallel their effective resistance is

a) 2 Ω b) 4 Ω c) 1 Ω d) 0.5 Ω

9. The transition temperature of mercury is

a) 4.2^0C b) 4.2 K c) 2.4^0C d) 2.4 K

10. The toaster operating at 240 V has a resistance of 120 Ω. The power is

a) 400 W b) 2 W c) 480 W d) 240 W

11. The relation between current and drift velocity is

a) $I = Av_d$ b) $I = nev_d$ c) $I = nv_d$ d) $I = neAv_d$

12. When the diameter of a conductor is doubled, its resistance

a) decreases twice b) decreases four times

c) decreases sixteen times d) increases four times

13. A cell of emf 2.2V sends a current of 0.2 A through a resistance of 10 Ω. The internal resistance of the cell is

a) 0.1 Ω b) 1 Ω c) 2 Ω d) 1.33 Ω

14. When n resistors of equal resistance (R) are connected in series the effective resistance is

a) n / R b) R / n c) 1/ nR d) nR

15. The electrical resistivity of a thin copper wire and a thick copper rod are respectively p_1 Ω m and p_2 Ω m. Then :

a) $p_1 > p_2$ b) $p_2 > p_1$ c) $p_1 = p_2$ d) $p_2/p_1 = \infty$

16. The unit of electrochemical equivalent is

a) Kg. coulomb b) kg/ ampere sec c) kg/ sec. d) C/kg

17. When 'n' resistors of equal resistance (R) are connected in series and in parallel respectively, then the ratio of their effective resistance is :

Based on concepts

1. Nichrome is used as heating element because it has
a) very low resistance b) low melting point
c) high specific resistance d) high conductivity
2. Peltier effect is the converse of
a) Joule effect b) Raman effect
c) Thomson effect **d) Seebeck effect**
3. In which of the following pairs of metals of a thermocouple the e.m.f. is maximum?
a) Fe – Cu b) Cu – Zn c) Pt - Ag **d) Sb – Bi**
4. Joule's law of heating is
a)$H = l^2 t/R$ b) $H = V^2Rt$ c) $H = IR^2t$ **d) H = Vlt**
5.. Fuse wire is an alloy of
a) Lead and Tin b) Tin and Copper
c) Lead and Copper d) Lead and Iron
6. Fuse wire
a) is an alloy of lead and copper b) has low resistance
c) has high resistance d) has high melting point
7. In the case of insulators, as the temperature increases, the resistivity **decreases**
8. The drift velocity acquired per unit electric field is called **mobility**
9. Kirchoff's first law is a consequence of conservation of **charges**
10. Kirchoff's second law is a consequence of conservation of . **energy**
11. 1 kWh is equal to **36×10^5** J.
12. The quantity of charge passing per unit time through unit area is called as **current density**
13. Germanium and silicon are called as **semiconductors**
14. The electric iron works on the principle of **Joule's heating** effect of current.
15. The melting point of tungsten is **3380**^{o}C.
16. Fuse wire has high resistance and **low** melting point.
17. The alloy of nickel and chromium is called **nichrome**
18. Sn, Au, Ag, Zn, Cd, Sb show **Positive Thomson** effect.
19. Bi, Ni, Pt, Co, Fe, Hg show **Negative Thomson** effect.
20. Seebeck effect is a **Reversible** process.
21. Which of the following has negative temperature coefficient of resistance?
(a) copper (b) tungsten **(c) carbon** (d) silver
22. The temperature co-efficient of resistance for alloys is
(a) low **(b) very low** (c) high (d) very high
23. .Joule heating effect is desirable in
(a) AC dynamo (b) DC dynamo **(c) water heater** (d) Transformer
24.The resistivity of a wire depends on
(a) Length (b) material (c) area of cross section **(d) all the above**

25. Ohm's law is applicable for
(a) Complicated circuit **(b)simple circuit** (c) Primary circuit (d) secondary circuit

Notes

1.Instaneous Current I = dq /dt

2.Current I = Q / t Unit : A

3.Drift velocity $v_d = a\tau$ Unit: m/s

4. **Mobility** $\mu = \frac{v_d}{E}$ **Unit :** m^2/Vs

5. **Current density** $J = \frac{I}{A}$ **Unit** : A/m^2 **Quantity :** Vector

6. **Ohm's law** $V \alpha I$ $V = IR$

V-potential difference **I** - current

R - resistance

7. **Resistance** $R = \frac{V}{I}$ **Unit :** ohm or Ω

8. **Electrical resistivity** $\rho = \frac{RA}{L}$ **Unit :** Ω m or ohm-meter

9.Resistors in series $R_s = R_1 + R_2 + R_3$

10.Resistors in parallel $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

11. **Temperature coefficient of resistance** $\alpha = \frac{\Delta\rho}{\Delta T\, \rho_0}$ **Unit :** per ^0C

12. Joule's law of heating. $H = I^2Rt$

13.Conductivity $\sigma = 1/\rho$ **Unit :** $\Omega^{-1}\ m^{-1}$

14.Internal resistance of the cell $r = \left(\frac{\xi - V}{V}\right) R$

15.Condition for bridge balance $\frac{P}{Q} = \frac{R}{S}$

16.In metre bridge ; Unknown resistance $P = Q\frac{l_1}{l_2}$

17.Electric power $P = VI = I^2R$

Two marks (Book back & Book inside)

1.Define electric current

The electric current in a conductor is defined as the rate of flow of charges through a given cross-sectional area A.

$\mathbf{I} = \frac{Q}{t}$ **Unit** : Ampere **Quantity** : scalar

2.Define 1 ampere current

1A of current is equivalent to 1 Coulomb of charge passing through a perpendicular cross section in 1second

$\mathbf{I} = \frac{1C}{1s}$

3.Define Drift velocity

The drift velocity is the average velocity acquired by the electrons inside the conductor when it is subjected to an electric field

$\mathbf{v_d = a\,\tau}$ **Unit:** m/s **quantity :** vector

4.Define mean free time

The average time between successive collisions is called the mean free time denoted by τ . $\tau = \frac{v_d}{a}$ **Unit :** s

5.Define mobility

It is defined as the magnitude of the drift velocity per unit electric field.

$\mu = \frac{v_d}{E}$ **Unit :** m^2/Vs **Quantity :** scalar

6.Define Current density (BB-10)

The current density (J) is defined as the current per unit area of cross section of the conductor.

$\mathbf{J} = \frac{I}{A}$ **Unit** : A/m^2 **Quantity :** Vector

7.Write down microscopic model of ohm's law (BB-3)

$$\vec{J} = \sigma\vec{E}$$

J- Current density **σ** – conductivity

E – Electric field

8. **Why current is a scalar? (BB-1)**

Current I is defined as the scalar product of the current density and area vector in which the charges cross.

It does not obey vector law of addition and multiplication .& it cannot be resolved into components unlike other vector quantities

18.Why temperature coefficient of resistance (α) is positive for conductor and negative for semiconductor

If the temperature of a conductor increases, the average kinetic energy of electrons in the conductor increases. This results in more frequent collisions and hence the resistivity increases.

As the temperature increases, more electrons will be liberated from their atoms . Hence the current increases and therefore the resistivity decreases.

19.Define thermistor

A semiconductor with a negative temperature coefficient of resistance is called a thermistor.

Ex: Germanium , silicon

20.Define transition or critical temperature

The resistance of certain materials become zero below certain temperature $T_{c.}$ This temperature is known as critical temperature or transition temperature.

21.What are superconductor

The resistance of certain materials become zero below certain temperature. The materials which exhibit this property are known as superconductors

22.When the car engine is started with headlights turned on, they sometimes become dim.

This is due to the internal resistance of the car battery.

23.Define Kirchhoff's first rule (Current rule or Junction rule) (BB-13)

It states that the algebraic sum of the currents at any junction of a circuit is zero. It is a statement of conservation of electric charge. Current entering the junction is taken as positive and current leaving the junction is taken as negative

24.Define Kirchhoff's Second rule (Voltage rule or Loop rule) (BB-14)

It states that in a closed circuit the algebraic sum of the products of the current and resistance of each part of the circuit is equal to the total emf included in the circuit. This rule follows from the law of conservation of energy for an isolated system.

25.Define Joule's heating effect.

When current flows through a resistor, some of the electrical energy delivered to the resistor is converted into heat energy and it is dissipated.

26. Define Joule's law of heating. (BB-17)

$$H = I^2Rt$$

It states that **the heat developed in an electrical circuit due to the flow of current varies directly as**

(i) the square of the current

(ii) the resistance of the circuit and

(iii) the time of flow.

27.Define thermoelectric effect

Just as current produces thermal energy, thermal energy may also be suitably used to produce an electromotive force.

$P = \frac{dW}{dt} = \frac{d}{dt}(V.dQ) = V\frac{dQ}{dt}$

Since $I = \frac{dQ}{dt}$

P = VI

38.State principle of potentiometer (BB-15)

When a constant current flows through a wire of uniform area of cross section , The emf of the cell is directly proportional to the balancing length of wire between two points

E α l

39.What do you meant by internal resistance of a cell (BB-16)

The resistance offered by electrolyte of a cell to the flow of current between its electrodes is called internal resistance of a cell

40.Distinguish between drift velocity and mobility (BB-2)

Drift velocity	Mobility
It is defined as velocity with which electrons get drifted towards positive terminal when electric field is applied	It is defined as the magnitude of the drift velocity per unit electric field
$v_d = a\tau$	$\mu = \frac{v_d}{E}$
Unit : m/s	**Unit :** $m^2V^{-1}s^{-1}$

41.Define instantaneous current

It is defined as limit of average current , $\Delta t \to 0$ $I = \lim_{\Delta t \to 0}\frac{\Delta Q}{\Delta t} = \frac{dQ}{dt}$

42.Why nickel is used as heating element

It has high specific resistance and can be heated to very high temperature without oxidation

43.What are factors on which resistivity of material depend

(i)Inversely proportional to number density of electrons

(ii) inversely proportional to average time between collisions

See all graphs , table , note , do you know and all derivations in book

Five marks (Book back)

1. Describe the microscopic model of current and obtain general form of Ohm's law

Consider a conductor with area of cross section A and an electric field applied from right to left. Suppose there are *n* electrons per unit volume in the conductor and assume that all the electrons move with the same drift velocity v_d

The electrons move through a distance *dx* within a small interval of *dt*

$v_d = \frac{dx}{dt}$ $\quad$ $dx = v_d dt$ **…………(1)**

A – area of cross section of the conductor

The electrons available in the volume of length dx = volume × n/V

= Adx × n **………….(2)**

Sub (2) in (1)

$= A v_d \; dt \times n$

Total charge in volume element dQ = charge × number of electrons in the volume element

$dQ = e A v_d \; dt \times n$

$I = \frac{dQ}{dt}$ **…………..(3)**

Sub (2) in (3)

$I = \frac{neAdtv_d}{dt}$

$I = neAv_d$

Since current density $\mathbf{J = I/A}$

$J = nev_d$ **……………(4)**

Sub v_d in (4)

$J = -\frac{n\tau e^2}{m}E$

$J = -\sigma E$

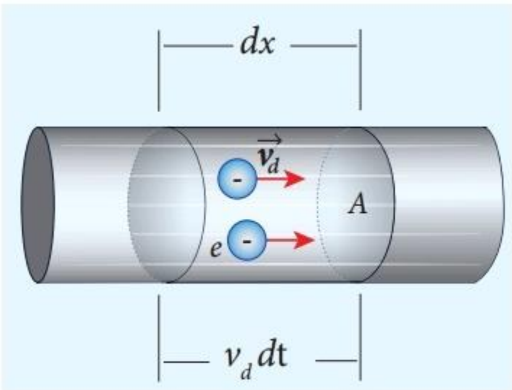


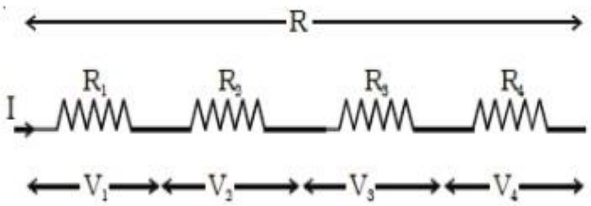
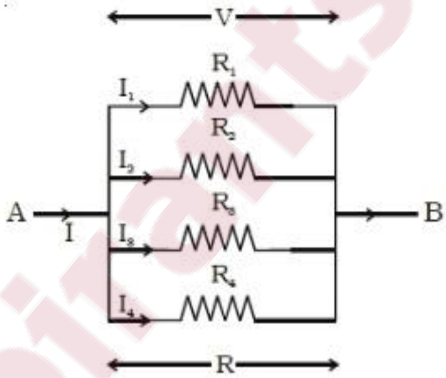
Figure 2.5 Microscopic model of current

But conventionally, we take the direction of (conventional) current density as the direction of electric field. So the above equation becomes

$\mathbf{J = \sigma E}$ **………(microscopic form's of ohm's law)**

$\boldsymbol{\sigma = \frac{n\tau e^2}{m}}$ is called conductivity

3.Explain the equivalent resistance of a series and parallel resistor network

Resisters in series	Resisters in parallel
1. R_1, R_2, R_3, R_4 Resisters are connected in series. Rs is the effective resistance.	1. R_1, R_2, R_3, R_4 are Resisters connected in parallel. R_P is the effective resistance.
2. 	2. 
3. Current flowing through each resistor is the same.	3. Potential difference (V) across each resistor is same.
4. $V = V_1 + V_2 + V_3 + V_4$	4. $I = I_1 + I_2 + I_3 + I_4$.
5. $V_1 = IR_1, V_2 = IR_2, V_3 = IR_3, V_4 = IR_4$ and $V = IR_S$ $IR_S = IR_1 + IR_2 + IR_3 + IR_4$ **(Or) $R_S = R_1 + R_2 + R_3 + R_4$**	5. $I_1 = \frac{V}{R_1}, \; I_2 = \frac{V}{R_2}, \; I_3 = \frac{V}{R_3}, \; I_4 = \frac{V}{R_4}$ $I = \frac{V}{R_P}$ $\frac{V}{R_P} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} + \frac{V}{R_4}$ $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$
6. The equivalent resistance of a number of resistors in series connection is equal to the sum of the resistance of individual resistors.	6. The sum of the reciprocal of the resistance of the individual resistors is equal to the reciprocal of the effective resistance of the combination.

This rule follows from the law of conservation of energy for an isolated system.

6. Obtain the condition for bridge balance in Wheatstone's bridge.

An important application of Kirchhoff 's rules is the Wheatstone's bridge. It is used to compare resistances and also helps in determining the unknown resistance in electrical network.

The bridge consists of four resistances P, Q, R and S connected .

A galvanometer G is connected between the points B and D.

The battery is connected between the points A and C. The current through the galvanometer is I_G and its resistance is G.

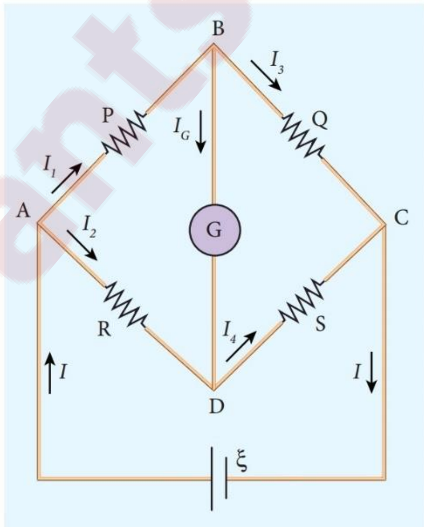


Figure 2.25 Wheatstone's bridge

Applying **Kirchhoff 's current rule to junction B**

$$I_1 - I_G - I_3 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Applying **Kirchhoff 's current rule to junction D,**

$$I_2 - I_G - I_4 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Applying **Kirchhoff 's voltage rule to loop ABDA,**

$$I_1P + I_GG - I_2R = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Applying Kirchhoff 's voltage rule to loop ABCDA,

$$I_1P + I_3Q - I_2R - I_4S = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

When the points B and D are at the same potential, the bridge is said to be balanced , no current flows through galvanometer ($I_G = 0$).

Substituting **$I_G = 0$** in (1) , (2) , (3) , (4)

$$I_1 = I_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots(5) \qquad I_2 = I_4 \quad \ldots\ldots\ldots\ldots\ldots\ldots(6)$$

$$I_1P = I_2R \quad \ldots\ldots\ldots\ldots\ldots\ldots(7)$$

Substituting **(5) & (6) in (4)**

$$I_1P + I_1Q - I_2R - I_2S = 0$$

$$I_1(P + Q) = I_2(R + S) \quad \ldots\ldots\ldots\ldots\ldots\ldots(8)$$

Dividing (8) by (7)

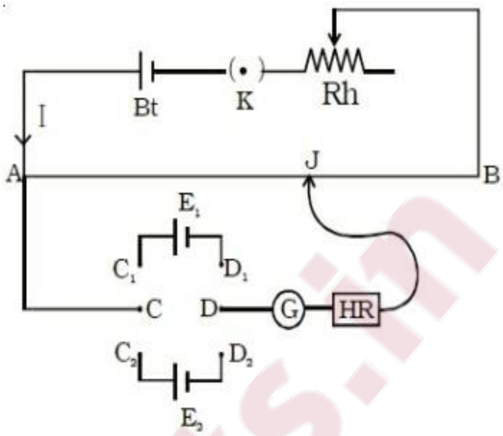
$$\frac{P+Q}{P} = \frac{R+S}{R}$$

$$1 + \frac{Q}{P} = 1 + \frac{S}{R}$$

$$\frac{P}{Q} = \frac{R}{S}$$

7. Explain the determination of unknown resistance using meter bridge

8. How the emf of two cells are compared using potentiometer?



- The end A of potentiometer is connected to the terminal C of a DPDT switch.
- Battery, key and rheostat are connected in series with B. terminal D is connected to the jockey (J) through a galvanometer and high resistance.
- Let I be the current flowing through the primary circuit and r be the resistance of the potentiometer wire per metre length.
- The jockey is moved on the wire and adjusted for zero deflection in galvanometer.
- $E_1 = Irl_1$ ---------------→(1)
- $E_2 = Irl_2$---------------→(2)

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

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

Book inside

1. Explain about cells in series and parallel

In series connection, the negative terminal of one cell is connected to the positive terminal of the second cell, the negative terminal of second cell is connected to the positive terminal of the third cell and so on.

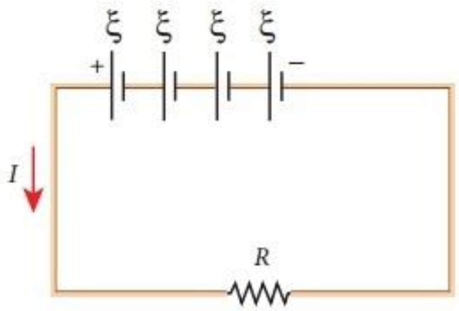
The free positive terminal of the first cell and the free negative terminal of the last cell become the terminals of the battery.

Suppose n cells, each of emf ξ volts and internal resistance *r* ohms are connected in series with an external resistance R

The total emf of the battery = $n\xi$

The total resistance in the circuit = $nr + R$

By Ohm's law, the current in the circuit is



Cells in series (circuit diagram)

Figure 2.21 cells in series

Potentiometer is used for the accurate measurement of potential differences, current and resistances.

It consists of ten meter long uniform wire of manganin or constantan stretched in parallel rows each of 1 meter length, on a wooden board.

The two free ends A and B are brought to the same side and fixed to copper strips with binding screws. A meter scale is fixed parallel to the wire. A jockey is provided for making contact.

Principle

A steady current is maintained across the wire CD by a battery*Bt*.

The battery, key and the potentiometer wire are connected in series forms the primary circuit. The positive terminal of a primary cell of emf ξ is connected to the point C and negative terminal is connected to the jockey through a galvanometer G and a high resistance HR. This forms the secondary circuit.Let contact be made at any point J on the wire by jockey. If the potential difference across CJ is equal to the emf of the cell ξ then no current will flow through the galvanometer and it will show zero deflection. CJ is the balancing length *l*. The potential difference across CJ is equal to *Irl* where *I* is the current flowing through the wire and *r* is the resistance per unit length of the wire. ξ = ***Irl***

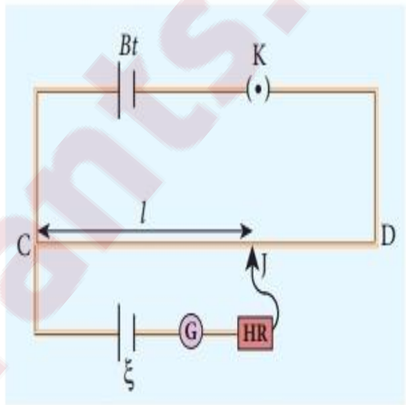


Figure 2.27 Potentiometer

Since *I* and *r* are constants

The emf of the cell is directly proportional to the balancing length.

3. Explain determination of internal resistance of a cell by potentiometer

To measure the internal resistance of a cell, the circuit connections are made

The end C of the potentiometer wire is connected to the positive terminal of the battery Bt and the negative terminal of the battery is connected to the end D through a key K_1. This forms the primary circuit.

The positive terminal of the cell ξ whose internal resistance is to be determined is also connected to the end C of the wire. The negative terminal of the cell ξ is connected to a jockey through a galvanometer and a high resistance. A resistance box R and key K_2 are connected across the cell ξ. With K_2 open, the balancing point J is obtained and the balancing length CJ = l_2 is measured. Since the cell is in open circuit, its emf is

$$\xi \propto l_1$$

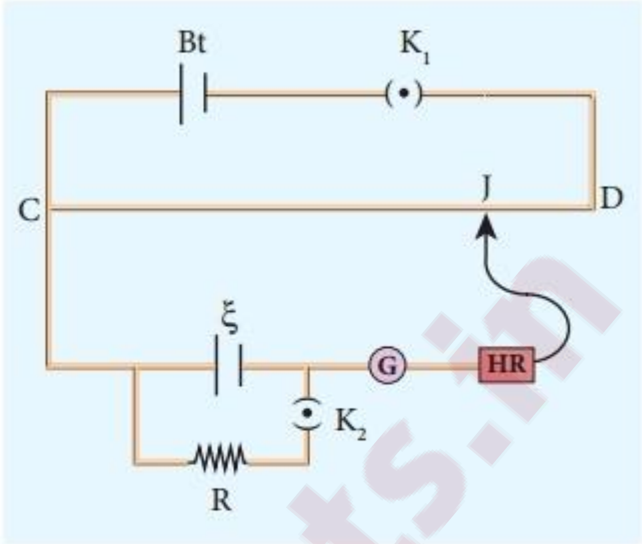


Figure 2.29 measurement of internal resistance

A suitable resistance (say, 10 Ω) is included in the resistance box and key K_2 is closed. Let r be the internal resistance of the cell. The current passing through the cell and the resistance R is given by

$$I = \frac{\xi}{R+r} \quad \text{.........(1)}$$

The potential difference across R is

$$V = \frac{\xi R}{R+r}$$

When this potential difference is balanced on the potentiometer wire, let $l2$ be the balancing length. $\frac{\xi R}{R+r} \propto l_2$ …………..(2)

From (1) & (2)

$$\frac{R+r}{R} = \frac{l_1}{l_2}$$

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

4. **Explain application of Joule's heating effect**

1. Electric heaters

Electric iron, electric heater, electric toaster are some of the home appliances that utilize the heating effect of current.

In these appliances, the heating elements are made of nichrome, an alloy of nickel and chromium.

2. Electric fuses

Fuses are connected in series in a circuit to protect the electric devices from the heat developed by the passage of excessive current. It is a short length of a wire made of a low melting point material. It melts and breaks the circuit if current exceeds a certain value.

Whenever there is an excessive current produced due to faulty wire connection, the circuit breaker switch opens. After repairing the faulty connection, we can close the circuit breaker switch

5.Explain seeback effect and its application

Seebeck discovered that in a closed circuit consisting of two dissimilar metals, when the junctions are maintained at different temperatures an emf (potential difference) is developed. The current that flows due to the emf developed is called thermoelectric current. The two dissimilar metals connected to form two junctions is known as thermocouple

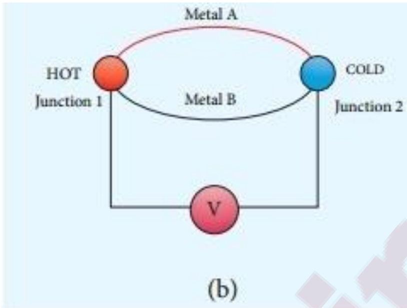


Figure 2.35 Seebeck effect (Thermocouple)

If the hot and cold junctions are interchanged, the direction of current also reverses. Hence the effect is reversible.

The magnitude of the emf developed in a thermocouple depends on (i) the nature of the metals forming the couple and (ii) the temperature difference between the junctions.

Applications of Seebeck effect

1. Seebeck effect is used in thermoelectric generators (Seebeck generators).These thermoelectric generators are used in power plants to convert waste heat into electricity.
2. This effect is utilized in automobiles as automotive thermoelectric generators for increasing fuel efficiency.
3. Seebeck effect is used in thermocouples and thermopiles to measure the temperature difference between the two objects.