Excel Coaching Classes

Date: 12-Jun-2026
Time: 60min

Current Electricity

Marks: 20

SECTION A

Q.1 **Select and write the correct answer for the following multiple choice type of questions:** **(3)**

i **Which of the following equations gives correct expression for the internal resistance of a cell by using potentiometer?**

- (A) $r = R\left(\frac{V}{E} - 1\right)$
- (B) $r = R\left(1 - \frac{E}{V}\right)$
- (C) $r = R\left(1 - \frac{V}{E}\right)$
- (D) $r = R\left(\frac{E}{V} - 1\right)$

Ans:

Explanation:

ii **A metrebridge cannot be used to determine**

- (A) resistance of a wire.
- (B) specific resistance.
- (C) conductivity.
- (D) e.m.f of a cell.

Ans:

Explanation:

A metre bridge, based on the Wheatstone bridge principle, is used to measure the resistance of a wire, specific resistance (if the wire's dimensions are known), and conductivity (since it's related to resistivity). However, it cannot measure the e.m.f. of a cell, as this requires a different setup, such as a potentiometer, which is specifically designed for measuring potential differences.

iii **In a potentiometer experiment, balancing length for first cell and second cell are 2.5 m and 2 m respectively, when cells are used separately. Hence E_1/E_2 is _____.**

- (A) 0.8
- (B) 1
- (C) 1.1
- (D) 1.25

Ans: (D)

Explanation:

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

$= \frac{2.5}{2}$

$= 1.25$

Q.2 **Answer the following questions:** **(3)**

i **Define Potential Gradient.**

Potential gradient is defined as potential difference per unit length of wire.

ii **What is the value of resistance for an ideal voltmeter?**

For an ideal voltmeter the value of resistance is infinite.

iii **What is shunt?**

Moving coil galvanometer is converted into an ammeter by connecting a low resistance in parallel with the galvanometer, which effectively reduces the resistance of the galvanometer. This low resistance connected in parallel is called as shunt (S).

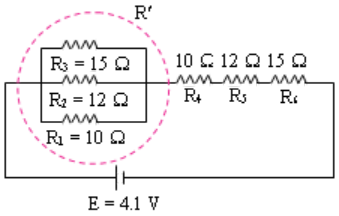
SECTION B

Attempt any TWO questions of the following: **(4)**

Q.3 **A set of three coils having resistances 10 Ω, 12 Ω and 15 Ω are connected in parallel. This combination is connected in series with series combination of three coils of the same resistances. Calculate the total resistance and current through the circuit, if a battery of e.m.f 4.1 volt is used for drawing current.**

Ans: The total resistance and current through circuit is **41 Ω** and **0.1 A** respectively.

Explanation:



$$\frac{1}{R'} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\therefore \quad \frac{1}{R'} = \frac{1}{10} + \frac{1}{12} + \frac{1}{15} = \frac{6 + 5 + 4}{60} = \frac{1}{4}$$

$$\therefore \quad R' = 4\ \Omega$$

$$R_{eq} = R' + R_4 + R_5 + R_6$$

$$= (4 + 10 + 12 + 15)\ \Omega = \mathbf{41\ \Omega}$$

$$I = \frac{E}{R_{eq}} = \frac{4.1}{41} = \mathbf{0.1\ A}$$

Q.4 **State any two sources of errors in metrebridge experiment. Explain how they can be minimized.**

Sources of errors:

i. The cross section of the wire may not be uniform.

ii. The ends of the wire are soldered to the metallic strip where contact resistance is developed, which is not taken into account.

iii. The measurements of l_X and l_R may not be accurate.

To minimize the errors

i. The value of R is so adjusted that the null point is obtained around middle one third of the wire (between 34 cm and 66 cm) so that percentage error in the measurement of l_X and l_R are minimum and nearly the same.

ii. The experiment is repeated by interchanging the positions of unknown resistance X and known resistance box R.

iii. The jockey should be tapped on the wire and not slided. The jockey is used to detect whether there is a current through the central branch. This is possible only by tapping the jockey.

[Any two sources of errors and their minimization]

Q.5 Distinguish between a potentiometer and a voltmeter.

No.	Potentiometer	Voltmeter
i.	Its resistance is infinite.	Its resistance is high but finite.
ii.	It does not draw any current from the source of known e.m.f.	It draws some current from the source of e.m.f.
iii.	The potential difference measured by it is equal to actual potential difference (p.d.).	The potential difference measured by it is less than the actual potential difference (p.d.).
iv.	It has high sensitivity.	It has low sensitivity.
v.	It measures e.m.f as well as p.d.	It measures only p.d.
vi.	It is used to measure internal resistance of a cell.	It cannot be used to measure the internal resistance of a cell.
vii.	It is more accurate.	It is less accurate.
viii.	It does not give direct reading.	It gives direct reading.
ix.	It is not portable.	It is portable.
x.	It is used to measure lower voltage values only.	It is used to measure lower as well as higher voltage values.

[Any four differences]

Q.6 (A) How can a galvanometer be converted into a voltmeter?

A galvanometer can be converted into a voltmeter by connecting a resistance of suitable high value in series with galvanometer.

(B) In a Wheatstone's metrebridge experiment, the null point is obtained in middle one third portion of wire. Why is it recommended?

In a Wheatstone's metrebridge experiment, the null point is obtained in middle one third portion of the wire (between 34 cm and 66 cm) so that percentage error in the measurement of l_X and l_R are minimum and nearly the same.

SECTION C

Attempt any TWO questions of the following: **(6)**

Q.7

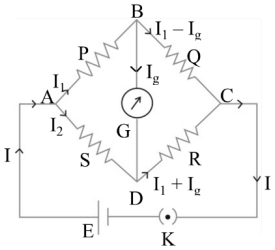
Obtain the balancing condition in case of a Wheatstone's network.

Construction:

i. Four resistances P, Q, R and S are connected to form a quadrilateral ABCD as shown in the figure.

ii. A battery of emf E along with a key is connected between the points A and C such that point A is at higher potential with respect to the point C.

iii. A galvanometer of internal resistance G is connected between points B and D.



Working:

i. When the key is closed, current I flow through the circuit. It divides into I_1 and I_2 at point A. I_1 is the current through P and I_2 is the current through S.

$\therefore \quad I = I_1 + I_2$

ii. The current I_1 gets divided at point B. Let I_g be the current flowing through the galvanometer. The currents flowing through Q and R are $(I_1 - I_g)$ and $(I_2 + I_g)$ respectively.

iii. Consider the loop ABDA, applying Kirchhoff's voltage law in the clockwise sense shown in the loop.

$\therefore \quad -I_1P - I_gG + I_2S = 0 \qquad \ldots.(1)$

iv. Now consider loop BCDB, applying Kirchhoff's voltage law in the clockwise sense as shown in the loop,

$-(I_1 - I_g)Q + (I_2 + I_g)R + I_gG = 0 \qquad \ldots.(2)$

v. The bridge is said to be balanced, when the current passing through the galvanometer is zero. i.e., $I_g = 0$. This condition can be obtained by adjusting the values of P, Q, R and S.

vi. Substituting $I_g = 0$ in equation (1),

$-I_1P + I_2S = 0$

$\therefore \quad I_1P = I_2S \qquad \ldots.(3)$

Substituting $I_g = 0$ in equation (2),

$-I_1Q + I_2R = 0$

$\therefore \quad I_1Q = I_2R \qquad \ldots.(4)$

Dividing equation (3) by equation (4),

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

This is the balancing condition for Wheatstone bridge.

Q.8 **State and explain Kirchhoff's voltage law in electric circuit. State their sign conventions.**

Kirchhoff's second law (Voltage law or loop theorem):

i. Statement: The algebraic sum of the potential differences (products of current and resistance) and the electromotive forces (emfs) in a closed loop is zero.

i.e., $\sum IR + \sum E = 0$

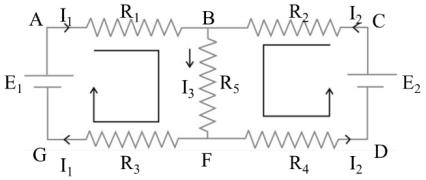
ii. Sign convention:

a. While tracing a loop through a resistor, if the tracing is along the direction of conventional current, the potential difference across that resistance is considered negative. If the loop is traced against the direction of the conventional current, the potential difference across that resistor is considered positive.

b. The emf of an electrical source is positive while tracing the loop within the source from the negative terminal of the source to its positive terminal. It is taken as negative while tracing within the source from positive terminal to the negative terminal.

iii. Explanation:

a. Consider an electrical network as shown in figure.



b. Consider the loop ABFGA in clockwise sense and applying the sign conventions,

$-I_1R_1 - I_3R_5 - I_1R_3 + E_1 = 0$

$\therefore \quad E_1 = I_1R_1 + I_3R_5 + I_1R_3$

c. Consider the loop BFDCB in anticlockwise direction and applying the sign conventions,

$-I_3R_5 - I_2R_4 + E_2 - I_2R_2 = 0$

$\therefore \quad E_2 = I_2R_2 + I_3R_5 + I_2R_4$

Q.9 When a resistance of 12 ohm is connected across a cell, its terminal potential difference is balanced by 120 cm length of potentiometer wire. When the resistance of 18 ohm is connected across the same cell, the balancing length is 150 cm. Find the balancing length when the cell is in open circuit. Also calculate the internal resistance of the cell.

Ans: i. The balancing length is **300 cm.**

ii. The internal resistance of the cell is **18 Ω.**

Explanation:

Given: $R_1 = 12\ \Omega$, $l_2 = 120$ cm,

$R_2 = 18\ \Omega$, $l'_2 = 150$ cm

To find: Balancing length (l_1),

Internal resistance (r)

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

Calculation: From first condition,

$r = 12\left(\frac{l_1 - 120}{120}\right)$ ….(i)

From second condition,

$r = 18\left(\frac{l_1 - 150}{150}\right)$ ….(ii)

From equation (i) and (ii),

$12\left(\frac{l_1-120}{120}\right) = 18\left(\frac{l_1-150}{150}\right)$

$\therefore \quad 5(l_1 - 120) = 6(l_1 - 150)$

$\therefore \quad l_1 =$ **300 cm**

Using equation (i) we get

Internal resistance,

$r = 12\left(\frac{l_1-120}{120}\right) = 12\left(\frac{300-120}{120}\right)$

$\therefore \quad r =$ **18 Ω**

SECTION D

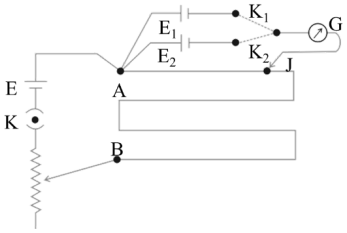
Attempt any ONE question of the following: **(4)**

Q.10 **Describe how a potentiometer is used to compare the emfs of two cells by connecting the cells individually.**

i. A potentiometer circuit is set up by connecting a battery of emf E, with a key K and a rheostat such that point A is at higher potential than point B.

ii. The cells whose emfs are to be compared are connected with their positive terminals at point A and negative terminals to the extreme terminals of a two way key K_1 and K_2.

iii. The central terminal of the two ways key is connected to a galvanometer. The other end of the galvanometer is connected to a jockey (J).



iv. Key K is closed and then, key K_1 is closed and key K_2 is kept open. Therefore, the cell of emf E_1 comes into circuit.

v. The null point is obtained by touching the jockey at various points on the potentiometer wire AB.

vi. Let l_1 be the length of the wire between the null point and the point A. Here, l_1 corresponds to emf E_1 of the cell. Therefore,

$E_1 = K\, l_1 \quad ....(1)$

where K is the potential gradient along the potentiometer wire.

vii. Now key K_1 is kept open and key K_2 is closed. The cell of emf E_2 now comes in the circuit. Again, the null point is obtained with the help of the Jockey.

viii. Let l_2 be the length of the wire between the null point and the point A. Here l_2 corresponds to the emf E_2 of the cell.

$\therefore \quad E_2 = K\, l_2 \quad ....(2)$

ix. Dividing equation (1) by equation (2),

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

Thus, emfs of the two cells can be compared and if any one of the emfs is known, the other can be determined.

Q.11 (A) Explain: Kirchhoff's current law is based on the law of conservation of charge.

i. In Kirchhoff's current law, some amount of charge is received per unit time due to the currents arriving at a junction and same amount of charge leaves the junction per unit time.

ii. Sum total of two is always constant implying conservation of charge.

Hence, Kirchhoff's first law is consistent with the conservation of electrical charge.

(B) A galvanometer has a resistance of 25 Ω and its full scale deflection current is 25 μA. What resistance should be added to it to have a range of 0 – 10 V?

Ans: Resistance to be added is **399.975×10^3 Ω**.

Explanation:

Given: $I_g = 25\ \mu A = 25 \times 10^{-6}$ A, maximum voltage V = 10 V

To find: Resistance (X)

Formula: $X = \frac{V}{I_g} - G$

Calculation: From formula,

$$X = \frac{10}{25 \times 10^{-6}} - 25$$

$$= 400000 - 25$$

$$= 399975\ \Omega = \mathbf{399.975 \times 10^3\ \Omega}$$