Excel Coaching Classes

Time: 60min | **12th Physics Current Electricity** | **Marks: 20**

SECTION A

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

i. **A metrebridge cannot be used to determine**

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

ii. **Sensitivity of a potentiometer is increased by**

- [ ] (A) increasing the emf of the cell.
- [x] (B) increasing the length of potentiometer wire.
- [ ] (C) decreasing the length of potentiometer wire.
- [ ] (D) none of these.

iii. **The algebraic sum of current at junction in any electric circuit is equal to ________.**

- [x] (A) zero
- [ ] (B) ∞
- [ ] (C) a positive integer
- [ ] (D) potential difference

2. **Answer the following questions:** **3**

i. **There can be three types of electrical conductors: good conductors (metals), semiconductors and bad conductors (insulators). Does a semiconductor diode and resistor have similar electrical properties?**

No, a semiconductor diode and resistor does not have similar electrical properties.

ii. **Define or describe a Potentiometer.**

A potentiometer is a device which does not draw any current from circuit, acting like an ideal voltmeter and measures potential difference accurately.

iii. **How can a galvanometer be converted into an ammeter?**

A galvanometer can be converted into an ammeter by connecting a low value resistance in parallel (shunt) with galvanometer.

SECTION B

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

3. Explain the necessary modifications to convert the moving coil galvanometer into an ammeter.

Modifications necessary to convert an MCG into an ammeter:

i. Effective current capacity of M.C.G. must be increased to the desired higher value.

ii. Its effective resistance must be decreased. The finite resistance G of the galvanometer when connected in series, decreases the current through the resistance R which is actually to be measured. In ideal case, an ammeter should have zero resistance.

iii. It must be protected from the possible damages, which are likely due to the passage of an excess electric current to be passed.

4. A voltmeter has a resistance of 100 Ω. What will be its reading when it is connected across a cell of emf 2 V and internal resistance 20 Ω?

The reading of the voltmeter is 1.67 V.

5. 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.

6. 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]

SECTION C

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

7. State and explain Kirchhoff's current law in electric circuit. State their sign conventions.

Kirchhoff's first law (Current law or junction law):

i. Statement: The algebraic sum of the currents at a junction is zero in an electrical network.

i.e., $\sum_{i=1}^{n} I_i = 0$

where I_i is the current in the i^{th} conductor at a junction having n conductors.

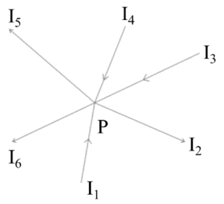
ii. Sign convention:

a. The currents arriving at the junction are considered positive.

b. The currents leaving the junction are considered negative.

iii. Explanation:

a. Consider a junction P in a circuit where six conductors meet as shown in the figure.



b. Arriving currents I_1, I_3 and I_4 are considered positive and leaving currents I_2, I_5 and I_6 are considered negative.

c. Applying the sign convention at junction P,

$I_1 - I_2 + I_3 + I_4 - I_5 - I_6 = 0$

$\therefore$ $I_1 + I_3 + I_4 = I_2 + I_5 + I_6$

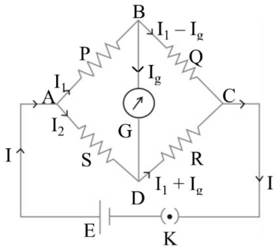
d. Thus the total current flowing towards the junction is equal to the total current flowing away from the junction.

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

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.

$\therefore$ $I = I_1 + I_2$

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.

$\therefore$ $-I_1P - I_gG + I_2S = 0$ ….(1)

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

$-(I_1 - I_g)Q + (I_2 + I_g)R + I_gG = 0$ ….(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),

$-I_1P + I_2S = 0$

$\therefore$ $I_1P = I_2S$ ….(3)

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

$-I_1Q + I_2R = 0$

$\therefore$ $I_1Q = I_2R$ ….(4)

Dividing equation (3) by equation (4),

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

This is the balancing condition for Wheatstone bridge.

B. **Why is potentiometer preferred over a voltmeter for measuring emf?**

i. Potentiometer is more sensitive than a voltmeter.

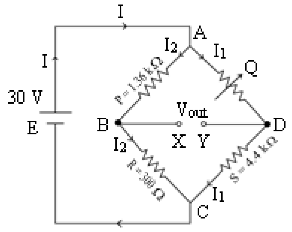
ii. A potentiometer can be used to measure a potential difference as well as an emf of a cell. A voltmeter always measures terminal potential difference, and as it draws some current, it cannot be used to measure an emf of a cell.

iii. Measurement of potential difference or emf is very accurate in the case of a potentiometer. A very small potential difference of the order 10^{-6} volt can be measured with it. Least count of a potentiometer is much better compared to that of a voltmeter.

Due to all these reasons potentiometer is preferred over a voltmeter for measuring emf.

9.

At what value should the variable resistor Q be set in the circuit such that the bridge is balanced? If the source voltage is 30 V find the value of the output voltage across XY, when the bridge is balanced.



The value of the output voltage across XY is **0 V**.

SECTION D

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

10.A. **State the applications of Wheatstone bridge.**

i. The Wheatstone bridge is used for measuring the values of very low resistance precisely.

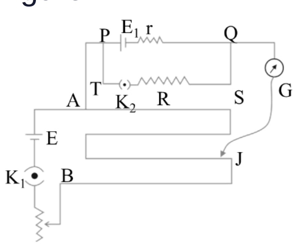
ii. Wheatstone bridge can also measure the quantities such as galvanometer resistance, capacitance, inductance and impedance.

B. **What is the value of the shunt resistance that allows 20% of the main current through a galvanometer of 99 Ω?**

The value of shunt resistance is 24.75 Ω.

11. **Describe with the help of a neat circuit diagram how you will determine the internal resistance of a cell by using a potentiometer. Derive the necessary formula.**

i. The experimental set up for this method consists of a potentiometer wire AB connected in series with a cell of emf E , the key K_1, and rheostat as shown in figure.



ii. The terminal A is at higher potential than terminal B. A cell of emf E_1 whose internal resistance r is to be determined is connected to the potentiometer wire through a galvanometer G and the jockey J.

iii. A resistance box R is connected across the cell E_1 through the key K_2. The key K_1 is closed and K_2 is open.

iv. The circuit now consists of the cell E , cell E_1 , and the potentiometer wire. The null point is then obtained.

v. Let l_1 be length of the potentiometer wire between the null point and the point A. This length corresponds to emf E_1 .

∴ $E_1 = Kl_1$ ….(1)

where K is potential gradient of the potentiometer wire which is constant.

vi. Now both the keys K_1 and K_2 are closed so that the circuit consists of the cell E , the cell E_1 , the resistance box, the galvanometer and the jockey. Some resistance R is selected from the resistance box and null point is obtained.

vii. The length of the wire l_2 between the null point and point A is measured. This corresponds to the voltage between the null point and point A.

∴ $V = Kl_2$ ….(2)

Dividing equation (1) by equation (2),

∴ $\frac{E_1}{V} = \frac{Kl_1}{Kl_2} = \frac{l_1}{l_2}$ ….(3)

viii. Consider the loop PQSTP,

$E_1 = IR + Ir$ and $V = IR$

∴ $\frac{E_1}{V} = \frac{IR + Ir}{IR} = \frac{R + r}{R} = \frac{l_1}{l_2}$ ….[From equation (3)]

$\Rightarrow r = R\left(\frac{l_1}{l_2} - 1\right)$

The above equation is used to determine the internal resistance of the cell.