CHAPTER : 3

CURRENT ELECTRICITY

STUDY NOTES

Electrical Conductivity: It is the reciprocal of specific resistance for a conductor. The specific resistance is the resistance of the unit cube of the material of the conductor,

$$\sigma = \frac{1}{\rho} = \frac{ne^2\tau}{m}$$

Where σ is the conductivity and p is resistivity.

The SI unit of conductivity is S/m.

Current. It is the rate of flow of charge through a given conductor.

Current Density Vector ($\vec{J}$): Its magnitude gives current per unit area flowing through area ΔA when it is held normal to the direction of charge flow. Note that the direction of $\vec{J}$ is the same as the direction of current flow.

It is given by:

$$J = nqv_d$$

where n is the number density (number per unit volume) of charge carriers each of charge q and v_d is the drift velocity of the charge carriers. For electrons $q = -e$. If j is normal to a cross-sectional area A and is constant over the area, the magnitude of the current I through the area is nev_dA.

Mobility: Mobility μ is the magnitude of drift velocity per unit electric field.

$$\mu = \left(\frac{v_d}{E}\right)$$

Now, $v_d = \frac{q\tau E}{m_q}$

where q is the electric charge of the current carrier and m_q is its mass.

$$\therefore \mu = \left(\frac{q_\tau}{m_q}\right)$$

Thus, it is a measure of response of a charge carrier to a given external electric field.

Resistivity is given by

$$\rho = \frac{1}{\sigma}$$

It is measured in ohm-metre (Ωm).

Resistivity of a material changes with temperature and is given as,

$$\rho_T = \rho_o[1 + \alpha(T - T_o)]$$

where α is the temperature coefficient of resistivity and ρ_T is the resistivity of the material at temperature T.

Resistivity of different materials:

(a) Metals have low resistivity that varies from 10^{-8} Ωm to 10^{-6} Ωm

(b) Insulators have high resistivity that varies from 10^{22} to 10^{24} times greater than that of metals.

(c) Semiconductors like Si and Ge have middle range of resistivity on algorithmic scale.

Total resistance in Series and in Parallel

(a) Total resistance R of *n* resistors connected in series is given by $R = R_1 + R_2 + ... + R_n$

(b) Total resistance R of n resistors connected in parallel is given by

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + ... + \frac{1}{R_n}$$

When a conductor is brought under the influence of an electric field $\vec{E}$ free charges i.e,the free electrons move under the influence of this field in such a manner, that the current density $\vec{J}$ due to their motion is proportional to the applied electric field and is given by

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

Where σ is a a constant of proportionality called electrical conductivity. This statement is one possible form of Ohm's law.

Ohm's law states that their is a linear relationship between the potential drop across a substance and the current passing through it. It is given by V = IR

Where $R = \frac{L}{\alpha A}$ called resistance of the material.

R is measured in ohm (Ω) , where 1 Ω = 1V/A

EMF: Electromotive force is defined as the electric potential produced by electrochemical cell.Typically in a battery, in which a chemical process achieves this task of doing work in driving the positive charge from a low potential to a high potential. The effect of such a source is measured in terms of work done per unit charge in moving a charge once around the circuit. This is denoted by ε.

Significance of Ohm's Law:

Ohm's law is obeyed by many substances but it fails if

(a) V depends on I non-linearly. Example is when ρ increases with I (even if temperature is kept fixed)

(b) The relation between V and I depends on the sign of V for the same absolute value of V.

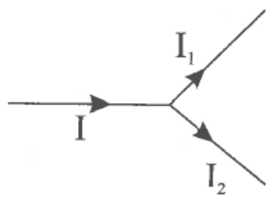
(c) The relation between V and I is non-linear for semiconductors. For e.g., GaAs

- When a source of emf (ε) is connected to an external resistance R, the voltage V_{ext} across R is given by

$$V_{ext} = IR = \frac{\varepsilon}{R+r}R$$

Where *r* is the internal resistance of the source.

Kirchhoff's current Law: At any junction of several circuit elements, the sum of currents entering the junction must equal the sum of currents leaving it.

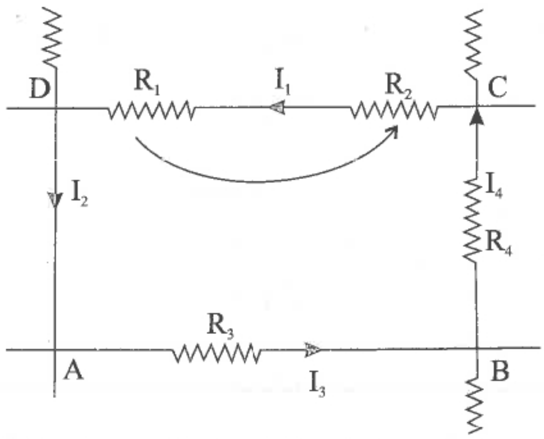


According to Kirchhoff's current law,

$$I = I_1 + I_2$$

It is a consequence of charge conservation and is based on the assumption that currents are steady, that is no charge piles up at the junction

Kirchhoff's Voltage Law: The algebraic sum of charges in potential around any closed resistor loop must be zero. This is based on the principle that electrostatic forces alone cannot do any work in a closed loop, since this work depends on potential difference, which is zero, if we start at one point of the loop and come back to it.



This gives : $(R_1 + R_2) I_1 + R_3 I_3 + R_4 I_4 = 0$

How to apply Kirchhoff's law:

(1) Choose any closed loop in the network and designate a direction (in this example counter clockwise) to traverse the loop.

(2) Go around the loop in the designated direction, adding emf's and potential differences. An emf is counted as positive when it is traversed (–) to (+) and negative in the opposite case i.e., from (+) to (–).

(3) Equate the total sum to zero.

Wheatstone bridge

Wheatstone Bridge is an arrangement of four resistances R_1, R_2, R_3, R_4.The null point condition is given by,

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

This is also known as the balanced condition. If R_1, R_2, R_3 are known, R_4 can be determined.

$$R_4 = \left(\frac{R_2}{R_1}\right) R_3$$

In a balanced condition of the **meter bridge**,

$$\frac{R}{S} = \frac{P}{Q} = \frac{l_1}{100 - l_1}$$

$$\therefore\ R = \frac{S l_1}{(100 - l_1)}$$

Where l_1 is the length of wire from one end where null point is obtained.

Potentiometer:

The potentiometer is a device that is used to compare potential differences. Since the method involves a condition of no current flow, it can be used to measure potential differences; internal resistance of a cell and compare emf's of two sources.

Potential Gradient:

The potential gradient of the wire in a potentiometer depends on the current in the wire,specific resistance of the material of the wire and area of cross section of the potentiometer wire.

If an emf ε_1 is balanced against length l_1, then

$$\varepsilon_1 = \rho l_1$$

Similarly, if ε_2 is balanced against l_2, then

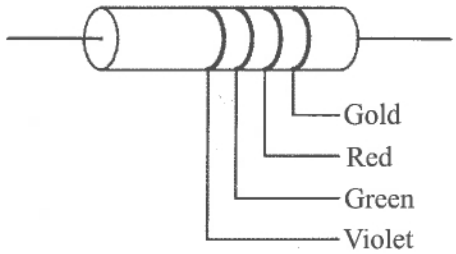
$$\varepsilon_2 = \rho l_2$$

The comparison of emf's of the two cells is given by,

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

MULTIPLE CHOICE QUESTIONS

1. The colour coding on a carbon resistor is shown in the given figure. The resistance value of the given resistor is :

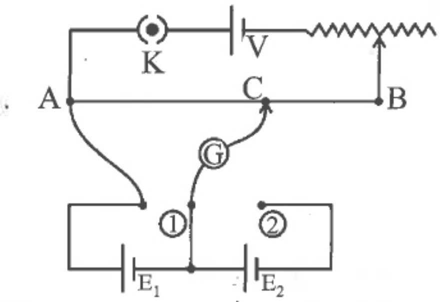


(a) (5700 ± 285) Ω (b) (7500 ± 750) Ω (c) (5700 ± 375) Ω (d) (7500 ± 375) Ω

2. If you are provided a set of resistances 2 Ω, 4 Ω,6 Ω and 8 Ω. Connect these resistances so as to obtain an equivalent resistance of (46/3) Ω
   (a) 4 Ω and 6 Ω are in parallel with 2 Ω and 8 Ω in series
   (b) 6 Ω and 8 Ω are in parallel with 2 Ω and 4 Ω in series
   (c) 2 Ω and 6 Ω are in parallel with 4 Ω and 8 Ω in series
   (d) 2 Ω and 4 Ω are in parallel with 6 Ω and 8 Ω in series

3. The resistance of a conductor at 15°C is 16 Ω and at 100°C is 20 Ω. What will be the temperature coefficient of resistance of the conductor?
(a) $0.010°C^{-1}$ (b) $0.033°C^{-1}$ (c) $0.003°C^{-1}$ (d) $0.042°C^{-1}$

4. In the given potentiometer circuit arrangement, the balancing length AC is measured to be 250 cm. When the galvanometer connection is shifted from point (1) to point (2) in the given diagram, the balancing length becomes 400 cm. The ratio of the emf of two cells, E_1/E_2 is :



(a) 5/3 (b) 8/5 (c) 4/3 (d) 3/2

5. A current of 10 A exists in a wire of cross-sectional area of 5 mm^2 with a drift velocity of 2×10^{-3} ms^{-1}. The number of free electrons in each cubic meter of the wire is __________
(a) 625×10^{25} (b) 1×10^{23} (c) 2×10^{25} (d) 2×10^{6}

6. A conducting wire of length 'l', area of cross-section A and electric resistivity ρ is connected between the terminals of a battery. A potential difference V is developed between its ends, causing an electric current. If the length of the wire of the same material is doubled and the area of cross-section is halved, the resultant current would be :
(a) $4\,\frac{VA}{\rho l}$ (b) $\frac{3}{4}\,\frac{VA}{\rho l}$ (c) $\frac{1}{4}\,\frac{VA}{\rho l}$ (d) $\frac{1}{4}\,\frac{\rho l}{VA}$

7. An oil drop of radius 2 mm with a density 3g cm^{-3} is held stationary under a constant electric field 3.55×10^{5} V m^{-1} in the Millikan's oil drop experiment. What is the number of excess electrons that the oil drop will possess? (consider g = 9.81 m/s^2)
(a) 48.8×10^{11} (b) 1.73×10^{10} (c) 17.3×10^{10} (d) 1.73×10^{12}

8. The length of a potentiometer wire is 1200 cm and it carries a current of 60 mA. For a cell of emf 5V and internal resistance of 20Ω, the null point on it is found to be a 1000 cm. The resistance of whole wire is :

(a) 80 Ω (b) 60 Ω (c) 120 Ω (d) 100 Ω

9. A material B has twice the specific resistance of A. The diameter of cross section of wire B is twice the diameter of cross section of wire A. Then for the two wires to have the same resistance, the ratio l_A / l_B of their respective lengths must be:

(a) 1 (b) 1/2 (c) 1/4 (d) 2

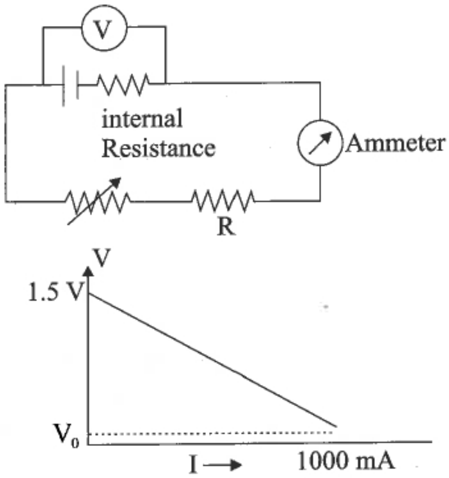
10. If a wire is stretched to make it 0.1% longer,its resistance will

(a) increase by 0.05% (b) increase by 0.2% (c) decrease by 0.2% (d) decrease by 0.05%

11. The resistance of wire is 5 ohm at 50°C and 6 ohm at 100°C.The resistance of the wire at 0°C will be

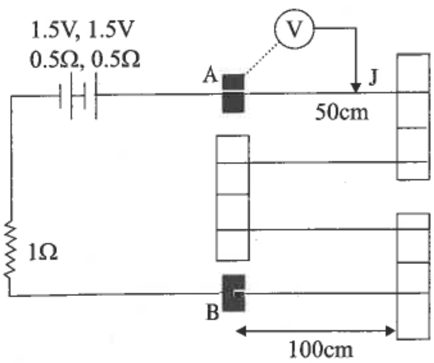
(a) 2 ohm (b) 1 ohm (c) 4 ohm (d) 3 ohm

12. To verify Ohm's law, a student connects the voltmeter across the battery as, shown in the figure. The measured voltage is plotted as a function of the current, and the following graph is obtained :



(a) The value of the resistance R is 1.5 Ω
(b) The emf of the battery is 1.5 V and its internal resistance is 1.5 Ω
(c) The emf of the battery is 1.5 V and the value of R is 1.5 Ω
(d) The potential difference across the battery is 1.5 V when it sends a current of 1000 mA

13. In the circuit shown, a four-wire potentiometer is made of a 400 cm long wire, which extends between A and B. The resistance per unit length of the potentiometer wire is $r = 0.01$/cm. If an ideal voltmeter is connected as shown with jockey J at 50 cm from end A, the expected reading of the voltmeter will be :



(a) 0.20 V
(b) 0.25 V
(c) 0.75 V
(d) 0.50 V

14. According to Ohm's law, which is the correct relation between v_d and electric field E?

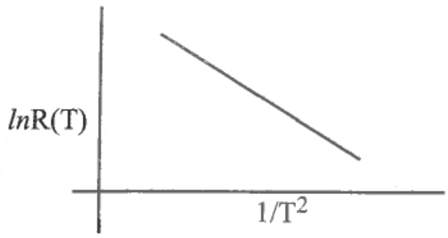
(a) v_d is proportional to E (b) v_d is proportional to E^2

(c) v_d is proportional to $\sqrt{E}$ (d) v_d = constant

15. Space between two concentric conducting spheres of radii a and b ($b > a$) is filled with a medium of resistivity ρ. The resistance between the two spheres will be :

(a) $\frac{\rho}{2\pi}\left(\frac{1}{a}+\frac{1}{b}\right)$ (b) $\frac{\rho}{4\pi}\left(\frac{1}{a}+\frac{1}{b}\right)$ (c) $\frac{\rho}{2\pi}\left(\frac{1}{a}-\frac{1}{b}\right)$ (d) $\frac{\rho}{4\pi}\left(\frac{1}{a}-\frac{1}{b}\right)$

16. In an experiment, the resistance of a material is plotted as a function of temperature (in some range). As shown in the figure, it is a straight line. One may conclude that :



(a) $R(T) = R_o e^{-T^2/T_0^2}$ (b) $R(T) = \frac{R_0}{T^2}$

(c) $R(T) = R_o e^{T^2/T_0^2}$ (d) $R(T) = R_o e^{-T_0^2/T^2}$

17. A current of 5 A passes through a copper conductor (resistivity = 1.7×10^{-8} Ωm) of radius of cross-section 5 mm. Find the mobility of the charges if their drift velocity is 1.1×10^{-3} m/s.

(a) 1.3 m^2/Vs (b) 1.0 m^2/Vs (c) 1.8 m^2/Vs (d) 1.5 m^2/Vs

18. A moving coil galvanometer has resistance 50 Ω and it indicates full deflection at 4 mA current. A voltmeter is made using this galvanometer and a 5 k Ω resistance. The maximum voltage, that can be measured using this voltmeter, will be close to:

(a) 15 V (b) 10 V (c) 40 V (d) 20 V

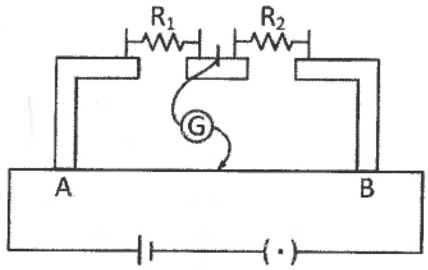
19. A cell of internal resistance r drives current through an external resistance R. The power delivered by the cell to the external resistance will be maximum when :

(a) R = 1000 r (b) R = r (c) R = 2 r (d) R = 0.001 r

20. A galvanometer, whose resistance is 50 ohm, has 25 divisions in it. When a current of 4×10^{-4} A passes through it, its needle (pointer) deflects by one division. To use this galvanometer as a voltmeter of range 2.5 V, it should be connected to a resistance of :

(a) 200 ohm (b) 250 ohm (c) 6200 ohm (d) 6250 ohm

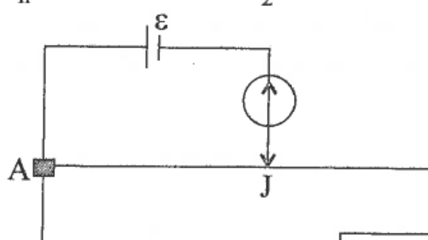
21. In the experimental set up of metre bridge shown in the figure, the null point is obtained at a distance of 40 cm from A. If a 10Ω resistor is connected in series with R_1, the null point shifts by 10 cm. The resistance that should be connected in parallel with $(R_1 + 10)$ Ω such that the null point shifts back to its initial position is:



(a) 40 Ω (b) 30 Ω

(c) 20 Ω (d) 60 Ω

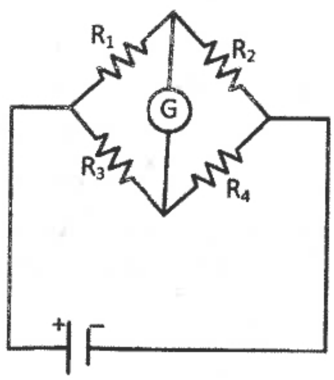
22. The resistance of the meter bridge AB in given figure is 4 Ω. With a cell of emf ε = 0.5 V and rheostat resistance R_h = 2 Ω the null point is obtained at some point J. When the cell is replaced by another one of emf ε = ε_2 the same null point J is found for R_h = 6 Ω. The emf ε_2 is



(a) 0.3 V (b) 0.6 V

(c) 0.5 V (d) 0.4 V

23. The Wheatstone bridge shown in figure, here, gets balanced when the carbon resistor used as R_1 has the colour code (Orange, Red, Brown). The resistors R_2 and R_4 are 80 Ω and 40 Ω respectively. Assuming that the colour code for the carbon resistors gives their accurate values, the colour code for the carbon resistor, used as R_3, would be



(a) Brown, Blue, Brown

(b) Grey, Black, Brown

(c) Red, Green, Brown

(d) Brown, Blue, Black

24. A potentiometer is an accurate and versatile device to make electrical measurements of E.M.F. because the method involves:

(a) A combination of cells, galvanometer and resistances

(b) Cells

(c) Potential gradients

(d) A condition of no current flow through the galvanometer

25. **Statement 1:** Total current entering a circuit is equal to leaving the circuit by Kirchhoff's law.

Statement 2: It is based on conservation of energy.

(a) Statement 1 and statement 2 are correct and statement 2 is the correct explanation of statement 1.

(b) Statement 1 and statement 2 are correct and statement 2 is not the correct explanation of statement 1.

(c) Statement 1 is correct but statement 2 is incorrect.

(d) Both statement 1 and statement 2 are correct.

26. A steady current flow in a metallic conductor of non-uniform cross-section. The quantity/quantities remaining constant along the whole length of the conductor is/are

(a) current, electric field and drift speed

(b) drift speed only

(c) current and drift speed

(d) current only

27. Wheatstone's bridge cannot be used for very ________ resistances.

(a) high (b) low (c) low (or) high (d) zero

28. The potential gradients on the potentiometer wire are V_1 and V_2 with an ideal cell and a real cell of same emf respectively, in the primary circuit then

(a) $V_1 = V_2$ (b) $V_1 > V_2$ (c) $V_1 < V_2$ (d) $V_1 \leq V_2$

29. For a particular appliance two batteries of ε_1 and ε_2 ($\varepsilon_2 > \varepsilon_1$) and internal resistances r_1 and r_2 respectively are connected in parallel so that the appliance do not get damaged.

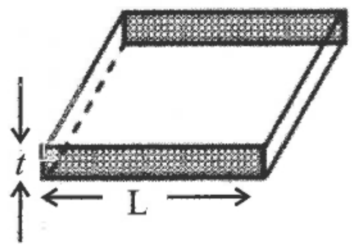
(a) Two equivalent emf ε_{eq} of the two cells is between ε_1 and ε_2, i.e, $\varepsilon_1 < \varepsilon_{eq} < \varepsilon_2$

(b) The equivalent emf ε_{eq} is smaller than ε_1

(c) The ε_{eq} is given by $\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2$ always

(d) ε_{eq} is independent of internal resistances r_1 and r_2

30. Consider a thin square sheet of side L and thickness t, made of a material of resistivity ρ. The resistance between two opposite faces , shown by the shaded areas in the figure is ________



(a) directly proportional to L

(b) directly proportional to t

(c) independent of L

(d) independent of t

31. A lab assistant was trying to find the potential drop across a resistor but was not able to detect any potential drop. To detect the potential drop across the resistor the sensitivity of potentiometer can be increased by

(A) increasing the series resistance in the primary circuit

(B) decreasing the length of the potentiometer wire

(C) using a thin and high resistivity wire as a potentiometer wire

(D) increasing the length of the wire

(a) (A) and (A) are correct
(b) (B) and (D) are correct
(c) (B) and (C) are correct
(d) (A) and (D) are correct

32. In a potentiometer of ten wires, the balance point is obtained on the sixth wire. To shift the balance point to eighth wire, we should

(a) increase resistance in the primary circuit

(b) decrease resistance in the primary circuit.

(c) decrease resistance in series with the cell whose e.m.f. has to be measured.

(d) increase resistance in series with the cell whose e.m.f. has to be measure.

33. A manufacturing unit a 8 ohm resistor is placed in the 6 ohm lot.While making an electric heater he used that 8 ohm resistor. If the heater is run for 10 minutes on 120 volt line, what is the ratio between amount of heat energy liberated and amount of heat energy expected to liberate?

(a) 1:2 (b) 2:3 (c) 3:4 (d) 3:2

34. In a house two bulbs are connected in different holders. Bulb A is brighter than bulb B. If R_A and R_B are their resistance respectively then (hint : household connection are parallel connections)

(a) $R_A > R_B$ (b) $R_A < R_B$ (c) $R_A = R_B$ (d) None of these

35. Ravi had a water heater that could be connected to a 220 V supply to heat the water of a vessel from 20°C to 60°C in 30 minutes. He asked his nephew Sam how they could reduce the time of heating the same vessel of water to the same range of temperature.He suggested to connect to coils serially.Is Sam right and what is time taken now for the same job to be done?

(a) yes, 15 minutes (b) no, 60 minutes (c) no, 80 minutes (d) no change in time taken

36. Battery of emf E has an internal resistance r. A variable resistance R is connected to the terminals of the battery. A current i is drawn from the battery. V is the terminal potential difference. If R alone is gradually reduced to zero, which of the following best describes i and V?

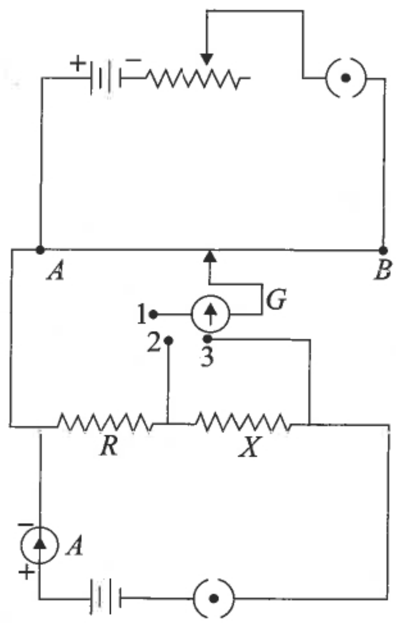
(a) i approaches zero, V approaches E

(b) i approaches E/r, V approaches zero

(c) i approaches E/r, V approaches E

(d) i approaches infinity, V approaches E

37. A potentiometer circuit is set up as shown. The potential gradient across the potentiometer wire, is k volt/cm and the ammeter, present in the circuit, reads 1.0 A when two way key is switched off. The balance points, when the key between the terminals (i) 1 and 2 (ii) 1 and 3, is plugged in are found to be at lengths l_1 cm and l_2 cm respectively. The magnitudes, of the resistors R and X, in ohm, are then, equal, respectively, to



(a) $k(l_2 - l_1)$ and kl_1

(b) $k(l_2 - l_1)$ and kl_2

(c) kl_1 and $k(l_2 - l_1)$

(d) kl_1 and kl_2

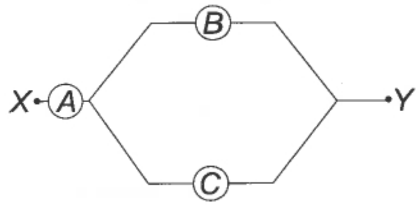
38. A galvanometer has a coil of resistance 100 ohm and gives a full scale deflection for 30 mA current. If it is to work as a voltmeter of 30 V range, the resistance(in ohms) required to be added will be

(a) 900 (b) 500
(c) 1000 (d) 1800

39. A battery of emf 2.1 V and internal resistance 0.05 ohm is shunted for 5 s by a wire of constant resistance 0.02 ohm, mass 1 g and specific heat 0.1 cal/g/°C. The rise in the temperature of the wire is

(a) 10.7°C (b) 21.4°C (c) 107°C (d) 214°C

40. Three voltmeters A, B and C having resistances R, 1.5 R and 3 R respectively are used in a circuit as shown. When a potential difference is applied between X and Y, the readings of the voltmeters are V_1, V_2 and V_3 respectively. Then



(a) $V_1 = V_2 = V_3$ (b) $V_1 < V_2 = V_3$ (c) $V_1 > V_2 > V_3$ (d) $V_1 > V_2 = V_3$

41. Three resistances P, Q, R each of 2 Ω and an unknown resistance S form the four arms of a Wheatstone's bridge circuit. When a resistance of 6 Ω is connected in parallel to S the bridge gets balanced. What is the value of S?

(a) 2 Ω (b) 3 Ω (c) 6 Ω (d) 1 Ω

42. If a wire of resistance 2012 is covered with ice (at 0°C) and a voltage of 210 V is applied across the wire, then the rate of melting of ice is

(a) 0.85 g/s (b) 1.92 g/s (c) 6.59 g/s (d) None of these

43. It two bulbs of wattages 25 and 100 W respectively each rated by 220 V are connected in series with the supply of 440 V, which bulb will fuse?

(a) 100 W bulb (b) 25 W (c) Both of them (d) None of them

44. It takes 16 min to boil some water in an electric kettle. Due to some defect it becomes necessary to remove 10% turns of heating coil of the kettle. After repairs, how much time will it take to boil the same mass of water?

(a) 17.7 min (b) 20.9 min (c) 14.4 min (d) 13.9 min

45. A steady current is set up in a metallic wire of non-uniform cross-section. How is the rate of flow K of electrons related to the area of cross-section A?

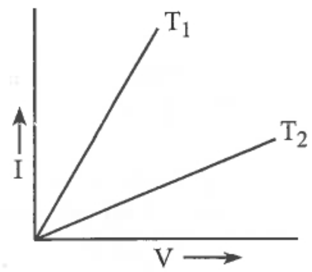
(a) K is independent of A (b) K is proportional to 1/A

(c) K is proportional to A (d) K is proportional to A^2

46. When the number of turns of the coil is doubled, the current sensitivity of a moving coil galvanometer is doubled whereas, the voltage sensitivity of the galvanometer

(a) remains the same (b) is doubled (c) is halved (d) is quadrupled

47. The current I and voltage V curves for a given metallic wire at two different temperatures T_1 and T_2 are shown in the figure. Then,



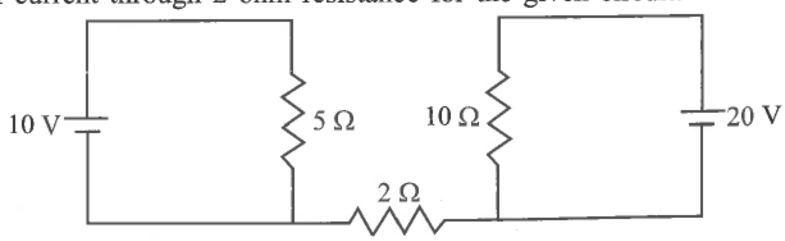
(a) $T_1 > T_2$

(b) $T_1 < T_2$

(c) $T_1 = T_2$

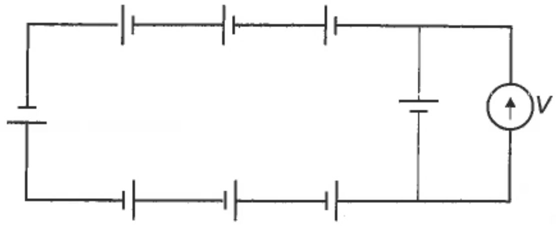
(d) $T_1 = 2T_2$

48. Find out the value of current through 2 ohm resistance for the given circuit.



(a) zero (b) 2 A (c) 5 A (d) 1 A

49. In the circuit shown below, each battery is of 5 V and has an internal resistance of 0.2 ohm The reading in the ideal voltmeter V is



(a) zero (b) 5 V (c) 7.5 V (d) 10 V

50. A constant voltage is applied between the two ends of a uniform metallic wire present in a iron box. Some heat is developed in it. If we need to double the heat developed then

(a) both the length and radius of wire are halved. (b) both length and radius of wire are doubled.

(c) the radius of wire is doubled. (d) the length of the wire is doubled.

51. A 25 W-220 V bulb and a 100 W-220 V bulb are joined in series and connected to the mains. Which bulb will glow brighter?

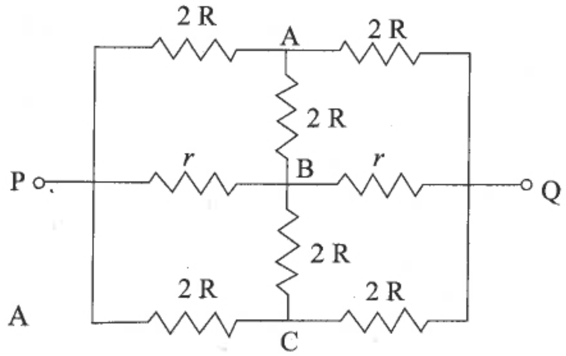
(a) 25 W bulb (b) 100 W bulb

(c) First 25 W bulb and then 100 W bulb. (d) Both will glow with same brightness.

52. A wire of length L and 3 identical cells of negligible internal resistances are connected in series. Due to the current, the temperature of the wire is raised by ΔT in time t. A number N of similar cells is now connected in series with a wire of the same material and cross-section but of length 2 L. The temperature of the wire is raised by the same amount ΔT at the same time. The value of N is

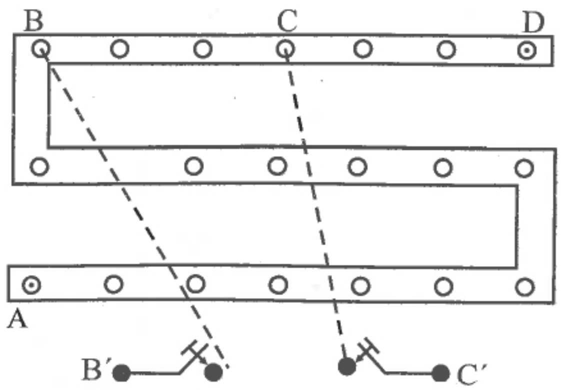
(a) 4 (b) 6 (c) 8 (d) 9

53. The effective resistance between points P and Q of the electrical circuit shown in the figure is



(a) $\dfrac{2Rr}{(R+r)}$ (b) $\dfrac{8R(R+r)}{3R+r}$ (c) $2r + 4R$ (d) $\dfrac{5R}{2}+2r$

54. A post office box is shown in the figure. In order to calculate the value of an external resistance, it should be connected between



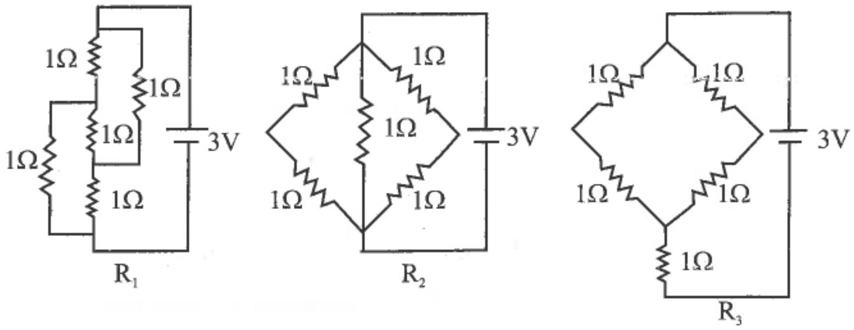
(a) B and C

(b) C and D

(c) A and D

(d) B′ and C′

55. Figure shows three resistor configurations R_1, R_2 and R_3 connected to 3 V battery. If the power dissipated by the configuration R_1, R_2 and R_3 is P_1, P_2 and P_3, respectively, then

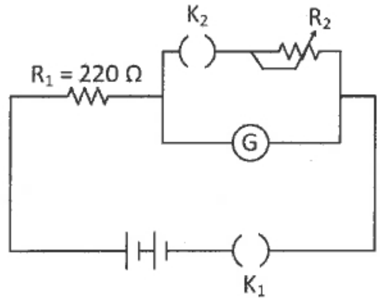


(a) $P_1 > P_2 > P_3$ (b) $P_1 > P_3 > P_2$ (c) $P_2 > P_1 > P_3$ (d) $P_3 > P_2 > P_1$

56. An energy source will supply a constant current into the load, if its internal resistance is
(a) zero
(b) non-zero but less than the resistance of the load
(c) equal to the resistance of the load
(d) very large as compared to the load resistance.

57. In a Wheatstone bridge, three resistances P, Q and R are connected in the three arms and the fourth arm is formed by two resistances S_1 and S_2 connected in parallel. The condition for the bridge to be balanced will be
(a) $\frac{P}{Q} = \frac{2R}{S_1+S_2}$ (b) $\frac{P}{Q} = \frac{R(S_1+S_2)}{S_1S_2}$ (c) $\frac{P}{Q} = \frac{R(S_1+S_2)}{2S_1S_2}$ (d) $\frac{P}{Q} = \frac{R}{S_1+S_2}$

58. The galvanometer deflection, when key K_1 is closed but K_2 is open, equals θ_0 (see figure). On closing K_2 also and adjusting R_2 to 5 Ω, the deflection in galvanometer becomes $\theta_0/5$. The resistance of the galvanometer is, then, given by [Neglect the internal resistance of battery]



(a) 5 Ω
(b) 25 Ω
(c) 12 Ω
(d) 22 Ω

59. Two conductors have the same resistance at 0^0 C but their temperature coefficients of resistance are α_1 and α_2. The respective temperature coefficients of their series and parallel combinations are nearly
(a) $\frac{\alpha_1+\alpha_2}{2}, \frac{\alpha_1+\alpha_2}{2}$ (b) $\frac{\alpha_1+\alpha_2}{2}, \alpha_1+\alpha_2$ (c) $\alpha_1+\alpha_2, \frac{\alpha_1+\alpha_2}{2}$ (d) $\alpha_1+\alpha_2, \frac{\alpha_1\alpha_2}{\alpha_1+\alpha_2}$

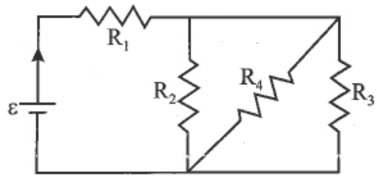
60. Statement 1. The temperature dependence of resistance is usually given as $R=R_0(1+\alpha\Delta t)$. The resistance of a wire changes from 100 Ω to 150 Ω when its temperature is increased from 27° C to 227° C. This implies that $\alpha = 2.5\times10^{-3}/°C$.

Statement 2. $R = R_0(1 + \alpha\Delta T)$ is valid only when the change in the temperature ΔT is small $\Delta R=(R-R_0)<<R_0$
(a) Statement 1 is true, Statement–2 is false.
(b) Statement–1 is true, Statement–2 is true,Statement 2 is the correct explanation of Statement-1.
(c) Statement–1 is true, Statement 2 is true; Statement –2 is not the correct explanation of Statement –1.
(d) Statement–1 is false, Statement–2 is true.

61. The current in a conductor varies with time t as $I = 2t + 3t^2$ where I is in ampere and t in seconds. Electric charge flowing through a section of the conductor during t = 2 sec to t = 3 sec is
(a) 10 C (b) 24 C (c) 33 C (d) 44 C

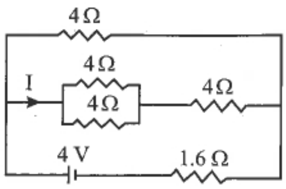
62. The physical quantity having the dimensions $[M^{-1} L^{-3} T^3A^2]$ is
(a) resistance (b) resistivity (c) electrical conductivity (d) electromotive force

63. In the circuit given E = 6.0 V, R_1 = 100 Ω, R_2 = R_3 = 50 Ω and R_4 = 75 Ω. The equivalent resistance of the circuit, in ohms, is



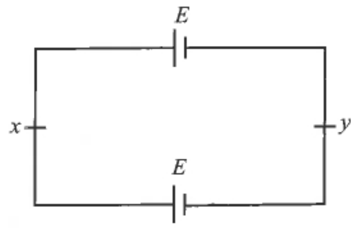
(a) 11.875 (b) 26.31
(c) 118.75 (d) none of these

64. In the circuit shown the value of I in ampere is



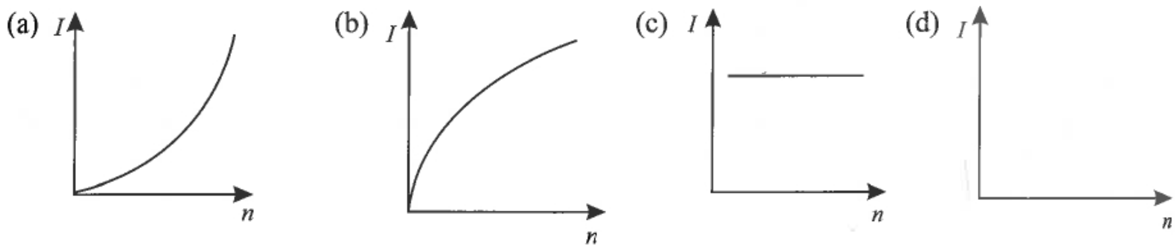
(a) 1
(b) 0.60
(c) 0.4
(d) 1.5

65. Two similar accumulators each of emf E and internal resistance *r* are connected as shown in the figure.

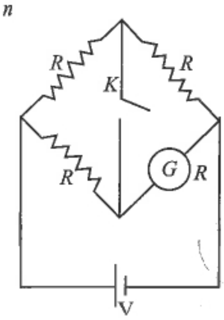


Then, the potential difference between *x* and *y* is
(a) 2 E (b) E
(c) zero (d) none of these

66. A battery consists of a variable number (n) of identical cells, each having an internal resistance r connected in series. The terminals of the battery are short-circuited. A graph of current (I) in the circuit versus the number of cells will be as shown in figure.



67. In the balanced Wheatstone's bridge circuit as shown in the figure, when the key is pressed, what will be the change in the reading of the galvanometer?

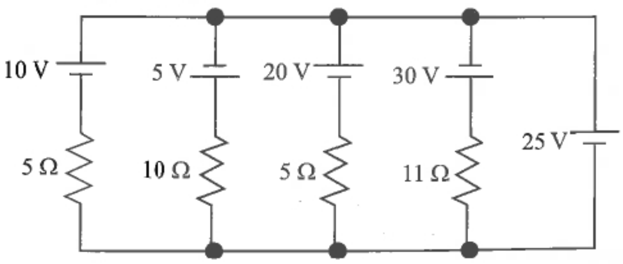


(a) remains same
(b) increased
(c) decreased
(d) none of these

68. The maximum power drawn out of the cell from a source is given by
(a) $E^2/2r$ (b) E^2/r (c) $E^2/3r$ (d) $E^2/4r$

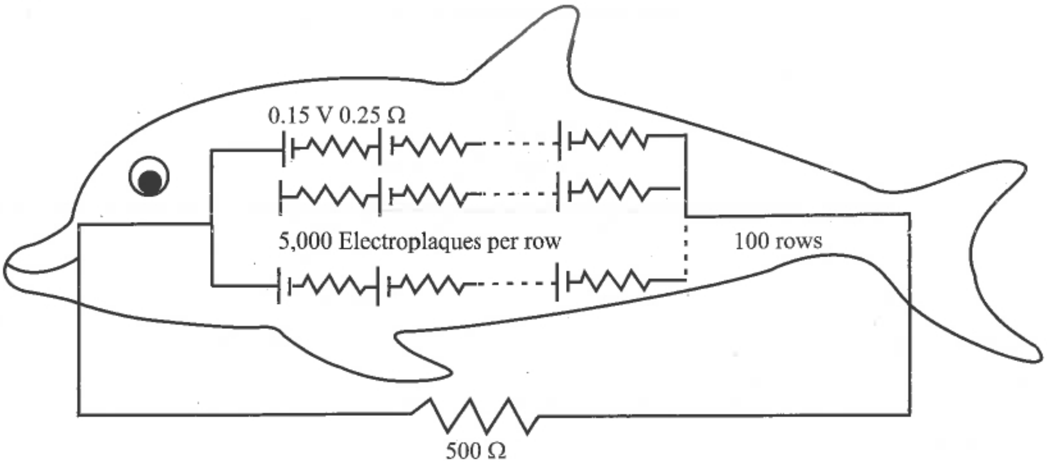
69. A lead-acid battery of a car has an emf of 12 V. If the internal resistance of the battery is 0.5Ω, the maximum current that can be drawn from the battery will be
(a) 30 A (b) 20 A (c) 6 A (d) 24 A

70. In the circuit shown, current flowing through 25 V cell is



(a) 7.2 A (b) 10 A (c) 12 A (d) 14.2 A

71. Eels are able to generate current with biological cells called electro-plaques. The electro-plaques in an eel are arranged in 100 rows, each row stretching horizontally along the body of the fish containing 5000 electro-plaques. The arrangement is suggestively shown below. Each electro-plaque has an emf of 0.15 V and internal resistance of 0-25 Ω. The water surrounding the eel completes a circuit between the head and its tail. If the water surrounding it has a resistance of 500 Ω, the current an eel can produce in water is about

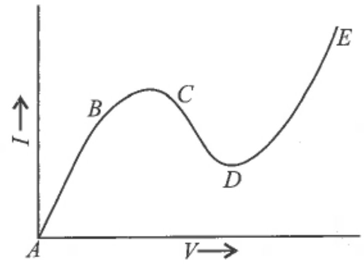


(a) 1.5 A (b) 3.0 A (c) 15 A (d) 30 A

72. Ten identical cells each of emf E and internal resistance r are connected in series to form a closed circuit. An ideal voltmeter connected across three cells, will read

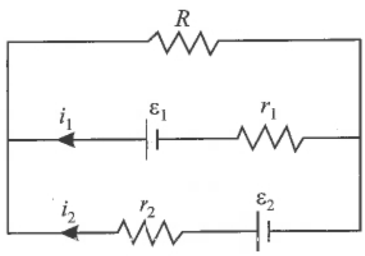
(a) 3 E (b) 7 E (c) 10 E (d) 13 E

73. From the graph between current (I) and voltage (V) as shown in the figure, identify the portion corresponding to negative resistance.



(a) AB
(b) BC
(c) CD
(d) DE

74. See the electric circuit shown in this figure. Which of the following equations is a correct equation for it?



(a) $\varepsilon_2 - i_2 r_2 - \varepsilon_1 - i_1 r_1 = 0$
(b) $-\varepsilon_2 - (i_1 + i_2)R + i_2 r_2 = 0$
(c) $\varepsilon_1 - (i_1 + i_2)R + i_1 r_1 = 0$
(d) $\varepsilon_1 - (i_1 + i_2)R - i_1 r_1 = 0$

75. Potentiometer measures the potential difference more accurately than a voltmeter, because

(a) It does not draw current from external circuit. (b) It draws a heavy current from external circuit.
(c) It has a wire of high resistance. (d) It has a wire of low resistance.

76. The rate of increase of thermo emf with temperature at the neutral temperature of thermocouple

(a) is positive
(b) is zero
(c) depends upon the choice of the two materials of the thermocouple
(d) is negative

77. Three identical bulbs are connected in series and these together dissipate a power P. If now the bulbs are connected in parallel, then the power dissipated will be

(a) P/ 3 (b) 3 P (c) 9 P (d) P/9

78. In the potentiometer experiment there are 10 lines in the potentiometer. In first situation the null point is at the 7th line. If we want to obtain the null point in the 9th line, then it can be done by

(a) increasing resistance R in series with the battery whose emf is to be measured.

(b) decreasing resistance R in series with the battery whose emf is to be measured.

(c) increasing resistance R in the main circuit.

(d) decreasing resistance R in the main circuit.

79. A teacher asked the student to compare two cells of emfs approximately 5 V and 10 V using a potentiometer of length 400 cm. It can be accurately compared when

(a) The battery that runs the potentiometer have voltage of 8 V

(b) The battery of potentiometer have a voltage of 15 V and R is adjusted so that the potential drop across the wire slightly exceeds 10 V.

(c) The first portion of 50 cm of wire itself have a potential drop of 10 V

(d) Never as potentiometer is usually used for comparing resistances and not voltages.

INPUT TEXT BASED MCQs

1. Ohm's law states that the potential difference between the ends of a conductor is directly proportional to current I which is flowing through the conductor.

or, $V = R I$

where the constant of proportionality R is called the resistance of the conductor.The resistance R is inversely proportional to the cross-sectional area and directly proportional to the length of the conductor, i.e,

$$R \propto \frac{l}{A}$$

and hence for a given conductor,

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

Where the constant of proportionality depends on the material of the conductor but not its dimensions is called resistivity.

(i) Dimension of electric resistance is

(a) $[ML^2T^2A^2]$ (b) $[ML^2T^{-3}A^{-2}]$ (c) $[M^{-1}L^{-2}T^{-1}A]$ (d) $[M^{-1}L^2T^2A^{-1}]$

(ii) If I μA current flows through a conductor when potential difference of 2 volt is applied across its ends, then the resistance of the conductor is

(a) $2\times10^6\ \Omega$ (b) $3\times10^5\ \Omega$ (c) $1.5\times10^5\ \Omega$ (d) $5\times10^7\ \Omega$

(iii) Specific resistance of a wire depends upon

(a) length (b) cross-sectional area (c) mass (d) none of these

(iv) The slope of the graph between potential difference and current through a conductor is

(a) a straight line (b) curve

(c) first curve then straight line (d) first straight line then curve

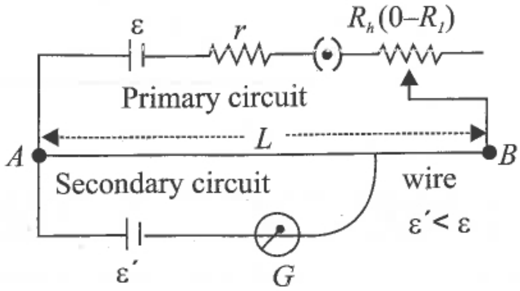
(v) The resistivity of the material of a wire 1.0 m long 0.4 mm in diameter and having a resistance of 2.0 ohm is

(a) $1.57\times10^{-6}\ \Omega$ m (b) $5.25\times10^{-7}\ \Omega$ m (c) $7.12\times10^{-5}\ \Omega$ m (d) $2.55\times10^{-7}\ \Omega$ m

2. **Potentiometer** is a versatile instrument. It is basically a long piece of uniform wire, sometimes a few meters in length across which a standard cell (B) is connected.A current I flows through the wire which can be varied by a variable resistance (rheostat, R) in the circuit. Since the wire is uniform, the potential difference between A and any point at a distance l from A is

$$\varepsilon(l) = \phi(l)$$

where ϕ is the potential drop per unit length.It is used to measure the emf of a cell or potential difference between two points in an electrical circuit or the internal resistance of a cell. The potentiometer wire must be uniform and its resistance should be high.



(i) Which one of the following is true about potentiometer?
(a) Its sensitivity is low
(b) It measures the emf of a cell very accurately.
(c) It is based on deflection method.
(d) None of these

(ii) A current of 1.0 mA is flowing through a potentiometer wire of length 4 m and of resistance 4Ω. The potential gradient of the potentiometer wire is
(a) 10^{-3} Vm^{-1}
(b) 10^{-5} Vm^{-2}
(c) 2×10^{-3} Vm^{-1}
(d) 4×10^{-3} Vm^{-1}

(iii) Sensitivity of a potentiometer can be increased by
(a) decreasing potential gradient along the wire
(b) increasing potential gradient along the wire
(c) decreasing current through the wire
(d) increasing current through the wire.

(iv) A potentiameter is an accurate and versatile device to make electrical measurements of EMF because the method involves
(a) potential gradients
(b) a condition of no current flow through the galvanometer
(c) a combination of cells, galvanometer and resistance
(d) cells

(v) In a potentiometer experiment, the balancing length is 8 m, when the two cells E_1 and E_2 are joined in series. When the two cells are connected in opposition the balancing length is 4 m. The ratio of the e.m.f. of two cells (E_1/E_2) is
(a) 1:2
(b) 2:1
(c) 1:3
(d) 3:1

ANSWERS

1. (d)	**2.** (d)	**3.** (c)	**4.** (a)	**5.** (a)	**6.** (c)	**7.** (b)	**8.** (d)	**9.** (b)	**10.** (b)
11. (c)	**12.** (b)	**13.** (b)	**14.** (a)	**15.** (d)	**16.** (d)	**17.** (b)	**18.** (d)	**19.** (b)	**20.** (a)
21. (d)	**22.** (a)	**23.** (a)	**24.** (d)	**25.** (c)	**26.** (d)	**27.** (b)	**28.** (b)	**29.** (a)	**30.** (c)
31. (d)	**32.** (a)	**33.** (c)	**34.** (b)	**35.** (b)	**36.** (b)	**37.** (c)	**38.** (a)	**39.** (d)	**40.** (a)
41. (b)	**42.** (c)	**43.** (b)	**44.** (c)	**45.** (c)	(**46.** (b)	**47.** (b)	**48.** (a)	**49.** (a)	**50.** (b)
51. (a)	**52.** (b)	**53.** (a)	**54.** (c)	**55.** (c)	**56.** (d)	**57.** (b)	**58.** (d)	**59.** (a)	**60.** (d)
61. (b)	**62.** (c)	**63.** (c)	**64.** (c)	**65.** (c)	**66.** (c)	**67.** (a)	**68.** (d)	**69.** (d)	**70.** (c)
71. (a)	**72.** (a)	**73.** (c)	**74.** (d)	**75.** (a)	**76.** (b)	**77.** (c)	**78.** (c)	**79.** (b)	

Input Text Based MCQs

1. (i) (b), (ii) (a), (iii) (d), (iv) (a), (v) (d)   **2.** (i) (b), (ii) (a), (iii) (a), (iv) (b), (v) (d)