Assinment-2
Answers Key

1. Current density is vector quantity.

2. Yes, electric field exists within the conductor because it is the electric field which imparts acceleration to electrons for the flow of current.

3. No, the resistance remains same, because length and cross-sectional area of the wire remain unchanged.

4. The specific resistance of wire depends only on the material (at given temperature). Therefore by changing the radius, the specific resistance of copper remains unchanged.

5. $V_d = eE\frac{c}{m}$

By heating conductor, the collisions electrons occur more frequently; relaxation time decreases and hence drift velocity decreases.

6. 2 ohms

7. Power $P=I^2Rt \infty I^2$

Clearly current doubled, power dissipated becomes times.

8. The resistivity of material of conductor defined the resistance offered by conductor length 1m and area cross-section 1 m^2. Its unit ohm metre

9. New resistivity will be (unchanged) because resistivity independent of dimensions

10. Resitivity increases with increase in temperature.

11. Resistivity decreases with increase in temperature.

12. As the battery or cell is in continuous use, consuming electrolyte and the chemical reaction keeps occurring in the cell, due to which the concentration of ions in the cell decreases and this resists the flow of charge through it. Hence, the internal resistance increases with time.

13. $E = V + Ir$.

14. During charging.

15. When temperature of the conductor decreases, ionic vibration in the conductor decreases so relaxation time increases.

16. High resistivity and low temperature Coefficient of resistance.

Multiple Choice Questions (Each 1M) -solution

17.(a)

18.(b)

19. (d) 100 S and 10^5 S m^{-1}

R =$\frac{pl}{A}$

G = 1/R = 100 S

Conductivity = 1/Resistivity = 10^5 S m^{-1}

20.(a)

21.(b)

22. (b)

23. (b)

24.(b)

25. (a)

26. (a)

27. (a)

28. (a)

29. (c)

30. (c)

31. (b)

32. (d)

Here, i=nE/ n, r= E/ r Because I is totally independent of n, hence it will remain constant.

33. (a) v_d aE

34. (b)

35. (c) flow from B to A

36. (a) 0.3 A

37. (a)

$I = \frac{8-4}{1+2+9} = \frac{4}{12}$ = 1/3 A

$V_P - V_Q = (4 - \frac{1}{3} X\ 3) = \ 3\ V$

38. (a) 2 R

39

40.

41.

2 MARKS QUESTIONS -ANSWERS

42. Product of resistivity and conductivity is constant = 1

Product independent temperature.

43. Smaller the resistivity of substance, larger is conductivity. The resistivity of silver is least so silver is the best conductor

44. Nichrome wire gets heated up more. Heat dissipated in a wire is given by

$H = I^2Rt = I^2\frac{pl}{A}t$

$H \propto p$

p of nichrome>p of copper

H of nichrome>H of copper

45. Answer

$R_1 = V_1/I$ and $R_2 = V_2/I$

$V_2 > V_1$ So $R_2 > R_1$ and $T_1 < T_2$

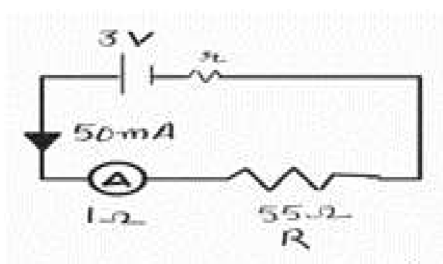
46.Ohm's law is valid to high accuracy. This means that the resistivity of the alloy manganin is nearly independent of temperature.

47. Resistance of bulb=V^2/P = 20 Ω, I = 5A, for the same power dissipation, current should be 5A when the bulb is connected to a 200V supply. The safe resistance R' = V'/I= 40Ω. Therefore, 20Ω resistors should be connected in series.

48.For measuring lower resistance all other resistances should have low value so that bridge is sensitive, this requires galvanometer of very low resistance, also the end resistance and resistance of connecting wires becomes comparable to the resistance measured hence error may be introduced.

49. For measuring higher resistance all other resistances forming the wheat stone bridge should be high but this reduces the current through the galvanometer and hence it becomes insensitive.

50.Emf = 3 V

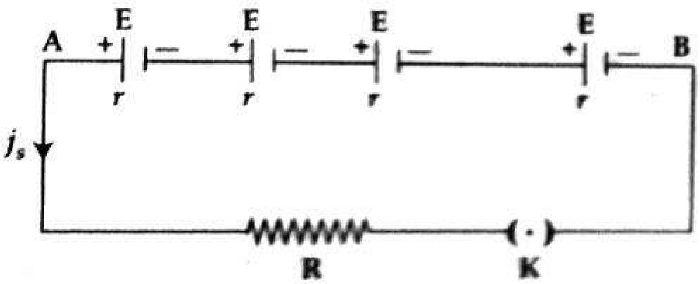


R_{net} = 55 +1+r = 56+r

I= 50 x 10^{-3}A

I= E/R_{net}

R = 4 ohm



51.I $= \frac{nE}{R+nr}$

If R>> nr

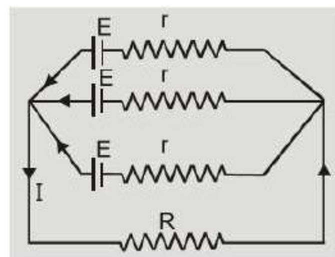
I $= \frac{nE}{R}$ = n x current from a single cell

When external resistance is much higher than the total internal resistance then the cells should be connected in series to get maximum current.

52.

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

$$I = \frac{n\varepsilon}{nR + r}$$



IF $\frac{r}{n}$>> R

r>> Nr

I $= \frac{nE}{r}$ = n X current from a single cell

When external resistance is much smaller than the total internal resistance then the cells should be connected in parallel to get maximum current.

53. E_{Series}= 2 E $E_{Parallel}$= E

I $= \frac{2E}{2r+1}$ I $= \frac{E}{\frac{r}{2}+1}$

$\frac{2E}{2r+1} = \frac{E}{\frac{r}{2}+1}$

$\frac{2}{2r+1} = \frac{1}{\frac{r}{2}+1}$ r = 1 ohm

54.where ρ= specific resistance of wire

for copper wire $R=\rho_c L/A_c$,

for manganin wire $R=\rho_m L/A_m$

or $\rho_c/A_c=\rho_m/A_m$

or $A_c/A_m=\rho_c/\rho_m$

we know $\rho_m>\rho_c$ (as manganin is an alloy)

therefore $A_c<A_m$ Hence manganin wire is thicker

55. (i) When the cell is being charged terminal potential difference (V) becomes greater than emf (E), $V = E + Ir$

(ii) When the cell is discharged, then $V < E$, $V = E - I r$

56. Dry cell used in series will have high resistance (= 10Ω) and hence provide low current, while a car battery has low internal resistance (0.1Ω) and hence gives high current for the same emf, needed to start the car.

57. The resistance of first case, $R_1 = V_1 / I_1 = 50 / 2 \times 10^{-3} = 25,000\ \Omega$ the resistance of second case, $R_2 = V_2 / I_2 = 60 / 3 \times 10^{-3} = 20,000\ \Omega$

As resistance changes with current, so the given conductor is non-ohmic.

3 MARKS QUESTIONS

58. The resistivity of a conductor depends on two factors i.e., nature of the material of the conductor and temperature.

$p = \frac{m}{ne^2\tau}$

Copper wires are used as connecting wires because the electrical resistivity of copper is low. It prevents any wastage of electric current.

59. The supply voltage is $V = 230$ V

The initial current drawn is $I_1 = 3.2$ A

Consider the initial resistance to be R 1, which can be found by the following relation:

$R = V/I = 71.87\ \Omega$

Value of current at steady state, I 2 = 2.8 A

Value of resistance at steady state = R_2

R_2 can be calculated by the following equation :

$R_2 = 82.14\Omega$

The temperature coefficient of nichrome averaged over the temperature range involved is

$1.70 \times 10^{-4}\ °C^{-1}$

Value of initial temperature of nichrome , T 1 = 27.0 ° C

Value of steady state temperature reached by nichrome = T 2

This temperature T 2 can be obtained by the following formula

$$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$$

$$T_2 - 27 = \frac{82.14 - 71.87}{71.87 \times (1.7 \times 10^{-4})}$$

$$T_2 - 27 = 840.5$$

$T_2 = 840.5 + 27 = 867.5\ ^\circ C$

60. (a) Current is given to be steady. Therefore, it is a constant. The current density, electric field, drift speed depends on the area of cross-section inversely.

(b) No, examples of non-ohmic elements are vacuum diode, semiconductor diode etc.

(c) Because the maximum current drawn from a source = ε/r.

61. $E_{eq} = (\varepsilon_2 r_1 + \varepsilon_1 r_2)/(r_1 + r_2)$

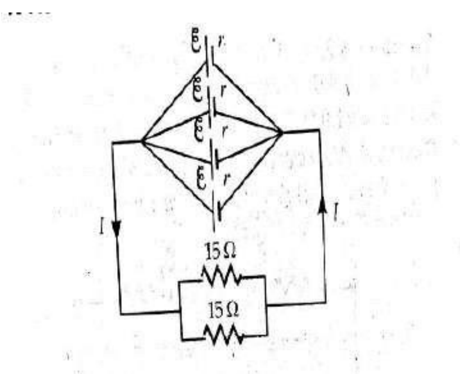
$(1/R_{eq}) = (1/R_1) + (1/R_2) + (1/R_3) \ldots\ldots (1/R_n)$

62. E= 110- 12= 98 V

$I = \frac{98}{R+0.5}$, R= 19.1 ohm , V= E + ir = 12 + 5x0.5 = 14.5 Volt

63. (i) 1.4 V (ii) I_{max} = 0.28 A (iii) $r = E/I_{max}$ = 1.4/.28 = 5 ohm

64. E = 2 V



$r_{eq} = r/4$

$R_{ex} = R/2 = 7.5$

V= 1.6 V

$E = V + I\, r_{eq}$

$E - V = I\, r_{eq}$ $I = V/R_{ex}$

$r_{eq} = \frac{(E-V)Rex}{V} = \frac{(2-1.6)5}{1.6}$ = 15 /8 ohm

$\frac{r}{4} = \frac{15}{8}$

r = 7.5 ohm

65.

E.M.F. OF A CELL	TERMINAL VOLTAGE OF A CELL
1.It is measured by the amount of work done in moving a unit positive charge in the complete circuit inside and outside the cell.	1.It is measured by the amount of work done in moving a unit positive charge in the circuit outside the cell.
2.It is the characteristic of the cell i.e.; it does not depend on the amount of current drawn from the cell	2.It depends on the amount of current drawn from the cell. More the current is drawn from the cell, less is the terminal voltage
3.It is equal to the terminal voltage when cell is not in use while greater than the terminal voltage when cell is in use.	3.It is equal to the emf of cell when cell is not in use, while less than the emf when cell is in use.

66. E = 12 V $\quad$ R_{net} = 2 + 4 = 6 ohm

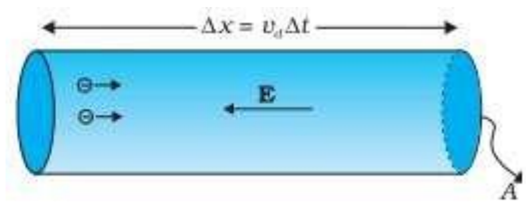
I = 12 /6 = 2 A

VOLTMETER READING = I R = 2 x 4 = 8 V,

Ammeter reading=2A

5 MARKS QUESTIONS

67.



Relaxation time of free electrons drifting in a conductor is the average time elapsed between two successive collisions.

Consider a conductor of length 1 and cross-sectional area A. When a potential difference V is applied across its ends, the current produced is I.

If n is the number of electrons per unit volume in the conductor and v_d the drift velocity electrons, then the relation between current and drift velocity is $I = -neAv_d$

Where -e is the charge on electron

Electric field produced at each point of wire, $= \frac{V}{l}$

If τ is relaxation time and E is electric field strength, then drift velocity $v_d = -\frac{ecE}{m}$

$I = -neA(-\frac{ecE}{m})$ or $I = -\frac{ne^2c}{m}AE$

As $E = \frac{V}{l}$

$I = \frac{ne^2}{m} r A \frac{V}{l}$ or $\frac{V}{l} = \frac{m}{ne^2c}\frac{l}{A}$

Current density $J = \frac{I}{A} = \frac{ne^2c}{ml}V$

This is relation between current density J and applied potential difference V.

Under give physical conditions (temperature, pressure) for a given conductor

$\frac{m\ \ l}{ne^2cA}$ = Constant ∴ This constant is called the resistance of the conductor (i.e. R)

i.e. $R = \frac{m\ \ l}{ne^2cA}$--------------------- 1

$\frac{V}{I} = R$

This is Ohm's law from equation it is clear that the resistance of a wire depends on its length (l), cross-sectional area (A), number of electrons per m3 (n) and the relaxation time

Expression for resistivity

As $R = \frac{pl}{A}$ -----------------------2

Comparing 1 and 2, we get

Resistivity of a conductor $p = \frac{m}{ne^2c}$

clearly, resistivity of a conductor is inversely proportional to number density of free electrons and relaxation time.

Resistivity of the material of a conductor depends upon the relaxation time - i.e. temperature and the number density of free electrons. This is because constantan and manganin show very weak dependence of resistivity on temperature.

68. (a) Each 'free' electron does accelerate, increasing its drift speed until it collides with a positiveion of the metal. It loses its drift speed after collision but starts to accelerate and increases its driftspeed again only to suffer a collision again and so on. On the average, therefore, electrons acquireonly a drift speed.

(b) Simple, because the electron number density is enormous, $\sim 10^{29}\ m^{-3}$.

(c) By no means. The drift velocity is superposed over the large random velocities of electrons.

(d) In the absence of electric field, the paths are straight lines; in the presence of electric field, thepaths are, in general, curved

69. Definition, SI unit is A / m^2

Current density is a vector quantity. Its direction is same as that of motion of positive charge.

$$J = \frac{I}{A} = \frac{neAv}{A} = \frac{neeE\tau}{m} = nee\frac{V\tau}{ml} = ne^2\frac{V\tau}{ml}$$

(a) With increase in potential gradient, J increase.

(b) With increase in temperature, τ decreases, so J decreases.

(c) With increase in length J decreases.

(d) With increase in area, J remains unchanged as J is independent of A.

70. DERIVATION, CIRCUIT DIAGRAM

71.The current should not flow in the Set up for a long time, otherwise the wire will become hot and itsresistance will be changed.

The null point should be between 45cm and 55cm.

It is most sensitive When all four registers P,Q,R,S are nearly of same magnitude and null point isobtained in the middle of alloy wire.