Speed Test-17

1. **(b)** $V = IR = (neAv_d)\rho\frac{\ell}{A}$

$\therefore \quad \rho = \frac{V}{V_d lne}$

Here V = potential difference

l = length of wire

n = no. of electrons per unit volume of conductor.

e = no. of electrons

Placing the value of above parameters we get resistivity

$$\rho = \frac{5}{8\times10^{28}\times1.6\times10^{-19}\times2.5\times10^{-4}\times0.1}$$

$= 1.6 \times 10^{-5}\Omega m$

2. **(d)** From the curve it is clear that slopes at points A, B, C, D have following order $A > B > C > D$.
And also resistance at any point equals to slope of the V-i curve.
So order of resistance at three points will be
$R_A > R_B > R_C > R_D$

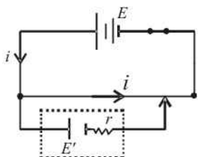
3. **(d)** From the principle of potentiometer, $V \propto l$

$\Rightarrow \frac{V}{E} = \frac{l}{L}$; where

V = emf of battery, E = emf of standard cell.

L = length of potentiometer wire

$$V = \frac{El}{L} = \frac{30E}{100}$$



NOTE In this arrangement, the internal resistance of the battery E does not play any role as current is not passing through the battery.

4. **(d)** $R = \frac{\rho l}{\pi r^2}$. But $m = \pi r^2 ld \therefore \pi r^2 = \frac{m}{ld}$

$$\therefore R = \frac{\rho l^2 d}{m},\ R_1 = \frac{\rho l_1^2 d}{m_1},\ R_2 = \frac{\rho l_2^2 d}{m_2}$$

$$R_3 = \frac{\rho l_3^2 d}{m_3}$$

$$R_1 : R_2 : R_3 = \frac{l_1^2}{m_1} : \frac{l_2^2}{m_2} : \frac{l_3^2}{m_3}$$

$$R_1 : R_2 : R_3 = \frac{25}{1} : \frac{9}{3} : \frac{1}{5} = 125 : 15 : 1$$

5. **(c)** In series, $R_s = nR$

In parallel, $\frac{1}{R_p} = \frac{1}{R} + \frac{1}{R} + \ldots n$ terms

$\therefore R_s/R_p = n^2/1 = n^2$

6. **(a)** Efficiency is given by $\eta = \frac{\text{output}}{\text{input}}$

$$= \frac{5\times15\times14}{10\times8\times15} = 0.875 \text{ or } 87.5\%$$

7. **(b)** According to the condition of balancing

$$\frac{55}{20} = \frac{R}{80} \Rightarrow R = 220\Omega$$

8. **(a)** $J = \sigma E \Rightarrow J\rho = E$
J is current density, E is electric field
so $B = \rho$ = resistivity.

9. **(d)** Kirchhoff's first law is based on conservation of charge and Kirchhoff's second law is based on conservation of energy.

10. **(c)** $R = \frac{\rho\ell}{A}$

When wire is cut into 4 pieces and connected in parallel.

$$R_{eff.} = \frac{R}{16} \Rightarrow P_C = 16P$$

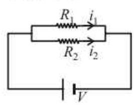
$$P_A : P_B : P_C : P_D = \frac{V^2}{R} : \frac{V^2}{R/4} : \frac{V^2}{R/16} : \frac{V^2}{R/2}$$

11. **(b)** $S = \frac{I_g R}{nI_g - I_g} \Rightarrow S = \frac{I_g}{(n-1)I_g}R$

12. **(d)** Resistance of a conductor, $R = \frac{m}{ne^2\tau}\frac{l}{A}$

As the temperature increases, the relaxation time τ decreases because the number of collisions of electrons per second increases due to increase in thermal energy of electrons.

13. **(b)**



$R_1 = \frac{\rho \ell_1}{\pi r_1^2};\ R_2 = \frac{\rho \ell_2}{\pi r_2^2}$

$i_1 R_1 = i_2 R_2$ (same potential difference)

$\therefore\ \frac{i_1}{i_2} = \frac{R_2}{R_1} = \frac{\ell_2}{\ell_1} \times \frac{r_1^2}{r_2^2} = \frac{3}{4} \times \frac{4}{9} = \frac{1}{3}$

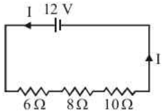
14. **(c)** $\frac{R_1}{R_2} = \frac{\ell_1}{\ell_2}$ where $\ell_2 = 100 - \ell_1$

In the first case $\frac{X}{Y} = \frac{20}{80}$

In the second case

$\frac{4X}{Y} = \frac{\ell}{100 - \ell} \Rightarrow \ell = 50$

15. **(c)** Before connecting E, the circuit diagram is



Then, $R_{eq} = 6\,\Omega + 8\,\Omega + 10\,\Omega = 24\,\Omega$

Current in the 8 Ω resistance, $I = \frac{12V}{24\Omega} = \frac{1}{2}A$

After connecting E, the current through 8 Ω is

$I = \frac{1}{2}A$

$\therefore\ E = \frac{1}{2}A \times 8\Omega = 4V$

16. **(d)** By junction rule at point B

$-I + 1A + 2A = 0$

So, $I = 3A$

By Loop rule,

$-3 \times 2 - 1 \times 1 - E + 12 = 0$

$E = 5V$

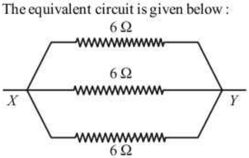
17. **(d)** Resistance of bulb $R_b = \frac{(1.5)^2}{4.5} = 0.5\Omega$

Current drawn from battery $= \frac{E}{2.67 + 0.33} = \frac{E}{3}$

Share of bulb $= \frac{2}{3} \times \frac{E}{3} = \frac{2E}{9}$

$\therefore\ \left(\frac{2E}{9}\right)^2 \times 0.5 = 4.5$ or $E = 13.5$ V.

18. **(d)** The equivalent circuit is given below :



The equivalent resistance is given by

$\frac{1}{R} = \frac{1}{6} + \frac{1}{6} + \frac{1}{6} = \frac{3}{6} = \frac{1}{2}$

$\Rightarrow R_{eq} = 2\Omega$

19. **(a)** Since average drift velocity $= \frac{1}{2}\frac{eE}{m} \times (\tau)$

Now $I = NeA \times$ (avg. drift velocity)

$= \frac{Ne^2AE}{2m\ell} \times \tau = \frac{Ne^2AV}{2m\ell} \times \tau$

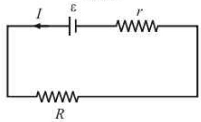
$R = \frac{V}{I} = \frac{2m\ell}{Ne^2\tau A}$, where N is electron density.

20. **(c)** The current through the resistance R

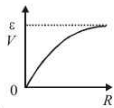
$I = \left(\frac{\varepsilon}{R + r}\right)$

The potential difference across R

$V = IR = \left(\frac{\varepsilon}{R + r}\right)R$



$V = \frac{\varepsilon}{\left(1 + \frac{r}{R}\right)}$



when $R = 0$, $V = 0$,

$R = \infty$, $v = \varepsilon$

Thus V increases as R increases upto certain limit, but it does not increase further.

21. **(c)** Resistance of bulb is constant

$P = \frac{V^2}{R} \Rightarrow \frac{\Delta p}{p} = \frac{2\Delta V}{V} + \frac{\Delta R}{R}$

$\frac{\Delta p}{p} = 2 \times 2.5 + 0 = 5\%$

22. **(a)** Potential gradient = Potential fall per unit length. In this case resistance of unit length.

$R = \frac{\rho l}{A} = \frac{10^{-7} \times 1}{10^{-6}} = 10^{-1}\Omega$

Potential fall across R is

$V = I.R = 0.1 \times 10^{-1} = 0.01$ volt/m.

$= 10^{-2}$ volt / m

23. **(d)** $R_1 + R_2$ = Constant, R_1 will increase, R_2 will decrease.

$R_1\alpha\Delta T - R\beta\Delta T = 0 \Rightarrow R_1\alpha\Delta T = R_2\beta\Delta T$

$\therefore \frac{R_1}{R_2} = \frac{\beta}{\alpha}$

24. (d) Given : Number of cells, $n=5$, emf of each cell $=E$
Internal resistance of each cell $=r$
In series, current through resistance R

$$I=\frac{nE}{nr+R}=\frac{5E}{5r+R}$$

In parallel, current through resistance R

$$I'=\frac{E}{\frac{r}{n}+R}=\frac{nE}{r+nR}=\frac{5E}{r+5R}$$

According to question, $I=I'$

$$\therefore\ \frac{5E}{5r+5R}=\frac{5E}{r+5R}\Rightarrow 5r+R=r+5R$$

or $R=r$ $\quad\therefore\ \frac{R}{r}=1$

25. (d) The total volume remains the same before and after stretching.

Therefore $A\times\ell=A'\times\ell'$

Here $\ell'=2\ell$

$$\therefore\ A'=\frac{A\times\ell}{\ell'}=\frac{A\times\ell}{2\ell}=\frac{A}{2}$$

Percentage change in resistance

$$=\frac{R_f-R_i}{R_i}\times100=\frac{\rho\left(\frac{\ell'}{A'}-\frac{\ell}{A}\right)}{\rho\frac{\ell}{A}}\times100$$

$$=\left[\left(\frac{\ell'}{A'}\times\frac{A}{\ell}\right)-1\right]\times100=\left[\left(\frac{2\ell}{A/2}\times\frac{A}{\ell}\right)-1\right]\times100$$

$=300\%$

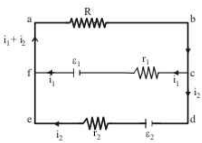
26. (a) Pot. gradient $=0.2\,\text{mV/cm}$

$$=\frac{0.2\times10^{-3}}{10^{-2}}=2\times10^{-2}\,\text{V/m}$$

Emf of cell $=2\times10^{-2}\times1\,\text{m}=2\times10^{-2}\,\text{V}=0.02\,\text{V}$
As per the condition of potentiometer
$0.02\,(R+490)=2\,(R)$ or $1.98\,R=9.8$

$$\Rightarrow\quad R=\frac{9.8}{1.98}=4.9\,\Omega$$

27. (d)



Applying Kirchhoff's rule in loop **abcfa**
$\varepsilon_1-(i_1+i_2)R-i_1\ r_1=0.$

28. (c) Total power consumed by electrical appliances in the building, $P_{total}=2500\,\text{W}$

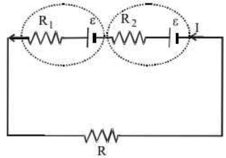
Watt = Volt × ampere

$\Rightarrow\ 2500=V\times I\Rightarrow 2500=220\,I$

$$\Rightarrow\ I=\frac{2500}{220}=11.36\approx12\,\text{A}$$

(Minimum capacity of main fuse)

29. (a)



$$I=\frac{2\varepsilon}{R+R_1+R_2}$$

Potential difference across second cell

$=V=\varepsilon-iR_2=0$

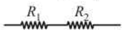
$$\varepsilon-\frac{2\varepsilon}{R+R_1+R_2}.R_2=0$$

$R+R_1+R_2-2R_2=0$

$R+R_1-R_2=0$

$\therefore\ R=R_2-R_1$

30. (c)



Resistance of the series combination,
$S=R_1+R_2$
Resistance of the parallel combination,

$$P=\frac{R_1R_2}{R_1+R_2}$$

$$S=nP\Rightarrow R_1+R_2=\frac{n(R_1R_2)}{(R_1+R_2)}$$

$\Rightarrow(R_1+R_2)^2=nR_1R_2$
Minimum value of n is 4 for that

$(R_1+R_2)^2=4R_1R_2\ \Rightarrow(R_1-R_2)^2=0$

31. (c) To convert a galvanometer into a voltmeter we connect a high resistance in series with the galvanometer.
The same procedure needs to be done if ammeter is to be used as a voltmeter.

32. (c) Given, emf of cell $E=200\,\text{V}$
Internal resistance of cells $=1\,\Omega$
D. C. main supply voltage $V=220\,\text{V}$
External resistance $R=?$

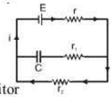
$$r=\left(\frac{E-V}{V}\right)R$$

$$1=\left(\frac{20}{220}\right)\times R$$

$\therefore\quad R=11\,\Omega.$

33. (a) In steady state, flow fo current through capacitor will be zero.

Current through the circuit,



$$i = \frac{E}{r + r_2}$$

Potential difference through capacitor

$$V_c = \frac{Q}{C} = E - ir = E - \left(\frac{E}{r + r_2}\right) r$$

$$\therefore \quad Q = CE\frac{r_2}{r + r_2}$$

34. (c) $i = neAV_d$ and $V_d \propto \sqrt{E}$ (Given)

or, $i \propto \sqrt{E}$

$i^2 \propto E$

$i^2 \propto V$

Hence graph (c) correctly dipicts the V-I graph for a wire made of such type of material.

35. (b) Current, $I = (2.9 \times 10^{18} + 1.2 \times 10^{18}) \times 1.6 \times 10^{-19}$

$= 0.66$A towards right.

36. (a) Copper rod and iron rod are joined in series.

$$\therefore R = R_{Cu} + R_{Fe} = (\rho_1 + \rho_2)\frac{\ell}{A}$$

$$\left(\because R = \rho\frac{\ell}{A}\right)$$

From ohm's law $V = RI$

$= (1.7 \times 10^{-6} \times 10^{-2} + 10^{-5} \times 10^{-2}) \div 0.01 \times 10^{-4}$ volt

$= 0.117$ volt $(\because I = 1A)$

37. (d) $I = \dfrac{E}{R + r}$, Internal resistance (r) is zero, $I = \dfrac{E}{R} =$ constant.

38. (b) $R_t = R_0(1 + \alpha t)$

Initially, $R_0(1 + 30\alpha) = 10\,\Omega$

Finally, $R_0(1 + \alpha t) = 11\,\Omega$

$$\therefore \frac{11}{10} = \frac{1 + \alpha t}{1 + 30\alpha}$$

or, $10 + (10 \times 0.002 \times t) = 11 + 330 \times 0.002$

or, $0.02t = 1 + 0.66 = 1.066$ or $t = \dfrac{1.66}{0.02} = 83°C$.

39. (b) As $P = I^2 R$, so $P_1 = (1.01\,I)^2 R = 1.02\,I^2 R = 1.02\,P$.

It means % increase in power

$$= \left(\frac{P_1}{P} - 1\right) \times 100 = 2\%.$$

40. (b) Let I_1 be the current throug $5\,\Omega$ resistance, I_2 through $(6 + 9)\,\Omega$ resistance. Then as per question,

$I_1^2 \times 5 = 20$ or, $I_1 = 2A$.

Potential difference across C and D $= 2 \times 5 = 10V$

Current $I_2 = \dfrac{10}{6 + 9} = \dfrac{2}{3}A$.

Heat produced per second in $2\,\Omega$

$$= I^2 R\left(\frac{8}{3}\right)^2 \times 2 = 14.2\,\text{cal/s}.$$

41. (b) $\dfrac{P}{Q} = \dfrac{R}{S}$ where $S = \dfrac{S_1 S_2}{S_1 + S_2}$

42. (c) $R = \dfrac{\rho \ell_1}{A_1}$, now $\ell_2 = 2\ell_1$

$A_2 = \pi(r_2)^2 = \pi(2r_1)^2 = 4\pi r_1^{\,2} = 4A_1$

$$\therefore \quad R_2 = \frac{\rho(2\ell_1)}{4A_1} = \frac{\rho \ell_1}{2A_1} = \frac{R}{2}$$

$\therefore$ Resistance is halved, but specific resistance remains the same.

43. (d) $E = V + Ir$

$V = 12 - 3 = 9$ volt

44. (c) $I = neAV_d$

$$V_d = \frac{I}{neA} = 5 \times 10^{-3}\ \text{m/sec}$$

45. (d) Since due to wrong connection of each cell the total emf reduced to 2ε then for wrong connection of three cells the total emf will reduced to $(n\varepsilon - 6\varepsilon)$ whereas the total or equivalent resistance of cell combination will be nr.