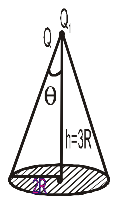
WEEKLY CLASS TEST

Batch : S1 **SOLUTION** **Date : 13/08/2023**

1. [B] When charge is at O_1 the flux through the face having radius 2R is



$$\phi_1 = \frac{q}{\varepsilon_0}\cdot\frac{2\pi(1-\cos\theta)}{4\pi}$$

$$= \frac{q}{\varepsilon_0}\cdot(1-\cos\theta)$$

$$= \frac{q}{2\varepsilon_0}\left[1-\frac{3R}{\sqrt{(2R)^2+(3R)^2}}\right] = \frac{q}{2\varepsilon_0}\left[1-\frac{3}{\sqrt{13}}\right]$$

Similarly,

$$\phi_2 = \frac{q}{2\varepsilon_0}\left[1-\frac{3R}{\sqrt{R^2+(3R)^2}}\right] = \frac{q}{2\varepsilon_0}\left[1-\frac{3}{10}\right]$$

$$\frac{\phi_1}{\phi_2} = \left(\frac{\sqrt{13}-3}{\sqrt{10}-3}\right)\cdot\sqrt{\frac{10}{13}}$$

2. [C]There are two capacitor in series. Equivalent capacitance is

$$C_0 = \frac{1}{2}\left(\frac{\varepsilon_0 A/2}{d}\right) = \frac{\varepsilon_0 A}{4d}$$

$\therefore$ **Charge supplied by the cell**

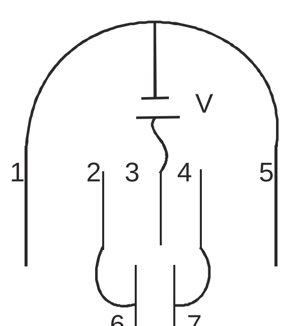
$$Q = C_0 V = \frac{\varepsilon_0 A}{4d}V$$

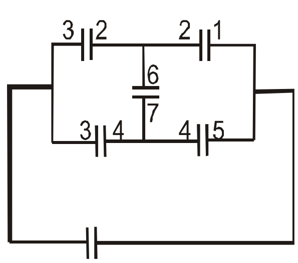
$$\therefore \quad W_{batt} = QV = C_0V^2 = \frac{\varepsilon_0 A}{4d}V^2$$

3. [A] There are five capacitor each of capacitance

C = $\frac{\varepsilon_0 A}{d}$

The arrangement is a Wheastone bridge as shown in figure.
It is a balanced bridge and equivalent capacitance is





$$C_0 = C = \frac{\varepsilon_0 A}{d}$$

$$\therefore \quad Q = C_0 V = \frac{\varepsilon_0 A}{d}V$$

4. [B] As, X > Y and P = Q
$\therefore$ **Potential of point a is less than of b. Current flows from b to a.**

5. [B] At null deflection position, equivalent emf of cell combination (of 2 cells in parallel) is balanced against potential drop of AN length of potentiometer wire.
Now, equivalent emf of combination is

$$E_{ed} = \frac{E_1r_2+E_2r_1}{r_1+r_2} = \frac{2\times6+4\times2}{2+6} = \frac{12+8}{8}$$

$$\therefore \quad E_{eq} = \frac{20}{8} = 2.5V$$

and potential drop across AN length = potential drop per unit length x length AN
Now, current in potentiometer wire

$$= I_{AB} = \frac{E}{R_{total}} = \frac{12}{4+4} = \frac{12}{8}A = 1.5A$$

So, V_{AB} **= potential drop across AB length of wire**

$$= I_{AB}R_{AB} = 1.5\times4 = 6V$$

Hence, potential drop across AN length

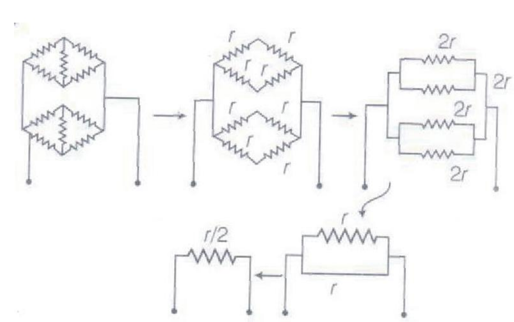
$$= \frac{V_{AB}}{I_{AB}}\times AN = \frac{6}{4}\times AN$$

So, $\frac{6}{4}AN = E_{eq}$

As, N is null deflection point

$$\Rightarrow \frac{6}{4}\times AN = 2.5 \Rightarrow AN = \frac{2.5\times4}{6} = \frac{5}{3}m$$

6. [D] Given network of resistance is equivalent to two balanced Wheatstone bridge



As, meter bridge is balanced,

$$\therefore \quad \frac{10}{30} = \frac{r/2}{60} \Rightarrow \frac{10\times60}{30}\times2 = r$$

or $r = 40\Omega$

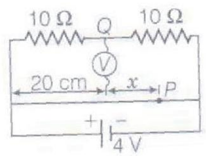
7. [D]At 20 cm mark, reading of voltmeter is zero
At some distance x from centre,

$$V_P = 4\left(\frac{20+x}{40}\right)$$

and $$V_Q = 2V$$

$$\therefore \quad V_P - V_Q = \frac{x}{10} volt$$

$$\Rightarrow \quad 2\sin\omega t = \frac{x}{10}$$



As, x = 20 sin ω t

$$\therefore \quad \frac{dx}{dt} = velocity$$

= 20 ω cos ω t cm/s

8. [A] Ohm's law V = IR $\Rightarrow V \propto I$ (for ammeter)

$$\therefore \quad \frac{V_2}{V_1} = \frac{I_2}{I_1} = 2$$

$$\Rightarrow \quad 10 = 2\times 10 \times \frac{R}{2+R}$$

$$\Rightarrow \quad R = 2\Omega$$

9. [ABC]The force F experience by the electron (towards the +ve plate) is given by

$$F = qE = 1.6\times10^{-19}\times 3000 = 4.8\times10^{3-16} N$$

Hence the acceleration experienced by the electron [is given by

$$a = \frac{F}{m} = \frac{4.8\times10^{-16} N}{9.1\times10^{-31} kg} = 5.3\times10^{14} m/s$$

Now the electron is released from the negative plate and is travelling to the positive plate. We have

$$v_0 = 0 \qquad x = 0.15m$$

and $$a = 5.3\times10^{14} m/s^2$$

Substituting these values in the relation

$$x = v_0 t + \tfrac{1}{2}at^2$$

$$t = \sqrt{\frac{2x}{a}}\sqrt{\frac{2\times0.15m}{5.3\times10^{14} m/s^2}}$$

$$= 2.4\times10^{-8} s$$

$$v = v_0 + at$$

$$= 0 + (5.3\times10^{14} m/s^2)(2.4\times10^{-8} s)$$

$$= 1.30\times10^{7} m/s$$

10. [AC]Since all the changes are placed along the x-axis, the field due to all are all along the x-axis. The magnitude of total field at x = 0 is therefore just the sum of the magnitude of the field due to the individual charges.

The total field at x = 0 is, therefore,

$$E = \frac{1}{4\pi\varepsilon_0} a\left[\frac{q}{1^2}+\frac{q}{2^2}+\frac{q}{4^2}+\frac{q}{8^2}+....\infty\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{1}+\frac{1}{4}+\frac{1}{16}+\frac{1}{64}....\infty\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\frac{1}{1-1/4}$$

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{4}{3}q\right)$$

When the consecutive charges are of opposite sign, the resulttants field is given by

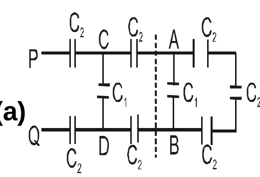
$$E = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{1^2}-\frac{q}{2^2}+\frac{q}{4^2}-\frac{q}{8^2}+.....\infty\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\left\{\frac{1}{1^2}+\frac{1}{4^2}+\frac{1}{16^2}+.....\infty\right\}-\left\{\frac{1}{2^2}+\frac{1}{8^2}+\frac{1}{32^2}+....\right\}\right]$$

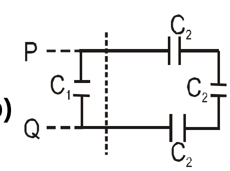
$$= \frac{q}{4\pi\varepsilon_0}\left[\left(\frac{1}{1-1/16}\right)-\left(\frac{1/4}{1-1/16}\right)\right]$$

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{4q}{5}\right)$$

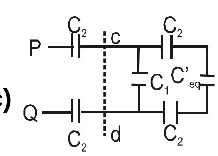
11. [ACD](a)



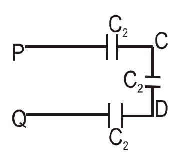
(b)



(c)



(d)



Let $C'eq$ **be the equivalent capacity between points a and b. Obviously, from fig. (b)**

$$C'eq = C_1 + \frac{C_2}{3}$$

$$= 1 + \frac{3}{3} = 2\mu F \qquad \textbf{....(i)}$$

Similarly, the equibalent capacity C'' eq between points and d is

$$C''eq = C_1 + \frac{C_2 C'eq}{2C'eq + C_2}$$

$$= 1 + \frac{3\times2}{4+3}$$

$$= 1 + \frac{6}{7} = \frac{13}{7} \mu F \quad \textbf{...(ii)}$$

If C is equivalent capacity between points P and Q, we note that $C_2 C"_{eq}$ C_2 are connected in series as shown in Fig (d)

Therefore,

$$\frac{1}{C_{eq}} = \frac{1}{C_?} + \frac{1}{C_2} + \frac{1}{C"_{eq}}$$

or $$C_{eq} = \frac{C_a C"_{eq}}{2C"_{eq} + C_2}$$

$$= \frac{3 \times (13/7)}{2(13/7) + 3} = \frac{39}{47} \mu F$$

The total charge q on the arrangement is q = $C_{eq} \times V$

$$= \frac{39}{47} \times 410 \mu C = 340.2 \mu C \quad \textbf{...(iv)}$$

From fig (d) clearly capacitors $C_2 C"_{eq}$ and C_2 are in series across 470 V.

12. [AC] Let cell delivers current i and i_1 is apart of current i that goes through R_3

So, by toop rule

$E - iR_2 - i_1 R_3 - iR_1 = 0$ (loop 1) ....(i)

$i_1 R_3 (i - i_1) R_v = 0$ (loop 2) ....(ii)

On solving for i_i, Eq (ii) yields

$$i = \frac{R_3 - R_v}{R_v} \cdot i_1$$

Substituting this into Eq.(i), we get

$$E - \left(\frac{R_3 + R_v}{R_v}\right) R_2 i_1 - i_1 R_2 - \left(\frac{R_3 + R_v}{R_v}\right) R_1 i_1 = 0$$

$$\Rightarrow \quad E = i_1 \left\{ \left(\frac{R_3 + R_v}{R_v}\right) R_2 - R_3 - \left(\frac{R_3 + R_v}{R_v}\right) R_1 \right\}$$

$$= i_1 \left\{ \frac{(R_3 + R_v)R_2 - R_v R_3 - (R_3 + R_v)R_1}{R_v} \right\}$$

So, $$i_1 \frac{ER_v}{(R_3 + R_v)R_2 - R_v R_3 - (R_3 + R_v)R_1}$$

$$= \frac{3 \times 5 \times 10^3}{\left[\begin{array}{l} (250 + 5 \times 10^3)300 - 5 \times 10^3 \\ \times 250 - (250 + 5 \times 10^3) \times 100 \end{array} \right]}$$

and potential drop across resistance $R_3 = i_1 R_3 = 1.12V$

Current in the absence of voltmeter is

$$i' = \frac{E}{R_1 + R_2 + R_3}$$

$\therefore$ True potential drop across

$$R_3 = i' R_3 = \frac{3 \times 250}{250 + 300 + 100} = 1.15V$$

So, fraction error is

$$\frac{1.15 - 1.12}{1.15} = 0.030$$

This is about 3%

13. [BD] The mass of a wire of length l, cross-sectional area A and density d is given by

m = Ald

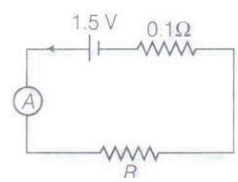
Since, A and d are the same for the two wires and since, their masses are in the ratio of 1 : 2, their lengths and hence, their resistance are in the ratio of 1 : 2 , when the wires are connected in series, the same current I flows in each. Since, the heat H produced in time t is given by

$$H = l^2 Rt \text{ or } H \propto R$$

On the other hand, if the wires are connected in parallel, the potential difference V is the same across the two wires. Since, H is also given by

$$H = \frac{V^2 t}{R} \text{ or } H \propto \frac{1}{R}$$

14. [ABC]



As ammeter shows 2A, an external resistance or R ohm is connected in the circuit.

$$l = \frac{V}{r + R}$$

$$2 \times (0.1 + R) = 1.5$$

$$0.2 + 2R = 1.5$$

$$2R = 1.3$$

$$R = \frac{1.3}{2} = 0.65\Omega$$

Rate of chemical energy consumption

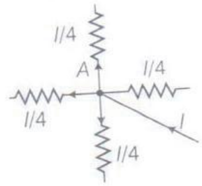
$$£ = \frac{dQ}{dt} = £l = 1.5 \times 2 = 3W$$

Rate of energy dissipation in the cell $= l^2 r = 4 \times 0.1 = 0.4$ W

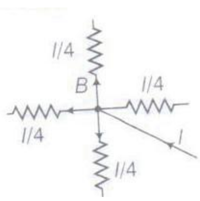
Rate of energy dissipation inside the resistor

$$= l^2 R = 4 \times 0.65 = 2.60W$$

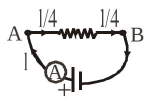
15. [AD] As, current enters through A and disbutes in infinite network. So, by symmetry current equally in 4 equal parts



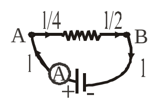
and currnet from circuit are directed towards B,



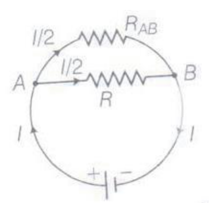
When we consider A and B as



So, currents in AB branch superimposes and $l_{AB} = \frac{l}{2}$



and so we consider remaining circuit as R'_{AB}



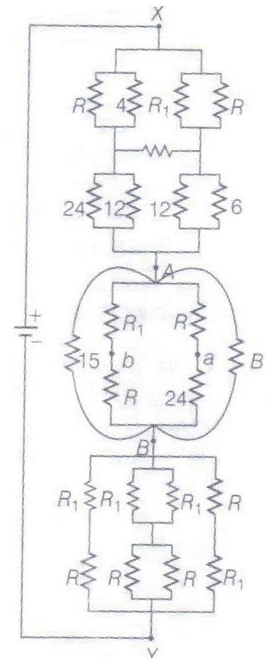
Now, $V_{AB} = \frac{l}{2}R = \frac{I}{2}R_{eq} \Rightarrow R'_{eq} = \frac{R}{2}$

So, equivalent resistance is $\frac{R}{2}$.

Also, $V = lR_{eq}$

$\Rightarrow \quad l = \frac{V}{R_{eq}} = \frac{V}{R/2}$ = 2A

16. [AC] Given circuit can be redrawn as,



If value of R_2 is changed, it has no effect on equivalent resistance of circuit.

$\therefore$ Wheatstone bridge between X and Y is balanced.

So, $$\frac{\left(\frac{PR_1}{R+R_1}\right)}{\left(\frac{4R}{4+R}\right)} = \frac{\left(\frac{6\times 12}{6+12}\right)}{\left(\frac{12\times 24}{12+24}\right)}$$

On solving, we get $R_1 = \frac{4R}{4+2R} = \frac{2R}{2+R}$

17. [AD] Equivalent emf

of three cells is $E_{eq} = \frac{\sum (E/r)}{\sum (1/r)} = 2V$

Equivalent circuit is

Since, no current is drawn from cell,

$V_{AB} = 2V$ and $V_{AB} = V_A - V_B = E_1 - i_1 r_1$

$\therefore \quad i_1 = \frac{V_B - V_A + E_1}{r_1} = \frac{-2+3}{1} = 1A$

$i_2 = \frac{V_B - V_A + E_2}{r_2} = \frac{-2+3}{1} = 0$

$i_3 = \frac{V_B - V_A + E_3}{r_3} = \frac{-2+3}{1} = -1A$

18. [ABC] Let us consider that ball is first touched to +ve plate, as a result,it acquires +ve charge and due to electric field from + ve to -ve plate, it acceleration and comes into contact with -ve plate. There it release +ve accelerating from -ve to +ve plate and this process repeats.

19. [A] 252000J
20. [A] 201600 J
Obtain power dissipated as heat the remaining power is the sum of te mechanical power yielded by the motor and the chemical power stored in the battery.
21. [A] The emf of cell = potential drop of balance length
$= xll_{(AC)}$

Here, x = $\frac{99\Omega}{99m} = \frac{1\Omega}{cm}$

I = current in potentiometer wire

$= \frac{V_{AB}}{R_{AB}} = \frac{10V}{100\Omega} = \frac{1}{10}A$

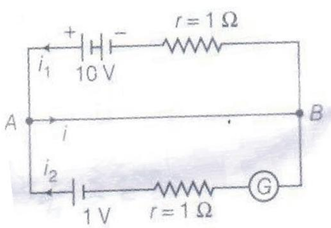
$\therefore \quad E = 1\Omega / cm \times \frac{1}{10} A \times 40cm = 4V$

22. [A] When jockey is touched at point B, the circuit will be applying Kirchhoff's law.

$-99i - i_1 + 10 = 0$ ..... (i)

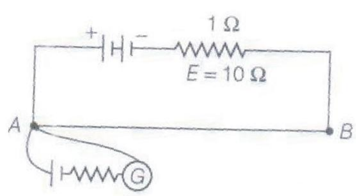
$-99i - i_2 + 1 = 0$ ..... (ii)

and $i_1 + i_2 = i$ ..... (iii)



On solving these equations, we get i and potential

23. [D] When jockey is touched at point A, then there are two separate loops.



24. [A] When jockey is touched at point A, then potential difference across the terminals of driver cell is given V = E - Ir = 9.9 V

25. [A] $neA^3{}_d = i \Rightarrow {}^3{}_d = \frac{i}{neA}; t = \frac{l}{{}^3{}_d}$

26. [A] $neA^3{}_d = i \Rightarrow {}^3{}_d = \left(\frac{eE}{m}\right)^2$ and $\because {}^3 = IR$

$\Rightarrow \quad \frac{ne^2AE^2}{m} = i \Rightarrow \left(u \sin gE = \frac{V}{L}\right)$

$\Rightarrow \quad {}^\circ = \frac{m}{ne^{22}} \Rightarrow {}^2 = \frac{m}{ne^2 l}$

$= \frac{9.1\times10^{-31}}{8\times10^{28}\times(1.6\times10^{-19})^2\times(1.6\times10^{-8})} \approx 10^{-14}$

27. [A]

$\because \quad V = iR \Rightarrow V = i\frac{\circ}{A}\times l = \frac{i^{\circ\,3}{}_d t}{A}$

28. **[A] Wheatstone bridge is balanced.**

As, $\frac{P}{Q} = \frac{R}{S}$

$\Rightarrow \quad \frac{40}{60} = \frac{60}{15} = \frac{4}{1}$

$\Rightarrow \quad V_{AB} = V_{AD}$

So, $40l_1 = 60l_2$

$l_1 - 1.5l_2$

Heat produced in AB $= l_1^2Rt = (1.5l_2)^2 \times 40 \times t = 90l_2^2t$

Heat produced in BC $= l_1^2Rt = (1.5l_2)^2 \times 10 \times t = 22.5l_2^2t$

Heat produced in AD $= l_2^2Rt = l_2^2 \times 60 \times t = 60l_2^2t$

Heat produced in DC $= l_2^2Rt = l_2^2 \times 15 \times t = 15l_2^2t$

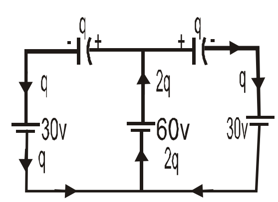
$(i) \to (s), (ii) \to (r), (iii) \to (q), (iv) \to (p)$

29. [B] $(i) \to (q, r, s), (ii) \to (s), (iii) \to (p, q), (iv) \to (r)$
All are Wheat stone bridge. Only S is balanced as

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

To get direction of current, find V_B and V_D.

30. [1.8]With switch S open the potential difference across t group of capacitors is zero. There is no charge on both of them.
With S closed, potential difference across both of them is 30 V. Charge on each of them is



$q = (2\mu F)(30V) = 60\mu C$

Polarity is as shown. The charge flow in various path has also been shown.
Energy supplied by 60 V cell = 60 × 2q = 60 × 120 μJ
Energy absorbed by each of 30 V cell = 30 × q = 30 × 60 μJ

Energy stored in capacitor $= \frac{1}{2}CV^2 = \frac{1}{2}\times2\times30^2\mu J$

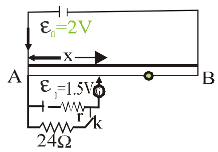
$\therefore$ **Heat dissipated =** $60\times120 - 2\times30\times60 - 2\times30^2$

$= 60[120 - 60 - 30]$

$= 60\times30 = 180\mu J = 1.8mJ$

31. [0.6]
32. [1]
33. [1]

34. [6] Let α is resistance per unit length of wirre AB. When k is opened



$$I(\alpha x_1) = E_1 \qquad \textbf{...(i)}$$

k is closed $\quad I\alpha x_2 = E_1 - ir \qquad$ **...(ii)**

$$i = \frac{E_1}{R+r} \qquad \textbf{...(iii)}$$

$$\Rightarrow \quad r = \left(\frac{x_1}{x_2} - 1\right)R = \left(\frac{0.75}{0.60} - 1\right)24; r = 6\Omega$$