XII – MAIN 1 – PHYSICS SOLUTIONS

1. Conceptual

2. Charge on the inner surface must be equal and opposite to the charge at the center (otherwise, Gauss law would fail)

   Moreover, net charge on the spherical shell is –q, which should not change(otherwise, law of conservation of charge would fail).

3. $\phi = \vec{E}.\vec{S}$

4. Conceptual

5. Key: B

   Hint: $dV = \frac{dq}{4\pi\varepsilon_0 r} = \frac{\sigma r \frac{\pi}{2} .dr}{4\pi\varepsilon_0 r}$ $\therefore V = \frac{\sigma}{8\varepsilon_0}\int_{R/2}^{R} dr = \frac{\sigma R}{16\varepsilon_0}$

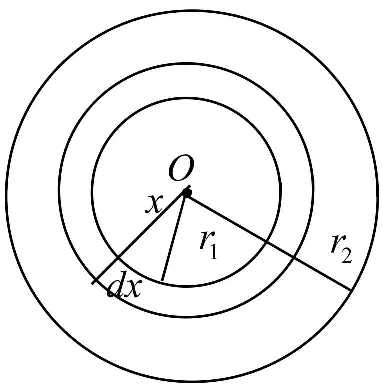
6. A

   The electrostatic potential energy can be found by bringing all these charges (+2Q and –Q) from infinity to their respective positions and finding work done by external agent in this process. Whatever will be work done in bringing these charges from infinity to their respective positions, same will be the P.E. of this system.

7. Ans: A

   Sol: dR = $\frac{\rho.dx}{4\pi x^2}$

   R = $\frac{p}{4\pi}\int_{r_1}^{r_2}\frac{dx}{x^2} = \left(\frac{r_2 - r_1}{r_1 r_2}\right)\frac{p}{4\pi}$



8.

Current needed by bulb to glow with full intensity

$I = \frac{P}{V} = \frac{4.5}{1.5} = 3A$

$(0.3 + 1.5)$

∴ Now current in $\frac{1}{2}\Omega$ be 3A, in 1Ω it will be 1.5 A.

∴ Total current taken from battery = $(0.3+1.5)$ =4.5 A

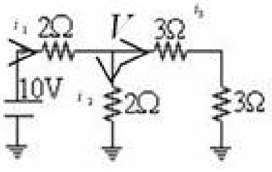
$R_t = \frac{1 \times 1/2}{1+1/2} + 2.6 = \frac{1}{3} + 2.67 = 3.0\Omega$

Where $R_t = \frac{1 \times 1/2}{1+1/2} + 2.6 = \frac{1}{3}2.67$ =3.0 Ω

Putting in (1)

9. $5 = \frac{E}{3}$ or E=13.5 volt

10. $V_F = V_E - 5 = 6 - 5 = 1V$

11. $\frac{10-V}{2} = \frac{V}{2} + \frac{V}{6}$ 

$V = \frac{30}{7}$

$i = \frac{5}{7}$

12. Velocity component along x direction after time t is

$v_x = \sqrt{4v_0^2 - v_0^2}$

$$v_x = \frac{qE}{m}t$$

13.

Ans : A

The centripetal force is provided by the magnetic forces

$$\frac{mv^2}{r} = qvB \Rightarrow \frac{mv}{r} = qB$$

$$\Rightarrow r = \frac{mv}{qB} = \frac{p}{qB}[\therefore p = mv]$$

But $KE = \frac{p^2}{2m} \Rightarrow p = \sqrt{2mKE}$

Here, KE and B are same for the three particles

$$\therefore \ r \alpha \frac{\sqrt{m}}{q}$$

$$\therefore \qquad r_p : r_d : r_\alpha = \frac{\sqrt{1}}{1} : \frac{\sqrt{2}}{1} : \frac{\sqrt{4}}{2} = 1 : \sqrt{2} : 1$$

$$\Rightarrow \ r_\alpha = r_p < r_d$$

$\therefore$ (a) is the correct option

14. Key: D

Hint: Magnetic field induction due to component of wire which is parallel to x–axis,

$$\vec{B}_1 = \frac{\mu_0}{4\pi r}[\sin 90° + \sin 0°]\left(-\hat{k}\right) = \frac{\mu_0 I}{4\pi r}\left(-\hat{k}\right)$$

Magnetic field induction due to circular segments, $B_2 = 0$

Magnetic field induction due to the wire in yz plane,

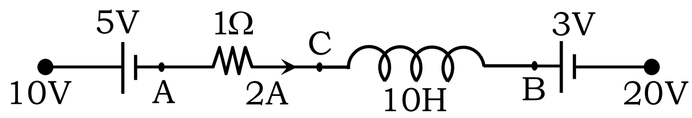
$$\vec{B}_3 = \frac{\mu_0 I}{4\pi\left(\frac{r}{\sqrt{2}}\right)}[\sin(-45°) + \sin 90°]\hat{i}$$

$\vec{B}_3 = \frac{\mu_0 I}{4\pi r}\left(\sqrt{2}-1\right)\hat{i}$ $\therefore$Net field induction at 0, $\vec{B} = \frac{\mu_0 I}{4\pi r}\left(\sqrt{2}-1\right)\hat{i} - \frac{\mu_0 I}{4\pi r}\hat{k}$.

15. $I = \frac{\varepsilon}{R} = \frac{1}{R}\left|\frac{d\phi}{dt}\right| = \frac{1}{R} Ba \times v$ and $IlB = mg \Rightarrow v = \frac{mgR}{B^2 a^2}$.

16. $\varnothing = BA = \frac{\mu_0 i \pi}{2b} a^2$

17. Ans: (B)



$V_A = 5V,\ V_C = 3V,\ V_B = 23V$

$\therefore L\left|\frac{di}{dt}\right| = V_B - V_C = 20v$ $\Rightarrow \left|\frac{di}{dt}\right| = 2\ A/s$

18.

The rate of increase of magnetic energy $\left(E = \frac{LI^2}{2}\right)$ is the difference between the power output of the battery and the power dissipated in the resistor.

$\frac{dE}{dt} = VI - RI^2 = -R\left(I - \frac{V}{2R}\right)^2 + \frac{V^2}{4R} \le \frac{V^2}{4R}$ $\therefore$ The rate of increase is maximum when $I = \frac{V}{2R}$

19.

$R = \frac{E - V}{I} = \frac{120 - 115}{25} = 0.2\Omega$

20. Path difference $\Delta = d \sin\theta = \frac{\lambda}{4}\sin\theta$

Phase difference $\phi = \frac{2\pi}{\lambda}\Delta = \frac{2\pi}{\lambda} \times \frac{\lambda}{4}\sin\theta = \frac{\pi}{2}\sin\theta$

$I_\theta = I_1 + I_2 + 2\sqrt{I_1 I_2 \cos\phi} = I_0 + I_0 + 2\sqrt{I_0 . I_0}\ \cos\left(\frac{\pi}{2}\sin\theta\right)$

$$= 2I_0 + 2I_0 \cos\left(\frac{\pi}{2}\sin\theta\right) = 2I_0\left[1 + \cos\left(\frac{\pi}{2}\sin\theta\right)\right] = 2I_0 \times 2\cos^2\left(\frac{\pi}{4}\sin\theta\right) = 4I_\theta^2 \cos^2\left(\frac{\pi}{4}\sin\theta\right)$$

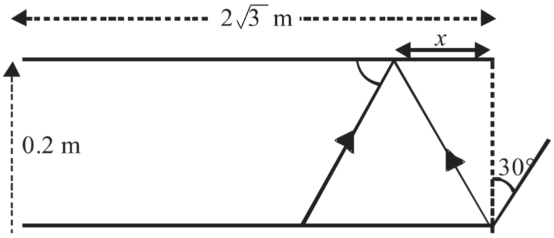
21. $\Delta y = \frac{\beta}{\lambda}(\mu - 1)t$

$\Rightarrow 30\beta = \frac{\beta}{\lambda}(\mu - 1)t$

$\Rightarrow t = \frac{30\lambda}{\mu - 1} = \frac{30 \times 4800 \times 10^{-10}}{(1.6 - 1)} = 24 \times 10^{-6}\,\text{m}.$

22. Let x be the distance of one reflection along the mirrors then

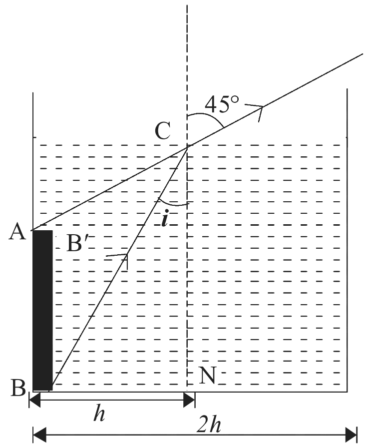
$\tan 30° = \frac{x}{0.2} \Rightarrow x = \frac{0.2}{\sqrt{3}}$



Number of reflections $= \frac{2\sqrt{3}}{(0.2/\sqrt{3})} = 30.$

23. The lower end B of rod will appear to observer O at B' due to refraction

$\frac{1}{\mu} = \frac{\sin i}{\sin r}$



Here $CN = 2h, BN = h$

$$\therefore \quad CB = \sqrt{h^2 + (2h)^2} = \sqrt{5}\, h$$

$$\therefore \sin i = \frac{h}{\sqrt{5}h} = \frac{1}{\sqrt{5}}, r = 45°$$

$$\therefore \frac{1}{\mu} = \frac{1/\sqrt{5}}{\sin 45°} = \sqrt{\frac{2}{5}} \Rightarrow \sqrt{\frac{5}{2}}$$

24. Key: A

Hint: $(KE)_{\max} = 10.4\,eV \qquad \therefore \Delta E = 12.1 eV$

$$\therefore 13.6\left(1 - \frac{1}{9}\right) = \frac{108.8}{9} \approx 12.1 eV$$

25.

$$\text{Intensity} = \frac{\text{no of photns incident}}{\text{second} \times \text{Area}}$$

$$\text{current } \alpha \frac{\text{no ; of photons incident}}{\text{seconds}}$$

26. $|E| \propto Z^2$

So targets of higher atomic numbers have higher energy differences

27. Longest wavelength implies lesser energy

Balmer series $n \to 2$

Lyman series $n \to 1$

28. Ans. (d)

$$B_n = \frac{\mu_0 I_n}{2r_n}$$

or $B_n \infty \frac{I_n}{r_n}$

$\infty \frac{(f_n)}{r_n}$

$\therefore$ $B_n \infty \frac{(v_n / r_n)}{r_n}$

$\infty \frac{v_n}{(r_n)^2}$

$\infty \frac{(z/n)}{(n^2/z)^2}$

$\infty \frac{z^3}{n^5}$

$${}_1D^2 +_6 C^{12} \rightarrow_7 N^{13} +_a Y^b$$

29. $a = 6+1-7 = 0$

$b = 12+2-13 = 1$

30. Probability that either decrees

$$\lambda dt = \lambda_1 dt + \lambda_2 dt$$

$$\lambda = m^2 \left[\frac{1}{T_1} + \frac{1}{T_2}\right]$$