PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. Bohr's model is applicable for single electron atom of atomic number z. Dependency of frequency of rotation of electron in n^{th} principal quantum number is proportional to

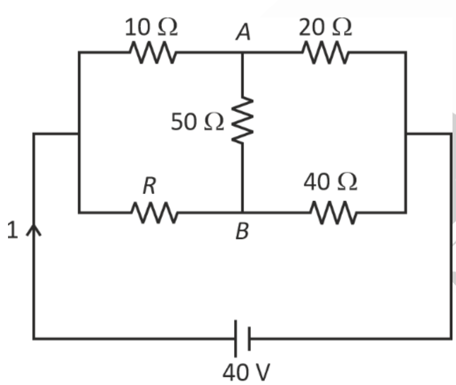
(1) $\frac{z}{n^2}$ (2) $\frac{z^2}{n^3}$

(3) $\frac{n^3}{z}$ (4) $\frac{z}{n}$

Answer (2)

Sol. $f = \frac{v}{2\pi r} \propto \frac{z}{n\left(\frac{n^2}{z}\right)} = \frac{z^2}{n^3}$

2. In the given circuit, find I if the potentials at A and B are equal



(1) $1A$

(2) $2A$

(3) $3A$

(4) $4A$

Answer (2)

Sol. Given potential at A and B are equal.

$\Rightarrow$ This is a wheat-stone Bridge

i.e., $\frac{R}{10\Omega} = \frac{40\Omega}{20\Omega}$

or $R = 20\Omega$

Equivalent resistance = 20Ω

$$I = \frac{40V}{20\Omega} = 2A$$

3. In an electromagnetic wave, the magnetic field is given as $\vec{B} = \left(\frac{\sqrt{3}}{2}\hat{i} + \frac{1}{2}\hat{j}\right)30\sin(\omega t - kz)$, the corresponding electric field is

(1) $\left(\frac{1}{2}\hat{i} + \frac{\sqrt{3}}{2}\hat{j}\right)9\times10^9\sin(\omega t - kz)$

(2) $\left(\frac{1}{2}\hat{i} - \frac{\sqrt{3}}{2}\hat{j}\right)9\times10^9\sin(\omega t - kz)$

(3) $\left(\frac{1}{2}\hat{i} + \frac{\sqrt{3}}{2}\hat{j}\right)9\times10^9\cos(\omega t - kz)$

(4) $\left(\frac{1}{2}\hat{i} - \frac{\sqrt{3}}{2}\hat{j}\right)9\times10^9\cos(\omega t - kz)$

Answer (2)

Sol. $E = BC$

$= 30 \times 3 \times 10^8 = 9 \times 10^9$ N/C

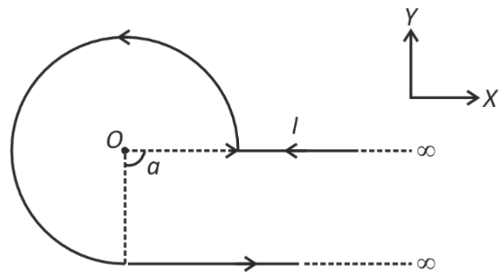
$\hat{E} = \hat{B} \times \hat{C}$

$= \left(\frac{\sqrt{3}}{2}\hat{i} + \frac{1}{2}\hat{j}\right) \times k$

$= \left(\frac{\sqrt{3}}{2}\hat{j} + \frac{1}{2}\hat{i}\right)$

$\vec{E} = \left(\frac{1}{2}\hat{i} - \frac{\sqrt{3}}{2}\hat{j}\right)9\times10^9\sin(\omega t - kz)$

4. The magnetic field $\vec{B}$ at the centre O of the given arrangement is



(1) $\dfrac{+\mu_0 I}{8\pi a}(3\pi+2)\hat{k}$

(2) $\dfrac{-\mu_0 I}{8\pi a}(3\pi+2)\hat{k}$

(3) $\dfrac{+\mu_0 I}{8\pi a}(3\pi-2)\hat{k}$

(4) $\dfrac{-\mu_0 I}{8\pi a}(3\pi-2)\hat{k}$

Answer (1)

Sol. $\vec{B}_{\text{net}} = \vec{B}_{\text{circle}} + \vec{B}_{\text{wire 1}} + \vec{B}_{\text{wire 2}}$

$$= \frac{3}{4}\left(\frac{\mu_0 I}{2a}\right)(+\hat{k}) + \vec{O} + \frac{\mu_0 I}{4\pi a}(+\hat{k})$$

$$= \frac{+\mu_0 I}{8\pi a}(3\pi+2)\hat{k}$$

5. A cube of side 10 cm having bulk modulus of 1.4×10^{11} Pa is placed in atmosphere. Now it is subjected to extra pressure of 7×10^6 Pa then magnitude of change in volume of cube is

(1) 0.03 mL

(2) 0.3 mL

(3) 0.05 mL

(4) 0.2 mL

Answer (3)

Sol. $B = \dfrac{\Delta P}{\Delta V / V}$

$$|\Delta V| = \frac{\Delta P V}{B}$$

$$|\Delta V| = \frac{7\times10^6\times10^{-3}}{1.4\times10^{11}}$$

$$|\Delta V|_{\text{mL}} = \frac{5\times10^3}{10^{11}}\times10^6$$

$$= 0.05 \text{ mL}$$

6. Choose the correct option representing the energy density between the plates of a parallel plate capacitor with plate area A, plate separation d and potential difference V.

(1) $\dfrac{\varepsilon_0 V^2}{2d^2}$

(2) $\dfrac{\varepsilon_0 V d^2}{2}$

(3) $\dfrac{\varepsilon_0 A V^2}{2d}$

(4) $\dfrac{\varepsilon_0 A V^2}{2d^2}$

Answer (1)

Sol. $E = \dfrac{V}{d}$

Energy density $= \dfrac{1}{2}\varepsilon_0 E^2$

$$= \frac{1}{2}\frac{\varepsilon_0 V^2}{d^2}$$

7. Which of the following phenomenon is not explained by wave theory of light

(1) Reflection of light

(2) Refraction of light

(3) Diffraction

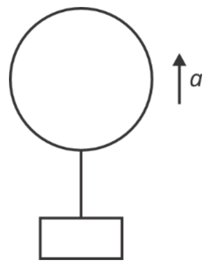
(4) Compton effect

Answer (4)

Sol. Compton effect is based on particle nature of light.

8. A balloon system having mass m is moving up with acceleration a, find the mass to be removed from it to have acceleration $3a$.

(Neglect the volume of mass attached)



(1) $\dfrac{2ma}{3a+g}$

(2) $\dfrac{2ma}{2a+g}$

(3) $\dfrac{ma}{3a+g}$

(4) $\dfrac{ma}{g-3a}$

Answer (1)

Sol. $F_B - mg = ma$ ...(i)

$F_B - (m-x)g = 3(m-x)a$ ...(ii)

On solving

$$x = \frac{2ma}{3a+g}$$

9. Mass M and radius R of a planet is related with mass M_e and Radius R_e of earth as $M_e = 8M_P$ and $R_e = 2R_P$. If escape speed for earth is 11.2 km/sec, then escape speed for the planet is

(1) $11.2\sqrt{2}$ km/sec

(2) 5.6 km/sec

(3) $5.6\sqrt{2}$ km/sec

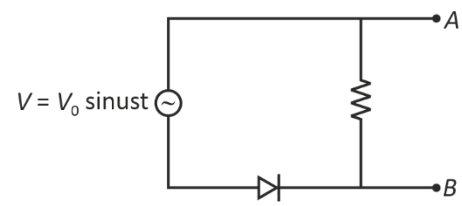
(4) 11.2 km/sec

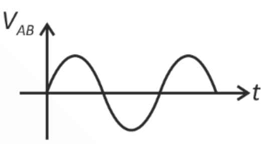
Answer (2)

Sol. $\dfrac{v'}{v_e} = \sqrt{\dfrac{\dfrac{GM}{R}}{\dfrac{G(8M)}{2R}}} = \dfrac{1}{2}$

$v' = \dfrac{v_e}{2} = \dfrac{11.2}{2} = 5.6$

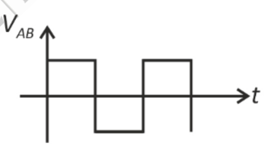
10. The correct variation of voltage across AB is given by (consider that the threshold voltage of the diode is very small)



(1)


(2)


(3)


(4)


Answer (2)

Sol. The diode will only conduct in negative half.

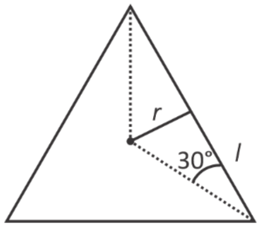
11. An equilateral triangle frame of side l is carrying current i, find magnetic field at its centroid

(1) $\dfrac{3\mu_0 i}{4\pi l}$ (2) $\dfrac{3\mu_0 i}{\pi l}$

(3) $\dfrac{9\mu_0 i}{2\pi l}$ (4) $\dfrac{\mu_0 i}{\pi l}$

Answer (3)

Sol.



$$B = 3\left(\frac{\mu_0 i}{4\pi l \tan 30^\circ}\right)2\cos 30^\circ$$

$$= \frac{3\mu_0 i}{2\pi l}\sqrt{3}\cdot\frac{\sqrt{3}}{2}$$

$$= \frac{9\mu_0 i}{2\pi l}$$

12. Select the correct match for dimensions

	Column-I		Column-II
(A)	Angular Momentum	(I)	$[MLT^{-2}]$
(B)	Force	(II)	$[ML^2T^{-1}]$
(C)	Energy	(III)	$[ML^{-1}T^{-2}]$
(D)	Pressure	(IV)	$[ML^2T^{-2}]$

(1) A-(II), B(III), C-(I), D-(IV)

(2) A-(I), B(II), C-(III), D-(IV)

(3) A-(II), B(I), C-(IV), D-(III)

(4) A-(II), B(I), C-(III), D-(IV)

Answer (3)

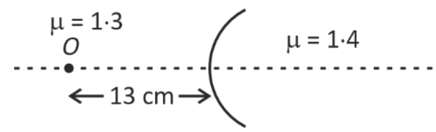
Sol. Angular momentum = $[ML^2T^{-1}]$

Force = $[MLT^{-2}]$

Energy = $[ML^2T^{-2}]$

Pressure = $[ML^{-1}T^{-2}]$

13. In the figure shown the object kept at a distance 13 cm from the interface forms a real image which is double in size. The radius of currature of the interface is



(1) $\frac{3}{2}$ cm

(2) $\frac{2}{3}$ cm

(3) $\frac{3}{4}$ cm

(4) $\frac{4}{3}$ cm

Answer (2)

Sol. Magnification $= m = \dfrac{\frac{v}{\mu_2}}{\frac{u}{\mu_1}}$

$$\Rightarrow m = -2 = \frac{\frac{v}{1\cdot 4}}{\frac{-13}{1\cdot 3}}$$

$\Rightarrow$ v = + 28 cm

Using formula for refraction at a curved surface

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

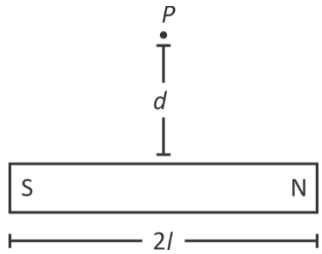
$$\frac{1\cdot 4}{+28\text{ cm}} - \frac{1\cdot 3}{-13\text{ cm}} = \frac{1\cdot 4 - 1\cdot 3}{R}$$

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

$$R = \frac{2}{3}\text{ cm}$$

14. Due to the bar magnet shown, if the % uncertainity in d is 1%, find uncertainity in the magnetic field at P.

[d : 10 units, l = 10 units]



(1) 2%

(2) 3%

(3) 1.5%

(4) 0.5%

Answer (3)

Sol. $B = \dfrac{2\mu_0 m}{4\pi r^2}\cos\theta$

$r = \sqrt{(10)^2 + d^2}$

$\cos\theta = \dfrac{10}{\sqrt{(10)^2 + (d)^2}}$

$B = 2\left(\dfrac{\mu_0}{4\pi}\right)\dfrac{10m}{(10^2 + d^2)^{3/2}}$

$\dfrac{dB}{dd} = \dfrac{3B}{2}\dfrac{2d}{(10^2 + d^2)}$

$\dfrac{dB}{B} = \left(\dfrac{3d^2}{10^2 + d^2}\right)\left(\dfrac{dd}{d}\right)$

= 1.5%

15. A capacitor of capacitance 1 μF is charged to potential of 20 V. Distance between plates is 10 μm, then charge density on plates is

(1) 17.7 nC/m^2 (2) 17.7 μC/m^2

(3) 8.85 nC/m^2 (4) 4.42 μC/m^2

Answer (2)

Sol. $Q = 20 \times 10^{-6}$ C

$\dfrac{\varepsilon_0 A}{d} = 10^{-6}$

$A = \dfrac{10^{-6} \times 10 \times 10^{-6}}{8.85 \times 10^{-12}} = \dfrac{10}{8.85}$

$\sigma = \dfrac{20 \times 10^{-6}}{10} \times 8.85$

$= 17.7 \times 10^{-6}$

$= 17.7\ \mu$C/m^2

16. A ring of radius 3 cm has a soap film which is getting evaporated. Light of wavelength λ = 580 nm gives minimum transmission every 12 s. Find the rate of evaporation. (refractive index = 1.45)

(1) 1.5 $\pi \times 10^{-13}$ m^3/s

(2) 15 $\pi \times 10^{-12}$ m^3/s

(3) 3 $\pi \times 10^{-13}$ m^3/s

(4) 3 $\pi \times 10^{-12}$ m^3/s

Answer (2)

Sol. $2\mu l = n\lambda$

$2\mu\Delta l = \Delta n\lambda$

$\left(\dfrac{\Delta l}{\Delta t}\right) = \dfrac{\Delta n}{\Delta t}\dfrac{\lambda}{2\mu}$

$= \dfrac{1}{12}\dfrac{580\,\text{nm}}{2 \times 1.45\,\text{s}} = \dfrac{50}{3}\,\text{nm/s}$

Rate of evaporation $= \pi R^2 \dfrac{\Delta l}{\Delta t}$

$= \pi\left(a \times 10^{-4}\right) \times \left(\dfrac{50}{3} \times 10^{-9}\right)^{\text{m}^3/\text{s}}$

$= 15\pi \times 10^{-12}\,\text{m}^3/\text{s}$

17.

18.

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

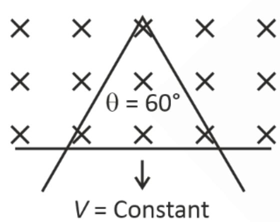
21. An electric dipole of moment 6×10^{-6} cm is placed parallely in electric field of strength 10^6 N/C. Work done required to rotate the dipole by 180° is X joules, then X is

Answer (12)

Sol. $\omega = \Delta U = -pE\cos180° - (-pE\cos0)$

$= 2pE = 2 \times 6 \times 10^{-6} \times 10^6$

22. The figure shows a conducting rod sliding on two conducting rails having angle (θ = 60°) in a uniform magnetic field with a constant velocity V. Find n if the motional emf E various with time as $E = ct^n$.



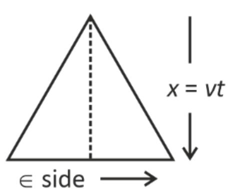
Answer (1)

Sol. Slide $= \dfrac{2}{\sqrt{3}}x$

$= \dfrac{2}{\sqrt{3}}vt$

$Emf = B\left(\dfrac{2}{\sqrt{3}}vt\right)v$

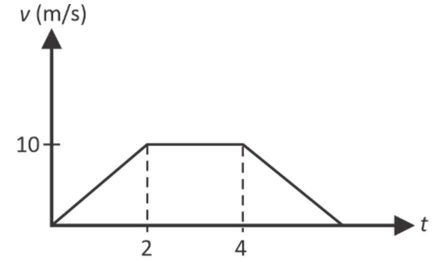
$= \dfrac{2Bv^2}{\sqrt{3}}t$



$E \propto t$

or $n = 1$

23. The velocity vs time graph of a particle moving along X-axis is plotted as shown. The distance travelled (in metre) by the particle in the interval t = 0 s to t = 4 s is



Answer (30)

Sol. Distance = displacement as direction of velocity does not change in the given interval.

$\Rightarrow$ Distance $= \dfrac{1}{2}(2\text{s} + 4\text{s}) \times 10$ m/s

[Area of trapezium with base 4s]

$= 30$m

24. Distance between real object and its three times magnified image formed by concave mirror is 20 cm then radius of curvature of the mirror is X cm, then X is

Answer (15)

Sol. $\left|\dfrac{v}{u}\right| = 3$

$|v| = 3|u|$

$|u| = X$

$|v| = 3X$

$3X - X = 20$

$X = 10$ cm

$\dfrac{1}{-30} - \dfrac{1}{10} = \dfrac{1}{f}$

$-\dfrac{4}{30} = \dfrac{1}{f}$

$R = \dfrac{2 \times 30}{4} = 15$ cm

25.