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. Find the dimensions of $\frac{B}{\mu_0}$

(1) [AL] (2) $[AL^{-1}]$

(3) [MAL] (4) $[MALT^{-1}]$

Answer (2)

Sol. $\oint B \cdot dl = \mu_0 i \Rightarrow \frac{B}{\mu_0} = \frac{i}{l} \equiv [AL^{-1}]$

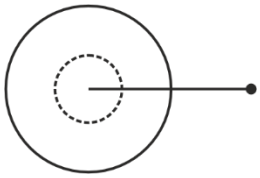
2. Solid sphere of mass M, radius R exerts force F on a point mass. Now a concentric spherical mass $\frac{M}{7}$ is removed. What is new force?

(1) $\frac{F}{7}$ (2) $\frac{6}{7}F$

(3) $\frac{5F}{7}$ (4) $\frac{3F}{7}$

Answer (2)

Sol.

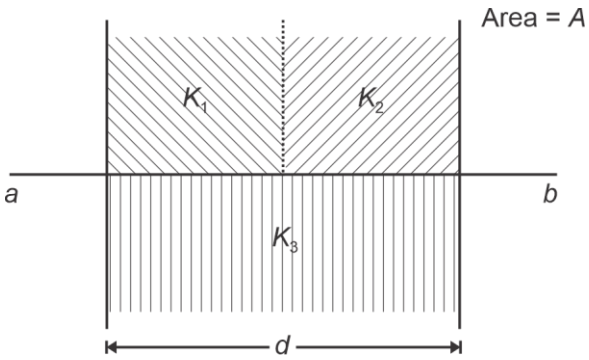


$$F = \frac{GMm}{r^2}$$

$$F' = \frac{G\left(M - \frac{M}{7}\right)m}{r^2}$$

$$\Rightarrow \quad F' = \frac{6}{7}F$$

3. Find out equivalent capacitance for the situation show in figure.



(1) $C_{eq} = \frac{A\varepsilon_0}{d}\left(\frac{K_1K_2 + K_2K_3 + K_3K_1}{K_1 + K_2}\right)$

(2) $C_{eq} = \frac{A\varepsilon_0}{d}\left(\frac{2K_1K_2 + K_2K_3 + K_3K_1}{2(K_1 + K_2)}\right)$

(3) $C_{eq} = \frac{A\varepsilon_0}{d}\left(\frac{K_1K_2 + K_2K_3 + K_3K_1}{2(K_1 + K_2)}\right)$

(4) $C_{eq} = \frac{A\varepsilon_0}{2d}\left(\frac{K_1K_2 + K_2K_3 + K_3K_1}{(K_1 + K_2)}\right)$

Answer (2)

Sol. Here,

$$C_1 = \frac{2 \times A\varepsilon_0K_1}{2d} = \frac{A\varepsilon_0K_1}{d}$$

$$C_2 = \frac{A\varepsilon_0K_2}{d}$$

$$C_3 = \frac{A\varepsilon_0K_3}{2d}$$

Now C_1 and C_2 are in series

So, $\frac{1}{C_1'} = \frac{1}{C_1} + \frac{1}{C_2}$

$$\Rightarrow \frac{1}{C_1'} = \frac{d}{A\varepsilon_0K}\left[\frac{1}{K_1} + \frac{1}{K_2}\right] = \frac{d(K_1 + K_2)}{A\varepsilon_0K_1K_2}$$

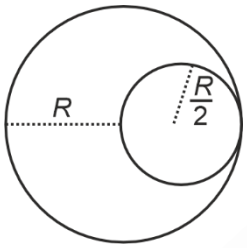
$$\Rightarrow C_1' = \frac{A\varepsilon_0 K_1 K_2}{d(K_1 + K_2)}$$

Now C_1' is parallel to C_3

$$\Rightarrow C_{eq} = \frac{A\varepsilon_0}{d}\left[\frac{K_1 K_2}{K_1 + K_2} + \frac{K_3}{2}\right]$$

$$\Rightarrow C_{eq} = \frac{A\varepsilon_0}{d}\left[\frac{2K_1K_2 + K_2K_3 + K_3K_1}{2(K_1 + K_2)}\right]$$

4. From a sphere of mass M and radius R, a cavity of radius $\frac{R}{2}$ is created. Find the moment of inertia about an axis passing through the centre of sphere and cavity.



(1) $\frac{31}{48} MR^2$

(2) $\frac{31}{80} MR^2$

(3) $\frac{13}{32} MR^2$

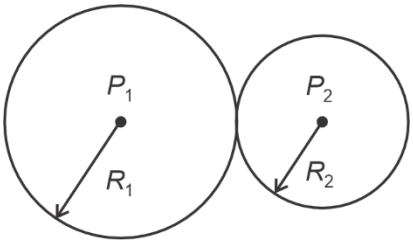
(4) $\frac{21}{32} MR^2$

Answer (2)

Sol. $I = \frac{2}{5} MR^2 - \frac{2}{5}\left(\frac{M}{8}\right)\left(\frac{R}{2}\right)^2$

$= \frac{31}{80} MR^2$

5. Find the radius of curvature of the common surface of two bubbles ($R_1 > R_2$)



(1) $R = \frac{R_1 R_2}{R_1 + R_2}$

(2) $R = \frac{2R_1 R_2}{R_1 - R_2}$

(3) $R = \frac{R_1 R_2}{R_1 - R_2}$

(4) $R = \frac{R_1 R_2}{(R_1 - R_2)}$

Answer (3)

Sol. $P_1 - P_0 = \frac{4S}{R_1}; P_2 - P_0 = \frac{4S}{R_2}$

So, $P_2 - P_1 = \Delta P = \frac{4S}{R} = 4S\left[\frac{1}{R_2} - \frac{1}{R_1}\right]$

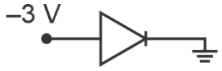
or $\frac{1}{R} = \frac{R_1 - R_2}{R_1 R_2}$

6. From the given option, identify the diode connected in forward bias.

(1) 

(2) 

(3) 

(4) 

Answer (1)

Sol. Only in option (1), the p-side is connected at higher potential than the n-side of the diode.

7. Radius of electron in ground state for hydrogen is a_0, then radius of electron in He^+ ion in 3rd excited state is a. Then $\frac{a_0}{a}$ is

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

(2) $\frac{1}{4}$

(3) $\frac{1}{16}$

(4) $\frac{1}{8}$

Answer (4)

Sol. $\boxed{r = \frac{n^2}{z} r_0} \Rightarrow$ for H

$a_0 = \frac{1}{1} r_0$

$a = \frac{4^2}{2} r_0$

$\frac{a_0}{a} = \frac{1}{8}$

8. Ice at –10°C is to be converted into steam at 110°C. Mass of ice is 10^{-3} kg. What amount of heat is required?

(1) ΔQ = 730 cal (2) ΔQ = 900 cal

(3) ΔQ = 1210 cal (4) ΔQ = 870 cal

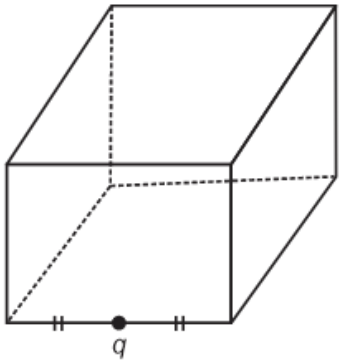
Answer (1)

Sol. –10°C ice to 0°C ice → 0°C ice to 0°C water + 0°C water to 100°C water + 100°C water to 100°C steam + 110°C steam.

$\Rightarrow \quad \Delta Q = \left(1 \times \frac{1}{2} \times 10\right) + (1 \times 80) + (1 \times 1 \times 100)$

$+(1 \times 540) + \left(1 \times \frac{1}{2} \times 10\right) = 730 \text{ cal}$

9. A charge of value q is placed at the edge of a imaginary cube of side a as shown in figure. Find the net flux through the cube



(1) $\frac{q}{6\varepsilon_0}$ (2) $\frac{q}{4\varepsilon_0}$

(3) $\frac{q}{8\varepsilon_0}$ (4) $\frac{q}{2\varepsilon_0}$

Answer (2)

Sol. ϕ_4 such cubes $= \frac{q}{\varepsilon_0}$

ϕ_1 cube $= \frac{q}{4\varepsilon_0}$

10. A closed organ pipe in 9th harmonic resonates with 4th harmonic of open organ pipe [l_{closed} = 10 cm]. Find length of open organ pipe.

(1) $L_0 = 15$ cm

(2) $L_0 = \frac{100}{9}$ cm

(3) $L_0 = \frac{110}{7}$ cm

(4) $L_0 = \frac{80}{9}$ cm

Answer (4)

Sol. $\frac{9v}{4L_c} = \frac{4v}{2L_0} \Rightarrow L_0 = \frac{8L_c}{9}$

11. A capacitor is charged by battery to charge Q_1. Now the battery is disconnected and dielectric slab of dielectric constant K is inserted between the gaps of the plates. Now charge on capacitor is Q_2. Find $\frac{Q_1}{Q_2}$.

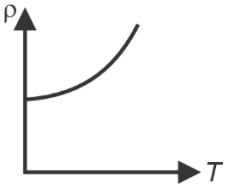
(1) 1 (2) $\frac{1}{2}$

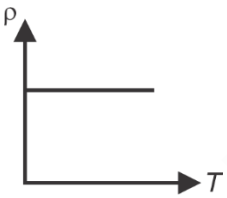
(3) 2 (4) $\frac{2}{3}$

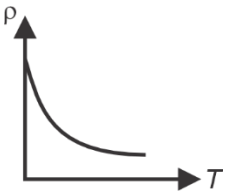
Answer (1)

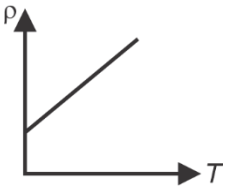
Sol. $\frac{Q_1}{Q_2} = 1$ (No further charge is supplied)

12. Which of the following graphs correctly represents the variation of resistivity (ρ) with temperature (T).

(1) 

(2) 

(3) 

(4) 

Answer (1)

Sol. The resistivity of conductors increases with increase in temperature non-linearly.

13. If whole YDSE apparatus is immersed in a liquid of refractive index μ, then what is the effect on fringe width?

(1) Fringe width increases

(2) Fringe width decreases

(3) Fringe width remains unchanged

(4) It may increase on one side and decrease on other side

Answer (2)

Sol. $\Delta\omega = \frac{\lambda D}{\lambda}$

So, for RI of μ

$\Delta\omega' = \frac{\lambda D}{\mu d}$

14. Two spherical black bodies of radius 0.8 m and 0.2 m are at temperatures of 400 K and 800 K respectively. Find ratio of rate of heat loss.

(1) 8

(2) 4

(3) 2

(4) 1

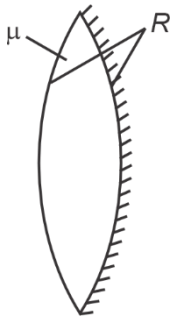
Answer (4)

Sol. $P_1 = \sigma 4\pi (0.8)^2 (400)^4$

$P_2 = \sigma 4\pi (0.2)^2 (800)^4$

$\frac{P_1}{P_2} = \frac{4 \times 4}{2^4} = 1$

15. The equiconvex lens shown in figure is silvered on one side. For what distance of object from the lens is the image formed on the object itself?



(1) μR (2) $\frac{R}{\mu}$

(3) $\frac{R}{2\mu-1}$ (4) $\frac{R}{2\mu-2}$

Answer (3)

Sol. Silvering of lens

$$\frac{1}{F_{eq}}=\frac{1}{f_m}-\frac{2}{f_\ell} \qquad \frac{1}{f_\ell}=(\mu-1)\left(\frac{1}{R}-\left(\frac{1}{-R}\right)\right)$$

$$=\frac{-2}{R}-\frac{4(\mu-1)}{R} \qquad \frac{1}{f_\ell}=\frac{2(\mu-1)}{R}$$

$$=\frac{-2(1+2\mu-2)}{R}$$

$$F=\frac{-R}{2(2\mu-1)}$$

For object-image to coincide distance should be $2f$

$|u| = 2|F|$

$$=\frac{R}{2\mu-1}$$

16. Light of wavelength 550 nm is incident an surfaces of cerium and lithium. Work function are respectively 1.9 eV and 2.5 eV. Then electron will be ejected from

(1) Cerium only (2) Lithium only

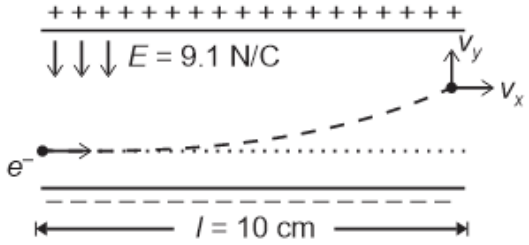
(3) From both of them (4) None of them

Answer (1)

Sol. $\mathrm{E(eV)}=\frac{1240}{\lambda(\mathrm{nm})}=\frac{1240}{550}\simeq 2.25$

2.25 > 1.9 for cerium only

17. The figure shows an electron entering the space between the plates of a parallel plate capacitor with an initial velocity, $v_x = 10^6$ m/s parallel to the plates. If the length of plates is $l = 10$ cm and the electric field in the region $E = 9.1$ N/C, then the value of v_y when the electron comes out of the plates is (Electronic mass = 9.1×10^{-31} kg)



(1) 1.6×10^4 m/s (2) 1.6×10^5 m/s

(3) 1.6×10^7 m/s (4) 1.6×10^3 m/s

Answer (2)

Sol. Time inside the electric field, $t = \frac{l}{v_x}$

Acceleration of electron along y-axis, $a = \frac{eE}{m}$

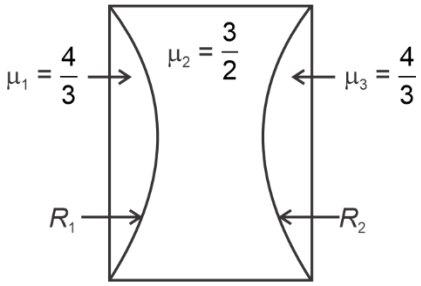
Velocity $v_y = at$

$$=\frac{eE}{m}\cdot\frac{l}{v_x}$$

$$=\frac{1.6\times10^{-19}\times9.1\times10\times10^{-2}}{9.1\times10^{-31}\times10^{6}}\ \text{m/s}$$

$= 1.6 \times 10^5$ m/s

18. Find the equivalent power of the thin lens combination shown in the figure.



(1) $+\left(\frac{R_1+R_2}{R_1+R_2}\right)$ (2) $-\left(\frac{R_1+R_2}{R_1R_2}\right)$

(3) $-\left(\frac{R_1+R_2}{6R_1R_2}\right)$ (4) $+\left(\frac{R_1+R_2}{6R_1R_2}\right)$

Answer (3)

Sol. Net power = $P_1 + P_2 + P_3$

$$= \frac{(\mu_1 - 1)}{R_1} + (\mu_2 - 1)\left(\frac{1}{-R_1} + \frac{1}{-R_2}\right) + \frac{(\mu_3 - 1)}{R_2}$$

$$= \frac{(\mu_1 - \mu_2)}{R_1} + \frac{(\mu_3 - \mu_2)}{R_2}$$

$$= \left(\frac{4}{3} - \frac{3}{2}\right)\frac{1}{R_1} + \left(\frac{4}{3} - \frac{3}{2}\right)\frac{1}{R_2}$$

$$= -\frac{1}{6}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$= -\left(\frac{R_1 + R_2}{6R_1R_2}\right)$$

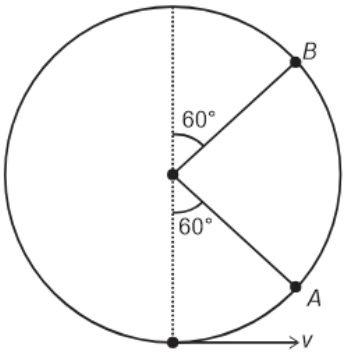
19.

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. The particle shown in figure is just able to complete the vertical circular motion. Find the ratio of kinetic energy at *A* to the kinetic energy at *B*.



Answer (2)

Sol. $v = \sqrt{5gR}$

$$KE_A = \frac{1}{2}mv^2 - mg\frac{R}{2}$$

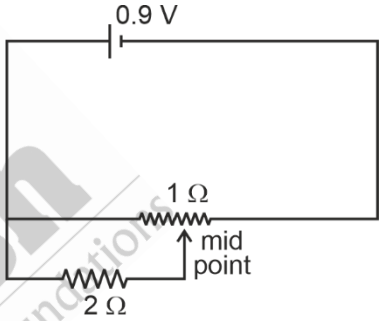
$$KE_A = 2mgR$$

$$KE_B = \frac{1}{2}mv^2 - mg\left(\frac{3R}{2}\right)$$

$$= mgR$$

$$\frac{KE_A}{KE_B} = 2$$

22. The current drawn from battery in the circuit shown below is _____ *A*



Answer (1)

Sol. $\frac{1}{R_1'} = \frac{1}{2} + 2 = \frac{5}{2}$

$$\Rightarrow \quad R_1' = \frac{2}{5}\Omega$$

Now, $R = \frac{2}{5} + \frac{1}{2} = \frac{9}{10}\Omega$

So, $I = \frac{9 \times 10}{10 \times 9} = 1\text{A}$

23.

24.

25.