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. The ratio of radius of gyration of uniform hollow sphere and uniform solid sphere about its diameter is _____. (Both having same radius)

(1) $\sqrt{\frac{4}{3}}$ (2) $\sqrt{\frac{5}{3}}$

(3) $\sqrt{\frac{3}{2}}$ (4) $\sqrt{\frac{3}{5}}$

Answer (2)

Sol. For hollow sphere, $I_1 = \frac{2}{3}mR^2 = mk_1^2, k_1 = \sqrt{\frac{2}{3}}R$

For solid sphere, $I_2 = \frac{2}{5}mR^2 = mk_1^2, k_2 = \sqrt{\frac{2}{5}}R$

$\frac{k_1}{k_2} = \sqrt{\frac{2}{3}\times\frac{5}{2}} = \sqrt{\frac{5}{3}}$,

2. In closed rigid chamber, collision frequency of molecules of ideal gas at 27°C is ν. The collision frequency of gas at temperature 127°C becomes

(1) $\frac{\sqrt{3}}{2}\nu$

(2) $\sqrt{\frac{127}{27}}\nu$

(3) $\frac{2}{\sqrt{3}}\nu$

(4) $\frac{27}{127}\nu$

Answer (3)

Sol. $\tau = \frac{\lambda}{v_{th}} = \frac{1\,V}{\sqrt{2}\pi d^2 N\, v_{th}}$

$\nu \propto \frac{v_{th}}{V}$

$\nu \propto \frac{\sqrt{T}}{V}$

$\Rightarrow \frac{\nu_1}{\nu_2} = \frac{\sqrt{300}}{\sqrt{400}}$ (at constant volume)

$\nu_l = \frac{2}{\sqrt{3}}\nu$

3. If the time period of a pendulum at height R (where R is radius of earth) from surface of earth is T_1 and at height $2R$ it is T_2, then

(1) $3T_1 = 2T_2$

(2) $2T_1 = 3T_2$

(3) $T_1 = 3T_2$

(4) $3T_1 = 4T_2$

Answer (1)

Sol. $T = 2\pi\sqrt{\frac{l}{g}}$

at R, $g' = \frac{GM}{(2R)^2} = \frac{g}{4}$

$2R$, $g' = \frac{GM}{(3R)^2} = \frac{g}{9}$

$\therefore \quad T_1 = 2\left(2\pi\sqrt{\frac{l}{g}}\right)$

$T_2 = 3\left(2\pi\sqrt{\frac{l}{g}}\right)$

$3T_1 = 2T_2$

4. A point source of light is placed at focus of convex lens, then what is the shape of wavefront after passing through the lens?

(1) Planar

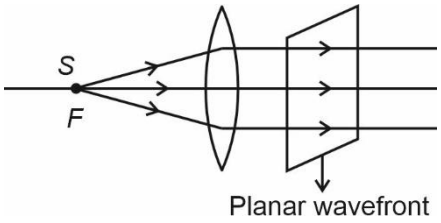
(2) Cylindrical

(3) Spherical

(4) Elliptical

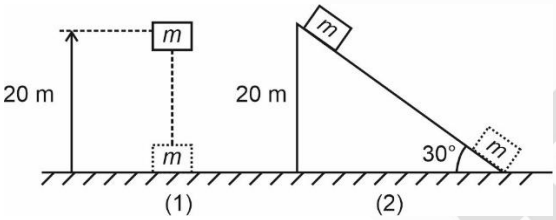
Answer (1)

Sol.



$\therefore$ As the source is at focus, rays get parallel after passing through the lens, hence planar wavefront.

5. A block of mass m = 50 kg is lifted from ground to a height 20 m in two different ways as shown in figure (1) and (2). The ratio of work done in these two will be



(1) 1 : 1

(2) 1 : 2

(3) 2 : 1

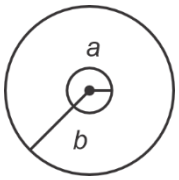
(4) 1 : 5

Answer (1)

Sol. For I $\rightarrow$ $W_1 = mgh$

For II $\rightarrow$ $W_2 = mgh$

6. Two concentric conducting coplanar rings of radius a and b are placed as shown in diagram ($a << b$). Find coefficient of mutual inductance of rings.



(1) $\frac{\mu_0 \pi b^2}{a}$

(2) $\frac{\mu_0 \pi a^2}{2b}$

(3) $\frac{\mu_0 a^2}{2b}$

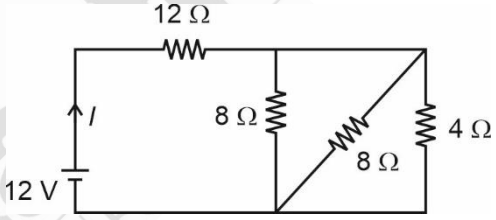
(4) $\frac{\mu_0 a^3}{2\pi b^2}$

Answer (2)

Sol. $\phi_{ab} = \frac{\mu_0 i}{2b} \times \pi a^2$

$M = \frac{\mu_0 \pi a^2}{2b}$

7. Find current I in the given circuit



(1) $\frac{12}{13}$ A

(2) $\frac{6}{7}$ A

(3) $\frac{5}{6}$ A

(4) $\frac{7}{8}$ A

Answer (2)

Sol. $R_{eq.} = 12 + 2 = 14\ \Omega$

$I = \frac{12}{14} = \frac{6}{7}$ A

8. Find dimension of $\sqrt{G.\mu}$, where G is universal gravitational constant and μ is energy gradient.

(1) $[LT^{-2}]$ (2) $[L^2T^{-2}]$

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

Answer (2)

Sol. Dimension of $\sqrt{G.\mu} = \sqrt{M^1L^3T^{-2}\frac{M^1L^2T^{-2}}{L^1}}$

$= \sqrt{M^0L^4T^{-4}}$

$= [L^2T^{-2}]$

9. The correct relation between kinetic energy ($K.E$) and total energy ($T.E$) of a satellite orbiting around the planet is

(1) $K.E = |T.E|$ (2) $K.E = 2|T.E|$

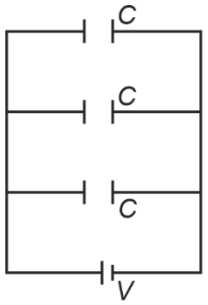
(3) $K.E = \frac{|T.E|}{2}$ (4) $|T.E| = 3K.E$

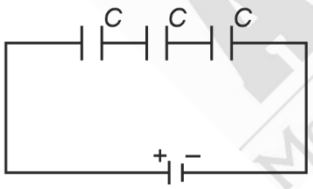
Answer (1)

Sol. $T.E = -\frac{Gmm}{2R}$

$K.E = \frac{Gmm}{2R}$

10. Given two circuits. Find the ratio of energy stored in capacitor system. $E_1 : E_2$





(1) 2 : 1 (2) 4 : 1

(3) 9 : 1 (4) 1 : 1

Answer (3)

Sol. $E_1 : C_{eq} = 3C$

$E_1 = \frac{1}{2} \times 3C \times V^2 = \frac{3}{2}CV^2$

$E_2 : C_{eq} = \frac{C}{3}$

$E_2 = \frac{1}{2} \times \left(\frac{C}{3}\right) \times V^2 = \frac{CV^2}{6}$

$E_1 : E_2 = 9 : 1$

11. Match the column :

[Given : Mass of sun = M_s

Mass of earch = M_e

Radius of earth = R

Distance between sun and earth = a]

(a)	Kinetic energy of earth	(i)	$-\frac{GM_sM_e}{a}$
(b)	Potential energy of earth and sun	(ii)	$\frac{GM_sM_e}{2a}$
(c)	Total energy of earth and sun	(iii)	$\frac{GM_e}{R}$
(d)	Escape energy from surface of earth per unit mass	(iv)	$-\frac{GM_sM_e}{2a}$

(1) (a)-(iii), (b)-(i), (c)-(ii), (d)-(iv)

(2) (a)-(i), (b)-(ii), (c)-(iv), (d)-(iii)

(3) (a)-(ii), (b)-(i), (c)-(iv), (d)-(iii)

(4) (a)-(ii), (b)-(i), (c)-(iii), (d)-(iv)

Answer (3)

Sol. $U = -\frac{GM_sM_e}{a}$

$K : U : E = 1 : -2 : -1$

Escape energy from earth surface per unit mass = $\frac{GM_e}{R}$

12. Three helium atoms form carbon at high temperature due to fusion. Masses of helium and carbon nuclei in a.m.u. are 4.0002 and 12 respectively. Find energy released in the process.

(1) 0.18 MeV (2) 0.56 MeV

(3) 0.10 MeV (4) 4.3 KeV

Answer (2)

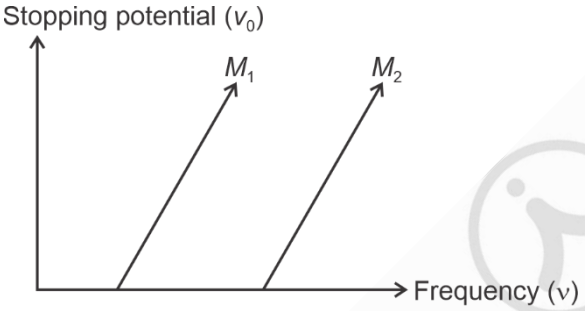
Sol. $3He \rightarrow C$

$\Delta m = 0.0006$

$\Delta E = 0.0006 \times 931$

$= 0.56$ MeV

13. For the graph ($v_0 - \nu$) for photoelectric effect given below for two metal, M_1 and M_2



Statement-I : For the incident light of same frequency, kinetic energy of ejected electron from metal M_1 will be more than that of metal M_2.

Statement-II : Slope of the graph is equal to $\frac{h}{e}$, where h is planck's constant and e is electronic charge.

(1) Both statements are correct

(2) Statement-I is correct while statement-II is incorrect

(3) Statement-II is correct while statement-I is incorrect

(4) Both are incorrect

Answer (1)

Sol. $h\nu = ev_0 + \phi$

$ev_0 = h\nu - \phi$

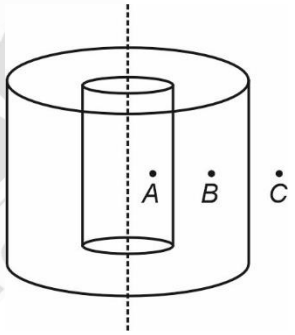
$$v_0 = \frac{-\phi}{e} + \frac{h}{e}\nu$$

Slope of curve $= \frac{h}{e}$

$K.E = E - \phi$

$(K \cdot E)_1 > (K \cdot E)_2$ for same light.

14. Figure shows two long co-axial cylindrical cables, carrying same current along their wall in opposite directions. The magnetic field will be zero at



(1) None of the points

(2) A and B

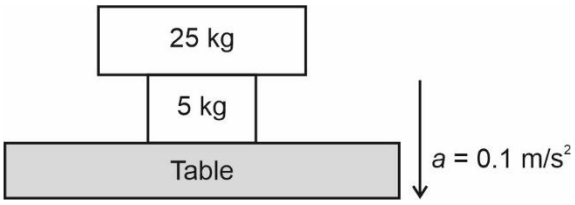
(3) A and C

(4) B and C

Answer (3)

Sol. By applying ampere's-circuital law magnetic field is zero at A and C.

15. Find the normal force between the table and 5 kg block as shown in the diagram (take g = 10 m/s^2)

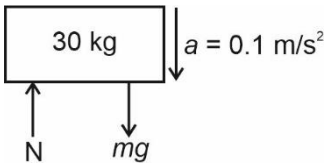


(1) 306 N (2) 303 N

(3) 296 N (4) 297 N

Answer (4)

Sol.



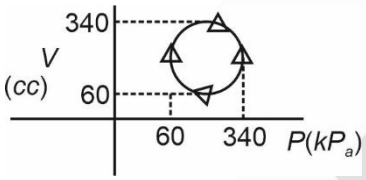
$mg - N = ma$

$N = m(g - a)$

$= 30 \times 9.9$

$= 297$ N

16. Find net heat exchanged in the given cyclic process,



(1) 81.5 J

(2) 61.5 J

(3) 100.2 J

(4) 40.2 J

Answer (2)

Sol. In cyclic process $\Delta Q = \Delta W$ as $\Delta U = 0$

$$\Rightarrow \pi \times \frac{280}{2} \times \frac{280}{2} \times 10^{-6} \times 10^{3}$$

17. Find kinetic energy of O_2 at temperature 300 K?

(1) 10.35×10^{-21} J/molecule

(2) 9.35×10^{-22} J/molecule

(3) 20.70×10^{-21} J/molecule

(4) 10.70×10^{-21} J/molecule

Answer (1)

Sol. Total KE of O_2 molecule = Translational KE + Rotational KE

$$= \frac{3}{2}KT + \frac{2}{2}KT$$

$$= \frac{5}{2}KT$$

$$= \frac{5}{2} \times 1.38 \times 10^{-23} \times 300$$

$= 10.35 \times 10^{-21}$ J/molecule

18. The speed of electron in the first orbit of hydrogen atom is

(1) 1.2×10^5 m/s

(2) 2.2×10^5 m/s

(3) 2.8×10^6 m/s

(4) 2.2×10^6 m/s

Answer (4)

Sol. For n^{th} orbit,

$$V_n = \frac{2.186 \times 10^6}{n} \text{ m/s}$$

$$\approx 2.2 \times 10^6 \text{ m/s for } n = 1$$

19. An electron and a proton are placed at a certain distance apart. Then the ratio of coulombic force and gravitational force between them is of order

(1) 10^{32}

(2) 10^{39}

(3) 10^{36}

(4) 10^{42}

Answer (2)

Sol. $\frac{F_c}{F_g} = \frac{k q_1 q_2}{G m_1 m_2}$

$= \frac{9\times10^9 \times (1.6)^2 \times 10^{-38}}{6.67\times10^{-11}\times9.1\times10^{-31}\times1.67\times10^{-27}}$

$= 2.27\times10^{39}$

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. In *YDSE*; for wavelength λ = 5000 Å, slit distance d = 3 mm and screen distance of 2 m. The intensity at a point which is 3 cm away from central maxima (Assume intensity of light for each source is I_0) is xI_0 then x is _____.

Answer (4)

Sol. $\Delta x = \frac{dy}{D} = \frac{3\times10^{-3}\times3\times10^{-2}}{2}$

$\Delta d = \frac{2\pi}{5000\times10^{-10}} \times \frac{9\times10^{-5}}{2}$

$= \frac{2\pi}{10^{-6}} \times 9\times10^{-5}$

$\Delta d = 180\pi$

$\Rightarrow$ maxima

$\therefore$ Intensity = $4I_0$

$x = 4$

22. What is angle (in degrees) between resultant of $2\vec{q} - 2\vec{p}$ and $2\vec{q} + 2\vec{p}$ with $\vec{q}$?

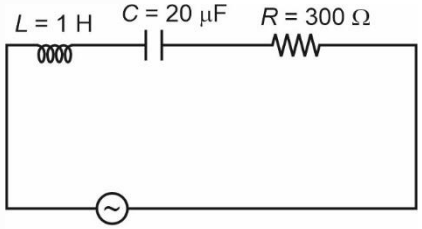
Answer (0)

Sol. $\vec{r} = (2\vec{q} - 2\vec{p}) + (2\vec{q} + 2\vec{p})$

$\vec{r} = 2\times2\vec{q} = 4\vec{q}$

Angle of $\vec{r}$ with $\vec{q}$ = angle between $4\vec{q}$ and $\vec{q}$ = 0°

23. In a LCR series AC circuit as given, the voltage across the capacitor is $25\sqrt{x}$ volts then x is



$V = 50\sqrt{2}\sin(100t)$

Answer (8)

Sol. $Z = \sqrt{\left(L\omega - \frac{1}{\omega C}\right)^2 + R^2}$

$= \sqrt{\left(100 - \frac{1}{100\times20\times10^{-6}}\right)^2 + 300^2}$

$= \sqrt{(400)^2 + 300^2}$

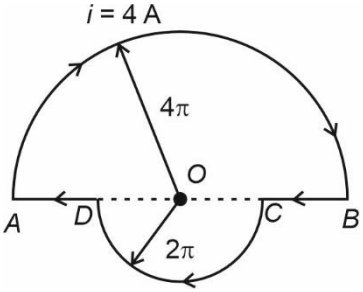
$Z = 500\ \Omega$

$i = \frac{50\sqrt{2}}{500}$ A

$\chi_C = \frac{1}{100\times20\times10^{-6}} = \frac{1000}{2} = 500\ \Omega$

$V_C = 50\sqrt{2} = 25\sqrt{8}$

24. The magnetic field at centre O is $k \times 10^{-7}$ T. Radius given. Find k.



Answer (3)

Sol. B due to section BC and DA of wire = 0

$$B_{net} = B_{AB} + B_{CD}$$

$$B_{net} = \frac{\mu_0 i\pi}{4\pi \cdot 4\pi} + \frac{\mu_0 i\pi}{4\pi \cdot 2\pi} = \frac{\mu_0 i}{\pi}\left(\frac{1}{16} + \frac{1}{8}\right)$$

$$B_{net} = \frac{3\mu_0 i}{\pi \times 16} = \frac{\mu_0}{4\pi} \times \frac{3i}{4} = 10^{-7} \times \frac{3 \times 4}{4}$$

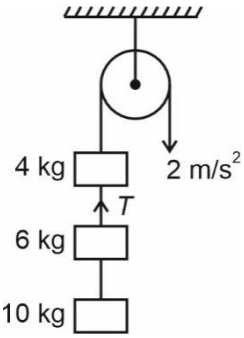
$$\boxed{B_{net} = 3 \times 10^{-7}\ \text{T} \otimes}$$

25. A particle is moving in straight line with constant acceleration with initial velocity of zero. The ratio of distance travelled by particle in $(n-1)^{th}$ second to that in n^{th} second, where $n = 10$ is $\frac{A}{B}$ then $(A + B)$ is _____. (A and B are co-prime number)

Answer (36)

Sol. $S_n = u + \frac{a}{2}(2n-1) \Rightarrow \frac{S_9}{S_{10}} = \frac{17}{19}$

26. Find the tension (T) in the given string (in N).



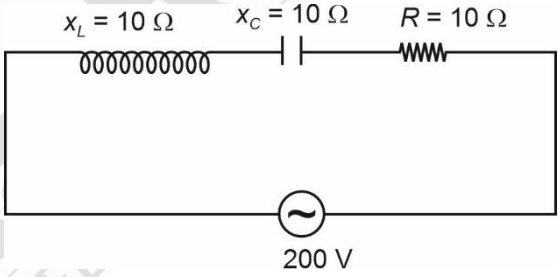
Answer (192)

Sol. $T = (6 + 10)(g + a)$

$= 16 \times 12$

$= 192\ N$

27. An alternating voltage applied to a series LRC circuit as shown in figure.



The current the circuit is _____ Ampere

Answer (20)

Sol. $z = \sqrt{R^2 + (x_C - x_L)^2} = R$

$$i = \frac{200}{z} = 20 \text{ Ampere}$$

28.

29.

30.