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 molar specific heat capacity at constant pressure (C_P) to that at constant volume (C_V) varies with temperature (T) as : [Assume temperature to be low]

(1) T^0 (2) $T^{1/2}$

(3) T^1 (4) $T^{3/2}$

Answer (1)

Sol. $\frac{C_P}{C_V} = \frac{f+2}{f} = \nu = 1 + \frac{2}{f} = \text{constant}$

We take 'f' to be constant for molecule at low temperature.

$$\boxed{\frac{C_P}{C_V} \propto T^0}$$

2. If n : Number density of charge carriers

A : Cross-sectional area of conductor

q : Charge on each charge carrier

I : Current through the conductor

then the expression of drift velocity is

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

(3) $nAqI$ (4) $\frac{IA}{nq}$

Answer (2)

Sol. We Know $I = nAe\,v_d$

$\Rightarrow \quad v_d = \frac{I}{nAq}$

3. If R, X_L and X_C denote resistance, inductive reactance and capacitive reactance respectively. Then which of the following options shows the dimensionless physical quantity.

(1) $\frac{X_L X_C}{R}$ (2) $\frac{R}{\sqrt{X_L X_C}}$

(3) $\frac{R}{X_L X_C}$ (4) $\frac{R}{(X_L X_C)^2}$

Answer (2)

Sol. X_L = Inductive reactance = [R] = dimension of R

X_C = Capacitive reactance = [R] = dimension of R

R = Resistance

$\frac{R}{\sqrt{X_L X_C}}$ = dimensionless

4. A drop of water of 10 mm radius is divided into 1000 droplets. If surface tension of water surface is equal to 0.073 J/m^2 then increment in surface energy while breaking down the bigger drop in small droplets as mentioned is equal to

(1) 8.25×10^{-5} J (2) 9.17×10^{-4} J

(3) 9.17×10^{-5} J (4) 8.25×10^{-4} J

Answer (4)

Sol. Let the radius of one small droplet is r then

$$1000\frac{4}{3}\pi r^3 = \frac{4}{3}\pi(10)^3$$

$\Rightarrow \quad r = 1$ mm

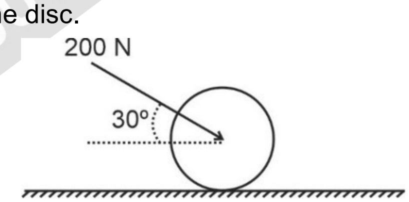
$U_f = 1000\ 4\pi r^2\ T = 1000 \times 4\pi \times 10^{-6} \times 0.073$

$= 9.17 \times 10^{-4}$ J

$U_i = 4\pi \times (10^{-2})^2\ T = 9.17 \times 10^{-5}$ J

So $\Delta U = 8.25 \times 10^{-4}$ J

5. A force 200 N is exerted on a disc of mass 70 kg as shown. Find the normal reaction given by ground on the disc.

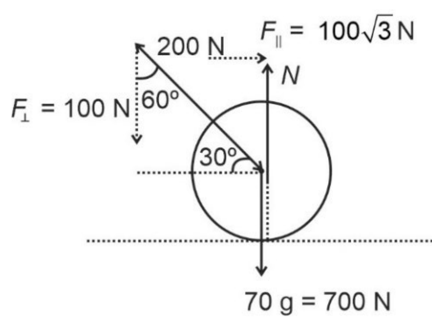


(1) 200 N (2) 600 N

(3) 800 N (4) $\frac{200}{\sqrt{3}}$N

Answer (3)

Sol.



$N = Mg + F_\perp$

$= 700 + 100$

$= 800$ N

6. At depth d from surface of earth acceleration due to gravity is same as its value at height d above the surface of earth. If earth is a sphere of radius 6400 km, then value of d is equal to

(1) 2975 km (2) 3955 km

(3) 2525 km (4) 4915 km

Answer (2)

Sol. $g_0\left(1-\frac{d}{R}\right)=\frac{g_0}{\left(1+\frac{d}{R}\right)^2}$

$$\left(1-\frac{d}{R}\right)\left(1+\frac{d}{R}\right)^2=1$$

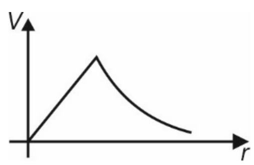
On solving

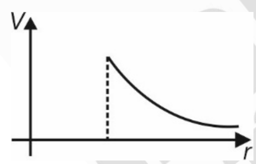
$$\frac{d}{R}=0,\ -\left(\frac{\sqrt{5}+1}{2}\right),\ \frac{\sqrt{5}-1}{2}$$

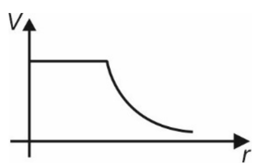
So, $d=\frac{\sqrt{5}-1}{2}R$

$\Rightarrow d$ = 3955 km

7. Which of the following graphs depicts the variation of electric potential with respect to radial distance from centre of a conducting sphere charged with positive charge.

(1)


(2)


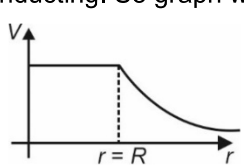
(3)


(4)


Answer (3)

Sol. $V(r)=\begin{cases}\frac{q}{4\pi\varepsilon_0 R} & \text{if } r<R\\ \frac{q}{4\pi\varepsilon_0 r} & \text{if } r>R\end{cases}$

Where r is radial distance and R is radius of sphere, as charge will be on the surface because the sphere is conducting. So graph will be



8. In a sample of hydrogen atoms, one atom goes through a transition n = 3 → ground state with emitted wavelength λ_1. Another atom goes through a transition n = 2 → ground state with emitted wavelength λ_2. Find $\frac{\lambda_1}{\lambda_2}$.

(1) $\frac{6}{5}$ (2) $\frac{5}{6}$

(3) $\frac{27}{32}$ (4) $\frac{32}{27}$

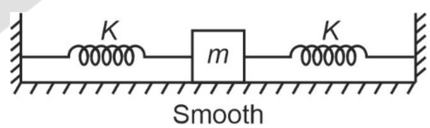
Answer (3)

Sol. $\frac{1}{\lambda_1}=RZ^2\left[1-\frac{1}{9}\right]$

$$\frac{1}{\lambda_2}=RZ^2\left[1-\frac{1}{4}\right]$$

$$\Rightarrow\frac{\lambda_1}{\lambda_2}=\frac{\frac{3}{4}}{\frac{8}{9}}=\frac{27}{32}$$

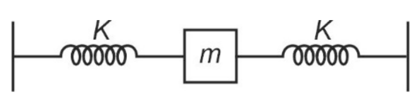
9. A block of mass m is connected to two identical springs of force constant K as shown. Find total number of oscillations of block per unit time.



(1) $2\pi\sqrt{\frac{2m}{K}}$ (2) $\frac{1}{2\pi}\sqrt{\frac{K}{m}}$

(3) $2\pi\sqrt{\frac{m}{2K}}$ (4) $\frac{1}{2\pi}\sqrt{\frac{2K}{m}}$

Answer (4)

Sol.


K_{eq} = 2K

$$\omega=\sqrt{\frac{K_{eq}}{m}}=\sqrt{\frac{2K}{m}}$$

$f=\frac{\omega}{2\pi}=\frac{1}{2\pi}\sqrt{\frac{2K}{m}}$ oscillation per second.

10. Consider the two statements:

Assertion : The beam of electrons shows wave nature and exhibits interference and diffraction.

Reason : Davisson-Germer experiment verified the wave nature of electrons.

(1) Both are correct. Reason correctly explains assertion

(2) Both are incorrect

(3) Assertion is correct but Reason is incorrect

(4) Both are correct. Reason does not explain assertion.

Answer (1)

Sol. Davisson Germer experiment verified wave nature of electrons.

Option (1) is correct.

11. A projectile is launched on horizontal surface such that if thrown with initial velocity of u, it has velocity of $\frac{\sqrt{3}u}{2}$ at maximum height. Then time of flight of the projectile is equal to

(1) $\frac{\sqrt{3}u}{g}$ (2) $\frac{2u}{g}$

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

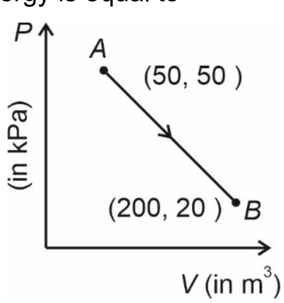
Answer (3)

Sol. $u\cos\theta = \frac{\sqrt{3}u}{2}$

$\Rightarrow \theta = \frac{\pi}{6}$ angle of projection

$T = \frac{2u\sin\theta}{g} = \frac{u}{g}$

12. A diatomic gas is taken from point A to point B in a thermodynamic process as described in the Pressure-Volume graph shown. The change in internal energy is equal to



(1) 3.75×10^6 J

(2) 2.25×10^6 J

(3) 7.5×10^6 J

(4) 4.5×10^6 J

Answer (1)

Sol. $\Delta U = \frac{f}{2}nR\Delta T$

$= \frac{5}{2}(P_f V_f - P_i V_i)$

$= \frac{5}{2}\left(200 \times 20 \times 10^3 - 50 \times 50 \times 10^3\right)$ J

$= \frac{5}{2} \times 1500 \times 10^3$ J $= 3.75 \times 10^6$ J

13. A conductor of length l and cross-sectional area A has drift velocity v_d when used across a potential difference V. When another conductor of same material and length l but double cross-sectional area than first is used across same potential difference than drift velocity is equal to

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

(3) $2v_d$ (4) $4v_d$

Answer (2)

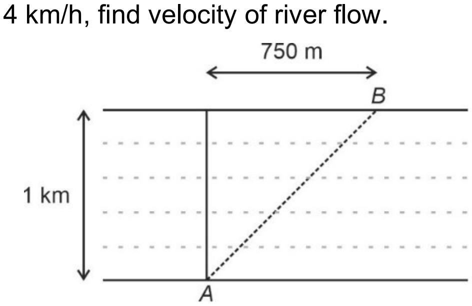
Sol. $I = \eta e v_d A$

$\frac{V}{2} = \eta e v_d A$

$\frac{VA}{\rho l} = \eta e v_d A$

$\Rightarrow$ v_d is independent of area of cross-sectional of conductor.

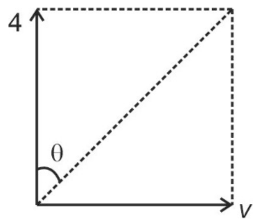
14. A swimmer swims perpendicular to river flow and reaches point B. If velocity of swimmer in still water is 4 km/h, find velocity of river flow.



(1) 3 km/hr (2) 5 km/hr

(3) 2 km/hr (4) 6 km/hr

Answer (1)

Sol. 

$\Rightarrow \quad \frac{v}{4} = \tan\theta = \frac{750}{1000}$

$\Rightarrow \quad v = 3$ km/hr

15. A bar magnet with magnetic moment of 5 Am^2 is lying at stable equilibrium in external uniform magnetic field of strength 0.4T. Work done in slowly rotating the bar magnet to the position of unstable equilibrium is equal to

(1) 1 J
(2) 2 J
(3) 3 J
(4) 4 J

Answer (4)

Sol. $U_i = -MB\cos 0°$

$U_f = -MB\cos 180°$

so, $W = \Delta U$

$= 2MB$

$= 2 \times 5 \times 0.4$

$= 4$ J

16. Unpolarised light (of intensity I_0) is incident on a polarizer *A* and subsequently on polarizer *B* whose pass axis is perpendicular to that of *A*. Now a polarizer *C* is introduced between *A* and *B* such that pass axis of *C* is at 45° with pass axis of *A*. Find intensity that comes out of *B*.

(1) $\frac{I_0}{8}$

(2) $\frac{I_0}{4}$

(3) Zero

(4) $\frac{3I_0}{8}$

Answer (1)

Sol. $I_{net} = I_0 \times \frac{1}{2} \times \cos^2 45° \times \cos^2 45°$

$= \frac{I_0}{8}$

17.

18.

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g., 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. A solid sphere is rolling on a smooth surface with kinetic energy = 7 × 10^{-3} J. If mass of the sphere is 1 kg, find the speed of centre of mass in cm/s. (Consider pure rolling)

Answer (10.00)

Sol. $\frac{1}{2}mv_{cm}^2 + \frac{1}{2}\cdot\frac{2}{5}mv^2 = 7 \times 10^{-3}$

$\Rightarrow \frac{7}{10}mv^2 = \frac{7}{1000}$

$\Rightarrow v = \frac{1}{10}\text{m/s} = 10 \text{ cm/s}$

22. A lift of mass 500 kg starts moving downwards with initial speed 2 m/s and accelerates at 2 ms^{-2}. The kinetic energy of the lift when it has moved 6 m down is _____ kJ.

Answer (07.00)

Sol. $u = 2$ m/s

$a = 2$ m/s^2

$s = 6$ m

$v^2 - u^2 = 2as$

$\Rightarrow \quad v^2 = u^2 + 2as = 4 + 2 \times 2 \times 6 = 28$

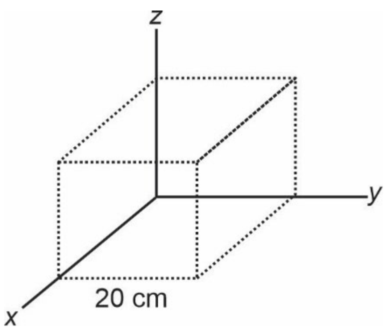
$\text{K.E.} = \frac{1}{2}MV^2 = \frac{1}{2} \times 500 \times (28)$

$= 500 \times 14$

$= 7000$ J

$= 7$ kJ

23. Electric field in a region is $4000x^2\hat{i}$ N/C. The flux through the cube is $\frac{x}{5}$ Nm^2/C. Find x.



Answer (32)

Sol. ϕ = 4000(0.2)^2 × Area

= 4000(0.2)^2 × (0.2)^2

$= \frac{4000 \times 16}{10000}$

= 6.4 Nm^2/C

24. For an series LCR circuit across an A.C source, current and voltage are in same phase. Given the resistance of 20 Ω and voltage of the source is 220 V. Find current (in A) in the circuit.

Answer (11.00)

Sol. The given circuit is in resonance

$\therefore i = \frac{220}{20} = 11\text{ A}$

25. For a particle performing SHM, maximum potential energy is 25 J. The kinetic energy (in J) at half the amplitude is $\frac{x}{4}$. Find x

Answer (75.00)

Sol. $\text{KE} = \frac{1}{2}kA^2 - \frac{1}{2}k\left(\frac{A}{2}\right)^2$

$= \frac{1}{2}kA^2\left[\frac{3}{4}\right]$

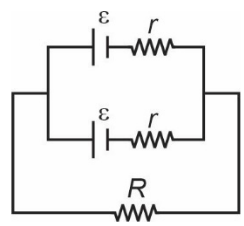
$= \frac{3}{4} \times 25\text{ J}$

$= \frac{75}{4}\text{ J}$

26. The current through a 5 Ω resistance remains same, irrespective of its connection across series or parallel combination of two identical cells. Find the internal resistance (in Ω) of the cell.

Answer (05.00)

Sol.



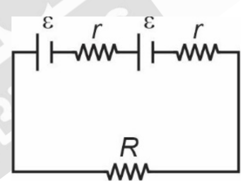
$\frac{\varepsilon_{eq}}{\left(\frac{r}{2}\right)} = \frac{\varepsilon}{r} + \frac{\varepsilon}{r}$

$\varepsilon_{eq} = \varepsilon$

$r_{eq} = \left(\frac{r}{2}\right)$

$\text{current} = i = \frac{\varepsilon}{R + \left(\frac{r}{2}\right)}$

When connected in series



$\varepsilon_{eq} = 2\varepsilon$

$i = \left(\frac{2\varepsilon}{R + 2r}\right)$

$\Rightarrow \quad \frac{\varepsilon}{R + \frac{r}{2}} = \frac{2\varepsilon}{R + 2r}$

$\Rightarrow \quad R + 2r = 2R + r$

$\Rightarrow \quad \boxed{r = R = 5\ \Omega}$

27.

28.

29.

30.