PART : PHYSICS

1. Which of the following statement (s) is correct is/are for the adiabatic process?
(A) Molar heat capacity is zero.
(B) Molar heat capacity is infinite
(C) Work done on gas is equal to increase in internal energy
(D) The increase in temperature results in decrease in internal energy
(1) AC (2) BC (3) CD (4) AD

Ans. **(1)**

Sol. $q + w = \Delta E$ Heat Capacity (C) $= \frac{Q}{n\Delta T}$

$w = \Delta E$ $Q = 0$

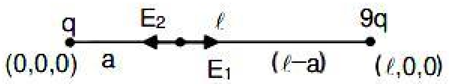
2. Two point charges q and 9q are placed at distance of ℓ from each other. Then the electric field is zero at

(1) Distance $\frac{\ell}{4}$ from charge 9q (2) Distance $\frac{3\ell}{4}$ from charge q

(3) Distance $\frac{\ell}{3}$ from charge 9 q (4) Distance $\frac{\ell}{4}$ from charge q

Ans. **(4)**

Sol.



$|E_1| = |E_2|$

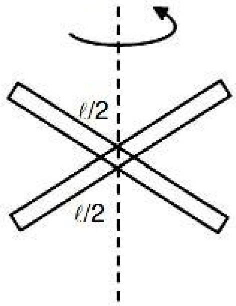
$\frac{kq}{a^2} = \frac{k_{9q}}{(\ell - a)^2}$, $\frac{1}{a} = \frac{3}{(\ell - a)}$

$\ell - a = 3a$

$a = \frac{\ell}{4}$

Distance $\frac{\ell}{4}$ from charge q.

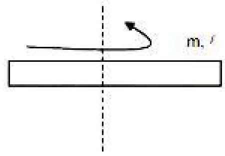
3. The moment of Inertia of a uniform rod of mass m and length l is α when rotated about an axis passing through centre and perpendicular to the length. If the rod is broken into equal halves and arranged as shown then the moment of Inertia about the given axis is

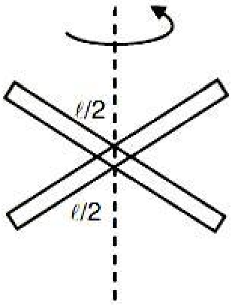


(1) 2α (2) $\frac{\alpha}{2}$ (3) 4α (4) $\frac{\alpha}{4}$

Ans. **(4)**

Sol.





$I = \frac{ml^2}{12}$, $\alpha = \frac{ml^2}{12}$

$I = I_1 + I_2$

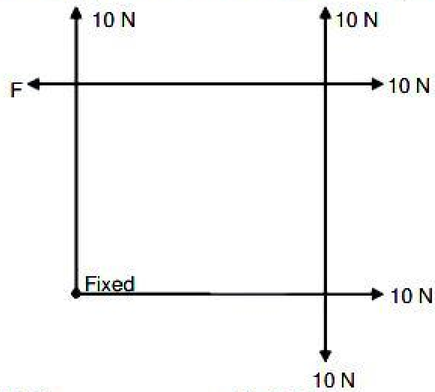
$= \frac{\left(\frac{m}{2}\right)\left(\frac{l}{2}\right)^2}{12} + \frac{\left(\frac{m}{2}\right)\left(\frac{l}{2}\right)^2}{12}$

$= \frac{1}{8}\frac{ml^2}{12} + \frac{1}{8}\frac{ml^2}{12} = \frac{1}{4}\frac{ml^2}{12}$

$I = \frac{1}{4}\alpha$

$I = \frac{\alpha}{4}$

4. A square shape lamina of mass M kg is at rest . Find value of F (in N)



(1) 10 N (2) 15 N (3) 20 N (4) 30 N

Ans. **(1)**

5. Relation between magnetic susceptibility and magnetic permeability ?

(1) $\mu_r = 1 - x_m$ (2) $\mu_r = 1 + x_m$ (3) $\mu_0 = 1 + x_m$ (4) $\mu = 1 + x_m$

Ans. **(2)**

Sol. $\mu_r = 1 + x_m$

$\frac{\mu}{\mu_0} = 1 + x_m$

$\mu = \mu_0 (1 + x_m)$

6. The ratio of magnetic field to center of circular coil to magnetic field at distance x from the centre of circular coil $\left(\frac{x}{R}=\frac{3}{4}\right)$

(1) $\frac{64}{28}$ (2) $\frac{125}{64}$ (3) $\frac{135}{74}$ (4) $\frac{125}{32}$

Ans. **(2)**

Sol. Magnetic field at center of circular coil $\dot{\beta}_1=\frac{\mu_0 I}{2R}$ ....(1)

magnetic field at distance x from the centre of circular coil is $\dot{\beta}_2=\frac{\mu_0 I R^2}{2(R^2+x^2)^{3/2}}$ ....(2)

Ratio

$$\frac{\dot{\beta}_1}{\dot{\beta}_2}=\frac{\frac{\mu_0 I}{2R}}{\frac{\mu_0 I R^2}{2(R^2+x^2)^{3/2}}}=\frac{2(R^2+x^2)^{3/2}}{2R^3}$$

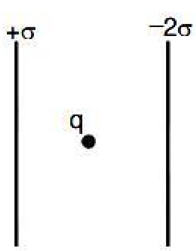
$$\Rightarrow \frac{R^3\left(1+\frac{x^2}{R^2}\right)^{3/2}}{R^3}$$

$$=\left(1+\frac{9}{16}\right)^{3/2}$$

$$\left(\frac{25}{16}\right)^{3/2}\Rightarrow\left(\frac{5}{4}\right)^3$$

$$\Rightarrow \frac{125}{64}$$

7.



Find net electric force on point charge q :

(1) $\frac{3}{2}\frac{\sigma q}{\epsilon_0}$ (2) $\frac{3\sigma q}{\epsilon_0}$ (3) $\frac{\sigma q}{2\epsilon_0}$ (4) $\frac{3\sigma q}{\epsilon_0}$

Ans. **(1)**

Sol. $F=qE$

$$-q\left\{\frac{\sigma}{2\epsilon_0}+\frac{2\sigma}{2\epsilon_0}\right\}$$

$$=\frac{q\sigma}{2\epsilon_0}\times 3$$

8. Match the column

Column – I	Column - II
(A) Coefficient of viscosity	(i) $M^{-1}LT^{2}$
(B) Pressure gradient	(ii) $ML^{-1}T^{-1}$
(C) compressibility	(iii) $ML^{-2}T^{-2}$
(D) Plank constant	(iv) $ML^{2}T^{-1}$

(1) (A)- (i), (B)-(iii), C-(ii), D-(iv)
(2) (A)- (iii), (B)-(ii), C-(i), D-(iv)
(3) (A)- ii, (B)-(iii), C-(iv), D-(i)
(4) (A)- ii, (B)-(iii), C-(i), D-(iv)

Ans. **(4)**

Sol. (A) $F = 6\pi\eta rv$

$$\eta = \frac{mLT^{-2}}{L \times LT^{-1}}$$

$$\eta = mL^{-1}T^{-1}$$

(B) $$PG = \frac{p}{x} = \frac{F}{A \times x}$$

$$= \frac{mLT^{-2}}{L^2 \times L}$$

$$= M L^{-2}T^{-2}$$

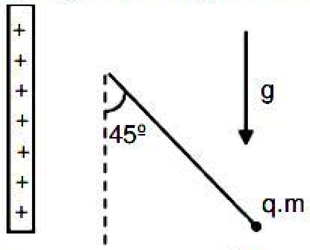
(C) $$\text{Comp} = \frac{1}{B}$$

$$= \frac{\Delta v}{\Delta p \times v} = \frac{A}{F}$$

$$= \frac{L^2}{MLT^{-2}}$$

$$= M^{-1} LT^{2}$$

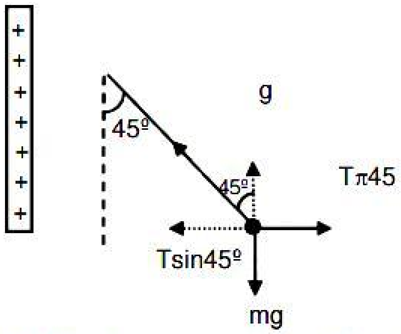
9. The figure shown an infinite plane having uniform charge. density σ and a small changed particle having charge q and mass m suspended by a light insulating thread. Find σ if the charge is in equilibrium



(1) $\frac{2 \epsilon_0 mg}{q}$ (2) $\frac{\epsilon_0 mg}{2q}$ (3) $\frac{2q}{\epsilon_0 mg}$ (4) $\frac{2q \epsilon_0}{mg}$

Ans. **(1)**

Sol.



$T \sin 45^\circ = E_q$ $\qquad$ $T \cos 45^\circ = mg$

$\frac{T}{\sqrt{2}} = E_q$ ......(i) $\frac{T}{\sqrt{2}} = mg$ ....(ii)

$E_q = mg$

$\frac{\sigma}{2\epsilon_0} = mg$

$\sigma = \frac{2\epsilon_0 mg}{q}$ $\qquad$ ans.

10. Find the dimension of ab^{-2} from the given formula $\left(P + \frac{a}{v^2}\right)(v - b) = RT$ where symbols have their usual meaning

(1) Energy $\qquad$ (2) Energy density $\qquad$ (3) Intensity $\qquad$ (4) power

Ans. **(2)**

Sol. $\frac{a}{v^2} = p$

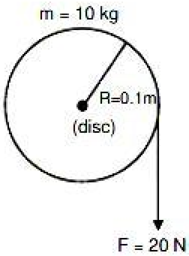
$\mathbf{a = pv^2}$

$\mathbf{b = v}$

$\frac{a}{b^2} = \frac{pv^2}{v^2} = P$

$P = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$

11. Find angular velocity when 1 m rope is pulled.



(1) $\omega = 30\sqrt{2}$ rad/sec $\qquad$ (2) $\omega = 20\sqrt{2}$ rad/sec $\qquad$ (3) $\omega = 2\sqrt{2}$ rad/sec $\qquad$ (4) $\omega = 2\sqrt{20}$ rad/sec

Ans. **(2)**

Sol. $C = I\alpha = F \times R$

$\alpha = \dfrac{F}{\frac{1}{2}mk} = \dfrac{2F}{mk}$

$l = \theta \times R$

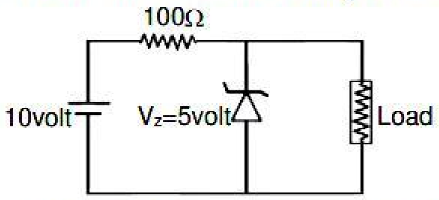
$w^2 = w^2 + 2\alpha\,\theta$

$= 2 \times \dfrac{2F}{mk} \times \dfrac{1}{R}$

$\omega = \sqrt{\dfrac{4 \times 20}{10x} \times \dfrac{1}{0.1}}$

$\omega = 20\sqrt{2}$

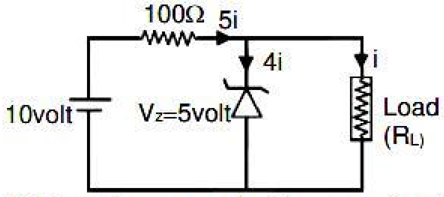
12. A zener diode of $V_z = 5$ volt is used as a voltage regulator. The unregulated supply voltage of the battery is 10 volt. The value of the series resistance is 100Ω. The current through the zener diode is 4 times the load current. The load resistance and the current through the load should be :



(1) 10 mA, 500 Ω (2) 5 mA, 200 Ω (3) 20 mA, 100 Ω (4) 15 mA, 300 Ω

Ans. **(1)**

Sol.



We have to assume that the zener breakdown is occurring. So the voltage across the zener diode as well as the load should be 5 volt. So the voltage across the series resistance will be

$i_1 = \dfrac{10-5}{100} = 50mA$

$5i = 50$ mA $\Rightarrow$ $I = 10$ mA

Resistance of the load should be $= \dfrac{\Delta v}{i} = \dfrac{5}{10 \times 10^{-3}} = 500\Omega$

13. Which statement is correct

(A) Energy of Ground state of H atom is equal to energy of He^+ atom in first excited state

(B) Energy of Ground state of H atom is equal to energy of He^+ atom is second excited state.

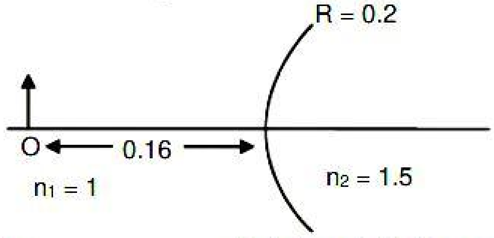
(C) Energy of H atom is equal to energy of Li^{+3} atom in second excited state

(D) Energy of H atom is equal to energy of Li^{+3} atom in their excited state

(1) AC (2) AD (3) BC (4) BD

Ans. **(1)**

14. Which of the following is correct about image.



(1) 0.4 cm left of current surface
(2) 0.4 cm right of current surface
(3) 0.2 cm left of current surface
(4) 0.2 cm right of current surface

Ans. **(1)**

Sol. $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$

$\frac{1.5}{v} - \frac{1}{-0.16} = \frac{1.5-1}{0.2}$

$\frac{1.5}{v} = \frac{0.5}{0.2} - \frac{1}{0.16}$

$= \frac{5}{2} - \frac{100}{16}$

$\frac{1.5}{v} = \frac{40}{16} - \frac{100}{16} = \frac{-60}{16}$

$v = -\frac{16 \times 1.5}{60} = -0.4$ cm

15. A cell phone has rating of 4.2 V, 5800 mA.hr. Find energy stored by cell phone battery within 1 hr.

(1) 65 kJ
(2) 87 kJ
(3) 123 kJ
(4) 175 kJ

Ans. **(2)**

Sol. $E = v\ i\ t$

$= 4.2 \times \frac{5800}{1000} \times 3600$

$= 4.2 \times 58 \times 360$

$= 42 \times 58 \times 36$

$= 87696$

$= 87$ kJ

16. $X_1 = \sqrt{7}\sin(5t)$

$X_2 = 2\sqrt{7}\sin(5t + \pi/3)$

maximum acceleration for resultant SHM will be

(1) $2\sqrt{7}\ m/s^2$
(2) $2\sqrt{10}\ m/s^2$
(3) $175\ m/s^2$
(4) $125\ m/s^2$

Ans. **(3)**

Sol. $R = \sqrt{4(7) + 7 + 2(\sqrt{7})(2\sqrt{2})\frac{1}{2}}$

$= \sqrt{35+14}$

$= \sqrt{49}$

$= 7$

Resultant SHM will be

$x = 7\sin(5t + \phi)$

$\therefore$ Maximum acceleration $= a\omega^2 = 7 \times 25 = 175\ m/s^2$

17. Angular separation between second maximum of left side of central maxima and third maxima of right side of central maxima is 30° when 628 nm light is used in YDSD then slit width in μm will be

Ans. **06.00**

Sol. $\frac{5\beta}{D} = \frac{\pi}{6}$

$\frac{5\lambda D}{Dd} = \frac{\pi}{6}$

$d = 5\lambda \times \frac{6}{\pi}$

$= 5 \times 628 \times 10^{-9} \times 6$

$= 6000 \times 10^{-9}$ m

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

$= 6\ \mu$m

18. A car travels a distance x with a constant speed of $v_1 = 5$ m/sec and then it travels further $\frac{3}{2}$x distance with a constant speed of v_2 (in m/sec). If the average speed during the entire journey is $\frac{50}{7}$ m/sec. then write the value of v_2.

Ans. **10**

Sol.

$$\langle |v| \rangle = \frac{x + \frac{3}{2}x}{\frac{x}{v_1} + \frac{\frac{3}{2}x}{v_2}}$$

$$\frac{50}{7} = \frac{5\frac{x}{2}}{x\left(\frac{1}{5} + \frac{3}{2v_2}\right)} \Rightarrow v_2 = 10 \text{ m/sec}$$

19. A mono-atomic gas 'A' has only three translator degree of freedoms while a polyatomic gas has three translatory, three rotational and one vibrational mode. If the ratio if the adiabatic exponents $\frac{r_A}{r_B} = 1 + \frac{1}{n}$, then write the value of n in integers.

Ans. **3**

Sol. For the gas A, f = 3

$\Rightarrow r_A = 1 + \frac{2}{f} = 1 + \frac{2}{3} = \frac{5}{3}$

For the gas B, f = 3 + 3 + 2 = 8 (1 Vibrational mode = 2 vibrational degree of freedom)

$r_B = 1 + \frac{2}{f} = 1 + \frac{2}{8} = \frac{5}{4}$

$\Rightarrow \frac{r_A}{r_B} = \frac{5/3}{5/4} = \frac{4}{3} = 1 + \frac{1}{n} \Rightarrow n = 3$

20. The equation of wave front of a light wave is x + y + z = constant. The angle made by the direction of the light wave propagation with x-axis will be :

(1) $\frac{\pi}{4}$ (2) $\cos^{-1}\frac{1}{\sqrt{3}}$ (3) $\frac{\pi}{3}$ (4) $\cos^{-1}\left(\frac{1}{3}\right)$

Ans. **(2)**

Sol. The equation of the wavefront is

$x + y + z = \text{constant}$

The directional ratios of its normal (i.e. the direction of wave propagation) will be (1, 1, 1) so the

directional cosines of its normal = $\left(\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}\right)$

unit vector of the direction of light propagation

$\hat{A} = \frac{1}{\sqrt{3}}\hat{i} + \frac{1}{\sqrt{3}}\hat{j} + \frac{1}{\sqrt{3}}\hat{k}$

for angle with x-axis

$$\cos\theta = \frac{\hat{A}.\hat{i}}{|\hat{A}||\hat{i}|} = \frac{\left(\frac{1}{\sqrt{3}}\right)(1)}{1} = \frac{1}{\sqrt{3}}$$

$$\theta = \cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$$