JEE Main 2020 Paper

Date : 4th September 2020

Time : 09 : 00 am - 12 : 00 pm

Subject : Physics

Q.1 Starting from the origin at time t = 0, with initial velocity $5\hat{j}\,ms^{-1}$, a particle moves in the x-y plane with a constant acceleration of $\left(10\hat{i} + 4\hat{j}\right)ms^{-2}$. At time t, its coordinates are (20 m, y_0 m). The values of t and y_0 are, respectively:

(1) 5s and 25 m (2) 2s and 18 m (3) 2s and 24 m (4) 4s and 52 m

Sol. **2**

Equation of motion gives us

$y = u_y t + \frac{1}{2} a_y t^2$

Here $u_y = 5ms^{-1}$, $u_x = 0$ ms–1, $a_x = 10ms^{-2}$, $a_y = 4ms^{-2}$

$y = 5t + \frac{1}{2}(4)\ t^2$

$y = 5t + 2t^2$

and $x = 0 + \frac{1}{2}\ (10)\ (t^2) = 20$

t = 2 s

$\Rightarrow y = 10 + 8 = 18m$

Q.2 A small bar magnet placed with its axis at 30° with an external field of 0.06 T experiences a torque of 0.018 Nm. The minimum work required to rotate it from its stable to unstable equilbrium position is:

(1) 7.2×10^{-2} J (2) 6.4×10^{-2} J (3) 9.2×10^{-3} J (4) 11.7×10^{-3} J

Sol. **1**

$\tau = MB \sin 30^o$

$0.018 = MB\left(\frac{1}{2}\right)$

MB = 0.036

$w = \Delta U = |MB \cos 0^0 — MB \cos 180^0| = 2MB = 0.072$ J

Q.3 Choose the correct option relating wave lengths of different parts of electromagnetic wave spectrum:

(1) $\lambda_{\text{radio waves}} > \lambda_{\text{micro waves}} > \lambda_{\text{visible}} > \lambda_{\text{x-rays}}$ (2) $\lambda_{\text{visible}} > \lambda_{\text{x-rays}} > \lambda_{\text{radio waves}} > \lambda_{\text{micro waves}}$

(3) $\lambda_{\text{visible}} < \lambda_{\text{micro waves}} < \lambda_{\text{radio waves}} < \lambda_{\text{x-rays}}$ (4) $\lambda_{\text{x-rays}} < \lambda_{\text{micro waves}} < \lambda_{\text{radio waves}} < \lambda_{\text{visible}}$

Sol. **1**

By property of electromagnetic wave spectrum.

Q.4 On the x-axis and at a distance x from the origin, the gravitational field due a mass distribution is given by $\frac{Ax}{\left(x^2+a^2\right)^{3/2}}$ in the x-direction. The magnitude of gravitational potential on the x-axis at a distance x, taking its value to be zero at infinity, is:

(1) $A\left(x^2+a^2\right)^{3/2}$ (2) $\frac{A}{\left(x^2+a^2\right)^{1/2}}$ (3) $A\left(x^2+a^2\right)^{1/2}$ (4) $\frac{A}{\left(x^2+a^2\right)^{3/2}}$

Sol. **2**

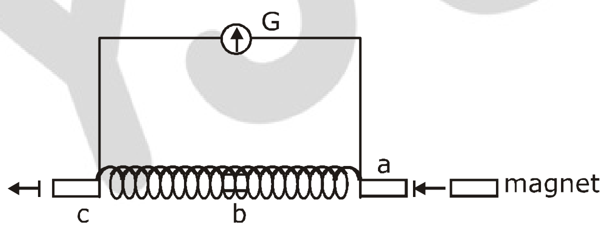
$$E_x = \frac{Ax}{(x^2+a^2)^{3/2}}$$

$$\frac{-dV}{dx} = \frac{Ax}{(x^2+a^2)^{3/2}}$$

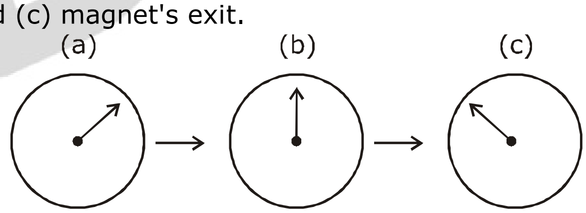
$$\int_0^V dV = -\int_\infty^x \frac{Ax}{(x^2+a^2)^{3/2}}\,dx$$

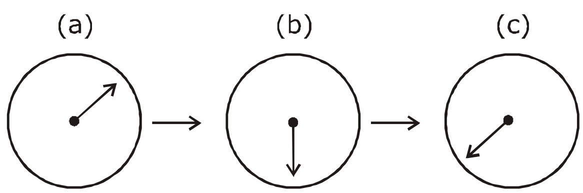
$$V = \frac{A}{(x^2+a^2)^{1/2}}$$

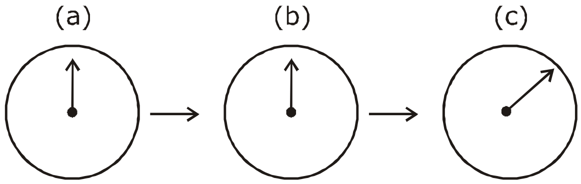
Q.5 A small bar magnet is moved through a coil at constant speed from one end to the other. Which of the following series of observations will be seen on the galvanometer G attached across the coil?

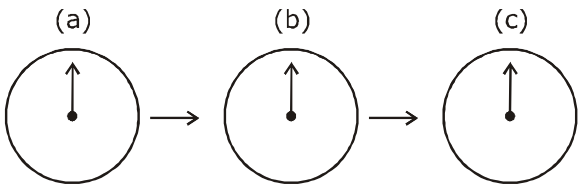


Three positions shown describe: (a) the magnet's entry (b) magnet is completely inside and (c) magnet's exit.

(1)


(2)


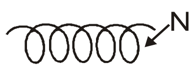
(3) 

(4) 

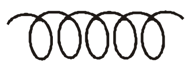
Sol. **1**

Let N S

→ When bar magnet enters the coil, emf is generated due to magnetic flux change.

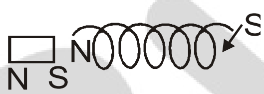


→ When completely inside



i = 0

→ when bar magnet exits the coil, emf is generated again but of opposite nature.



Q.6 A battery of 3.0V is connected to a resistor dissipating 0.5 W of power. If the terminal voltage of the battery is 2.5V, the power dissipated within the internal resistance is:

(1) 0.072 W (2) 0.10 W (3) 0.125 W (4) 0.50 W

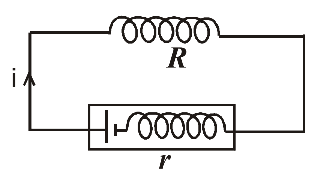
Sol. **2**

$P_0 = 0.5$ W

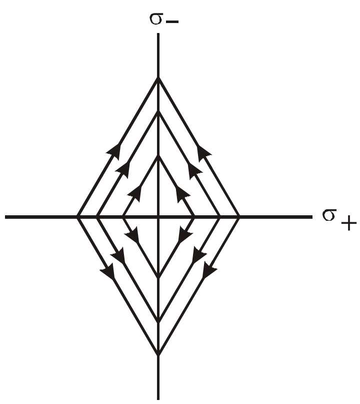
i. (2.5) = 0.5

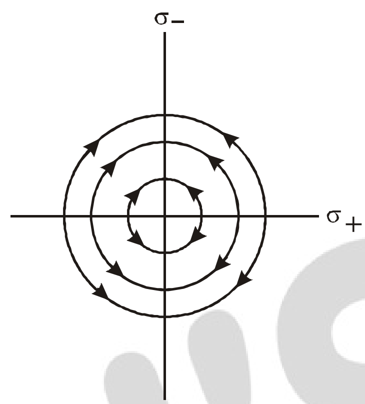
i = 1/5 A

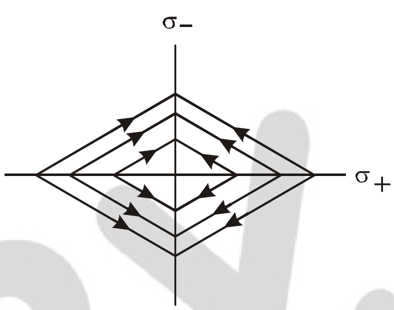
$P_r = \left(\frac{1}{5}\right)(0.5) = 0.1$ W

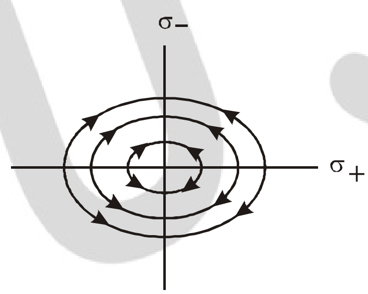


Q.7 Two charged thin infinite plane sheets of uniform surface charge density σ_+ and σ_-, where $|\sigma_+| > |\sigma_-|$, intersect at right angle. Which of the following best represents the electric field lines for this system:

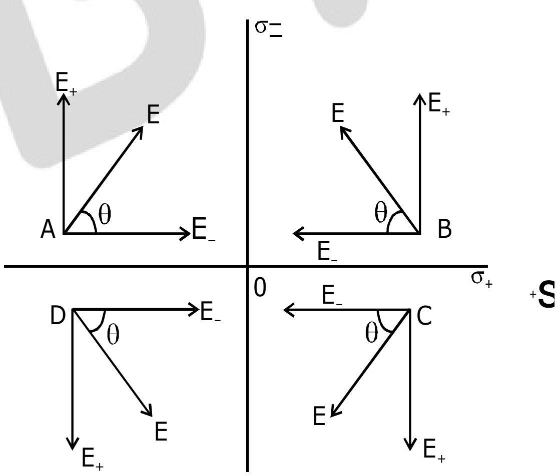
(1)


(2)


(3)


(4)


Sol. **1**
Let us choose points A,B,C,D as shown to understand the direction of net electric field to get a better picture.



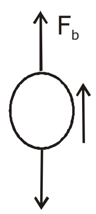
$\left|\vec{E}_+\right| > \left|\vec{E}_-\right|$

$\theta > 45°$

Q.8 An air bubble of radius 1 cm in water has an upward acceleration 9.8 cm s^{-2}. The density of water is 1 gm cm^{-3} and water offers negligible drag force on the bubble. The mass of the bubble is (g = 980 cm/s^2).

(1) 1.52 gm (2) 4.51 gm (3) 3.15 gm (4) 4.15 gm

Sol. **4**

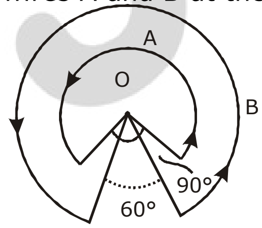


$F_b - mg = ma \qquad \Rightarrow m = \frac{F_b}{g+a}$

$m = \frac{V \cdot \rho_w g}{g+a}$

$m = \frac{(4/3)\pi r^3 . \rho_w . g}{g+a} = 4.15$ gram

Q.9 A wire A, bent in the shape of an arc of a circle, carrying a current of 2A and having radius 2 cm and another wire B, also bent in the shape of arc of a circle, carrying a current of 3 A and having radius of 4 cm, are placed as shown in the figure. The ratio of the magnetic field due to the wires A and B at the common centre O is:



(1) 2 : 5 (2) 6 : 5 (3) 6 : 4 (4) 4 : 6

Sol. **2**

$B_A = \frac{\mu(2)\left(\frac{3\pi}{2}\right)}{2(a)(2\pi)} = \frac{3\mu}{4a}$

$B_B = \frac{\mu(3)\left(\frac{5\pi}{3}\right)}{2(2a)(2\pi)} = \frac{5\mu}{8a}$

$\frac{B_A}{B_B} = \frac{3\mu}{4a} \times \frac{8a}{5\mu} = 6:5$

Q.10 Particle A of mass $m_A = \frac{m}{2}$ moving along the x-axis with velocity v_0 collides elastically with another particle B at rest having mass $m_B = \frac{m}{3}$. If both particles move along the x-axis after the collision, the change $\Delta\lambda$ in de-Broglie wavlength of particle A, in terms of its de-Broglie wavelength (λ_0) before collision is:

(1) $\Delta\lambda = \frac{5}{2}\lambda_0$ (2) $\Delta\lambda = 2\lambda_0$ (3) $\Delta\lambda = 4\lambda_0$ (4) $\Delta\lambda = \frac{3}{2}\lambda_0$

Sol. **3**

Speed of particle A after collision will be,

$$V_1 = \frac{m_1 - m_2}{m_1 + m_2} \cdot u_1 + \frac{2m_2}{m_1 + m_2} \cdot u_2$$

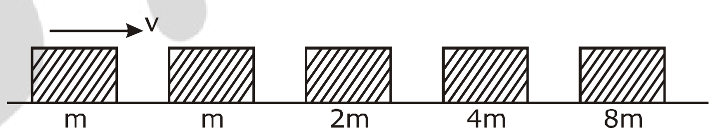
$$V_1 = \frac{\frac{m}{2} - m/3}{\frac{m}{2} + m/3} V_0 = V_0/5$$

de-Broglie wave length of particle A after collision will be

$$\lambda' = \frac{h}{\frac{m}{2} \cdot \frac{V_0}{5}} = 5 . \frac{h}{\frac{m}{2} . V_0} = 5\lambda_0$$

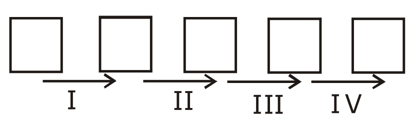
$\Rightarrow$ change in wavelength $\Delta\lambda = 4\lambda_0$

Q.11 Blocks of masses m, 2m, 4m and 8m are arranged in a line on a frictionless floor. Another block of mass m, moving with speed v along the same line (see figure) collides with mass m in perfectly inelastic manner. All the subsequent collisions are also perfectly inelastic. By the time the last block of mass 8m starts moving the total energy loss is p% of the original energy. Value of 'p' is close to:



(1) 94 (2) 87 (3) 37 (4) 77

Sol. **1**

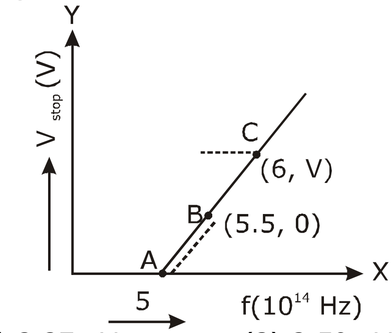


There will be total 4 collisions in each collision K.E. decreasing by 50%

$$E_f = \frac{1}{2^4} E_i = \frac{E_i}{16} = 6.25\%$$

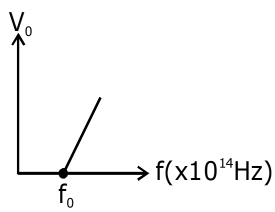
i.e. 93.75 % loss

Q.12 Given figure shows few data points in a photo-electric effect experiment for a certain metal. The minimum energy for ejection of electron from its surface is: (Plancks constant $h = 6.62 \times 10^{-34}$J.s)



(1) 2.10 eV (2) 2.27 eV (3) 2.59 eV (4) 1.93 eV

Sol. **2**



Threshold energy **=** $\phi = hf_0$, Here $f_0 = 5.5 \times 10^{14}$Hz

$\phi = hf_0 = 6.62 \times 10^{-34} \times 5.5 \times 10^{14}$

$= 36.41 \times 10^{-20}$J = 2.27 eV

Q.13 The specific heat of water = 4200 J $kg^{-1}K^{-1}$ and the latent heat of ice = 3.4×10^5 J kg^{-1}. 100 grams of ice at 0°C is placed in 200 g of water at 25°C. The amount of ice that will melt as the temperature of water reaches 0°C is close to (in grams):

(1) 63.8 (2) 64.6 (3) 61.7 (4) 69.3

Sol. **3**

Heat loss by water when it cools down to 0^0 C is,

$Q = m_w s \Delta\theta$

$= \left(\frac{200}{1000}\right)$. (4200) (25) = 21000 J

Which is less than the amount of heat (mL_f) required to melt ice completely.

$\Delta m_i L$ = 21000 J

To find the amount of ice melt (Δm_i), take

$\Delta m_i = \frac{21000}{3.4 \times 10^5} \times 10^3\, gm$ = 61.7 grams

Q.14 A beam of plane polarised light of large cross-sectional area and uniform intensity of 3.3 Wm^{-2} falls normally on a polariser (cross sectional area 3×10^{-4} m^2) which rotates about its axis with an angular speed of 31.4 rad/s. The energy of light passing through the polariser per revolution, is close to:

(1) 1.0×10^{-4} J (2) 1.0×10^{-5} J (3) 5.0×10^{-4} J (4) 1.5×10^{-4} J

Sol. **1**

From Malus's law

$p = p_0 \cos^2\omega t$

here, p_0 and p are incident and transmitted intensity respectively.

$E_{avg} = \langle p \rangle A \cdot T = \frac{p_0}{2} T A$

$E_{avg} = \langle P \rangle . TA = \frac{p_0}{2} . \frac{2\pi}{\omega} A = \frac{3.3 \times 3.14 \times 3 \times 10^{-4}}{31.4} = 9.9 \times 10^{-5} \approx 10 \times 10^{-5} \approx 1 \times 10^{-4}$ J

Q.15 For a transverse wave travelling along a straight line, the distance between two peaks (crests) is 5m, while the distance between one crest and one trough is 1.5m. The possible wavelengths (in m) of the waves are:

(1) 1, 3, 5,..... (2) 1, 2, 3,..... (3) $\frac{1}{2}, \frac{1}{4}, \frac{1}{6}$,.... (4) $\frac{1}{1}, \frac{1}{3}, \frac{1}{5}$,....

Sol. **4**

Given trough to crest distance

$1.5 = (2n_1 + 1)\, \lambda/2$ ...(1)

and crest to crest distance is

$5 = n_2 \lambda$ ...(2)

n_1 & n_2 are integer

$n_1 = 1, n_2 = 5$

$n_1 = 2$, n_2 is not integer

$n_1 = 3$, n_2 is not integer

$n_1 = 4, n_2 = 15, \quad \lambda = 1/3$

Q.16 Match the C_P/C_V ratio for ideal gases with different type of molecules:

Molecule Type	C_P/C_V
(A) Monoatomic	(I) 7/5
(B) Diatomic rigid molecules	(II) 9/7
(C) Diatomic non-rigid molecules	(III) 4/3
(D) Triatomic rigid molecules	(IV) 5/3

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

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

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

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

Sol. **4**

$\gamma = C_p/C_v$

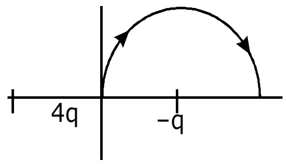
$\gamma_A = 1 + \frac{2}{3} = 5/3$

$\gamma_B = 1 + \frac{2}{5} = 7/5$

$\gamma_C = 1 + \frac{2}{7} = 9/7$

$\gamma_D = 1 + \frac{2}{6} = 4/3$

Q.17 Two point charges 4q and –q are fixed on the x-axis at x = $-\frac{d}{2}$ and x = $\frac{d}{2}$, respectively. If a third point charge 'q' is taken from the origin to x = d along the semicircle as shown in the figure, the energy of the charge will:



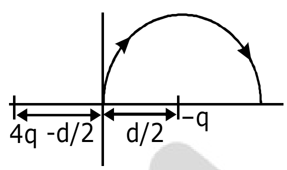
(1) decrease by $\frac{q^2}{4\pi \in_0 d}$

(2) decrease by $\frac{4q^2}{3\pi \in_0 d}$

(3) increase by $\frac{3q^2}{4\pi \in_0 d}$

(4) increase by $\frac{2q^2}{3\pi \in_0 d}$

Sol. **2**



Initial and final potential energy are,

$$U_i = \frac{1}{4\pi\varepsilon_0}\left[\frac{4q^2}{\left(\frac{d}{2}\right)} - \frac{q^2}{\left(\frac{d}{2}\right)}\right]$$

$$U_f = \frac{1}{4\pi\varepsilon_0}\left[\frac{4q^2}{\left(\frac{3d}{2}\right)} - \frac{q^2}{\left(\frac{d}{2}\right)}\right]$$

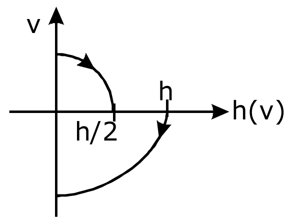
$$U_f - U_i = \Delta U = \frac{1}{4\pi\varepsilon_0} \cdot \frac{4q.q}{(3d/2)} - \frac{1}{4\pi\varepsilon_0} \cdot \frac{4q.q}{(d/2)}$$

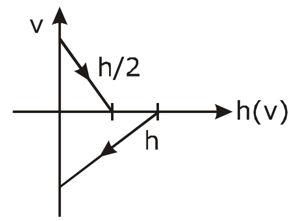
$$= \frac{4q^2}{4\pi\varepsilon_0}\left(\frac{2}{d}\right)\left(-\frac{2}{3}\right)$$

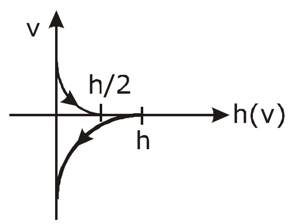
$$= (-)\ \frac{4q^2}{3\pi\varepsilon_0 . d}$$

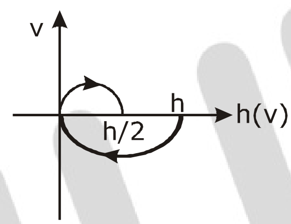
= decrease by (–)

Q.18 A Tennis ball is released from a height h and after freely falling on a wooden floor it rebounds and reaches height $\frac{h}{2}$. The velocity versus height of the ball during its motion may be represented graphically by: (graphs are drawn schematically and are not to scale)

(1)


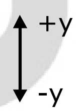
(2)


(3)


(4)


Sol. **1**

$\rightarrow$ V, h curve will be parabolic as for motion under gratity,



$v^2 = u^2 \pm 2gh$

$\rightarrow$ downward velocity is negative and upward is positive

$\rightarrow$ when ball is coming down graph will be in IV quadrant i.e. v is –ve and when going up graph will be in I quadrant i.e. v is +ve.

Q.19 Dimensional formula for thermal conductivity is (here K denotes the temperature):

(1) $MLT^{-3}K^{-1}$ (2) $MLT^{-2}K^{-2}$ (3) $MLT^{-2}K$ (4) $MLT^{-3}K$

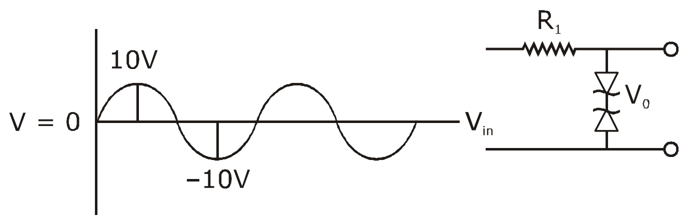
Sol. **1**

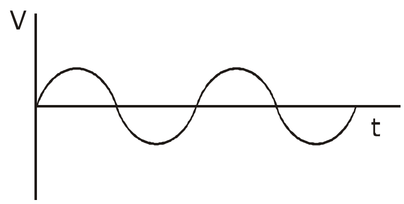
Thermal current during steady state conduction of heat along a rod is,

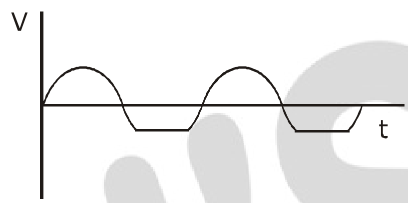
$$\frac{dQ}{dt} = -KA\frac{dT}{dx}$$

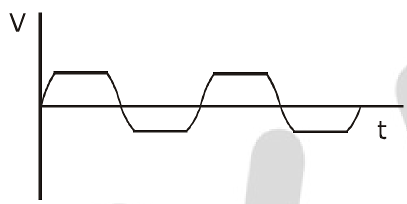
Using dimensional analysis we get $[M^1L^1T^{-3}\ k^{-1}]$

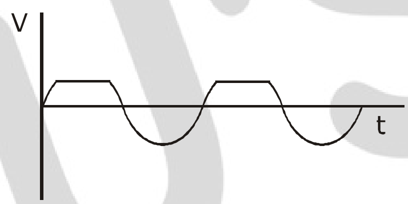
Q.20 Take the breakdown voltage of the zener diode used in the given circuit as 6V. For the input voltage shown in figure below, the time variation of the output voltage is : (Graphs drawn are schematic and not to scale)



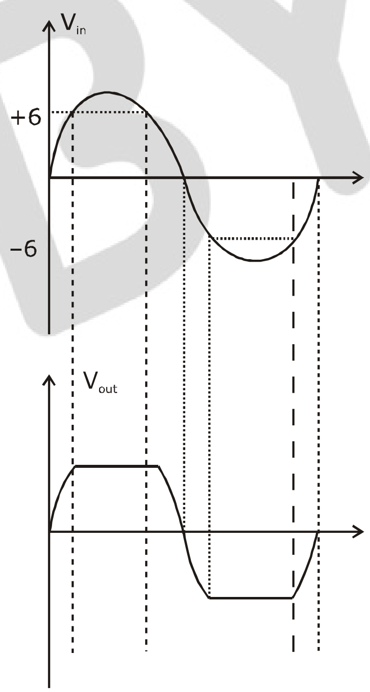
(1)


(2)


(3)


(4)


Sol. **3**



Q.21 In the line spectra of hydrogen atoms, difference between the largest and the shortest wavelengths of the Lyman series is 304Å. The corresponding difference for the Paschen series in Å is : ___________.

Sol. **10553**

For shortest wave length in Lyman, we have

$\frac{1}{\lambda} = R[1]$ (i.e. n= ∞ to n = 1)

For longest wave length in Lyman

$$\frac{1}{\lambda'} = R\left[1 - \frac{1}{4}\right] = \frac{3R}{4}$$

In Paschen series, for shortest wave length

$$\frac{1}{\lambda_s} = R\left(\frac{1}{3^2} - \frac{1}{(\infty)^2}\right)$$

$$\frac{1}{\lambda_s} = R\left(\frac{1}{3^2}\right) = \frac{R}{9}$$

And for longest wave length

$$\frac{1}{\lambda_l} = R\left(\frac{1}{3^2} - \frac{1}{4^2}\right) = \frac{7R}{144}$$

Now, taking ratio we get

$(\lambda_l - \lambda_s)$ = 10553 Å

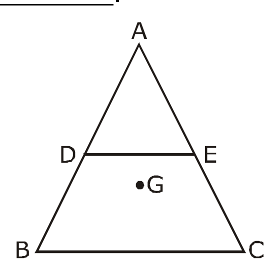
Q.22 A closed vessel contains 0.1 mole of a monoatomic ideal gas at 200 K. If 0.05 mole of the same gas at 400 K is added to it, the final equilibrium temperature (in K) of the gas in the vessel will be close to _______.

Sol. **267**

$$(0.1)\left(\frac{3}{2}R\right)(T-200) = (0.05)\left(\frac{3}{2}R\right)(400-T)$$

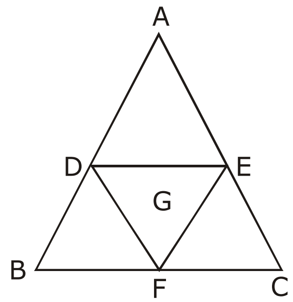
T = 266.6 K

Q.23 ABC is a plane lamina of the shape of an equilateral triangle. D, E are mid points of AB, AC and G is the centroid of the lamina. Moment of inertia of the lamina about an axis passing through G and perpendicular to the plane ABC is I_0. If part ADE is removed, the moment of inertia of the remaining part about the same axis is $\frac{NI_0}{16}$ where N is an integer. Value of N is _____________.



Sol. 11

If m is mass of lamina and l is its side length, then moment of inertia of lamina about an axis passing through G and perpendicular to plane is I_0.



Let $I_0 = kml^2$

$$I_{DEF} = K\left(\frac{m}{4}\right)\left(\frac{\ell}{2}\right)^2 = \left(\frac{I_0}{16}\right)$$

and $I_{ADE} = I_{BDE} = I_{EFC} = I$ (say)

$$\text{Then, } 3I = I_0 - \frac{I_0}{16} = \frac{15I_0}{16}$$

$$\Rightarrow I = \frac{5I_0}{16}$$

$$I_{remaining} = 2I + \frac{I_0}{16} = \frac{11I_0}{16}$$

Q.24 In a compound microscope, the magnified virtual image is formed at a distance of 25 cm from the eye-piece. The focal length of its objective lens is 1 cm. If the magnification is 100 and the tube length of the microscope is 20 cm, then the focal length of the eye-piece lens (in cm) is __________.

Sol. 6.25

$L = 20$, $f_0 = 1\text{cm}$, $M = 100$

$$M = \frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right)$$

$$M = \frac{L}{f_0}\left(1 + \frac{D}{f_e}\right) \quad [v_0 \approx L,\ u_0 \approx f_0]$$

$$\Rightarrow 100 = \left(\frac{20}{1}\right)\left[1 + \frac{25}{f_e}\right]$$

on solving we get

$f_e = 6.25$ cm

Q.25 A circular disc of mass M and radius R is rotating about its axis with angular speed ω_1. If another stationary disc having radius $\frac{R}{2}$ and same mass M is droped co-axially on to the rotating disc. Gradually both discs attain constant angular speed ω_2. The energy lost in the process is p% of the initial energy. Value of p is __________.

Sol. **20**

$I_f \omega_f = I_i \omega_i$

$$I_i = \frac{MR^2}{2}$$

$$I_f = \frac{MR^2}{2} + \frac{M(R/2)^2}{2}$$

$$= \frac{5}{4}.\frac{MR^2}{2}$$

$$\left[\frac{MR^2}{2} + \frac{M}{2}\left(\frac{R}{2}\right)^2\right]\omega' = \left(\frac{MR^2}{2}\right).\omega$$

$$\left[\frac{MR^2}{2}.\left(\frac{5}{4}\right)\right]\omega' = \frac{MR^2}{2}\omega$$

$$\omega' = \frac{4}{5}\omega$$

loss of K.E. = $\frac{Loss}{K_i} \times 100 = \frac{\omega^2 - \omega'^2 (5/4)}{\omega^2} \times 100$

$$\frac{\omega^2 - \frac{16}{25}\omega^2\left(\frac{5}{4}\right)}{\omega^2} = \left(1 - \frac{80}{100}\right) \times 100 = 20\%$$