IITJEE 2008 Physics

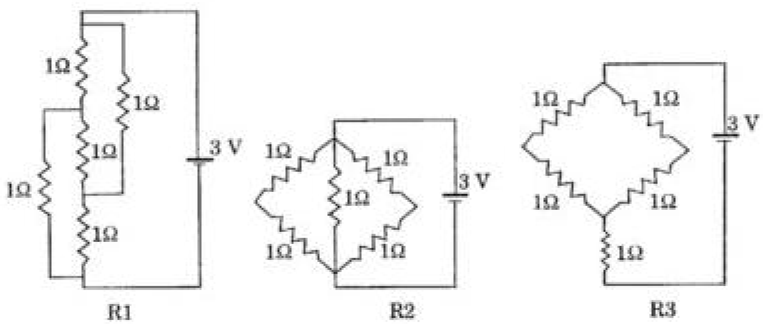
Paper 1 Code 2

SECTION – I

Straight Objective Type

This section contains 6 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D), out of which **ONLY ONE** is correct.

Q 24: Figure shows three-resistor configuration R1, R2 and R3 connected to 3V battery. If the power dissipated by the configuration R1, R2 and R3 is P1, P2 and P3, respectively, then



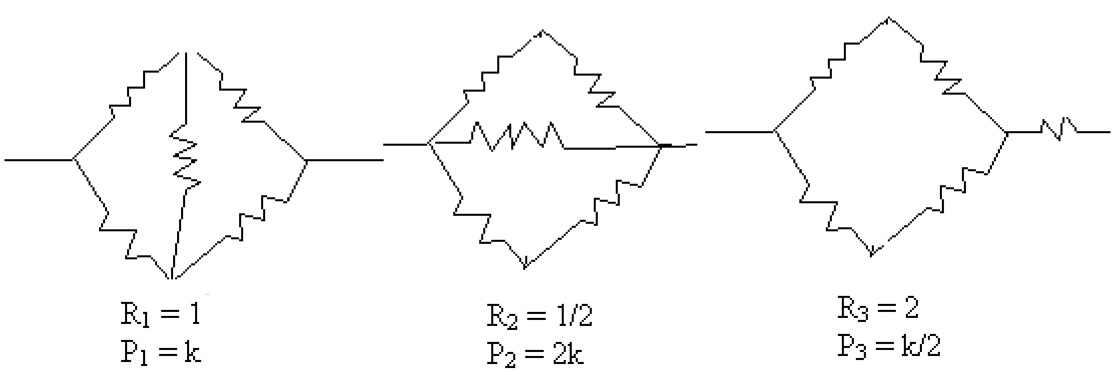
(A) P1 >P2 >P3

(B) P1>P3>P2

(C) P2>P1>P3

(D) P3>P2>P1

Solution: (C)



$P_2 > P_1 > P_3$

Q 25: Student I, II and III perform an experiment for measuring the acceleration due to gravity (g) using a simple pendulum. They use different length of the pendulum and/or record time for different number of oscillations. The observation are shown in the table

Least count for length = 0.1cm

Least count for time = 0.1 s

Student	Length of the pendulum (cm)	Number of oscillations (n)	Total time for (n) oscillations (s)	Time period (s)
I	64.0	8	128.0	16.0
II	64.0	4	64.0	16.0
III	20.0	4	36.0	9.0

If E_1, E_{II} and E_{III} are the percentage errors in g, i.e., $\left(\frac{\Delta g}{g}\times 100\right)$ for student I, II and III, respectively,

(A) E_I is 0

(B) E_I is minimum

(C) $E_I = E_{II}$

(D) E_{II} is maximum

Solution: (B)

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

$$g = \frac{4\pi^2 l}{T^2} \text{ But } T = \frac{T_1}{\eta} \Rightarrow g = \frac{4\pi^2 l \eta^2}{T_1^2}$$

$$\frac{dg}{g} = \frac{dl}{l} + 2\frac{dT_1}{T_1} + 2\frac{d\eta}{\eta} \quad \therefore 2\frac{d\eta}{\eta} = 0$$

Case - 1 $= \frac{0.1}{64} + \frac{2\times 0.1}{128}$

Case - 2 $= \frac{0.1}{64} + \frac{2\times 0.1}{64}$

Case - 3 $= \frac{0.1}{20} + \frac{2\times 0.1}{36}$

=> b is correct

Q 26: Which one of the following statement is wrong in the context of X-rays generated from a X-ray tube?

(A) Which one of the following statement is wrong in the context of X-rays generated from a X-ray tube?
(B) Cut-off wavelength of the continuous X-rays depends on the atomic number of the target.
(C) Intensity of the characteristic X-rays depends on the electrical power given to the X-rays tube.
(D) Cut-off wavelength of the continuous X-rays depends on the energy of the electrons in the X-ray tube

Solution: (B)

Cut off wave length does not depend on the atomic no of target

Q 27: Two beams of red and violet colours are made to pass separately through a prism (angle of the prism is 60^o). In the position of minimum deviation, the angle of refraction will be

(A) 30^o for both the colours
(B) greater for the violet colour
(C) greater for the red colour
(D) equal but not 30^o for both the colours

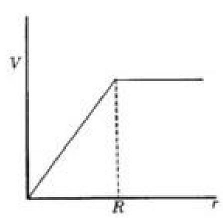
Solution: (A)

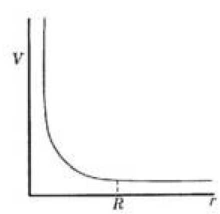
Angle of refraction will be 30^o for both the colours in the position of minimum deviation

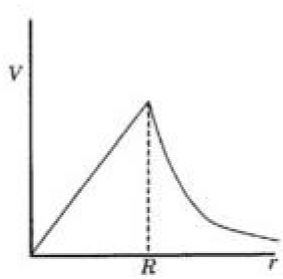
Q 28: A spherically symmetric gravitational system of particles has a mass density

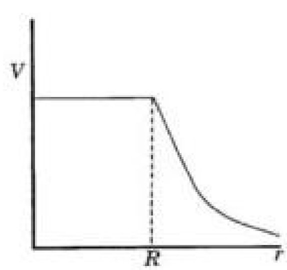
$$\rho = \begin{cases} \rho_0 \;\; for \;\; r \le R \\ 0 \;\; for \;\; r > R \end{cases}$$

Where ρ_0 is a constant. A test mass can undergo circular motion under the influence of the gravitational field of particles. Its speed V as a function of distance r($0 < r < \infty$) from the centre of the system is represented by

(A) 

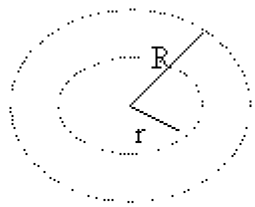
(B) 

(C) 

(D) 

Solution: (C)

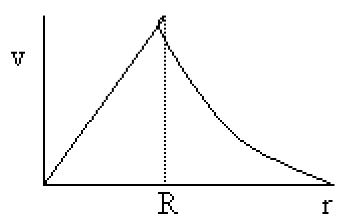
When $r \le R$



$$\frac{mv^2}{r} = \frac{GMm}{r^2} \Rightarrow \frac{mv^2}{r} = \frac{Gm\rho\left(\frac{4}{3}\pi r^3\right)}{r}$$

$$\Rightarrow v^2 = \frac{G\rho(4\pi)}{3} \cdot \frac{r^4}{r^2} \Rightarrow v \propto r \text{ (linear)}$$

When r > R



$$\frac{mv^2}{r} = \frac{GM\left(\frac{4}{3}\pi R^3\right)}{r^2} \Rightarrow v^2 = KR^3/r \Rightarrow v \propto \frac{1}{\sqrt{r}}$$

Q 29: An ideal gas is expanding such that PT^2 = constant. The coefficient of volume expansion of the gas is

(A) $\frac{1}{\sqrt{T}}$ (B) $\frac{2}{\sqrt{T}}$ (C) $\frac{3}{\sqrt{T}}$ (D) $\frac{4}{\sqrt{T}}$

Solution: (C)

$$PT^2 = C_1$$

$$\frac{PV}{T} = C_2 \text{ (ideal gas)}$$

$$\Rightarrow \frac{C_2 T^3}{V} = C_1$$

$$\Rightarrow \frac{T^3}{V} = k \Rightarrow 3T^2 \frac{dT}{dV} = k = \frac{T^3}{V} \Rightarrow \frac{1}{V}\frac{dV}{dT} = \frac{3}{T}$$

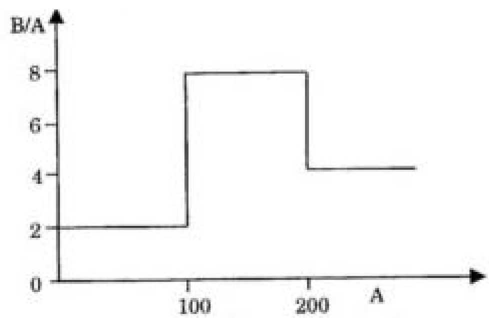
SECTION - II

Multiple Correct Answers Type

This section contains 4 multiple correct answer(s) type questions. Each question has

4 choices (A) , (B) , (C) , (D) , out of which **ONE OR MORE** is/are correct

Q 30: Assume that the nuclear binding energy per nucleon (B/A) versus mass number (A) is as shown in the figure. Use this plot to choose the correct choice (s) fiven bellow.



(A) Fusion of two nuclei with mass numbers lying in the range of 1 < A < 50 will release energy

(B) Fusion of two nuclei with mass numbers lying in range of 51 < A < 100 will release energy

(C) Fission of a nucleus lying in the mass range of 100 < A < 200 will release energy when broken into two equal fragment

(D) Fission of a nucleus lying in the mass range of 200 < A < 260 will release energy when broken into two equal fragment

Solution: (B, D)

(i) if both are between 1 & 50
new nuclear has moss no lying in the range 1 to 100. thus there will be no change in EPN therefore, fusion will not occur.

(ii) if mass no of both lies between51 & 100

=> Nuclear of mass EPN is formed

=> Energy is released

(iii) fission will not occur since EPN decreases

(iv) fission will occur, since EPN increases

- energy is released

Q 31: Two balls, having linear momenta $\vec{p}_1 = p\hat{i}$ and $\vec{p}_2 = -p\hat{i}$, undergo a collision in free space. There is no external force acting on the balls. Let $\vec{p}_1^{\,'}$ and $\vec{p}_2^{\,'}$ be their final momenta. The following option(s) is(are) **NOT ALLOWED** for any non-zero value of p, a_1, a_2, b_1, b_2, c_1, and c_2.

(A) $\vec{p}_1^{\,'} = a_1\hat{i} + b_1\hat{j} + c_1\hat{k}$, $\vec{p}_2^{\,'} = a_2\hat{i} + b_2\hat{j}$

(B) $\vec{p}_1^{\,'} = c_1\hat{k}$, $\vec{p}_2^{\,'} = c_2\hat{k}$

(C) $\vec{p}_1^{\,'} = a_1\hat{i} + b_1\hat{j} + c_1\hat{k}$, $\vec{p}_2^{\,'} = a_2\hat{i} + b_2\hat{j} - c_1\hat{k}$

(D) $\vec{p}_1^{\,'} = a_1\hat{i} + b_1\hat{j}$, $\vec{p}_2^{\,'} = a_2\hat{i} + b_2\hat{j}$

Solution: (A, D)

(i) $\vec{P}_1^1 + \vec{P}_2^1 = (a_1 + a_2)\hat{i} + (b_1 + b_2)\hat{j} + c_1\hat{k}$

since c_1 is non zero , $\therefore \vec{P}_1^1 + \vec{P}_2^1 \neq 0$

hence correct

(ii) $\vec{P}_1^1 + \vec{P}_2^1 = c_1\hat{k} + c_2\hat{k}$ when $c_1 = - c_2$

then $\vec{P}_1^1 + \vec{P}_2^1 = 0$

hence is correct

(iii) $\vec{P}_1^1 = a_1\hat{i} + b_1\hat{j} + c_1\hat{k}$

$\vec{P}_2^1 = a_2\hat{i} + b_2\hat{j} - c_1\hat{k}$

$\vec{P}_1^1 + \vec{P}_2^1 = (a_1 + a_2)\hat{i} + (b_1 + b_2)\hat{j}$

if $a_1+a_2 = 0 = b_1+b_2$

=> $\vec{P}_1^1 + \vec{P}_2^1 = 0$

hence is correct

(iv) $\vec{P}_1^1 + \vec{P}_2^1 = a_1\hat{i} + b_1\hat{j} + a_2\hat{i} + b_1\hat{j}$

$= (a_1 + a_2)\hat{i} + 2b_1\hat{j}$, since $b_1 \neq 0$

$\Rightarrow \vec{P}_1^1 + \vec{P}_2^1 \neq 0$

=> Hence is correct

Q 32: In a young's double slit experiment, the separation between the two slits is d and the wavelength of the light is λ. The intensity of light falling on slit 1 is four times the intensity of light falling on slit 2. Choose the correct choice(s).

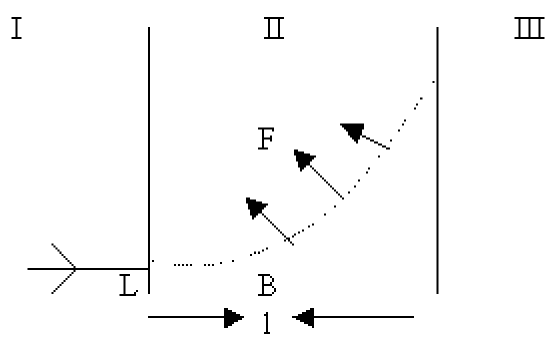
(A) If $d = \lambda$, the screen will contain only one maximum

(B) If $\lambda < d < 2\lambda$, at least one more maximum (besides the central maximum) will be observed on the screen

(C) If the intensity of light falling on slit 1 is reduced so that it becomes equal to that of slit 2, the intensity of the observed dark and bright fringes will increase

(D) If the intensity of light falling on slit w is increased so that it becomes equal to that of slit 1, the intensities of the observed dark and bright fringes will increase

Solution: (A,B)



(i) when $d = \lambda$, the path difference $d \sin\theta$ will never be equal to λ except when $\theta = 90^0$ i.e. at the center of the spectrum

=>only 1 maxima will be found

(ii) when $\lambda < d < 2\lambda$, the path difference $d \sin\theta$ will be equal to λ for 1 more +ve value of $\theta \neq 90^0$ $\therefore$ at least 3 maxima will be found

=> 1 at centre

=> 2 at +ve, -ve value of θ obtain

(iii) if intensity is reduced

$$\Rightarrow I = \left(\sqrt{4I_0} + \sqrt{I_0}\right)^2 = 9I_0$$

$$I' = \left(\sqrt{I_0} + \sqrt{I_0}\right)^2 = 4I_0$$

$\Rightarrow I' < I$ hence wrong

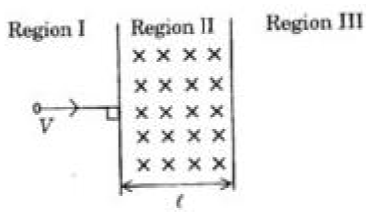
(iv) of both intensities are now $4I_0$

=> intensity of bright fringe increases

=> Intensity of dark fringes reduces to zero

Hence wrong

Q 33: A particle of mass m and charge q, moving with velocity V enters Region II normal to the boundary as shown in the figure. Region II has a uniform magnetic field B perpendicular to the plane of the paper. The length of the Region II is l. Choose the correct choice(s).



(A) The particle enters Region III only if its velocity $V > \frac{qlB}{m}$

(B) The particle enters Region III only if its velocity $V < \frac{qlB}{m}$

(C) Path length of the particle in Region II is maximum when velocity $V = \frac{qlB}{m}$

(D) Time spent in Region II is same for any velocity V as the particle returns to Region I

Solution: (A,C,D)

F(normal force on m)

$= q\left(\vec{V} \times \vec{B}\right) = qVB \perp$ to the motion

$\therefore$ Particle reaches region III

(=) $\frac{mv^2}{l} > qVB$

$\Leftrightarrow V > \frac{qlB}{m}$

(ii) (i) true and (ii) false
(iii) of the particle rotates at radius l
distance covered = πr

$0 \le r \le l \Rightarrow$ max distance is πl

$$\Rightarrow \frac{mv^2}{l} = qVB \Rightarrow V = \frac{qlB}{m}$$

(iv) if radius of half rotation is r
distance = πr

velocity =V and $\Rightarrow \frac{mv^2}{r} = qVB \Rightarrow V = \frac{qlB}{m}$

$$\Rightarrow time = \frac{\pi r}{V} = \frac{\pi rm}{qrB} = \frac{\pi m}{qB}$$

$$\Rightarrow time = \frac{\pi r}{V} = \frac{\pi rm}{qrB} = \frac{\pi m}{qB}$$ (const.wrt V)

SECTION - III

Reasoning Type

This section contains 4 reasoning type questions. Each question has 4 choices (A) , (B) , (C) , (D), out of which **ONLY ONE** is correct

Q 34: STATEMENT-1: Two cylinders, one hollow (metal) and the other solid (wood) the same mass and identical dimensions are simultaneously allowed to roll without slipping down an inclined plane from the same height. The hollow cylinder will reach the bottom of the inclined plane first.

And

STATEMENT-2: By the principle of conservation of energy, the total kinetic energies of both the cylinders are identical when they reach the bottom of the incline

(A) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is a correct explanation for STATEMENT-1

(B) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is not a correct explanation for STATEMENT-1

(C) STATEMENT-1 is True, STATEMENT-2 is False

(D) STATEMENT-1 is False, STATEMENT-2 is False

Solution: (D)

statement 1 is false

since $MI_{hollow} > MI_{solid}$

and $a = \dfrac{g\sin\theta}{1+K^2/R^2}$

$$a_1 = \frac{g\sin\theta}{(1+1)} = \frac{1}{2}x; a_2 = \frac{g\sin\theta}{(1+1/2)} = \frac{2}{3}x$$

=> $a_2 > a_1$

=> solid cylinder reaches earlier

statement II is true

Hence D

Q 35: STATEMENT-1: The stream of water flowing at high speed from a garden hose pipe tends to spread like a fountain when held vertically up, but tends to narrow down when held vertically.

And

STATEMENT-2: In any steady flow of an incompressible fluid, the volume flow rate of the fluid remains constant.

(A) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is a correct explanation for STATEMENT-1

(B) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is not a correct explanation for STATEMENT-1

(C) STATEMENT-1 is True, STATEMENT-2 is False

(D) STATEMENT-1 is False, STATEMENT-2 is False

Solution: (A)

statement I is true(by observation)

statement II is also true

but statement II does explain statement I since when water moves up velocity decreases and area increase while when water moves down, velocity increases and thus stream down.

Q 36: STATEMENT-1: In a meter bridge experiment, null point for an unknown resistance is measured. Now, the unknown resistance is put inside an enclosure maintained at a higher temperature. The null point can be obtained at the same point as before by decreasing the value of the standard resistance.

And

STATEMENT-2: Resistance of a metal increases in temperature.

(A) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is a correct explanation for STATEMENT-1

(B) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is not a correct explanation for STATEMENT-1

(C) STATEMENT-1 is True, STATEMENT-2 is False

(D) STATEMENT-1 is False, STATEMENT-2 is False

Solution: (D)

(By increasing g the temperature, the unknown hesitance increases

$\therefore$ value of standred resistance has to be increased for the same null points to match

=> statement I is false and statement II is true

Q 37: STATEMENT-1: An astronaut in an orbiting space station above the earth experiences weightlessness.
And
STATEMENT-2: An object moving around the earth under the influence of earth's gravitational force is in a state of 'free-fall'.

(A) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is a correct explanation for STATEMENT-1

(B) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is not a correct explanation for STATEMENT-1

(C) STATEMENT-1 is True, STATEMENT-2 is False

(D) STATEMENT-1 is False, STATEMENT-2 is False

Solution: (A)

Statement I is true & statement II also

Since an object moving around the earth under the earth's gravitational force is in free fall $\therefore$ astronaut within the space station experiences weight less ness because pseudo force is balanced by gravitational attraction.

This is same as in an object kept in a freely falling lift.

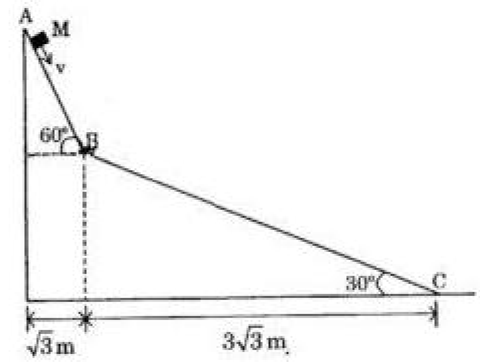
SECTION - IV

Linked Comprehension Type

This section contains 3 paragraphs. Based upon each paragraph , 3 multiple choice questions have to be answered. Each question has 4 choices (A) , (B) , (C) ,(D) ,out of which **ONLY ONE** is correct

Paragraph for question Nos. 38 to 40

A small block of mass M moves on frictionless surface of an inclined plane, as shown in figure. The angle of the incline suddenly changes from 60° to 30° at point B. The block is initially at rest at A. Assume that collisions between the block and the incline are totally inelastic (g = 10 m/s^2).



Q 38: The speed of the block at point B immediately after it strides the second incline is

(A) $\sqrt{60} m/s$ (B) $\sqrt{45} m/s$ (C) $\sqrt{30} m/s$ (D) $\sqrt{15} m/s$

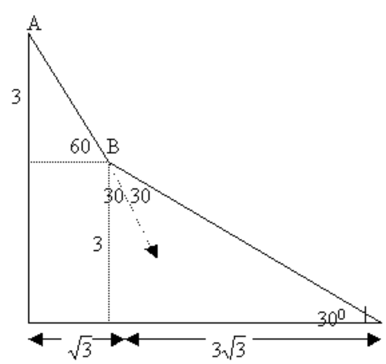
Q 39: The speed of the block at point C, immediately before it leaves the second incline is

(A) $\sqrt{120} m/s$ (B) $\sqrt{105} m/s$ (C) $\sqrt{90} m/s$ (D) $\sqrt{75} m/s$

Q 40: If collision between the block and the incline is completely elastic, then the vertical (upward) component of the velocity of the block at point B, immediately after it strikes the second incline is

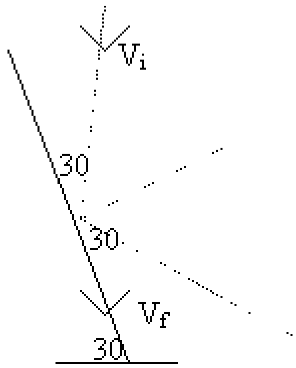
(A) $\sqrt{30} m/s$ (B) $\sqrt{15} m/s$ (C) 0 (D) $-\sqrt{15} m/s$

Solution: 38(B)



$$V_i = \sqrt{2 \times 10 \times 3} = 2\sqrt{15} m/s$$

$$V_f = V_i \cos 30 = 2\sqrt{15} \times \frac{\sqrt{3}}{2} = \sqrt{45} m/s$$



e = 0 => normal component is zero

Solution: 39(B)

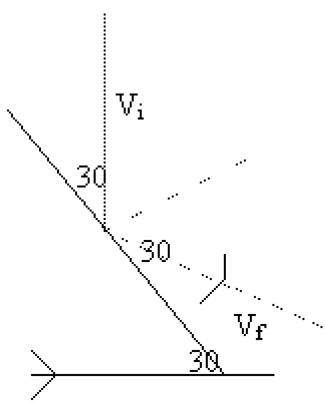
$$\frac{1}{2}MV^2 = \frac{1}{2}MV_f^2 + Mgh \Rightarrow V^2 = V_f^2 + 2gh$$

=45+2X10X3 = 105

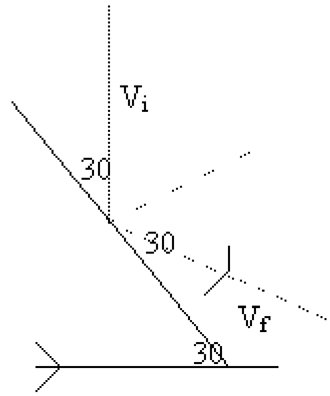
$$\Rightarrow V = \sqrt{105}m/s$$

Solution: 40(C)

if collision is completely elastic



=> V_f is horizontal => vertical velocity is zero

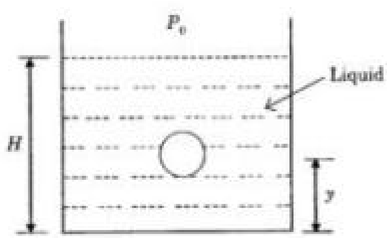


=> V_f is horizontal => vertical velocity is zero

Paragraph for question Nos. 41 to 43

A small spherical monatomic ideal gas bubble $\left(\gamma = \frac{5}{3}\right)$ is trapped inside a liquid of density ρ_l (see figure). Assume that the bubble does not exchange any heat with the liquid. The bubble contains n moles of gas. The temperature of the gas when-the bubble is at the bottom is T_0, the height of the liquid is H and the atmospheric is P_o (Neglect surface tension).

Figure:



Q 41: As the bubble moves upwards, besides the buoyancy force the following force are acting on it

(A) Only the force of gravity

(B) The force due to gravity and the force due to the pressure of the liquid

(C) The force due to gravity, the force due to the pressure of the liquid and the force due to viscosity of the liquid.

(D) The force due to gravity and the force due to viscosity of the liquid

Q 42: When the gas bubble is at a height y from the bottom, its temperature is

(A) $T_0\left(\frac{P_0 + \rho_l g H}{P_0 + \rho_l g y}\right)^{2/5}$

(B) $T_0\left(\frac{P_0+\rho_\ell g(H-y)}{P_0+\rho_\ell gH}\right)^{2/5}$

(C) $T_0\left(\frac{P_0+\rho_\ell gH}{P_0+\rho_\ell gy}\right)^{3/5}$

(D) $T_0\left(\frac{P_0+\rho_\ell g(H-y)}{P_0+\rho_\ell gH}\right)^{3/5}$

Q 43: The buoyancy force acting on the gas bubble is (Assume R is the universal gas constant)

(A) $\rho_\ell nRgT_0\frac{(P_0+\rho_\ell gH)^{2/5}}{(P_0+\rho_\ell gy)^{7/5}}$

(B) $\frac{\rho_\ell nRgT_0}{(P_0+\rho_\ell gH)^{2/5}[P_0+\rho_\ell g(H-y)]^{3/5}}$

(C) $\rho_\ell nRgT_0\frac{(P_0+\rho_\ell gH)^{3/5}}{(P_0+\rho_\ell gy)^{8/5}}$

(D) $\frac{\rho_\ell nRgT_0}{(P_0+\rho_\ell gH)^{3/5}[P_0+\rho_\ell g(H-y)]^{2/5}}$

Solution: 41(D)

forces acting on the body

=> gravitation force, => F viscosity force, => buoyancy force

force due to pressure is accelerated within buoyancy force

Solution: 42(B)

since no heat is exchanged => adiabatic process

$PV^r = cons\tan t$ and $P^{1/r-1}T = cons\tan t$

$(P_0+\rho g_1 H)^{-2/5}T_0 = (P_0+\rho g(H-h))^{-2/5}T_f$

height of water liquid =H - h

$$\Rightarrow T_f = T_0\left[\frac{P_0 + \rho g(H-h)}{P_0 + \rho gh}\right]^{2/5}$$

Solution: 43(B)

buoyancy force = weight of displaced water

$$PV^{\gamma} = cons\tan t$$

$$(P_0 + \rho gh)V_0^{\gamma} = (P_0 + \rho g(H-h))V^{\gamma}$$

$$\Rightarrow V^{\gamma} = \frac{V_0^{\gamma}(P_0 + \rho gh)}{(P_0 + \rho g(H-h))}$$

and $V_0 = \frac{nRT_0}{P_0} = \frac{nRT_0}{(P_0 + \rho gh)}$

=> buoyancy force = ρgV

$$= \rho g \frac{nRT_0}{(P_0 + \rho gH)} \frac{(P_0 + \rho gH)^{1/\gamma}}{(P_0 + \rho g(H-y))^{1/\gamma}}$$

$$= \frac{\rho gnRT_0}{(P_0 + \rho gH)^{2/5}(P_0 + \rho h(H-y))^{3/5}}$$

Paragraph for question Nos. 44 to 46

In a mixture of H-He$^+$ gas (He$^+$ is singly ionized He atom), H atoms and He$^+$ ions are excited to their respective first excited states. Subsequently, H atoms transfer their total excitation energy to He$^+$ ions (by collision). Assume that the bohr model of atom is exactly valid.

Q 44: The quantum number n of the states in finally populated in He$^+$ ions is

(A) 2 (B) 3 (C) 4 (D) 5

Q 45: The wavelength of light emitted in the visible region by He$^+$ ions after collisions with H atoms is

(A) $6.5\text{X}10^{-7}$ m (B) $5.6\text{X}10^{-7}$ m (C) $4.8\text{X}10^{-7}$ m (D) $4.0\text{X}10^{-7}$ m

Q 46: The ratio of the kinetic of the n = 2 electron for the H atom to that of He$^+$ ion is

(A) $\frac{1}{4}$ (B) $\frac{1}{2}$ (C) 1 (D) 2

Solution: 44(C)

first excitation energy of H – atom = $13.6\times 1^2\times\left(\frac{1}{1^1}-\frac{1}{2^2}\right)=10.2ev$

energy observed by He^+ ion = $10.2=13.6\times 2^2\times\left(\frac{1}{2^2}-\frac{1}{n_2^2}\right)ev$

=> $n_2 = 4$

Solution: 45(C)

visible region wavelength $4\rightarrow 3$ transition

$$\frac{hc}{\lambda}=13.6\times 2^2\times\left(\frac{1}{3^2}-\frac{1}{4^2}\right)\Rightarrow \lambda=4\times 10^{-7}m$$

Solution: 46(A)

$$\frac{(K.E.)^{e^-}_{H-atom}}{(K.E.)^{e^-}_{He^+ion}}=\frac{(-E_2)_{H-atom}}{(-E_2)_{He^+ion}}=\frac{13.6\times 1^2/2^2}{13.6\times 2^2/2^2}=\frac{1}{4}$$