set-E.

Group-B

(1) a) → It states that for the streamline flow of an ideal liquid, the total energy (K.E + P.E + pressure.E) per unit mass remains constant at every cross-section throughout the flow.

Application

(i) Atomyser or sprayer.

b) $P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$

$P_1 + 0 = P_2 + \frac{1}{2}\rho v_2^2$

$P_1 - P_2 = \Delta P = \frac{1}{2}\rho v_2^2$

$\Delta P = \frac{1}{2} \times 1.29 \times 30$

$= 580$ pa.

By defn,

$F = \Delta P\, A = 580\,P \times 300 =$ ~~[illegible]~~

$= 174150N$

(2)

(a) →

$W = 2200 J$

$Q_2 = 4300 J$

$Q_1 = ?$

$W = Q_1 - Q_2$

$Q_1 = 2200 + 4300$

$= 6500 J$

$\eta = \left(1 - Q_2/Q_1\right) \times 100\%$

$= \left(1 - \frac{4300}{6500}\right) \times 100\%$

$= 33.8\%$

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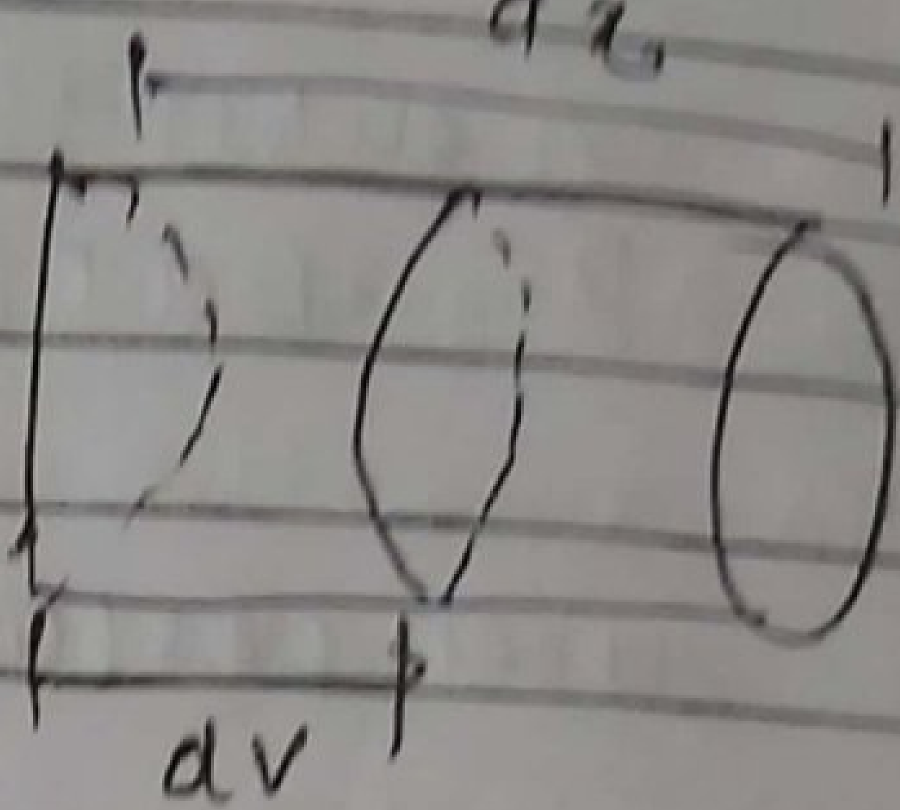
3 a) → The maximum fluctuation in pressure at a point in medium when a longitudinal wave travels through it.

b) →



$$B = \frac{\text{change in pressure}}{\left(\frac{\text{change in volume}}{\text{original volume}}\right)}$$

$$= \frac{-P}{\Delta V / V} = \frac{-PV}{\Delta V}$$

$V = A\,dx$ and $\Delta V = A\,dy$

$$B = \frac{-PV}{\Delta V} = \frac{-PA\,dx}{A\,dy} = \frac{-P\,dx}{dy}$$

$$P = -B\frac{dy}{dx}$$

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on differentiating,

$$\frac{dy}{dx} = -ka\cos(\omega t - kx)$$

on substituting

$$P = -Bak\cos(\omega t - kx)$$

when $\cos(\omega t - kx) = 1$

$$P = P_0$$

$$P = -P_0 \cos(\omega t - kx)$$

$$P_0 = Bak$$

$$P_0 \propto a$$

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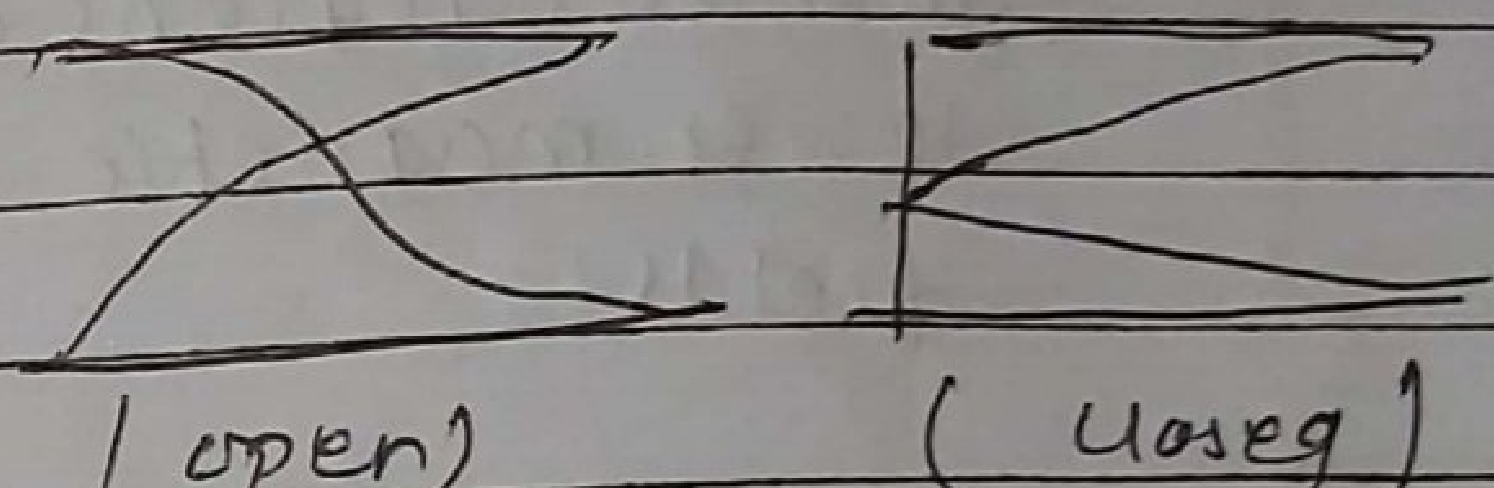
(9)

(a) → overtone means higher frequencies which when sets in closed organ pipe makes node at one end and antinode at other end are called overtones.

Harmonic → A sound wave that has a frequency that is an integral multiple of a fundamental tone.

(b) → $l_1 = \frac{\lambda_1}{4}$



(open) (closed)

$\lambda_1 = 4l_1$

$l_2 = \lambda/_2$

$\lambda_2 = 2l_2$

$n_1 = n_2$

$\frac{v}{\lambda_1} = \frac{v}{\lambda_2}$

$\Rightarrow \frac{v}{4l_1} = \frac{v}{2l_2} = \frac{l_1}{l_2} = \frac{1}{2}$

Or

) (a) →

diamagnetic	paramagnetic
(i) negative	(i) positive
(ii) anti-aligned and are pushed away, towards regions of lower magnetic fields.	(ii) align with the applied field and attracted to regions of greater magnetic field.

(b) →

$B = B_L + B_H$

$= \mu_0 I + \mu_0 H$

$= \mu_0 (I + H)$

$= \mu_0 H (1 + I/H)$

$B = \mu_0 (1 + \chi) H$

$\mu = \mu_0 [1 + \chi]$

$\mu = \mu_0 \cdot \mu_r$

$B = B_0 + B_m$

$= \mu_0 (H + I)$

$\chi = I/H$

so,

$B = \mu_0 (H + \chi H)$

$= \mu_0 H (1 + \chi)$

$B/H = \mu$

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

$\mu_r = \mu / \mu_0$

$\mu/\mu_0 = (1 + \chi)$

$\mu_r = (1 + \chi)$

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$\mu_r = (1+\chi)$

(b) (a) → current flowing in each two long infinitely long parallel conductor 1m apart, which results a force of exactly 2×10^{-7} N per meter length on each conductor.

(f) → ~~force on A due to C~~ $= \frac{\mu_0 I^2}{2\pi (2d)} l$

$= \frac{\mu_0 I^2 l}{4\pi d}$

force on A due to B $= \frac{\mu_0 I^2 l}{2\pi d}$

Net force on A $= \frac{\mu_0 I^2 l}{2\pi d} - \frac{\mu_0 I^2 l}{4\pi d}$

$= -\frac{\mu_0 I^2 l}{4\pi d}$.

(c) → $B = \frac{\mu_0}{4\pi} \frac{i}{a} \theta$

$60° = \pi/3$

$B = \frac{\mu_0}{4\pi} \frac{i}{r} \times \frac{\pi}{3}$

$= \frac{\mu_0 i}{12 r} = \frac{\mu_0 \times 5}{12 \times 0.5}$

$= 1.0 \ldots \times 10^{-6}$ ... 04×10^{-6} T.

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)

(a) → The time taken by a radioactive substance to disintegrate half of its atoms is called half life.

The mean life of a radioactive substance is equal to the sum of total life of the atoms divided by the total number of atoms in the element.

$$T_{mean} = \frac{1}{\lambda}$$

$$T = \frac{0.693}{\lambda}$$

$$T_{mean} = \frac{T}{0.693} = 1.443\,T$$

∴ Mean life of a radioactive substance is longer than its half life.

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∴ Mean life of a radioactive substance is longer than its half life.

(b) (i) → 5

(ii) $T_{1/2} = \frac{0.693}{\lambda}$ and $\lambda = \frac{0.693}{5} = 0.1386\,m$

$T_{avg} = 1/\lambda = 1/0.1386 = 7.21$

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(xii) $t_{1/2} = 5\ min$

$$\frac{A}{A_0} = \left(\frac{1}{2}\right)^{t/t_{1/2}}$$

$$\frac{5000}{40000} = \left(\frac{1}{2}\right)^{t/5}$$

$$\left(\frac{1}{2}\right)^{3} = \left(\frac{1}{2}\right)^{t/5}$$

$$t/5 = 3$$

$$t = 15\ min$$

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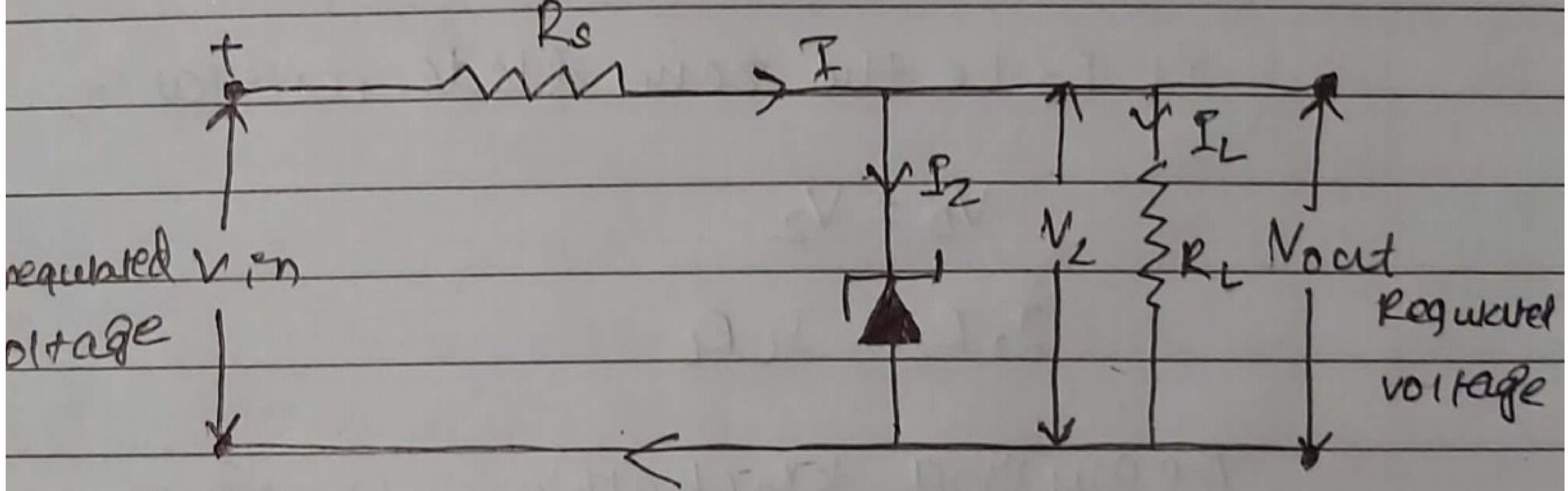
(8) (a) → A heavily dropped P-N junction diode which works in reverse breakdown region with a sharp breakdown voltage is called zener diode.

(b) → When the zener diode is reverse biased the junction potential increases. As the breakdown voltage is high this will provide high voltage handling capacity.



The zener diode and load resistance are connected in parallel such that the zener diode is reverse biased. The output voltage remains constant and is equal to zener voltage for the wide variation of input voltage and load resistance.

When $V_{in} < V_z$, then no current will follow through the zener diode.

When $V_{in} > V_z$, then the zener breakdown occurs and further increase in voltage will increase only the current but the voltage remains constantly.

Applying Kirchoff's law at a junction,

$$I = I_z + I_L \quad \text{--- (1)}$$

If R_z be the zener diode resistance,

$$V_0 = V_z$$

$$I_z R_z = I_L R_L$$

Applying Kirchoff's voltage law,

$$I R_s + V_z = V_{in}$$

$$V_z = V_{in} - I R_s \quad \text{--- (1.2)}$$

$$V_0 = V_{in} - I R_s \quad \text{--- (2)}$$

Hence, voltage is regulated.

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(9)(a) → Moment of inertia also be defined as twice the K.E. of a rotating body when its angular velocity is unity.

from K.E of rotation of body,

$$KE = \frac{I\omega^2}{2}$$

$$I = \sum_{i=1}^{n} m_i r_i^2$$

$$I = \frac{2 \times K.E}{\omega^2}$$

If $\omega = 1$ rad/s, then $I = 2 \times K.E$

(b) → Rotational K.E $= \frac{1}{2} I\omega^2$

Its centre of mass has linear motion i.e, changes its position w.r.t time. so, it has linear K.E which is given by, Page: Date:

Total K.E (E) = $E_R + E_T = \frac{1}{2} I\omega^2 + \frac{MV^2}{2}$

Let 'r' be the radius of spherical body

$\omega = v/r$

$I = MK^2$

K is radius of gyration.

$$E = \frac{MK^2}{2}\left(\frac{v}{r}\right)^2 + \frac{Mv^2}{2}$$

$$\therefore E = \frac{Mv^2}{2}\left(\frac{K^2}{r^2} + 1\right)$$

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(c)

$\Rightarrow I = 0.1\ kg\ m^2$

$r = 0.2m$

$s = 2m$

$m = 1\ kg$

$\theta = 30^\circ$

$\omega = ?$

when the disc rolls down a distance 2m along the plane then

~~Loss of~~

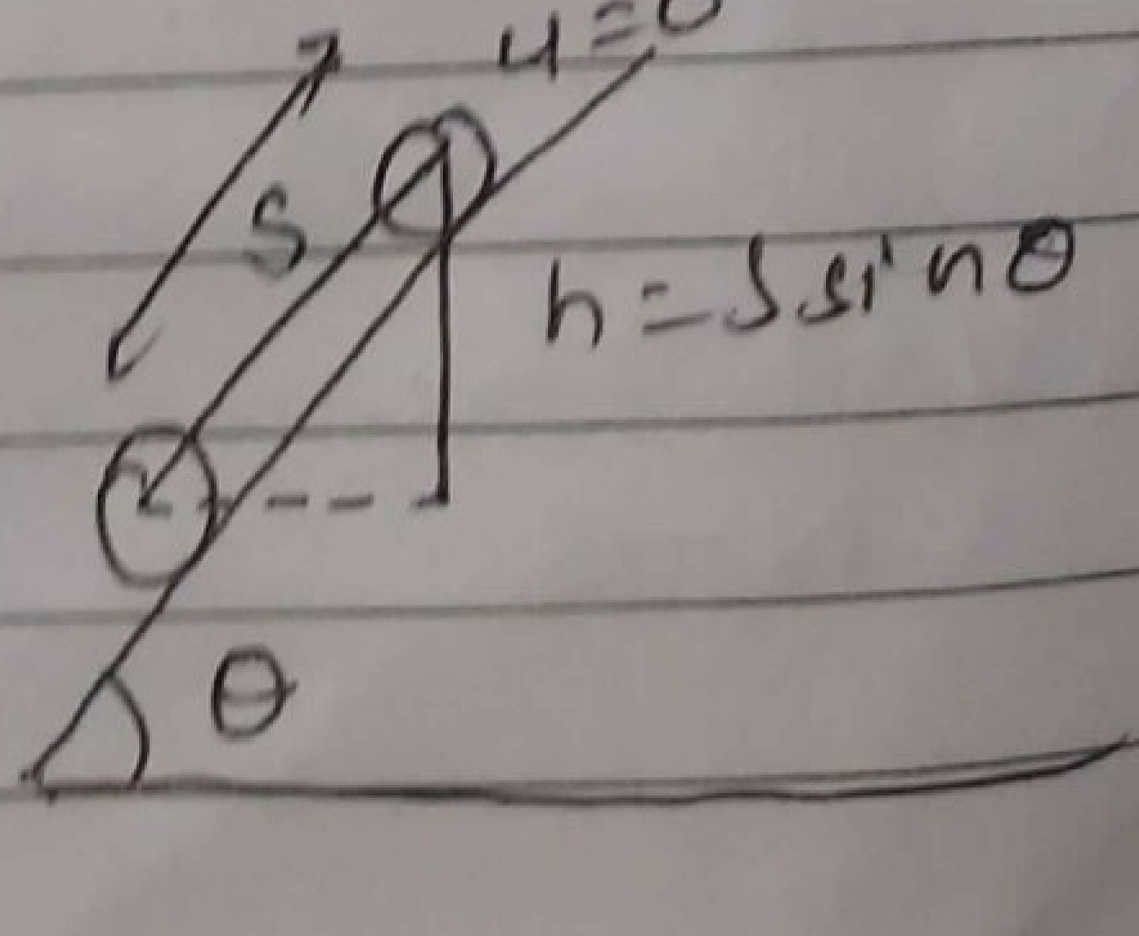
Loss in P.E.

$= mgh = mg\,s\sin\theta$ — (i)

Total K.E gained $= \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

$= \frac{1}{2}m\omega^2 r^2 + \frac{1}{2}I\omega^2$

$= \frac{1}{2}\omega^2(mr^2 + I)$ — (ii)



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From eqn (i) & (iv),

Loss in P.E = Gain in K.E.

$$mg\,s\sin\theta = \frac{1}{2}\omega^2(mr^2+I)$$

or, $5\times10\times2\times\sin30^\circ = \frac{1}{2}\omega^2[5\times(0.2)^2+0.1]$

or, $50 = \frac{1}{2}\omega^2\times0.3$

or, $\omega^2 = \frac{50\times2}{0.3} = 333.33$

$\therefore \omega = \sqrt{333.33}$

$= 18.25$ rads^{-1}.

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OR,

(a) → When an body is completely immersed in water, the opposing force acting on the body are,

(i) $f \propto \eta$

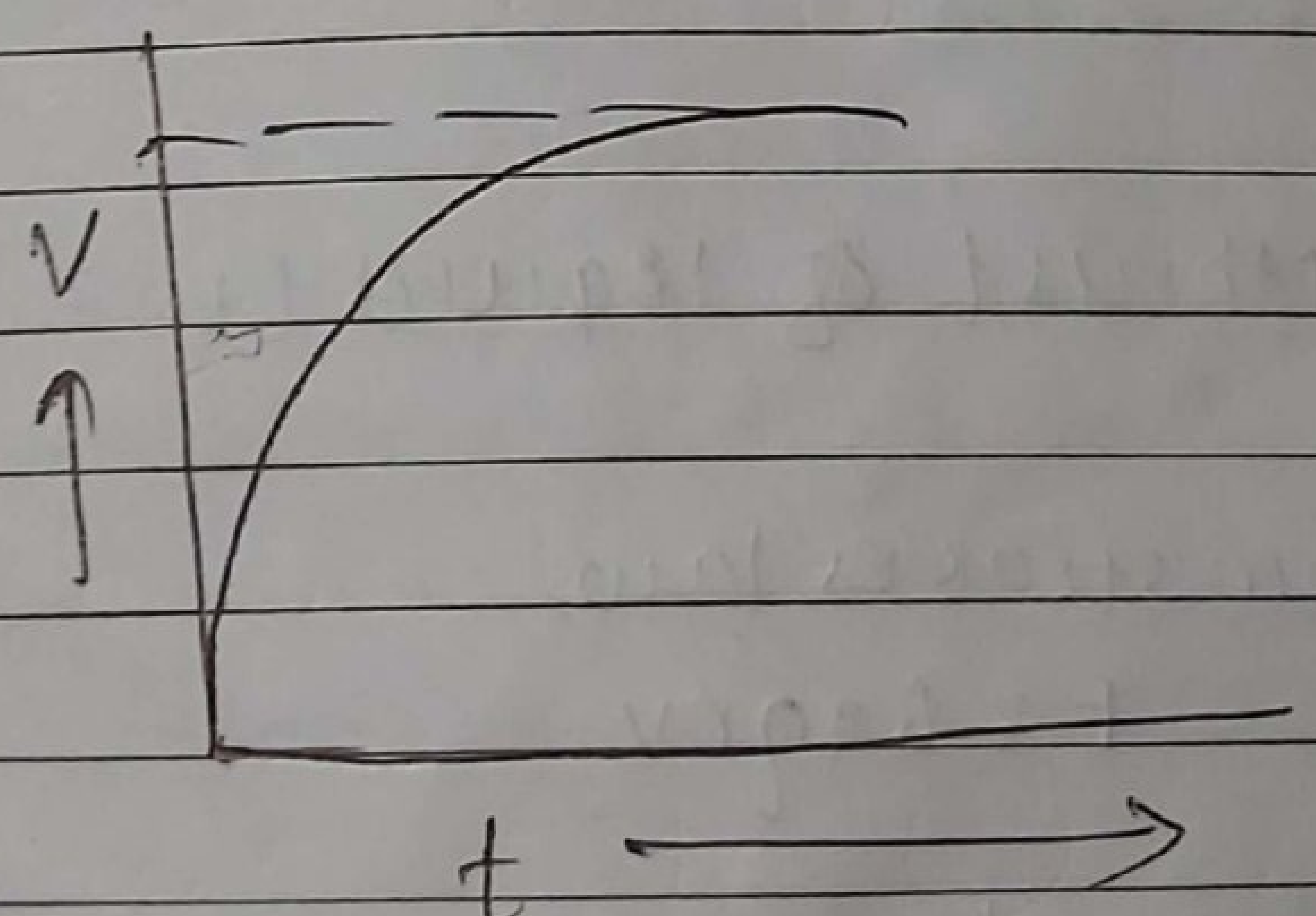
(ii) $f \propto r$

(iii) $f \propto v$

$\therefore f \propto \eta r v$

$$\boxed{f = 6\pi \eta r v}$$

(b) →



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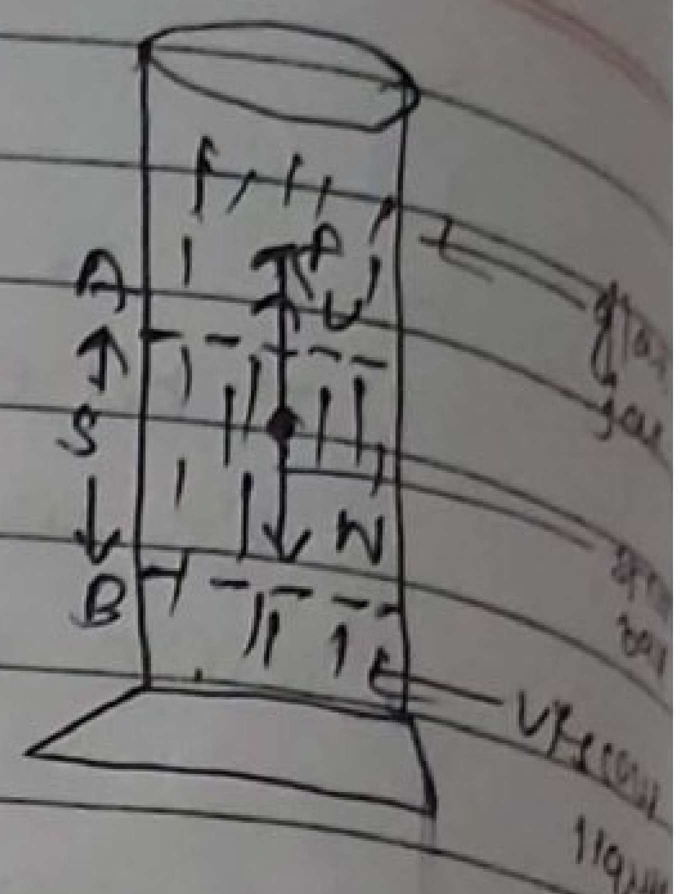
(b) →

Termination of velocity (v) = s/t



let; r = radius of spherical ball
ρ = density of material of spherical ball
σ = density of liquid.
η = coefficient of viscosity of liquid
v = terminal velocity of spherical ball.

Then,
weight of spherical ball (W) = mg
$= \left(\frac{4}{3}\pi r^3\right)\rho g$

Upthrust of liquid (U) = $\left(\frac{4}{3}\pi r^3\right)\sigma g$

From strokes law,
$F = 6\pi\eta r v$

When a ball attains terminal velocity,
Total upward force = total downward f

$U + F = W$

$F = W - U$

$6\pi\eta r v = \frac{4}{3}\pi r^3 \rho g - \frac{4}{3}\pi r^3 \sigma g$

or, $6\pi\eta r v = \frac{4}{3}\pi r^3 (\rho - \sigma) g$

$\therefore \eta = \frac{2r^2(\rho-\sigma)g}{9v}$ //

(c) → Falling of raindrops.

(a) → $dx = 2.5\,m$

$\eta = 10^{-3}$ decapoise

$f/A = 2 \times 10^{-3}\ N\,m^{-2}$

$dv = ?$

$f = \eta \cdot A \cdot \frac{dv}{dx}$

$dv = \frac{f \cdot dx}{A \cdot \eta}$

or, $dv = \frac{2 \times 10^{-3} \times 2.5}{10^{-3}}$ $\therefore dv = 5\,ms^{-1}$

(10)

(a)

→ $I_{rms} = \frac{I_0}{\sqrt{2}}$

Virtual value of A.C is 0.707 times the peak value of A.C.

(b) → (i) $I = I_0 \sin(\omega t)$

$\omega = 50\pi$

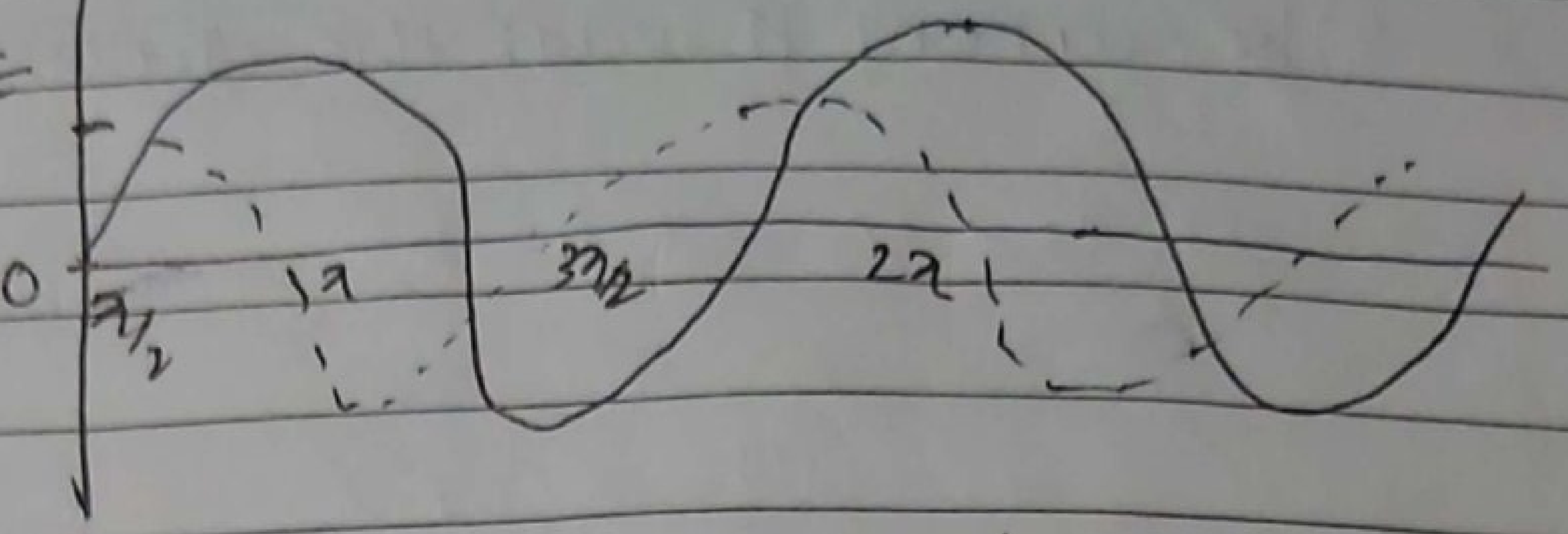
$2\pi f = 50\pi$

$f = 25 Hz$

(ii) → $I_{rms} = \frac{2}{\sqrt{2}} = \sqrt{2} =$ ~~0.707 ms⁻¹~~ 1.41 ms

$I = I_0 \sin(\omega t - \pi/2)$

→



from graph, it is seen that alternating current lags behind alternating e.m.f of phase angle $\pi/2$.

→ $E_v = 50V$

$F = 50Hz$

$L = 0.2H$

$R = 40\Omega$

p.d across resistor $(V_R) = 20V$

Let r be the resistance of the solenoid. The impedance in the circuit,

$Z = \sqrt{(R+r)^2 + X_L^2}$

$= \sqrt{(40+r)^2 + 4\pi^2 f^2 L^2}$

$= \sqrt{(40+r)^2 + 4\times10\times2500\times0.04}$

$= \sqrt{(40+r)^2 + 4000}$

The current through the circuit $= \frac{V_R}{R}$

$= \frac{20}{40}$

$= 0.5A$

Impedance of the circuit $= \frac{5V}{I_V} = \frac{50}{0.5} = 100\Omega$

$\sqrt{(40+r)^2 + 4000} = 100$

or, $(400+r)^2 + 4000 = 10,000$

or, $(40+r)^2 = 10,000 - 4000$

or, $(40+r)^2 = 6000$

or, $40 + r = 77.5$

$\therefore r = 37.5\Omega$.

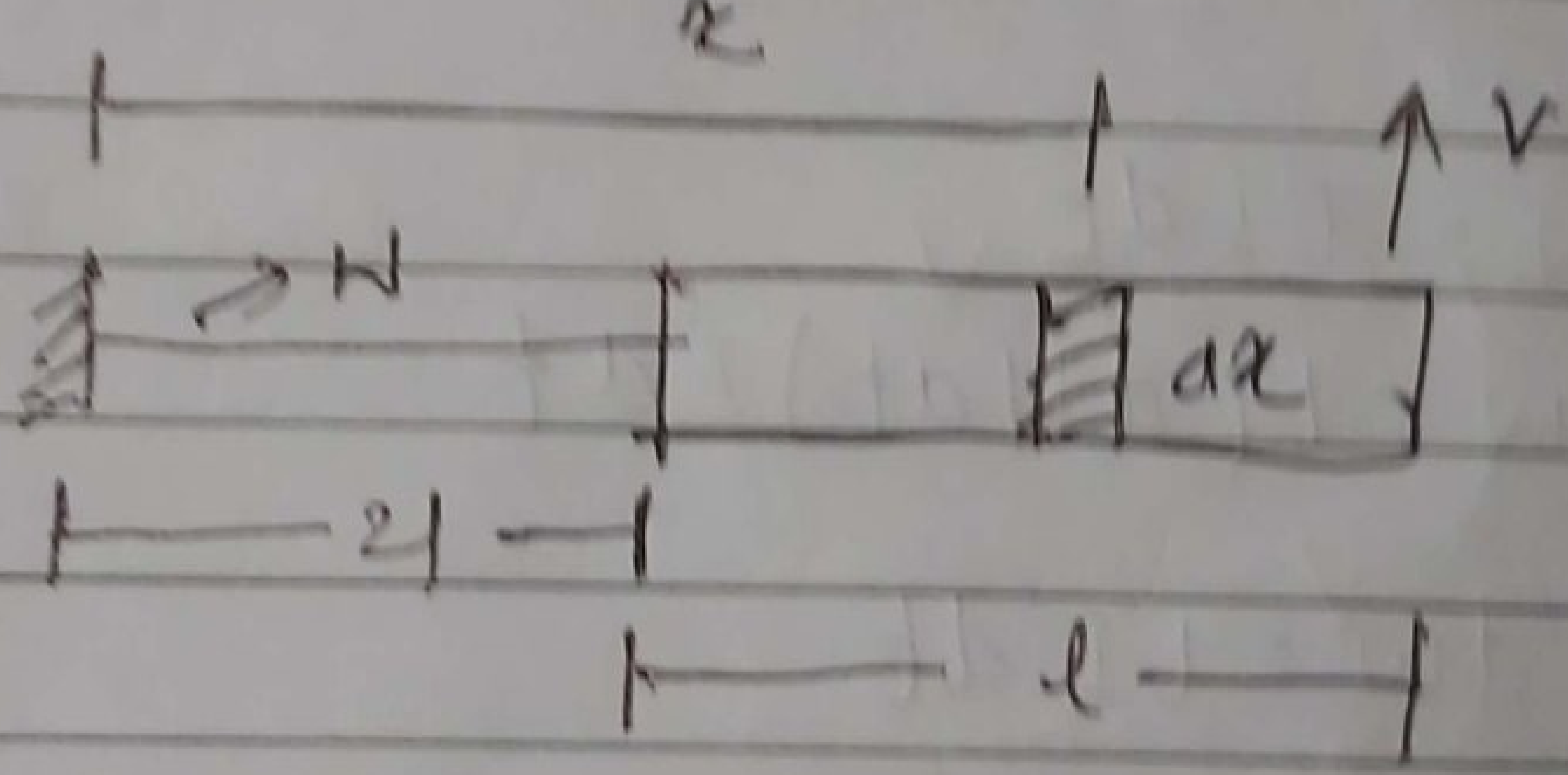
(4) a) $V = \int (\vec{v} \times \vec{B}) \cdot \vec{dl}$

$$V = \int_{2l}^{3l} x\, W\, B \cdot dx$$

$$= \frac{x^2}{2} W B \Big|_{2l}^{3l}$$

$$= \frac{9l^2 WB}{2} - \frac{4l^2 WB}{2}$$

$$= \frac{5l^2 WB}{2}$$



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(b)
→ let current flowing through the circuit at any instant t = I

rate of growth of current at that time = dI/dt

Induced emf set up in the circuit = E

$E = L\,dI/dt$

let dW be the work done by the source of electricity against back emf in a time dt.

$dW = EI\,dt$

or, $dW = L(dI/dt)I\,dt$

or, $dW = LI\,dt$

let W be the total work done by the source of current to change the current from 0 to its max[illegible]

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$$W = \int_0^I dW$$

$$= \int_0^I LI\,dI$$

$$= L\int_0^I I\,dI$$

$$= L\left|\frac{I^2}{2}\right|_0^I$$

$$= L\left(\frac{I^2}{2} - 0\right)$$

$$= \frac{1}{2} LI^2$$

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(11)
(i)

$$\frac{n_s}{n_p} = \frac{V_s}{V_p} = \frac{I_s}{I_p}$$

$$\frac{V_s}{V_p} = \frac{n_s}{n_p}$$

$$\frac{V_s}{220} = \frac{10}{1}$$

$\therefore V_s = 2200V$

$$\frac{n_p}{n_s} = \frac{I_s}{I_p}$$

$$1/10 = \frac{1}{I_p}$$

$\therefore I_p = 10A$

output power $= V_s I_s$
$= 2200 \times 1$
$= 2200W$

$h = \frac{eV_0}{f}$

→ Value of Planck's constant $= 6.62 \times 10^{-34}$ Js

$V_0 = \frac{h}{e} f - \frac{h}{e} f_0$

$V_0 = \frac{h}{e} f$

→ By Millikan's experiment (Determining the slope of curve between V_0 and f)

$\frac{e \cdot V_0}{f} = h$

(b) → To maintain temperature constant.

→ Planck constant $h = e \tan\theta$.

$$h = \frac{8 \times 10^{-19} \times 1.6}{(80 + 0) \times 10^{14}}$$

$$= 6.4 \times 10^{-34} \text{ Js}$$

(xi) → NO,

(A) → $f_0 = 10 \times 10^{14}$ Hz

$= 10^{15}$ Hz

$\phi = -KE_{max}$

$= -(-4 \times 1.6 \times 10^{-19})$

$= 4eV$

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OR,

$$r_n = \frac{\varepsilon_0 n^2 h^2}{\pi m e^2} \quad \text{— (I)}$$

$$r_1 = \frac{\varepsilon_0 h^2}{\pi m e^2} \quad \text{— (II)}$$

Dividing eqn (I) by (II)

$$\frac{r_n}{r_1} = \frac{\frac{\varepsilon_0 n^2 h}{\pi m e^2}}{\frac{\varepsilon_0 h^2}{\pi m e^2}}$$

$$\frac{r_n}{r_1} = n^2$$

$$\boxed{r_n = r_1 n^2}$$

(b) → velocity of electron in nth orbit is

$$v_n = \frac{e^2}{2\varepsilon_0 n h} \quad \text{— (I)}$$

radius of nth orbit of H-atom

$$r_n = \frac{\varepsilon_0 n^2 h^2}{\pi m e^2} \quad \text{— (ii)}$$

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We know,

$$v_n = r_n \omega$$

$$v_n = r_n \frac{2\pi}{T}$$

$$T_n = \frac{2\pi r_n}{v_n}$$

$$= \frac{\frac{2\pi \varepsilon_0 n^2 h^2}{\pi m e^2}}{\frac{e^2}{2 \varepsilon_0 n h}}$$

$$= \frac{4 \varepsilon_0^2 n^3 h^3}{m e^4} \longrightarrow \text{(iv)}$$

for, n = 1

$$T_1 = \frac{4 \varepsilon_0^2 h^3}{m e^4} \longrightarrow \text{(v)}$$

Dividing eqn (iv) by (v)

$$\frac{T_n}{T_1} = \frac{\frac{4 \varepsilon_0^2 n^3 h^3}{m e^4}}{\frac{4 \varepsilon_0^2 h^3}{m e^4}}$$

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$\therefore \frac{T_n}{T_1} = n^3$

$\therefore T_n = n^3 T_1$

proved

→ $m = 9.1 \times 10^{-31}$ kg
$e = 1.6 \times 10^{-19}$ C
$\varepsilon_0 = 8.854 \times 10^{-12}$
$n = 2$
$h = 6.62 \times 10^{-34}$ Js

we have,

$$f = \frac{me^4}{4\varepsilon_0^2 n^3 h^3}$$

$$= \frac{3.1 \times 10^{31} \times (1.6 \times 10^{-19})^4}{4 \times 7.84 \times 10^{-13} \times 8 \times (6.62 \times 10^{-34})^3}$$

$= 8.188 \times 10^{13}$ Hz