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WAKATA EXAMINATIONS COMMITTEE
"Affordable Quality Assessment"
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MARKING GUIDE MOCK 2024 PHYSICS P510/1

1.(a)(i) Is the way a derived quantity is related to the fundamental quantities of mass (M), length (L) and time (T) (01)

(ii) dim of L.H.S $= LT^{-1}$

Dim of R.H.S $= \frac{(LT^{-1}T^{-2})^{1/2}}{(ML^{-3})^{1/2}}$

$= LT^{-1}$

Since Dim of L.H.S = Dim of R.H.S then the relationship is dimensionally correct. (03)

(b)(i)

✓ Laminar flow is a type of fluid flow where the velocity of the layers equidistant from the axis of the tube are equal and layers are parallel to the axis of the tube.

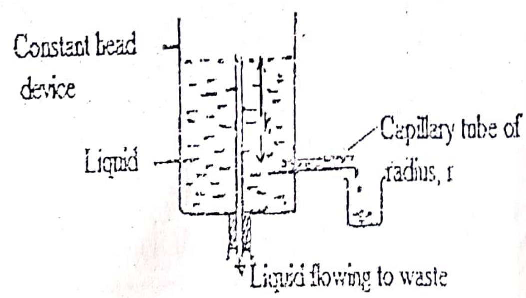
✓ Turbulent flow is a type of flow where the speed and direction of the fluid particles passing any point vary with time due to increase in flow velocity. (02)

(ii) Viscosity is due to the frictional force which exists between two adjacent layers of fluid which are in relative motion. (01)

(iii) Viscosity in liquids is due to the existence of molecular forces of attraction. But as the temperature increases, the intermolecular forces of attraction do weaken which consequently causes an increase in the molecular speeds and separation, therefore the viscosity of liquids decreases with increase in temperature. (02)

(c)(i) This is the frictional force per $1m^2$ area of a liquid (water) when it is in a region of $1s^{-1}$ velocity gradient.
(Reject unit area and unit velocity gradient) (01)

(ii)



✓ The liquid under test is made to flow steadily through the capillary tube from a constant head device and the volume, V of liquid which emerges in a known time, t is measured

✓ The pressure difference between the ends of the capillary tube is $h\rho g$, where ρ is the density of the liquid, h is the height of liquid above the capillary tube and g is the acceleration due to gravity.

From $\frac{V}{t} = \frac{\pi r^4 h\rho g}{8\eta l}$, the experiment is repeated for different values of h and a graph of $V/_t$ against h is plotted. The graph is linear and its slope, $s = \frac{\pi r^4 \rho g}{8\eta l}$ is determened

✓The coefficient of viscosity, $\eta = \frac{\pi \rho g}{8ls}$ (05)

(d)(i) Is the motion where the velocity of a body changes by equal magnitudes in equal time intervals no matter how small the intervals may be. (01)

(ii) During acceleration

$V^2 = u^2 + 2aS$

$20^2 = 0^2 + 2(1.25)S_1$

$\Leftrightarrow S_1 = 160m$

$S_2 = 1.56km$

$\Leftrightarrow S_2 = 1560m$

During deceleration

$V^2 = u^2 + 2as$

$0^2 = 20^2 - 2(2)S_3$

$\Leftrightarrow S_3 = 100m$

$\therefore$ Total distance, $AB = 160 + 1560 + 100$

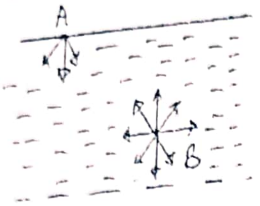
$= 1820m$ (03)

Total = 20 marks.

2. (a)(i) surface tension is the force acting normally on one side of an inaginally line of length $1m$ drawn in the liquid surface

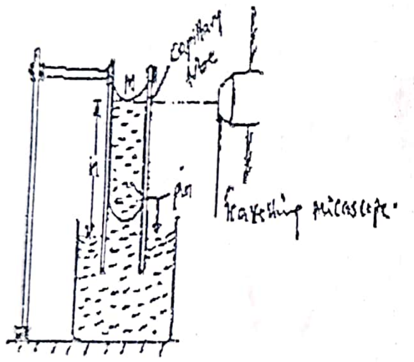
OR Is the work done in enlarging the srface area of a liquid by $1m^2$ under isotherenal conditions **(01)**

(ii)



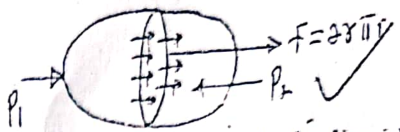
- ✓ According to molecular theory, surface tension is due to the intermolecular attraction between liquid molecules.
- ✓ A molecule like B inside the liquid is atttracted equally in all directions by neigbouring molecules so the net force on it is zero.
- ✓ However for a molecule like A in the surface the intermolecular separation is greater than the equilibrium value. Hence they experience attraction on either side due to their neighbouring molecules which puts them in a state of tension So liquid surface behaves like an elastic skin. **(04)**

(b)



- ✓ A clean capillary tube is supported in a beaker full of the liquid by use of a retort stand. A pin bent at <u>right angles</u> at two places is attached to the capillary tube by a rubber band.
- ✓ The pin is adjusted until its point touches the horizontal level of the liquid in the beaker.
- ✓ A travelling microscope is focused on the bottom of the meniscus, M and the scale reading h_1 is noted. With the beaker removed, the micrpscope is focused on the tip of the pin that was touching the liquid surface and scale reading h_2 is noted. The capillary rise, $h = |h_2 - h_1|$
- ✓ The radius, r of the capillary tube is got by breaking the tube at the menisus level and measuring the diameter using the travelling microscope. The angle of ... is measured and the surface tension, γ is got from the relation $\gamma = \frac{hr\rho g}{2cos\theta}$, Where ρ is the density of the ...

(c)



Consider a bubble formed inside the liquid

At equilibrium

External force exerted by P_1 + surface tension force = inside force exerted by P_2.

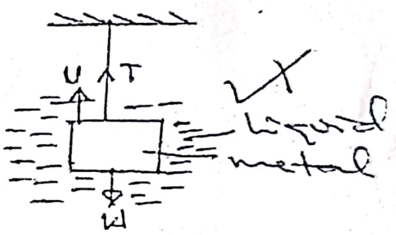
$2\pi\gamma r + \pi r^2 P_1 = \pi r^2 P_2$.

$(P_2 - P_1)r = 2\gamma$

$P_2 - P_1 = \frac{2\gamma}{r}$ is the pressure difference. **(05)**

(d)(i) Archimedes principle states that "when a body wholly or partially immersed in a fluid it experiences an upthrust equal to the weight of the fluid displaced.

(d)(ii)



$T = tension\ in\ string$

$Weight, W = mg = 4 \times 9.81$

$= 39.24N$

volume of metal $= m/\rho = \frac{4}{9.2\times10^3}$

$= 4.35 \times 10^{-4} m^3$

But volume of metal = volume of liquid displaced

Weight of liquid displaced = up thrust

$= 4.35 \times 10^{-4} \times 1000 \times 9.81$

$= 4.265N$

At equilibrium

Apparent weight = Tension + Up thrust weight

But apparent weight = Real weight + Up thrust

$= 39.24 - 4.265$

$= 34.97N$

$\Leftrightarrow T = 34.97 - 4.265$

$\therefore T = 30.705N$

Total = 20 marks

3.(a)(i) Spring constant is the measure of the stiffness of a spring (01)

(ii) Work done is stretching a spring by a force, F
= Average force × extension.
Before the spring is stretched, force, F=0

Average force $= \frac{F+0}{2}$

$= F/_2.$

Work done $= F/_2 \times e$

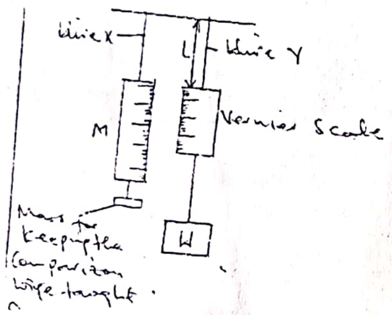
But $F = Ke$ (from Hooke's law)

$\therefore Work\ done = 1/_2\, ke^2$ (02)

(b)(i) This is the stress per tensile strain of a material.(01)

Or $E = \frac{stress}{strain}$

(ii)



- ✓ Two thin, long wires X and Y of the same material and length are suspended from a rigid support.
- ✓ Initial loads are added at the ends of X and Y to remove kinks
- ✓ Various loads are added at the end of wire Y (test wire) and the corresponding extensions caused are read off from the Vernier scale.
- ✓ After reading the load should be removed to check that the wire returns to its original position showing elastic limit has not been exceeded.
- ✓ Using a micrometer screw gauge the diameter, d of the test wire (Y) and hence cross – sectional area, A is determined.
- ✓ The original length of the wire, l is measured from a rigid support up to the Vernier scale.
- ✓ A graph of load against extension is plotted and its slope, S determined

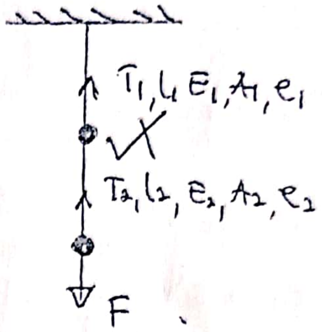
$Young's\ Modulus,\ E = \frac{Sl}{A}$

Where $A = \pi r^2$

$= \frac{\pi d^2}{4}$

$\therefore E = \frac{4Sl}{\pi d^2}$ (05)

(c)(i)



Total extension, $e = e_1 + e_2.$

$F = T_1 = T_2$ for series

$\frac{E_1A_1e_1}{l_1} = \frac{E_2A_2e_2}{l_2} = \frac{E_2A_2(e-e_1)}{l_2}$

$\frac{E_1A_1l_2e_1}{E_2A_2l_1} = e - e_1$

$E_1A_1l_2e_1 = E_2A_2l_1e - E_2A_2l_1e_1$

$(E_1A_1l_2 + E_2A_2l_2)e_1 = E_2A_1l_1e$

$\therefore e_1 = \frac{E_2A_2l_1e}{E_1A_1l_2+E_2A_2l_1}$

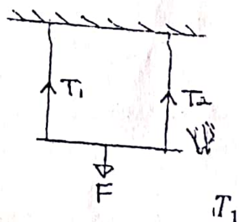
$\Leftrightarrow e_1 = \frac{E_2A_2l_1e}{E_1A_1l_2+E_2A_2l_1}$

$F = T_1 = \frac{E_1A_1e_1}{l_1}$

$= \left(\frac{E_1A_1E_2A_2l_1e}{E_1l_2A_1+E_2l_1A_2}\right)\frac{1}{l_1}$

$\therefore \quad F = \frac{eE_1E_2A_1A_2}{E_1l_1A_1+E_2l_1A_2}$ (04)

(ii)



$T_1 = \frac{E_1A_1e}{l_1}$

$T_2 = \frac{E_2A_2e}{l_2}$

$e_1 = e_2 = e$

$F = T_1 + T_2$

$$F = \frac{E_1A_1e}{l_1} + \frac{E_2A_2e}{l_2}$$

$$= \frac{E_1A_1el_2+E_2A_2el_1}{l_1l_2}$$

$$F = e\left(\frac{E_1A_1l_2+E_2A_2l_1}{l_1l_2}\right)$$

$$\text{Energy} = \frac{1}{2}T_1e + \frac{1}{2}T_2e$$

$$= \frac{1}{2}(T_1+T_2)e$$

$$= \frac{1}{2}Fe$$

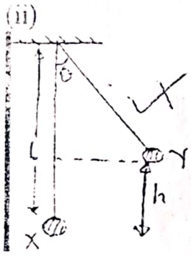
$$= \frac{1}{2}e^2\left(\frac{E_1A_1l_2+E_2A_2l_1}{l_1l_2}\right)$$

Assumption: Elastic limit is not exceeded.

(03)

(d)(i)It states that "in a closed system the total amount of energy is constant provided there are no external forces present"

(ii)



Potential energy, $PE = mgh$

But h $h = l - l\cos\theta$

$$= l(1-\cos\theta)$$

$$PE = mgl(1-\cos\theta)$$

$$= \frac{mgl(1-\cos\theta)\times(1+\cos\theta)}{(1+\cos\theta)}$$

$$= \frac{mgl(1^2-\cos^2\theta)}{1+\cos\theta}$$

$$\therefore PE = \frac{mgl\sin\theta}{1+\cos\theta}$$

(03)

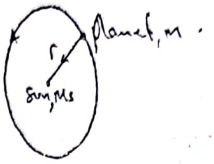
Total = 20 marks.

4. (a)(i) 1[st] **law:** Planets move in orbits which are eliptical with sun as one focus.

2[nd] **law:** Line joining sun and planet sweeps out equal areas in equal times.

3[rd] **law:** The squares of period of planets about sun are proportional to cubes of mean distance.

(ii) Newtons universal law of gravitation states that force of attraction between the planets is directly propertional to the product of the masses and inversely proportional to the square of distance between them.



$$F_1 = \frac{GM_sm}{r^2}$$

$$F_2 = m\omega^2r \text{ but } F_1 = F_2$$

$$GMs = \omega^2r^3 \text{ but } \omega = \frac{2\pi}{T}$$

$$GMs = \frac{4\pi^2r^3}{T^2}$$

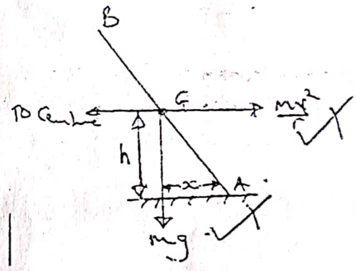
$$T^2 = \frac{4\pi^2r^3}{GMs}$$

But $\frac{4\pi^2}{GMs}$ is a constant

$$\therefore T^2 \propto r^3$$

(05)

(b)



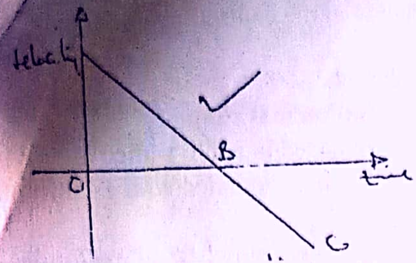
Rider's body experiences a centripetal force $F = \frac{mV^2}{r}$ which consitutes a moment $\frac{mV^2h}{r}$ about A on ground. This moment of F tends to turn the rider off the circular path. Hence it is necessary for him to lean towards the center so that the moment of his weight mgx balance $\frac{mv^2h}{r}$

(04)

(c)(i) It is motion of a body in a non- resistive medium

OR

Motion of body under the influnece of gravity. (01)



As the ball is thrown upwards with a velocity of $14.7ms^{-1}$ that is assumed to be positive, it is decelerated uniformly at $-9.81ms^{-1}$ and its velocity reduces to zero at B.

From $V = u + at \Leftrightarrow 0 = 14.7 - 9.81\ t_1$

$\Leftrightarrow t_1 = 1.5s$

So the time taken to reach the maximum point C i.e. the maximum height is 1.5s. The maximum height reached, h above the point of projection is given by the area under the triangle OAB

$\Leftrightarrow h = \frac{1}{2} \times 1.5 \times 14.7$

$h = 11.025m$

After reaching the maximum height i.e. point B, the ball falls downwards but its velocity is now negative since its direction is opposite to that along AB.

The acceleration it has is that due to gravity, g. It hits the ground at C. If t_2 is the ellapsed time to move from B to C, then from $S = ut + \frac{1}{2}at^2$

$\Leftrightarrow -19.6 = 14.7t + \frac{1}{2}(-9.81)t^2$

$-4 = 3t - t^2$

$t^2 - 3t - 4 = 0$

$(t - 4)(t + 1) = 0$

$t = 4s\ or\ t = -1s$

$\therefore t_2 = 4s$

If V_2 is the velocity of the ball at C, then from

$V^2 = u^2 + 2as$

$\Leftrightarrow V^2{}_2 = 0^2 + 2(9.81)(30.625)$

$V^2{}_2 = \pm 24.5\ ms^{-1}$

So $V_2 = -24.5ms^{-1}$ since it is due down wards.

(07)

Total = 20 marks

5.(a) Thermometric property is a physical property of a substance which varries uniformly and continuously with temperature.

(b) $R_\theta = R_0(1 + \alpha\theta + \beta\theta^2)$

When $\theta = 0^0C$

$R_0 = R_0(1 + \alpha(o) + \beta(0)^2) \Leftrightarrow R_0 = R_0$

When $\theta = 100^0C$

$R_{100} = R_0(1 + 100\alpha + 10{,}000\beta)$

$= R_0(1 + 100\alpha + 10\alpha)$

$R_{72} = R_0(1 + 72\alpha + 0.001 \times 72^2\alpha)$

$= R_0(1 + 72\alpha + (7.2)^2 \times 10^{-1}\alpha)$

Using $\theta = \frac{R_\theta - R_0}{R_{100} - R_0}$

$= \frac{R_0(1+72\alpha+5.184\alpha)-R_0}{R_0(1+100\alpha+10\alpha)-R_0} \times 100$

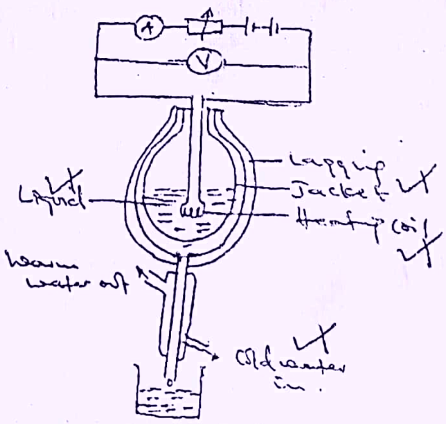
$= \frac{1+72\alpha+5.184\alpha-1}{1+100\alpha+10\alpha-1} \times 100$

$= \frac{72+5.184}{100+10}$

$\theta = 70.44^0C$ (05)

(c)(i) Specific latent heat of vaporization is the amount of heat required to change 1kg mass of substance to vapour at constant temperature. (01)

(ii) The liquid under test is heated to boiling point for some time untill the temperature of all parts of apparatus become steady.



- At asteady state the heat supplied is used in evaporating the liquid and off setting the heat losses.

- The mass m of the liquid emerging from the cendenser is then collected for measured time, t. If the mass collected per second is m and the reading of the voltimeter and ammeter are V and I respectively, then

$$\begin{matrix}\textit{Power supplied} \\ \textit{by heater}\end{matrix} = \begin{matrix}\textit{Power used in} \\ \textit{evaporation}\end{matrix} + \begin{matrix}\textit{Rate of heat} \\ \textit{loss to the} \\ \textit{sorrounding}\end{matrix}$$

$\Leftrightarrow IV = ml_V + h$ .... (1) where l_V is the specific latent heat of vaporisation of the liquid.

- The rate of Heat loses h can be eliminated by a second experiment with a different power input and evaporation rate.
- Suppose $I'V'$ and m' are the new values of current, and across the heat and evaporation rate respectively,

$$I'V' = m'l_V + h \text{ .... } (2)$$

$$Eqn\ (2) - eqn\ (2)$$

$$IV - I'V' = ml_V + h - (m'l_V + h)$$

$$l_V = \frac{IV - I'V'}{m - m'}$$

(07)

(d) Using $VI = \frac{m}{t} l_V + h$ ....(1)

$$4.60 \times 2.00 = \frac{5.50 \times 10^{-3}}{30 \times 60} l_V + h \text{ ....(1)}$$

$$3.00 \times 1.40 = \frac{2.20 \times 10^{-3}}{30 \times 60} Lv + h \text{........... (2)}$$

$$Eqn\ (1) - eqn\ (2)$$

$$\left(\frac{5.5 \times 10^{-3} - 2.2 \times 10^{-3}}{1800}\right) l_V = 9.20 - 4.20$$

$$\therefore l_V = 2.73 \times 10^6 Jkg^{-1}$$

(04)

(c) Evaporation causes the most energetic molecules at The liquid surface to escape. The molecules that remain are those with low kinetic energy. Since kinetic energy of molecules is directly proportional to temperature, the liquid cools. **(02)**

Total = 20 marks.

6.(a)(i) A reversible process is one which can be made to change the direction of its change of every stage by infinitesimal change in the controlling conditions.

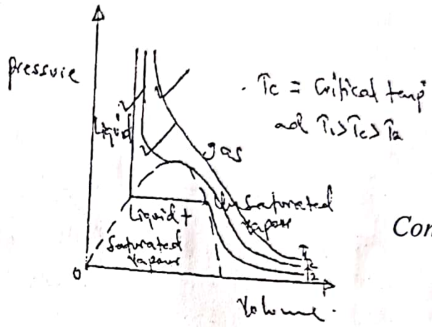
(ii) see conditions below

(iii) **Conditions for isothermal change**

- The gas has to be enclosed in a thin walled highly conducting vessel that is surrounded with a constant temperature bath.
- The change must occur very slowly to allow for the heat exchange so as to keep the temperature constant at every stage. *Any 1* (0

Conditions for adiabatic change

- The gas should be enclosed in a thick walled vessel.
- The change must occur very slowly to allow for the heat exchange so as to keep the temperaturre constant at every stage. (0



Consider shape (03)

(C) - $\frac{a}{v^2}$ is the pressure defect.

Because of intermolecular attractions, any molecule approaching the walls of the containor exerts less pressure than the pressure in the bulk. This accounts for the term $\frac{a}{v^2}$.

- b is the volume fraction. The volume of the molecules may not be negligible in relation to the volume of the contaniner occupied by the gas. Therefore b accounts for the finite volume of the molecules themselves.

(02)

(d)(i) The molar heat capacity at constant pressure is the heat required to raise the temperature of one mole of a gas at a constant pressure by $1K$. **(01)**

(ii) Consider one mole of a gas at a pressure p heated to cause the same temperature change dt at a constant pressure and then at a constant volume.

From the first law of thermodynamics,

$$dQ = du + dW$$

$$C_V dT = du + PdV.$$

But at a constant volume, $dV = 0$

$$\Leftrightarrow C_V dT = du$$

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At a constant pressure,

$$dQ = du + dW$$
$$dQ = du + PdV$$

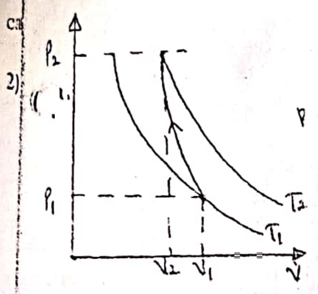
For an ideal gas, $PV = nRT$

but $n = 1$

$$PV = RT.$$
$$PdV = RdT.$$
$$\Leftrightarrow dQ = C_V dT + RdT$$
$$C_P dT = C_V dT + RdT$$

Dividing throug by dT,

$$C_P = C_V + R$$
$$\therefore C_P = C_V + R$$



$$p_1 V_1^{\gamma} = p_2 V_2^{\gamma}$$

$$\text{But } \gamma = \frac{C_P}{C_V} = \frac{2100}{1500}$$

$$\gamma = 1.4$$

$$760 \times V_1^{1.4} = P_2 \times \left(\tfrac{1}{2}V_1\right)^{1.4}$$
$$= P_2 \times \left(\frac{V_1}{2}\right)^{1.4}$$
$$= P_2 \times \left(\frac{V_1^{1.4}}{2^{1.4}}\right)$$
$$\therefore P_2 = 760 \times 2^{1.4}$$

Or $P_2 = 2005.7\ mmHg$.

For temperature adiabatically

$$TV^{\gamma-1} = constant$$
$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$$
$$290 \times V_1^{1.4-1} = T_2 \times \left(\tfrac{1}{2}V_1\right)^{1.4-1}$$
$$T_2 = 290 \times 2^{0.4}$$
$$\therefore T_2 = 382.66K$$

(04)

Total = 20 marks

7.(a) A black body is one which absorbs all the radiation of every wave length that falls on it. (01)

(b) Black body can be realised in practice by punching a small hole on the lid of an empty tin blackened with soot inside. Light which enters the tin through the lid has little chances of escaping because the energy that is not absorbed when the wall is first struck will be absorbed in the subsequent encounters with the walls after reflection. (02)

(c)(i) Stefan's law states that the total power radiated per meter^2 of a black body is directly proportional to the forth power of its absolute tempereture. (01)

OR

$$P = A\delta T^4,$$

$P = Power\ radiated$

$A = Surface\ area\ of\ body\ emitting$

$T = absolute\ temperature$

(ii) Assuming a black body

Net power absorbed per m^2

$$= \delta\left(T_2^{\,4} - T_1^{\,4}\right)$$
$$= 5.67 \times 10^{-8}(300^4 - 146^4)$$
$$= 433.5Wm^{-2}$$

$$\text{But net power absorbed } (m^{-2}) = \frac{Net\ heat\ absorbeds^{-1}}{surface\ area}$$
$$= \frac{mass \times SHC \times \Delta\theta}{surface\ area}$$

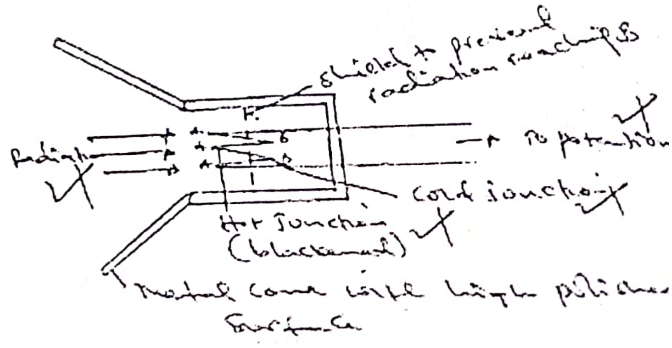
$$\Delta E = \frac{Net\ power\ absorbed\ m^{-2} \times Surface\ area}{mass \times SHC}$$

$$= \frac{433.5 \times 4\pi \times (6\times10^{-3})^2}{4\times10^4 \times {}^4/_3\pi(6\times10^{-3})^3 \times 3.7\times10^2}$$

$$\Delta\theta = 0.0146KS^{-1}$$

(0

(d)



(Any 4 points)

- Radiation is incident on exposed junction of the thermocouple.
- An emf is generated which depends on temperature between the junctions. **(04)**

(c)(i) Thermal conductivity is the rate of heat flow normal to $1m^2$ area when in a region of $1K\,m^{-1}$ temperature gradient. **(01)**

(ii) $$\frac{KA(\theta_2-\theta_1)}{L} = Mc\left(\frac{d\theta}{dt}\right)\theta_1$$

$$k = \frac{0.94\times400\times0.042\times3\times10^{-3}}{\pi(55\times10^{-3})^2\,(96-92)}$$

$$k = 1.25Wm^{-1}K^{-1}$$

(04)

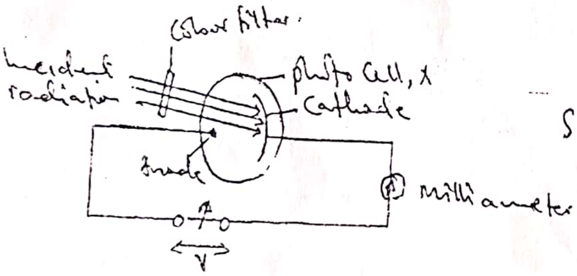
Total=20 marks.

8.(a) Photo electric emission is the ejection of electrons from a metal surface when electromagnetic radiations of very high frequency fall on the metal surface. **(01)**

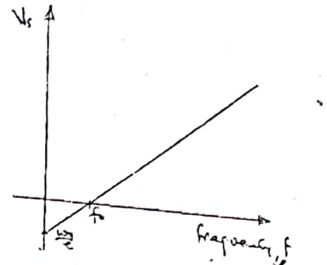
(b)- For a given metal, there is a minimum frequency of the incident radiation below which no photo electric emission occurs irrespective of the intensity of the radiaton.
- The number of photo electrons emitted per second or photo current is proportional to the intensity of the incident radiation.
- Photo electrons are emitted with variable kinetic energy which ranges from zero to a maximum. The kinetic energy increases with increase in frequency but it is independent of the intensity of the radiation.
- There is a negligible / no time lag between irradiation of metal surface and emission of elecrons by the metal surface.

(04)

(c)(i) Work function of a metal is the minimum amount of energy which must be supplied to a metal surface for it to discharge the outer most electrons. **(01)**



- Anode, A is made negative in potential relative to cathode, C using a potential divider.
- The photo electrons emitted from cathode, C when illuminated with a suitable beam do experience a retarding potential. The Pd, V is varied until the photo current becomes zero.
- The potential at that point is called stopping potential Vs and it is read off from the voltmeter.
- The procedure is repeated with light of different frequencies.
- A graph of V_s against, f is plotted and takes the shape below.



- The intercept C on the V_s. axis is determined.
- From Einstein's equation $V_s = \frac{hf}{e} - \frac{w_0}{e} \Rightarrow C = \frac{w_0}{e}$
- $w_0 = Ce$ when w_0 = work function, e = electron charge $(1.6\times10^{-19}C)$

(06)

(d)- Variation of maximum k.e with frequency. As per wave theory, increasing the intensity would mean increasing the energy per unit area so more energy would be absorbed by the electrons and consequently this would lead to an increase in the maximum k.e. But the maximum k.e. is dependent on frequency and independent of the intensity.
- Existence of thresh hold frequency. As per the wave theory, there's continuous absorption and accumulation of energy. Radiation of high enough intensity should therefore cause emission even when the frequency is below the minimum value. The theory cannot therefore account for a thresh hold frequency.
- Instantaneous emission. According to the wave theory, the energy incident on any particular electron is negligibly small such that the electron should take some considerable time to become free. This is contrary to the experimental observations where photo electric emission is an instantaneous process.

(06)

(e)Using $hf = hf_0 + eV$

$5.4\times10^{14}h = hf_0 + 1.2\times10^{-19}$ ……………(1)

$6.6\times10^{14}h = hfo + 2.0\times10^{-19}$ ……….(2)

$eqn\,(2) - eqn\,(1)$

$6.6 \times 10^{14}h = hf_0 + 2.0 \times 10^{-19}$

$-5.4 \times 10^{14}h = hf_0 + 1.2 \times 10^{-19}$

$1.2 \times 10^{14}h = 8 \times 10^{-20}$

$$h = \frac{8\times10^{-20}}{1.2\times10^{-14}}$$

$\therefore h = 6.667 \times 10^{-24} Js$

9.(a)(i)Binding energy for a nucleus is the energy needed to split the nucleus into its individual nucleons (01)

OR

Energy that is released in forming the nucleus from its components.

(ii) When a beam of $\alpha -$ particles is incident on a gold foil, most alpha particles pass through the gold foil un deflected.

Few $\alpha -$ particles are scattered through small angles.

Very few $\alpha -$ particles are scattered through angles greater than 90^0 (06)

Explanation.

- Since most alpha particles passed through un deflected, most space of the atom is empty.
- The small deflection of alpha particles was due to the repulsion by the positive charge.
- Very few $\alpha -$ particles were scattered through angles greater than 90^0 because the positive charge is concentrated in a small region of the atom.

Therefore, the positive charge of the atom and nearly all the mass is concentrated in a very small volume at the centre.

(iii) Total mass of 26 protons $= 26 \times 1.007825U$

$= 26.20345U$

Total mass of 30 neutrons $= 30 \times 1.008665U$

$= 30.259954U$

Total mass of nucleons $= 56.4634U$

Mass of nucleons $56.4634U$

Mass of $^{56}_{26}$Fe $= 56U$

Mass defect $= (56.4634 - 56)U = 0.4634U$

Binding energy $= 0.4634U \times 931$ MeV

$= 431.4254$ MeV

Binding energy per nucleon $= \dfrac{\text{binding energy}}{\text{Per no of nucleons}}$

$$= \frac{431.4254MeV}{56}$$

$= 7.704025MeV.$

But 1 MeV $= 1.6 \times 10^{-13} J$

$7.704025MeV = 7.704025 \times 1.6 \times 10^{-13}$

$= 1.232644 \times 10^{-12} J.$

$\therefore$ Binding energy Per nucleon $= 1.233 \times 10^{-12} J$ (04)

(b)At distance of closest approach

The initial kinetic energy of $\alpha -$ particle $=$ the electrostatic pottential energy of the $\alpha -$ nucleus system (04)

$$\frac{1}{2}mv^2 = \frac{(2e)(Ze)}{4\pi\epsilon_0 x_0}$$

$$\Leftrightarrow x_0 = \frac{4Ze^2}{4\pi\epsilon_0 mV^2}$$

$$\therefore x_0 = \frac{Ze^2}{\pi\epsilon_0 mV^2}$$

(c)(i) $2d\sin\theta = n\lambda$

Where d = inter atomic / planar spacing

$\theta =$ Glancing angle

$n =$ The order of diffraction

$\lambda =$ The wave length

OR Bragg's law states that the path difference when monochromatic x-rays strike the atoms in a crystal is equal to an integral multiple of wave length of the x-ray (01)

i.e. path difference$= n\lambda$.

(ii) $2d \sin\theta = 1.0 \times 10^{-10}$

$$d = \left(\frac{5\times10^{-11}}{\sin\theta}\right) m.$$

1 mole of $NaCl = 58.5g$

$= 5.85 \times 10^{-2} kg$

Mass of 1 molecule $= \dfrac{5.85\times10^{-2}}{2\times6.02\times10^{23}}$

$= 4.859 \times 10^{-26} kg$

Volume of 1 molecule $= d^3$

$$= \left(\frac{5\times10^{-11}}{\sin\theta}\right)^3$$

But Density $= \dfrac{mass}{volume}$

$$1980 = (4.859 \times 10^{-26}) \times \left(\frac{\sin\theta}{5\times10^{-11}}\right)^3$$

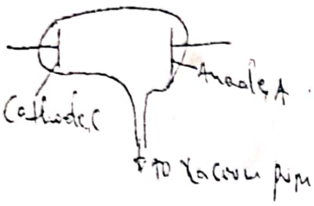
$\sin\theta = 7.986 \times 10^{-5}$

$\therefore \theta = 4.6^0$ (04)

Total = 20 marks

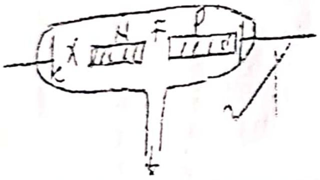
10. (a)(i)- They travel in straight lines.
- They are deflected by magnetic/ electric fields.
- They cause fluorescence
- They produce x-rays on hitting matter of high melting point.

(ii)



- Nothing is observed as air acts as an insulator at about 760mm Hg

Wavy violet streamers are observed at 100 mm Hg.



- A discharge becomes steady glow and spreads through the tube at a pressure of about 1-2 mmHg. A dark region called the cathode or Crooks dark space, X is formed nearest to the cathode. Beyond this dark space is a bright region called the negative glow, N which is followed by the faraday's dark space, F and beyond which is the luminous column called the positive column that fills the rest of the tube.

At about 0.01 mmHg the Crooke's dark space fills the tube and the negative glow and positive column disappears and the tube fluorescences.

(05)

Valency electrons in a metal are loosely bound to their parent nuclei. They move randomly through metal lattice. When a metal is heated sufficiently to high temperatures, surface electrons gain sufficient kinetic energy to over come their attraction by the atomic nuclei and leave metal surface. This process is known as thermionic emission.

(03)

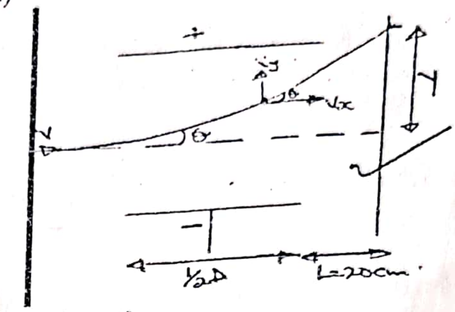
At low p.ds, the electrons emitted by cathode of the diode do not reach the anode. They form distribution of negative charge around the cathode called space charge.

(01)

(ii)Diode allows current flow only in one direction. If a.c source is connected in series with diode, and load, current flows through load only during positive half cycle, this is half wave rectification.

(ii) By use of Centre tap transformer and two diodes, current flows in the same direction during both half cycles, this is full wave rectification.

(d)



Vertical motion

$y = \frac{1}{2}at^2$ but $a = F/m$

$y = \frac{1}{2}\left(\frac{Ee}{m}\right)t^2$ ....(1)

$x = Vt$

$\Leftrightarrow t = x/V$

$y = \frac{1}{2}\left(\frac{Ee}{m}\right)\left(\frac{x}{V}\right)^2$

$y = \frac{1}{2}\left(\frac{Ee}{m}\right)\left(\frac{D}{V}\right)^2$

But $\tan\theta = \frac{y}{\frac{1}{2}D} = \frac{Y}{L+\frac{1}{2}D}$

$\frac{EeD}{mV^2} = \frac{Y}{L+\frac{1}{2}D}$ but $\frac{1}{2}mV^2 = eV$

$\frac{EeD}{2eV} = \frac{Y}{L+\frac{1}{2}D}$

$\frac{ED}{2V} = \frac{Y}{L+\frac{1}{2}D}$ but $E = V'/d$

$\frac{V'D}{2Vd} = \frac{Y}{L+\frac{1}{2}D}$ But $eV = 10^4 \times 1.6 \times 10^{19}$

since $V' = 10^4 V$

$\frac{Y}{22.5\times10^{-2}} = \frac{20\times5\times10^{-2}}{2\times10^4\times10^{-2}}$

$\therefore Y = 5.625 \times 10^{-4} m$

Total = 20 marks

******END********