MWALIMU EXAMINATIONS BUREAU

UACE RESOURCE MOCK EXAMINATIONS 2017

P510/1 PHYSICS MARKING GUIDE

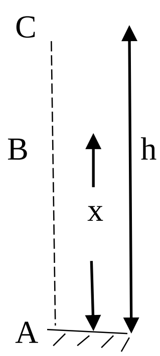
SECTION A

Qn.1 (a)(i). A conservative force is a force by which the work done on a body is moving from one point to another is independent of the path followed, but only depends on the initial and final positions of the body. **1mk**

Examples: gravitational force, electrostatic force, magnetic force, **any two examples ½ @**

(ii) In a conservative force field, the mechanical energy of a body is conserved. **1mk**

(iii) Consider a ball kicked vertically upwards from the ground so that it moves from point A to maximum height at C.



Let its initial velocity be u, mass =m

At A: Height =0, Potential energy P.e =0

kinetic energy k.e = $\frac{1}{2}mu^2$

mechanical energy of bcdl

$E_1 = 0 + \frac{1}{2}mu^2 = \frac{1}{2}mu^2$ **1mk**

At B
Height = x, P.e = mgx

Using $v^2 = u^2 + 2as$, where a = -g, s =x

We get $v^2 = u^2 - 2gx$

Kinetic energy = $\frac{1}{2}mv^2 = \frac{1}{2}m(u^2 - 2gx)$

- Mech energy
  $E_2 = mgx + \frac{m}{2}(u^2 - 2gx) = \frac{1}{2}mu^2$ **1mk**

  At C
  Height = h, p.e = mgh
  V=0, k.e = 0

full marks even when C not considered.

Using $v^2 = u^2 - 2as$,

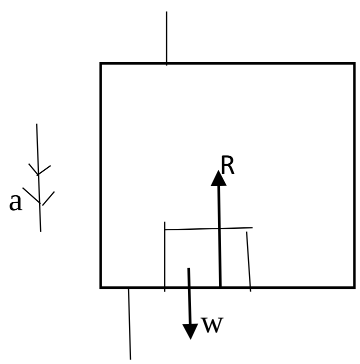
$O^2 = u^2 - 2gh$, $\quad h = \frac{u^2}{2g}$

- Mechanical energy
  $E_3 = mgh + O \quad = ½ \; mgh$ **1mk**

  $= mg.\frac{u^2}{2g} \quad = ½ \; mu^2$

Since $E_1 = E_2 = E_3$, mechanical energy of the ball is conserved **1mk**

(b). A body in a lift exerts its weight on the floor of the lift. By newton's third law, the lift exerts an equal and opposite force, the normal reaction when the lift is not moving. The resultant force on the body is zero. **1mk**



If the lift moves downwards with acceleration a =g,

the resultant force mg (N 2nd Law)

$\Rightarrow W - R = mg$ but $W = mg$

or $mg - R = mg$

$R = 0$ **1mk**

Where m is mass of the body since normal reaction R vanishes the body experience a ''feeling'' of weightless even when still on the floor of the lift. **1mk**

(c). (i). The total linear momentum of a system of interacting bodies remains constant provided no external force acts. **1mk**

(ii). $m_1 = 10kg$ $\quad u_1 = 45kmh^{-1} \quad = 12.5ms^{-1}$

$m_2 = 4x10^{-3}kg$ $\quad u_2 = 0$

Let V be the common velocity after collision from the principle of conservation of linear momentum.

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2 = (m_1 + m_2) V$

$10x12.5 + 0 = (10+0.004) V$

$V = 12.495 \; ms^{-1}$ **1mk**

Using the principle of conservation of energy we have

Change in kinetic energy = work done against friction.

$\frac{1}{2}(m_1 + m_2) v^2 - 0 = \mu (m_1 + m_2) g.s$

$V^2 = 2\mu gs$

$$s = \frac{v^2}{2\mu g} = \frac{12.495^2}{2x0.25x9.8}$$

$= 31.9$ m **Max 3mks**

OR

Applying $F = ma$

$-\mu(m_1 + m_2)g = (m_1 + m_2)a$

$a = -0.25x9.8 = -2.45ms^{-2}$ **max 2mks**

From $v^2 = u^2 - 2as$

$$s = \frac{v2 - u2}{2a} = \frac{O^2 - 12.49S^2}{2x(-2.45)}$$

(02mks)

$= 31.9m$ **max 2mks**

(d). (i). Scalar quantity is fully described by sating its magnitude only. **½ mk**

Examples, distance, mass, pressure **½ mk**

vector quantity is fully described by stating both its magnitude and direction. **½ mk**

Examples, displacement, force. **½ mk**

(ii). Time of flight is the total time taken by a projectile while through air from the initial point of projection to the final point where it stops moving. **1 mk**

The range is the horizontal distance moved from the initial to the final position along a horizontal place through the point of projection. **1 mk**

(iii). Initial speed = u, $\alpha = 30°$

Time of flight $T = \frac{2u\sin 30°}{g} = \frac{u}{g}$ s **2mks**

Or T= 0.102u s

Qn.2 (i). Tensile stress is the ratio of tensile force to the cross-sectional area of the wire **1mk**

Tensile strain is the ratio of the extension produced by the tensile force to the original length of the wire. **1mk**

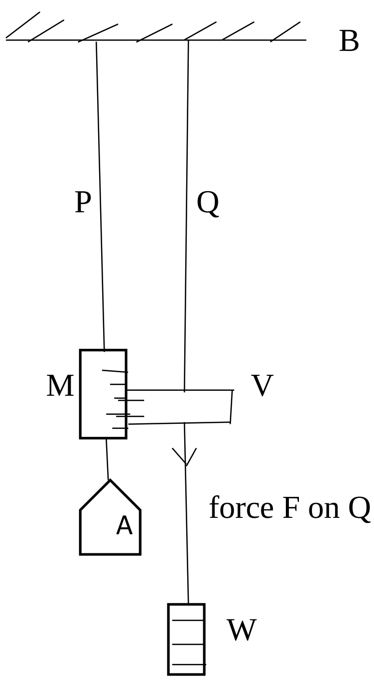
(ii). The proportional limit is the maximum point at which extension of a material is directly proportional to the applied force on a stress-strain graph. **1mk**

The elastic limit is the maximum point at which a material will regain its size and shape when the applied force is removed on a stress-strain graph. **1mk**

Between elastic and proportional limits a material regains its size and shape when applied load is removed but extension is not proportional to the applied load.

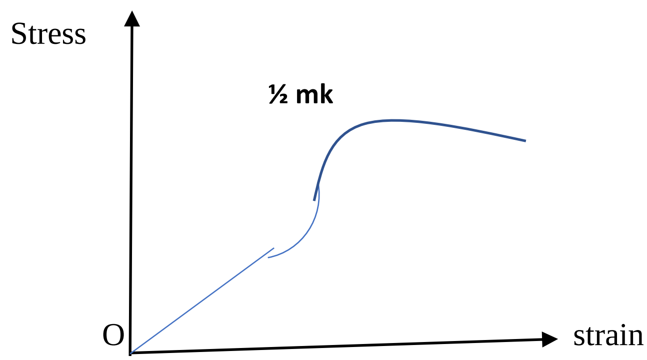
(b).

- Two long thin identical steel wires P, Q are suspended beside each other from a rigid support B. **1mk**
- Wire P is kept taut by a weight A at its end and carries a scale M. Wire Q carries a Vernier scale alongside M which measures the small extensions x of Q when the load W is increased. **1mk**
- Before adding weights to W, length L and diameter d of Q is measured and recorded. **1mk**
- As weight are added to W, the corresponding extension of Q is measured and strain of the values are calculated and recorded. **1mk**



1 mk provided it's labelled

- A graph of stress against strain is plotted and it appears as shown. **½ mk**



The slope of the straight line

Part of the graph = modulus of

Elasticity **1mk**

(c).(i). F = 60N L =2.5m E = 2.0×10^{11} Nm^{-2}

A = $0.22mm^2 = 0.22 \times 10^{-6} m^2$

$$E = \frac{FL}{Ae} \qquad = \frac{60 \times 2.5}{2.0 \times 10^{11} \times 0.22 \times 10^{-6}}$$ **(3mks)**

$= 3.41 \times 10^{-3}$ m

(ii). DL = αL (Δθ) α = 0.001% = 0.00001

= 0.00001 x 2.5 x4

= 1×10^{-4} m = 0.1mm **(3mks)**

(d). $V = \sqrt{\frac{E}{Y}}$

$[V] = LT^{-1}$

$$[E] = \frac{[stress]}{[strain]} = \frac{(MLT^{-2}/L^2)}{L/L} = ML^{-1}T^{-2}$$

$$[Y] = \frac{[mass]}{[volume]} = \frac{M}{L^3} = ML^{-3}$$

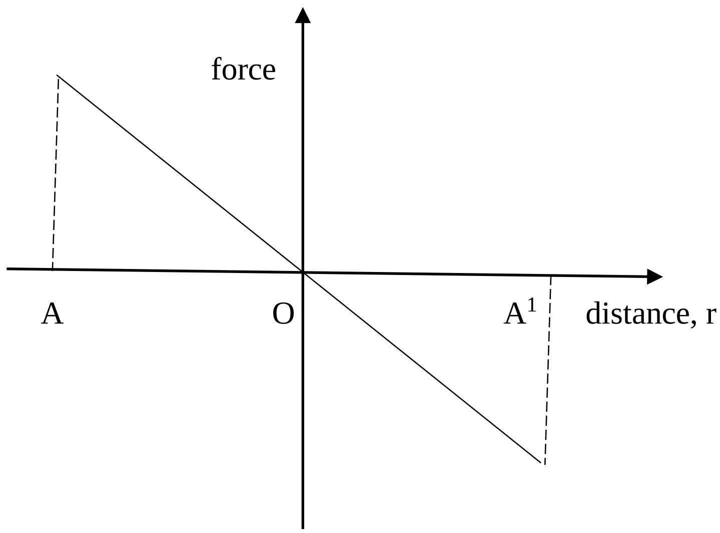
$$[R.H.S] = \sqrt{\frac{[E]}{[\gamma]}} = \left(\frac{ML^{-1}T^{-2}}{ML^{-3}}\right)^{\frac{1}{2}} = LT^{-1}$$

Since dimensions of LHS = dimensions of RHS, the equation is dimensionally correct.

Max 3mks

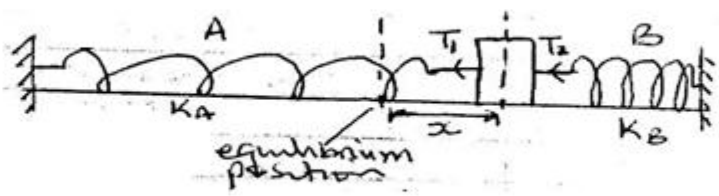
Qn.3 (a) (i). This is periodic motion in which the acceleration of a body is directly proportional to the displacement from a fixed point in the path of motion, and is always directed towards the fixed point. **1mk**

(ii)



2mks

(b). (i) When the block at displacement x from the equilibrium position to the right, the forces acting on it are as shown.



Mass of body = M. Spring constants are K_A, K_B for springs A and B resp.

$T_1 = K_A x$, $T_2 = K_B x$

Spring A is under tension whereas B is under compression. The resultant force away from equilibrium position is $F = -(K_A + K_B)x$

Applying Newton's second law of motion F =ma we obtain

$$m\frac{d^2x}{dt^2} = -(K_A + K_B)x$$

$$\frac{d^2x}{dt^2} = -\left(\frac{K_A+K_B}{M}\right)x = -w^2x$$

Hence $w = \sqrt{\frac{K_A+K_B}{M}}$

Freq. $= \frac{1}{T} = \frac{W}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{K_A+K_B}{M}}$ **Max 4mks** (ii). $K_A = K_B = 55.0Nm^{-1}$ $M = 50g = 0.05kg$

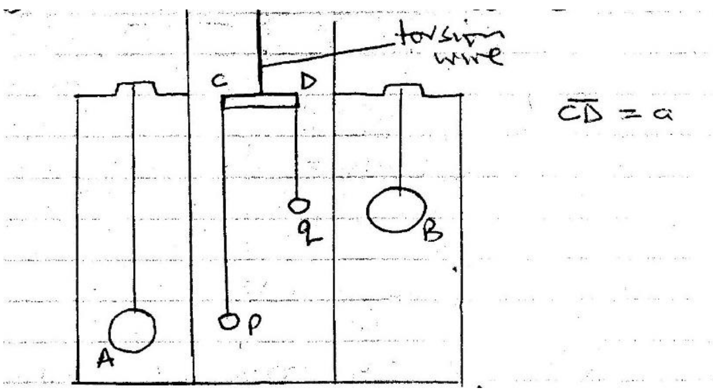
$$T = \frac{2\pi}{w} = 2\pi \sqrt{\left(\frac{M}{K_A+K_B}\right)}$$

$T = 2\pi \sqrt{\frac{0.05}{55+55}}$ $= 0.134$ s **Max 3mks**

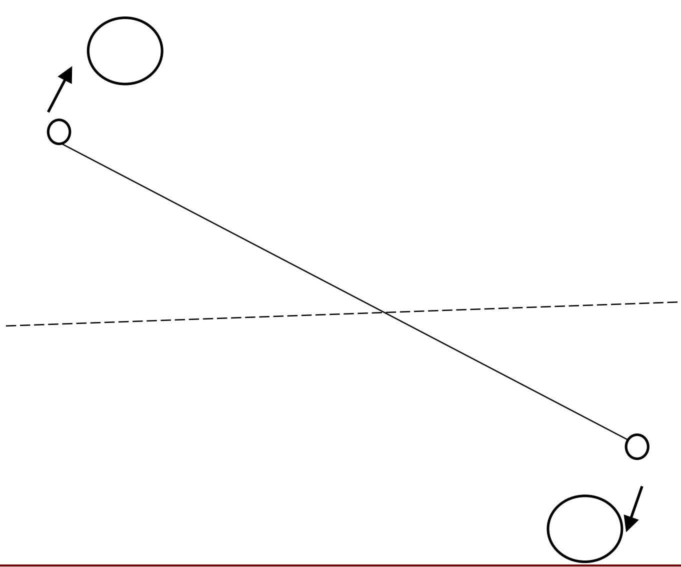
c (i). Two small gold balls p, q separated by distance a are suspended; one with a long thread and the other with a short thread.

Two large spheres A, B of lead are suspended by strings such that A rests adjacent to P and B adjacent to q.

Universal gravitational attraction between the small and large balls sets up a couple deflecting CD through angle θ . a ngle θ is measured and recorded.



let d be the distance between p and A or between q and B; m and M be the masses of p and A respectively.



Torque of the couple on CD = G $\frac{m\,M}{d^2}$ x a

But torque I = cθ where c is the torque per radian twist in the torsion wire.

Hence $\quad G\frac{m\,M}{d^2}$ x a $\quad = c\theta$

$$G = \frac{c\theta d^2}{mMa}$$

With known values of c, G can be determined. **Max 6mks**

(ii). For the moon in circular orbit of radius, its centripetal force is provided by the universal gravitational force of attraction towards the earth.

$$mrw^2 = \frac{GmM_e}{r^2} \quad \text{.................................} \text{ (eq1)}$$

Where m is mass of the moon, Me is mass of the earth and G the gravitational constant.

Suppose the moon was at the earth's surface, its weight would be equal to the universal gravitational force of attraction towards the center of the earth.

$$mg = \frac{GmM_e}{r_e^2} \quad \text{........................}\text{(eq2)}$$

Where r_e is the earth's radius.

Dividing equations eq2/eq1 we obtain

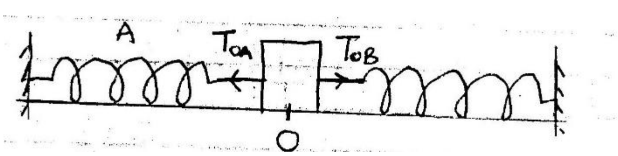
$$g = \frac{r^3w^2}{r_e^2} = \frac{r^3}{r_e^2}\left(\frac{4\pi^2}{T^2}\right)$$

But T = 27.3 days

$$g = \frac{(4.0x\ 10^8)^3}{(6.4x10^6)^2} \text{ x } \frac{4\pi^2}{(27.3x24x3tro)^2} = 11.1\text{ms}^{-2}$$ **Max 4mks**

Method II for 3(b) (i)

Let the extensions in springs A and B at equilibrium be e_1, and e_2 respectively.

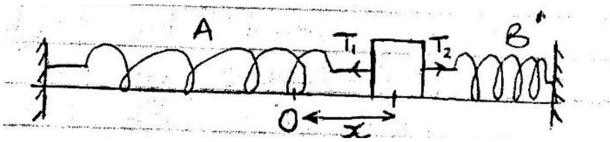


$To_A = KAe$, and $To_B = K_B e_2$

At equilibrium $To_A = To_A$

$= K_A(e_1) = K_B e_2$

Let the body be given a slight displacement x to the right.



The tensions now are

$T_1 = K_A (e_1 + x)$ and $T_2 = K_B (e_2 – x)$

Resultant force away from O is

$F = K_B (e_2 – x) - K_A (e_1 + x)$

$= K_B e_2 - K_B x – K_A e_1 - K_A x$

$= - (K_A + K_B) x$

From F = ma,

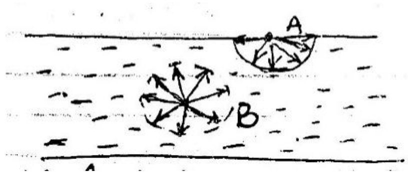
$$M \frac{d^2x}{d_t2} = - (K_A + K_B) x$$

$$\frac{d^2x}{d_t2} = \left(\frac{K_A+K_B}{M}\right)x \quad = -w^2x$$

4. (a).(i). Surface tension is the force acting per meter in the liquid surface at right angles to one side of an imaginary line drawn in the liquid surface. 1mk

$[\gamma] = mT^{-2}$ 1mk

(ii). Consider two molecules of a liquid; molecule A in the liquid surface and B inside the liquid. Molecule B is attracted equally in all directions. The net force on B is zero.



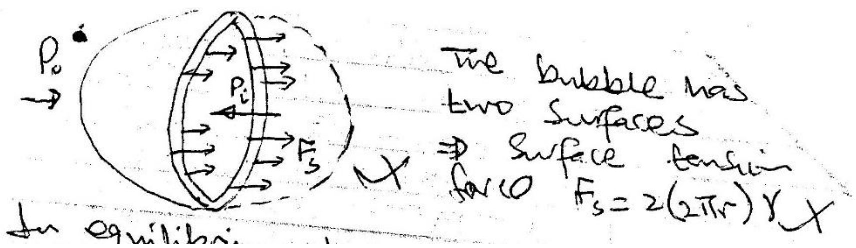
03

Molecule A has a net force acting on it because there are no molecules above the surface.
To bring a bulk molecule to the surface work must be done against the inward attraction. This work done is stored as potential energy and gives rise to surface tension.

(iii). Two applications of surface tension include: insect's ability to walk on water, liquid drops are spherical. **1mk**

(b). (i). Consider a soap bubble in air, let P_i P_o be the pressure inside and outside the bubble resp. of radius r and ɤ be the surface tension of the soap solution.

Consider the equilibrium of one half of the bubble. **1mk**



In equilibrium the resultant force is zero

$$\gg P_i \pi r^2 = P_0 \pi r^2 + 2(2\pi r)\gamma$$ **1mk**

$$P_i - P_o = \frac{4\gamma}{r}$$ **1mk**

OR $\Delta P = \frac{4\gamma}{r}$

(ii). Let r be the radius of new bubble after the two have coalesced.

$$V = V_1 + V_2$$

$$\frac{4}{3}\pi r^3 = \frac{4}{3}\pi(2.0)^3 + \frac{4}{3}\pi(3.0)^3$$

$$r^3 = 8 + 27$$

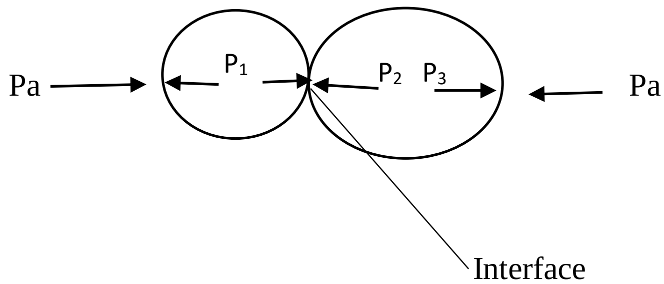
$$r = 3.27 \text{ cm}$$

Excess pressure $P = \frac{4\gamma}{r}$

$$P = \frac{4x2.6x10^{-2}}{3.27x10^{-2}} = 3.18 \text{ Nm}^{-2}$$ **Max 5mks**

Also consider alternative answer

Suppose the two bubbles coalesce such that they form a common interface.



Let r_1 = 2.0cm $\sqrt{2}$ = 3.0cm, and atmospheric pressure be Pa

$P_1 - P_a = \frac{4\gamma}{r_1}$

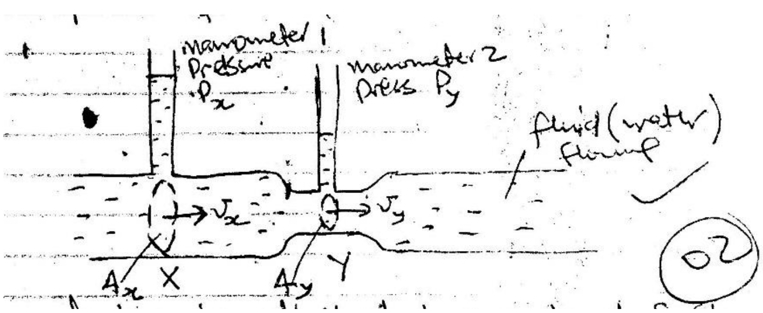
$P_2 - P_a = \frac{4\gamma}{r_1}$

Hence $P_1 - P_2 = 4\gamma\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$

Hence $P_1 - P_2 = 4x2.t\ x10^{-2}\ \left(\frac{1}{2x10^{-2}} - \frac{1}{3x10^{-2}}\right)$

$= 1.73\ Nm^{-2}$

(c). A venturimeter consists of a pipe with a construction. Manometers attached to two points measure the drop in presence, and into is used in determining the speed of the fluid in the tube.



The device is attached to the boat such that water passes through it at x with the speed of the boat.

Applying Bernoulli's equation at x and y gives

$P_x + ½\ \rho v_x^2 = P_y + ½\ \rho v_y^2$ …………………………………… (i)

If the cross-sectional areas at x and y are A_x and A_y. Then from the equation of continuity.

$A_x v_x = A_y v_x$ ………………………….. (ii)

$V_y = \frac{AxVx}{Ay}$

Sub in equation (i)

$$P_x + \tfrac{1}{2}\rho v_x^2 = P_y + \tfrac{1}{2}\rho\left(\frac{A_x v_x}{A_y}\right)^2$$

$$P_x - P_y = \tfrac{1}{2}\rho\left(\frac{A_x^2}{A_y^2} - 1\right)v_x^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{(iii)}$$

By measuring P_x & P_y, and determining Ax, Ay, the speed of the boat which equals speed v_x, of water through the still water. **Max 5mks**

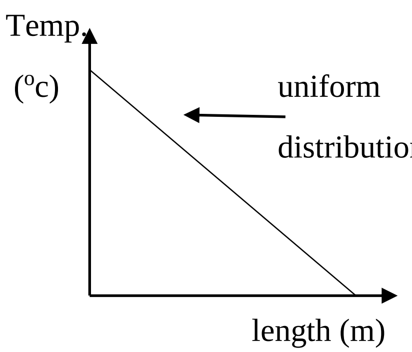
SECTION B (HEAT)

No5. (a)Coefficient of thermal conductivity SI unit is $Wm^{-1}K^{-1}$ **1mk**

- Is the rate of flow of heat between two surfaces of $1m^2$ separated by 1m length when the temperature difference between them is 1K. **OR**
- Is the rate of flow of heat per cross-sectional area of $1m^2$ by a temperature gradient of $1Km^{-1}$ **OR**
- Is the heat per second conducted thru an area of $1m^2$ by attempt gradient of $1Km^{-1}$ normal to the area. **1mk**

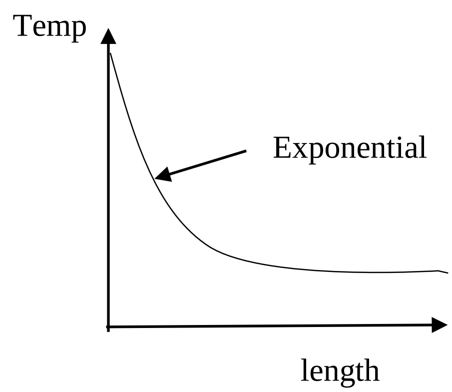
(b). Temperature distribution for

Lagged metal rod

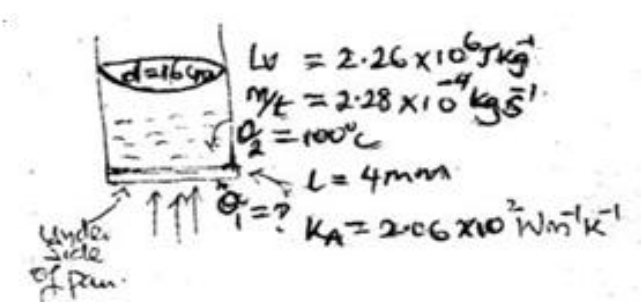


axes line ½ @

Unlagged metal rod



(c).



Rate of heat flow $\theta/_t = \frac{m}{t} l_v$ (i)

$$\theta/_t = \frac{KA\Delta\theta}{l} \quad \text{(ii)}$$

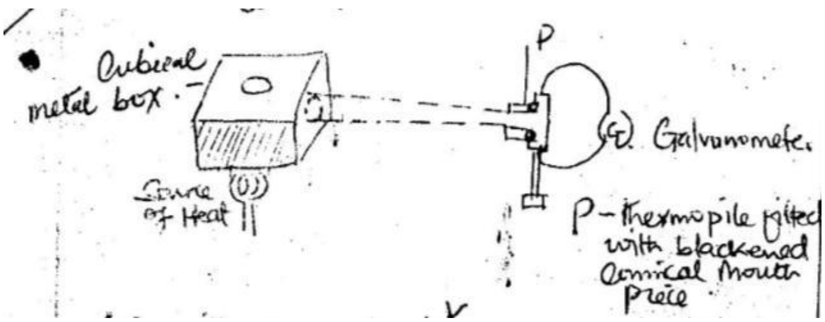
(i) = (ii), $\frac{m}{t} l_v = K\pi \frac{d^2}{4} \frac{(100-\theta)}{l}$

$2.28 \times 10^{-4} \times 2.26 \times 10^{6} = 2.06 \times 10^{2} \times \frac{22}{7} \times \frac{0.16^2}{4} \frac{(\theta-100)}{4 \times 10^{-3}}$

$(2.28 \times 2.26 \times 10^{2}) = 2.06 \times \frac{22}{7} \times 1.6 \times 10^{-2}$ (ϴ-100)

ϴ = 100.5°c

(d) Compare energy radiated by two different surfaces



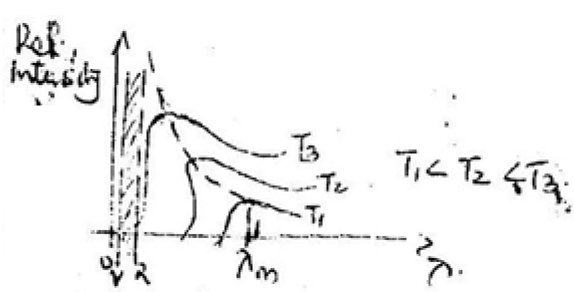
A cubical metal tank whose size has variety of furniture (dull black and highly polished) contains boiling water at constant temperature is facing the dark dull black face of the cube and least when it's facing the highly polished.

The highly polished is worst radiator of energy.

Dull black – is best radiator of energy.

3mks

e).

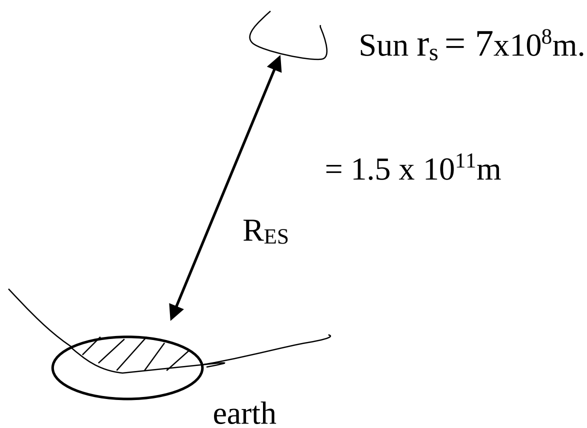


Characteristic features

- As temp. Increases, the intensities of every more length increases.
- At each temp, the intensity is max for a certain wave length, max, which decreases with increasing temperature
- But this this increase in intensity is more rapid for shorter wave lengths than for the longer wave lengths.
- The peak of each lure tends towards two visible as temperature increases.

4mks

f)



The solar constant is the solar energy falling per second at normal incidence on 1m area of the earth's surface. **1mk**

$$= \frac{\delta\, A_1 T_S^4}{A_2} \quad = \quad \frac{\delta.4\pi r_S^2 T_S^4}{4\pi R^2} \quad = \quad \frac{\delta.r_S^2 T_S^4}{R^2}$$

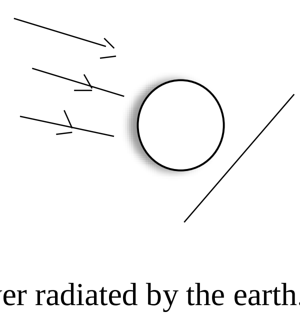
Power received by the earth

: P_a = solar constant x effective area on which radiation is incident. **1mk**

The effective area of earth on which the sun's radiation is incident is equal to the area of projection of earth onto a plane perpendicular to the rays of the solar radiation.

$$A_2 = \pi r_e^2$$

$$P_a = \frac{\delta.r_S^2 T_S^4}{R^2} = \pi r_e^2$$



1mk

Power radiated by the earth.

$$P_r = \delta.4\pi r_e^2 T_e^4$$

In radiation equilibrium power absorbed by = power radiated by the earth.

$$\frac{\delta.r_S^2 T_S^4}{R^2}.\pi r^2 \quad = \quad 4\delta\pi r^2 \, T_e{}^4$$

$T_e^4 \quad = \quad \frac{r_s^2}{4R^2} T_s{}^4$, $\quad R = R_{Es} + r_s$

$T_4 \quad = \quad \left[\frac{(7x10^0\,)^{\,2}}{4x(1.507x10^{11})2}\;\; (6000)^4\;\;\right]^{\frac{1}{4}}$ **1mk**

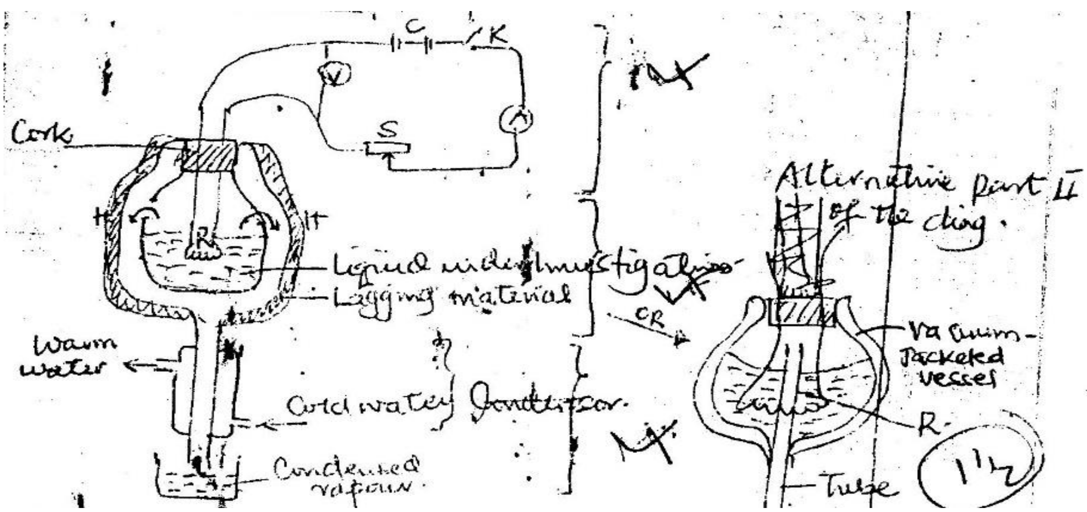
= 289.2k **1mk**

No.6

(a) (i). Specific latent heat – is the quantity of the energy required / given out when <u>1kg mass of a</u> substance (matter) changes from <u>one state to another</u> without change in temperature. **1mk**

(ii). The heat supplied goes to increase the Ke of the molecules so that they escape from the liquid surface, break the forces of attraction between them in order to free them, to give the freed molecules sufficient Ke in form of translation Ke. The breakdown of forces forms another state of matter with weaker forces (gaseous) state in a process called vaporization. **2mks**

b (i). Determination of SLH of vaporization.



Method.

- Using Rheostat S, an appropriate Loir I_1 is selected and passed through the heater R-the vapor produced passes through the holes H, and condensed as it passes through the condenser.
- At steady state (condensation ≈vaporization, evaporation) or at steady flow of condensed liquid, the liquid is now collected in the beaker for a time to the mass of liquid collected per unit time $\frac{m_1}{t_1}$ is obtained. **½ mk**
- The p.d V_i across the heater at B.P is read as V_1 assuming h as the heat lost to surrounding.
- Heat supplied by R = Heat received.

  $I_1V_1t_1 \quad = M_1L_v + h$

  $I_1V_1 = \frac{M_1}{t_1} Lv \;+ H$ ……………………. (i) **1mk**

In order to eliminate H, a 2nd set of reading is obtained under the same environmental conditions **½ mk**

If I, V and $\frac{m}{t}$ are the new current pd and mass evaporated per second resp. greater than set 1 then,

$IV = \frac{M}{t}$ Lv + H ……………………….. (ii) **1mk**

Equation (i) and (ii) $Lv = \frac{Iv - I_1V_1}{(\frac{m}{t} \frac{m_1}{t_1})}$ in$J\ kg^{-1}$ **1mk**

(ii). SLH of Vpn > SLH of fusion.

The change of state from liquid to gas <u>results in large increase in </u>volume and therefore a large amount of work has to be done against the surrounding atmosphere, the expanding gas to give the freed molecules sufficient K.e to escape, which is not the case with SLH of fusion. **2mks** (The energy appears partly as p.e of the molecules.)

c (i). Conditions for

<u>An adiabatic change</u>

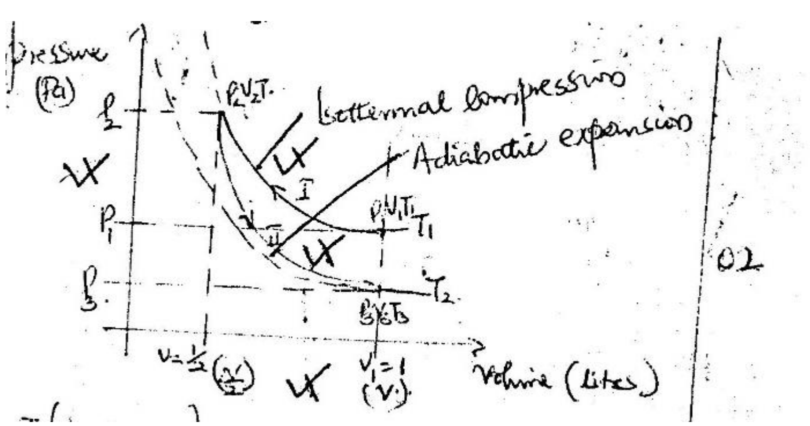
- The gas must be contained in a thick walled perfectly insulated and isolated container.
- The process must be carried out rapidly so that there is no time for heat to enter or leave the system. **2mks**

<u>An isothermal change</u>

- The process must be carried out very slowly so that internal energy doesn't change and allow enough time for the heat exchange.
- The gas is enclosed in a thin walled highly conducting water.
- The gas is enclosed in a constant temperature bath (vessel surrounded by a constant temperature reservoir)
- The piston must be frictionless for pressure outside and inside to be equal.

Any 2x1 = 2mks

(d)(i)



(ii). Using stage I (isothermal)

$P_1 = 1.0 \times 10^5$pa. P_2=?

$V_1 = 1L$ V_2= ½ L

T_1 =273 + 17 = 290K

P.V = const.

$P_1 V_1 = P_2V_2$

$$P_2 = \frac{P_1V_1}{V_2} = \frac{1.0x10^5x1}{\frac{1}{2}}$$

$P_2 = 2P_1$ **OR**

P_2 = $\underline{2.0 \times 10^5 \text{ pa}}$

Using stage (II) a diabatic

$P_2V_2^{\delta} = P_3V_3^{\delta}$

$P_3 = 2P_1(½)^{\delta} = P_3(1)^{\delta}$

$= 2P_1 (½)^{1.40-1}$

$= \underline{7.579 \times 10^4}$ pa

Using TV^{r-1} = Const.

$T_2V_2^{r-1} = T_3V_3^{r-1}$

$T_3 = T_2(½)^{1.40-1}$

$= 290(0.5)^{1.40-1}$

Final temperature (T_3) = $\underline{219.8 \text{ K}}$ **Max 04**

No.7

(a) (i) Thermometric fixed point.

- Is a single temperature at which it can be expected that a particular physical event always takes place **OR**
- It is a temperature that can be accurately obtained and reproduced to enable it to be used as a basis of a temp. scale. **1mk**

(ii). Tripple point of water

- Is that unique temp. at which pure ice, pure water and pure water vapor co-exist together in equilibrium. **OR**
- Is a point at which water exists mutually together in equilibrium (i.e. gas, solid and in liquid form). **1mk**

(iii). $X_t = X_0 + 0.50t + (2.0 \times 10^{-4})t^2$

At ice pt., X_0 on Celsius scale

$X_0 = X_0 + 0.50(0) + 2.0\times10^{-4}(0)^2$

$X_0 = X_0$

At steam pt., X_{100} on Celsius scale

$X_{100} = X_0 + (0.50 \times 100) + 2.0 \times10^{-4} (100)^2$

$= X_0 + 52$

At 50°C gas scale, X_{50} on Celsius scale

$X_{50} = X_0 + (0.50 \times 50) + 2.0 \times 10^{-4} (50)^2$

$= X_0 + 25.5$

Using $\theta = \left(\frac{X_{50}-X_0}{X_{100}-X_0}\right)$X 100°C

$= \left(\frac{X_0+2.55-X_0}{X_0-52-X_0}\right)$x 100°C

θ = 49.0°C **Max 04**

Celsius scale

(iv). It's because different thermometers have different thermometric properties that vary differently with temp. such that they are not necessary in step outside the two fixed points. **2mks**

OR

Precisely its because different thermometric properties respond differently to temperature variations (changes)

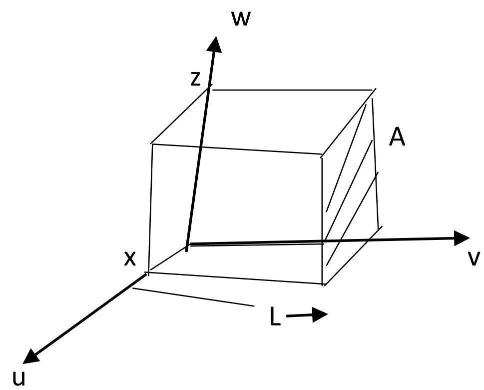
Compare

b.(i)

Ideal gas	Real gas
Is one which obeys all the gas laws exactly **OR** It's a gas which obeys Boyle's law under all conditions of pressure & temp	is one which possesses both attractive & repulsive **OR** Obeys the ideal gas equation only when they are at very low press & temperature above critical temp
Other ways to make the comparison	
Negligible intermolecular forces	appreciable intermolecular forces
Obeys Boyle's law exactly	Do not obey Boyle's law exactly

2mks

(ii). P = $\frac{1}{3}\rho\overline{c^2}$



consider molecule moving towards A with speed v, strike face A, & rebound with The same speed.

Momentum on impact is mv and on rebound is -mv **1mk**

Change in momentum =-2mv **1mk**

Force on the molecule due wall = Δmomentum of mol per second. (2nd Newton's law)

$= \frac{-2mv}{t}$ but t = $\frac{2l}{v}$ **1mk**

F = -2mv x $\frac{v}{2l}$

$\frac{-mv^2}{t}$ **½mk**

By 3rd Newton's Law; F = $\frac{mv^2}{t}$

Force exerted by N-molecule $F_N = \frac{m}{L}(v_1^2 + u_2^2 + - - v_3^2)$

Mean square $\overline{v^2}$ = $\frac{v_1+v_2^2+v_3^2)}{N}$ **½mk**

$F_N = \frac{Mn}{l}\overline{v^2}$ but P = F/A

P = $\frac{Mn\overline{V^2}}{l}$ $\frac{1}{l^2}$, l^3= v (volume of cuboid)

Mn= (mass of the gas)

P = $\frac{Mn\,(\overline{V^2})}{V}$ $\frac{Mn}{V}$ = ρ (density of gas)

P = $\rho\,\overline{v^2}$ ------------------- (i) **½mk**

For any molecule, the sq. of its resultant velocity C

$C^2 = \overline{u^2}+\overline{v^2}+\overline{w^2}$

For large N, molecules move randomly & there is no preference for any one direction.
Therefore the mean values of $\overline{u^2}$,$\overline{v^2}$,$and\ \overline{w^2}$
Are all equal i.e. $\overline{u^2} = \overline{v^2} = \overline{w^2}$
$\overline{v^2} = \frac{1}{3}\overline{c^2}$ ----------------------------------(ii)

$Subtitute\ (ii) in\ (i)$

$P = \frac{1}{3}\rho\overline{c^2}$ the pressure of an ideal gas **1mk**

c) (i). $T_1 = 0°C = 273K$, $T_2 = 130°C = 403K$,

$\rho = 1.43\ kgm^{-3}$

$P_1 = 1.0x10^5 Nm^{-2}$

$C_1 = ?$

Using $P_1 = \frac{1}{3}\rho\overline{c_1^2}$

$\overline{c_1^2} = \frac{3p_1}{\rho} = \frac{3\ x\ 1.0x10^5}{1.43}$

$\sqrt{\overline{c_1^2}} = 4.58 \times 10^2\ ms^{-1}$

Since $\sqrt{\overline{c_1^2}}\ \alpha\ T_1$ and $\sqrt{\overline{c_2^2}}\ \alpha\ \sqrt{T_2}$

$\sqrt{\frac{\overline{c_1^2}}{\overline{c_2^2}}} = \sqrt{\frac{T_1}{T_2}} = \sqrt{\frac{273}{403}}$

$\sqrt{\overline{c_2^2}} = \sqrt{\frac{273}{403}} \times 4.58 \times 10^2 ms^{-1}$

$\sqrt{\overline{c_2^2}}\ or\ Cms\ at\ 130°c = 5.56 \times 10^2\ ms^{-1}$ **Max 3mks**

(ii). On pumping the rate of change of momentum of the gas molecules increases due to the increased rate of bombardment with the barrel. This implies that the force exerted by the gas molecules on a unit area increases and since press of gas is due to the bombardment (no. of collision) of the walls of the barrel by the gas molecules, the no-of collections results into increased Ke which proportional to the temperature thus the pump of barrel gets warm.
1mk

[Can also give a summary using relevant equations/symbols]

8 (a)(i). Cathode rays are a beam of electrons moving at a high speed. **1mk**

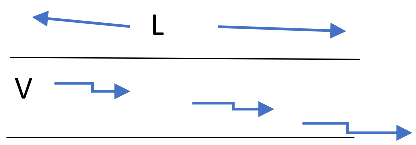
(ii). Kinetic energy of electrons = eV

v_1 = 3x10^3v

= ½ mv^2 = eV_1

V = $\sqrt{\left(\frac{2x2x10^3}{9.11\ x\ 10^{-31}}\right)}$ **2mks**

V = 3.246 x 10^7 ms^{-1}



L = 10cm = 0.1m
d= 5cm = 0.05m

Vertical force acting on electrons is

F = eE = $\frac{eV}{d}$ = ma

a= $\frac{eV_2}{md}$ V_2 = 1.0 x 10^3 **½ mk**

Since the initial vertical velocity V_y=0,

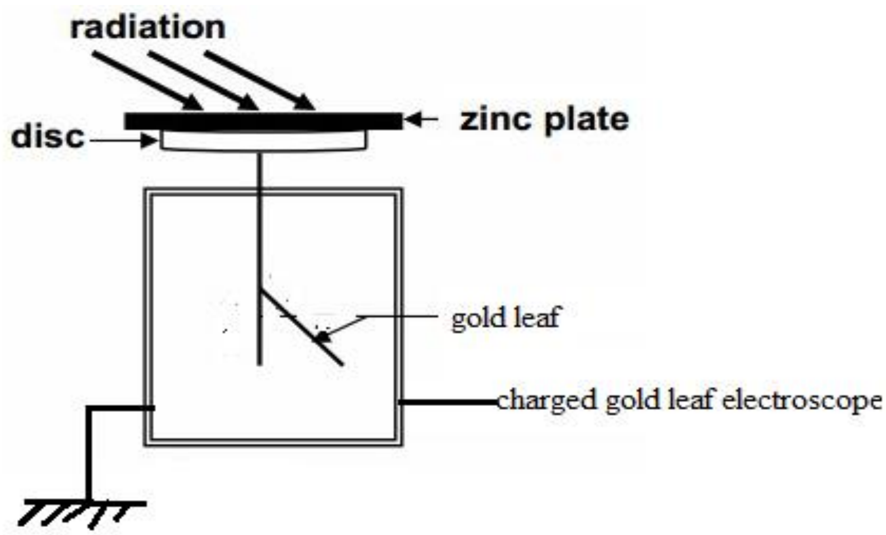
y = ½ $\left(\frac{eV_2}{md}\right) t^2$ But t = $\frac{L}{V}$ **1mk**

$\therefore y = \frac{1}{2}\left(\frac{eV_2}{md}\right)\frac{L^2}{V^2}$ = ½ $\left(\frac{1.6\ x\ 10^{-19}x1x10^3}{9.11x10^{-31}x0.05}\right)$ x $\left(\frac{0.1}{3.246x10^7}\right)^2$ **1mk**

= 0.0167 m

Or 1.67cm **½mk**

(b). (i). A freshly cleaned zinc plate is placed on the cap of a negatively charged electroscope ultra-violet radiation is directed onto the plate.



2mks

The leaf gradually falls.

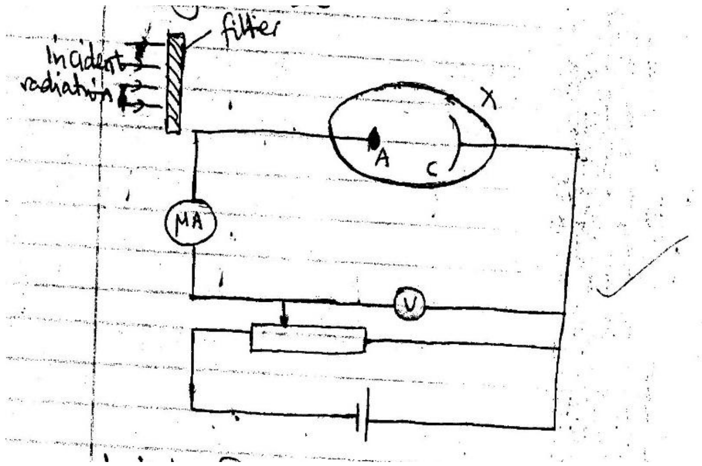
This shows that the gold leaf and zinc plate have both lost charge. This charge was proved to be electrons, which means photoelectric emission occurred. **2mks**

(ii).

- Instantaneous emission. From the wave theory, radiation energy is uniformly spread over the whole wave front. It's noted that electrons absorb only a fraction of the total energy. It's expected that there should be a time lag between the start of radiation and emission of electrons, according to the wave theory. However, such a time lag is not observed. **2mks**
- Variation of kinetic energy; according to the wave theory, increasing intensity would mean more energy and hence a greater value of maximum kinetic energy. However, maximum kinetic energy depends on frequency of incident radiation and not on intensity. **1mk**
- Existence of threshold frequency. The wave theory predicts the continuous absorption and accumulation of energy radiation of high enough intensity should therefore, because emission even when frequency is, below a given frequency, elections control be emitted even of the intensity is high. **1mk**

  The wave theory therefore cannot account for photoelectric emission.

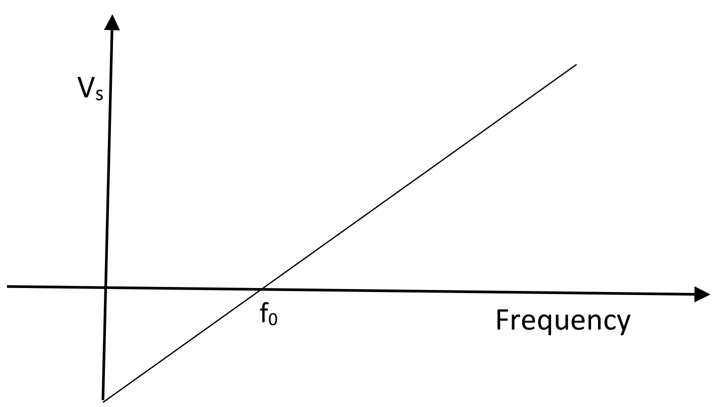
(b). (ii). The experiment is set up as shown in the diagram below.



Light of different intensities is obtained by using filters.

Radiation is made negative with respect to the cathode by the potential divider. P.d V is varied until the reading of micrometer is zero i.e. when current is zero. The potential at that point is called the stopping potentials and is read off from the voltmeter.

The procedure is repeated for radiation of different frequency frequencies. A graph of V_s against f is plotted as below;.



The straight line obtained verifies Einstein's equation $V = h_f - W_o$

From the equation h/e = slope S

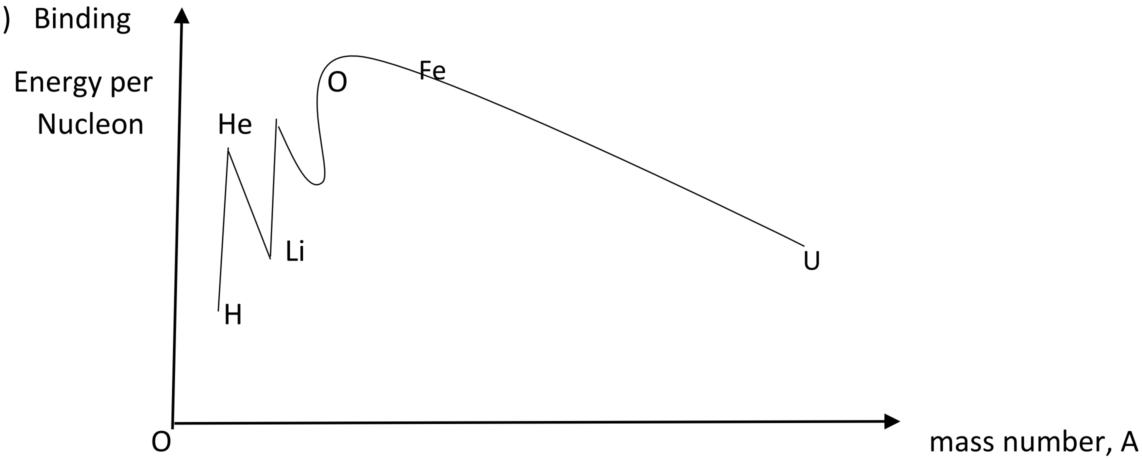
i.e. h/e = S

$\therefore h = eS$ **Max 5mks**

9. (a). Binding energy is the energy which must be supplied to the nucleus to break it up into free protons and neutrons. **1mk**

OR; It’s the energy lost when free protons and neutrons combine to form a nucleus.

(b).(i)



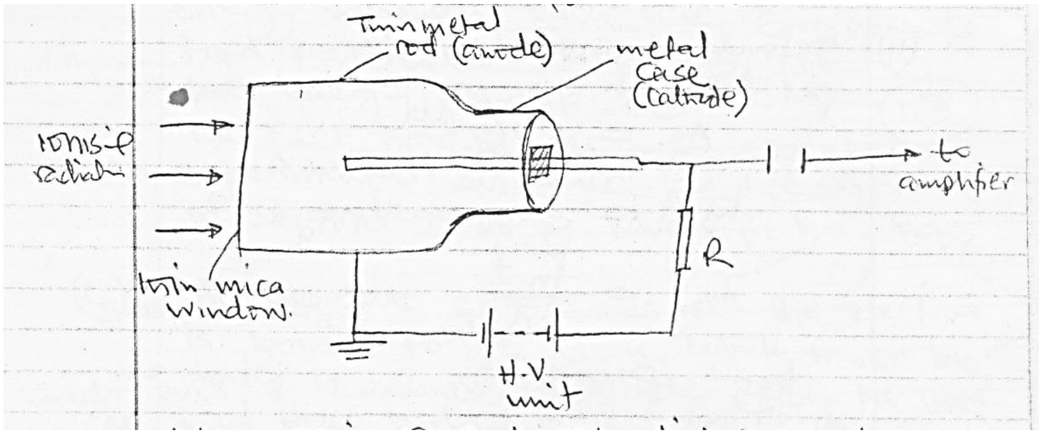
(ii). The binding energy per nucleus is least for very low mass numbers and highest for mass numbers between 50 and 60 of a nucleus of very high mass number is split into two lighter nuclei and consequently of higher binding, energy must be released .

When two nuclei of very low mass numbers are joined together to form a single heavier nucleus energy is released.

(c). Nuclear fission is a process by which a heavy nuclear consisting of two lighter nuclei accompanied to give emission of a lot of energy.

Nuclear fusion is a process by which two lighter nuclei combine to produce a heavier nucleus accompanied by the release of a lot of energy.

(d). The ionization chamber is used to detect x-rays, and p-rays. It consists of a metal case which contains air molecules at low pressure. The case forms the cathode and a metal rod in it forms the anode.



- When ionizing particle/radiation enters the tube air molecules get ionized +ve ions are accelerated towards the cathode, the free elections move towards the anode.
- As e's move towards the anode they acquire high kinetic energy and cause further ionization.
- Since the positive ions move slowly, they accumulate around the anode and cancel out the electric field. A large current pulse is produced
- The current pulse is amplified and fed to a rate meter. This indicates the rate at which pulses are received. Thus em radiation can be radiated.

(e).(i). The half-life of a radioactive source is the time taken for half of the radioactive nuclei present to decay.

Radioactive decay constant is the fraction of the radioactive nuclei which decay per second.

(ii). Activity is the number of disintegrations per second.

$$A = A_o e^{-\lambda t}$$

In A = - λ t + ln Ao

$T_{\frac{1}{2}} = \frac{1n\ 2}{\lambda}$ $\qquad$ $T_{\frac{1}{2}}$ = 5.3years

60g of Co contains 6.02 x 10^{23} atoms

= 1.10g $\qquad$ contains $\frac{1.10}{60}$ x 6.02 x 10^{23}

$\lambda = \frac{1n2}{5.3\ x\ 12x30x24x3600}$ $\qquad$ = 4.2x10^{-9}

=> A = $\frac{1.10}{60}$ x 0.02x 10^{23} $\quad e^{-4.2x10^{-9}t}$

10.(a). Line spectrum is a spectrum of electromagnetic radiation that consists of bright lines that are separated from one another. **1mk**

(b). When atoms of gases are heated some electrons obtain sufficient energy to excite the atom to higher energy levels.

When the electrons fall to lower energy levels the excess energy is emitted an electromagnetic radiation.

Line spectrum shows the change in energy whereby each line corresponds to a particular wave length given by the energy change.

The fact that the lines are separated is experimental evidence for the existence of separate energy levels in the atom. **Max 3mks**

(c).(i). The negative sign shows that the electron is bound to the atom. Work must be done to remove an electron from the atom and take it to infinity. (02mks)

(ii). Assuming there are electrons at all energy levels imitable energy is energy required to remove the most loosely bound electronic to infinity. **1mk**

Hence ionization energy = E_{∞} - E_4

= 0- (1.6 eV)

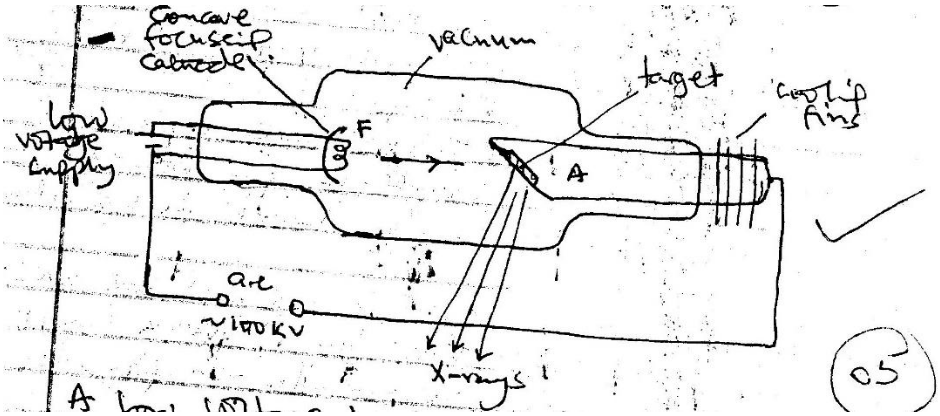
= 1.6 x 1.6 x 10^{-19}

= 2.56 x 10^{-19}J **1mk**

(iii). With 4.0 eV, the atom can be ionized by removal of the electron in energy level E_4 or E_3. **1mk**

With 11.0 eV, the atom will be ionized by removal of one or more electrons on $E_{4,}$ E_3 or E_2 ; or it can be ionized by removal of one electron on E_1 energy. **2mks**

(d). The modern x-ray tube consists of a filament and cup that form the cathode and copper block forms the anode. A metal embedded in the copper block forms the target. Inside the tube is empty space.



A low voltage heats the filament. Electrons are emitted by thermionic emission. A concave cup focusses the electrons onto the target.

A high a.c voltage is applied between the filament F and anode A. Electrons are cathode rays strike the target, x-rays are emitted.

The target, which becomes hot in the process, is cooled by copper fins mounted on the copper anode. The intensity of x-rays produced is controlled by the filament current while the penetrating power is controlled by the accelerating voltage. **Max 5mks**

(e).(i). I = ne

n= $^{I}/_{e}$ = $\frac{16x10^{-3}}{1.6x10^{-19}}$ = $1x10^{17}\ s^{-1}$ **2mks**

(ii). Power P = VI

Heat emitted per second.

Q = $\frac{99.5}{100}$ VI = $\frac{99.5}{100}$ x $20x10^{3}x16x10^{-3}$

= 318.4 J **2mks**

End