P510/1
PHYSICS
Paper 1
July/August 2019
2½ hours

WAKISSHA JOINT MOCK EXAMINATIONS

Uganda Advanced Certificate of Education

PHYSICS

Paper 1

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

- *Answer **five** questions, including **at least one,** but not more than **two** from each of the Sections **A, B** and C.*
- *Any additional question(s) answered will **not** be marked.*
- *Non programmable silent scientific calculators may be used.*

Assume where necessary:

Acceleration due to gravity	g	=	$9.81\ ms^{-2}$
Electron charge	e	=	$1.6 \times 10^{-19}\ C$
Electron mass		=	$9.11 \times 10^{-31}\ kg$
Mass of earth		=	$5.97 \times 10^{24} kg$
Planck's constant,	h	=	$6.6 \times 10^{-34} Js$
Stefan's – Boltzmann's constant,	σ	=	$5.67 \times 10^{-8}\ Wm^{-2}K^{-4}$
Radius of the earth		=	$6.4 \times 10^{6} m$
Radius of the sun		=	$7.0 \times 10^{8} m$
Radius of earth's orbit about the sun		=	$1.5 \times 10^{11} m$
Speed of light in a vacuum		=	$3.0 \times 10^{8} m$
Specific heat capacity of water		=	$4{,}200 Jkg^{-1}K^{-1}$
Specific latent heat of fusion of ice		=	$3.34 \times 10^{5}\ Jkg^{-1}$
Universal gravitational constant,	G	=	$6.67 \times 10^{-11} Nm^{2}kg^{-2}$
Avogadro's number	N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Density of mercury		=	$13.6 \times 10^{3} kgm^{-3}$
Charge to mass ratio,	e/m	=	$1.8 \times 10^{11}\ Ckg^{-1}$
The constant $\frac{1}{4\pi\varepsilon_0}$		=	$9.0 \times 10^{9}\ F^{-1}m$
Density of water		=	$1000 kgm^{-3}$
Gas constant	R	=	$8.31 Jmol^{-1}K^{-1}$

Turn Over

SECTION A

1. (a) (i) State **Newton's laws of motion.** (03 marks)

(ii) Derive the expression **F = ma,** and define the unit of force. (03 marks)

(b) (i) What is meant by a **perfectly inelastic collision?** (01 mark)

(ii) Give **two** examples of perfectly inelastic collisions. (02 marks)

(iii) Two bodies, each of mass 2.5M move at speeds of 2.0 ms^{-1} and 1.5 ms^{-1} respectively, at right angles to each other. If they make a perfectly inelastic collision, find their final velocity. (05 marks)

(c) (i) What is meant by time of flight as applied to projectile motion? (01 mark)

(ii) Derive an expression for the time of flight T of a projectile in terms of the horizontal range R, angle of projection θ and acceleration due to gravity g. (03 marks)

(iii) If the time of flight for the projectile in (c) (ii) above is 3.5 s, deduce the value for the maximum horizontal range. (02 marks)

2. (a) (i) What is meant by **static friction?** (01 mark)

(ii) Explain briefly, using molecular theory, how normal reaction affects friction between two solid surfaces. (03 marks)

(b) Describe an experiment to determine the coefficient of kinetic friction, and state **one** limitation that may lead to errors in the experiment. (04 marks)

(c) (i) State the **work – energy equation** and derive it. (03 marks)

(ii) A block of wood of mass 3kg rests on a rough horizontal floor. If it is given a horizontal blow and moves with an initial velocity of 4.0 ms^{-1} covering a distance of 6.0 m before coming to rest, find the coefficient of kinetic friction between the wooden block and the floor. (04 marks)

(d) (i) What is meant by the terms **viscosity** and **velocity gradient** as applied to fluid flow? (02 marks)

(ii) Explain how temperature affects viscosity in a gas. (03 marks)

3. (a) (i) What is **simple harmonic motion?** (01 mark)

(ii) Sketch separate graphs showing how velocity and acceleration vary with displacement for a body performing simple harmonic motion. (02 marks)

(b) Suppose you are provided with a helical spring of force constant K, a stop clock, a retort stand with its clamp and masses of different sizes.

(i) Describe an experiment you would carry out to determine the value of the force constant K of the spring. (04 marks)

(ii) State any **three** possible sources of error in the above experiment. (03 marks)

(c) A mass of 2 kg resting on a smooth horizontal surface is attached to one end of a spring lying horizontally, with its one end fixed onto a rigid support. If the force constant of the spring is 100 Nm^{-1} and the mass is pulled through a distance of 4.0cm and released, calculate the:

(i) maximum velocity attained by the attached mass. (03 marks)

(ii) acceleration of the mass when it is half way away from the equilibrium position. (02 marks)

(d) (i) What is meant by **geostationary orbit** as applied to a satellite? (01 mark)

(ii) Calculate the height of a communication satellite above the earth's surface if it is launched in its geostationary orbit. (04 marks)

4. (a) (i) What is meant by the term **relative density?** (01 mark)

(ii) Describe a simple experiment you would carry out to determine relative density of a liquid. (03 marks)

(b) A cylindrical solid of mass 200 g and uniform cross-sectional area 40 cm^2 is floated vertically in water of density 1.0 g cm^{-3}. When a mass of 100 g is carefully placed on top of the cylindrical solid and a certain liquid added to the water, the cylindrical solid floats at the same level as it was floating in water. Calculate the density of the mixture of water and the liquid. (04 marks)

(c) (i) Define **surface tension.** (01 mark)

(ii) A glass capillary tube of radius r is supported vertically in a liquid of density ρ and surface tension γ. Derive an expression for the height h to which the liquid rises in the tube if the angle of contact between the liquid and glass is θ. (04 marks)

(d) Find the work required to break up a drop of water of radius 0.5 cm into drops of water each of radii 1.0mm.
(Take surface tension of water = 7.0×10^{-2} Nm^{-1}). (04 marks)

(e) Explain why when lycopodium powder is sprinkled on water contained in a dish, and the middle of the water is touched with the end of a glass rod which had been previously dipped in soap solution, the powder is carried away to the sides by the water. (03 marks)

Turn Over

SECTION B

5. (a) (i) Define **thermometric property** and give **two** examples. (03 marks)

(ii) What is the lowest possible temperature that a substance can ever have? and under what condition can this temperature be attained? (02 marks)

(b) (i) With the aid of a labelled diagram, describe the structure and mode of operation of the filament - disappearing pyrometer. (05 marks)

(ii) State **one** advantage and **one** disadvantage of a pyrometer. (02 marks)

(c) (i) Define **specific latent heat of fusion** of a substance. (01 mark)

(ii) Explain why the specific latent heat of fusion of a substance is significantly different from its specific latent heat of vaporisation at the same pressure. (03 marks)

(d) Two kilograms of water is converted into steam at a temperature of 100^0C and a pressure of 98.5 kPa. If the density of steam is 0.60 kgm^{-3} and specific latent heat of vaporisation of water is 2.3×10^3 kJ kg^{-1}, calculate the work done to the surroundings. (04 marks)

6. (a) (i) What is an **ideal gas?** (01 mark)

(ii) Explain the conditions under which a real gas can behave like an ideal gas. (03 marks)

(b) The pressure, P, of an ideal gas is given by $P = 1/3\ \rho \overline{c^2}$, where ρ is the density of the gas and $\overline{c^2}$ is the mean square speed of its molecules. Show clearly the steps taken to derive the above expression. (06 marks)

(c) (i) What is meant by **critical temperature** as applied to a gas? (01 mark)

(ii) Sketch the pressure – volume curve for a real gas for temperature above and below the critical temperature. (02 marks)

(d) The masses of hydrogen and oxygen atoms are respectively 1.66×10^{-27} kg and 2.66×10^{-26} kg. What is the ratio of the root-mean-square speed of hydrogen to that of oxygen molecules at the same temperature? (04 marks)

(e) Use kinetic theory to explain how saturated vapour pressure of a liquid increases with temperature. (03 marks)

7. (a) (i) Define **coefficient of thermal conductivity.** (01 mark)

(ii) Explain the mechanism of thermal conduction in glass. (03 marks)

(iii) State any **two** factors that determine the rate of heat transfer through a material. (01 mark)

(b) With the aid of a labelled diagram, describe an experiment to determine the coefficient of thermal conductivity of copper. (06 marks)

(c) Metal rods of copper, brass and steel are welded together to form a Y – shaped figure. The cross – sectional area of each rod is 2 cm^2. The free end of the copper rod is maintained at 100^0C while the ends of brass and steel are maintained at 0^0C. If there is no heat loss from the surfaces of the rods and the rods are respectively 40 cm, 10 cm and 15 cm long, calculate the:

(i) temperature of the junction. (05 marks)

(ii) heat current in the copper rod. (02 marks)

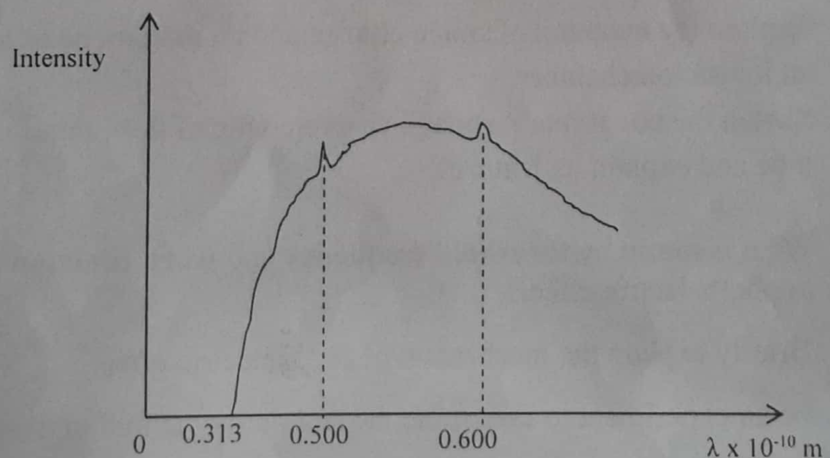
(d) With the aid of a suitable sketch graph, explain the temperature distribution along a well – lagged metal rod heated at one end. (02 marks)

SECTION C

8. (a) (i) What are **x – rays**? (01 mark)

(ii) State any **two** differences between x – rays and γ – rays. (02 marks)

(b) The diagram below shows an x – ray spectrum of a metallic target bombarded by 40 kV electron beam.



(i) What features does the spectrum show? (02 marks)

(ii) Calculate the value of *h/e* from the data given on the diagram, where *h* is Planck's constant and *e* is the electronic charge. (03 marks)

(iii) State **two** changes one would expect to be observed if the energy of the bombarding electrons were increased. (02 marks)

Turn Over

(c) An x – ray tube is operated at 35 kV with a electron current 10 mA in the tube. Estimate the:

(i) number of electrons hitting the target per second. (03 marks)

(ii) rate of production of heat assuming 90% of the kinetic energy of electrons is converted to heat. (03 marks)

(d) In the Millikan's oil experiment to determine the charge on an oil drop, explain why:

(i) the apparatus is surrounded in a constant - temperature bath. (02 marks)

(ii) large sized oil drops are not used. (02 marks)

9. (a) What is meant by the following terms:

(i) **radioactive decay.**

(ii) **half – life.**

(iii) **decay constant.**

(03 marks)

(b) Sketch a graph of number of atoms present against time for a radioactive nuclide and use it to explain how decay constant is obtained from it. (04 marks)

(c) A radioactive source of half – life 60 days initially contains 1.0×10^{20} radioactive atoms and the energy released per disintegration is 8.0×10^{-13} J. Calculate the:

(i) activity of the source after 120 days have elapsed. (04 marks)

(ii) total energy released during this period. (03 marks)

(d) (i) Explain the meaning of **space charge** and an **avalanche** as applied to an ionisation chamber. (03 marks)

(ii) Sketch the count rate – voltage characteristic of the Geiger – Muller tube and explain its features. (03 marks)

10. (a) (i) What is meant by **threshold frequency** and **work function** as applied to photoelectric effect?. (02 marks)

(ii) Briefly explain the mechanism of photoelectric effect. (03 marks)

(b) Describe an experiment to determine the stopping potential of a metal surface. (05 marks)

(c) Ultraviolet and infrared radiations are directed in turn onto a freshly cleaned zinc plate connected to a gold – leaf electroscope which is negatively charged.

Explain what is observed when:

(i) ultraviolet radiation falls on the zinc plate. (02 marks)

(ii) infrared radiation falls on the zinc plate. (02 marks)

(iii) ultraviolet radiation falls on the zinc plate if the gold – leaf electroscope is positively charge. (02 marks)

(d) When a certain metal surface is irradiated with light of wavelength 6.0×10^{-7}m, electrons just emerge from its surface. When light of wavelength 5.5×10^{-7} m is used, electrons each of energy 4.0×10^{-20} J are emitted from the metal surface. Find the value of Planck's constant. (04 marks)

END

WAKISSHA JOINT MOCK EXAMINATIONS
MARKING GUIDE
Uganda Advanced Certificate of Education
UACE August 2019
PHYSICS P510/1

SECTION A

1. (a) (i)
- A body continues in its state of rest or uniform motion in a straight line unless acted upon by an external force.
- The rate of change of momentum is directly proportional to the applied force and takes place in the direction of the force.
- For every action, there is an equal and opposite ~~force.~~ reaction **(03 marks)**

(ii) Consider a body of mass M, initially moving at a vel. U, and is acted upon by a force F so that after time t, its vel. Changes to v.
From Newton's 2nd law of motion;

$$F \propto \frac{mv - mu}{t} \Rightarrow F \propto m\left(\frac{v-u}{t}\right)$$

But $\frac{v-u}{t} = a \Rightarrow F \propto ma$ or $F = kma$

When $F = 1N, m = 1kg$ and $a = 1ms^{-2}$, $k = 1$

$\Rightarrow F = ma$

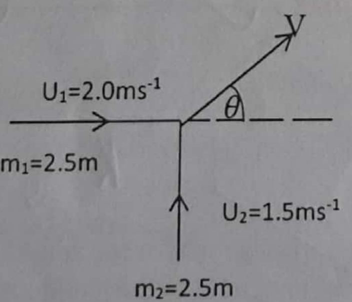
- The newton is the force that acts on a body of mass 1kg to produce an acceleration of $1ms^{-2}$ **(03 marks)**

(b) (i) A perfectly inelastic collision is a collision in which some k.e is kinetic energy lost and the bodies stick together after collision; ie move with a common velocity. **(01 mark)**

(ii) Examples of perfectly inelastic collisions: in which cars
- Car crash during, say, a head-on collision stick together after. first two
- Soft mud thrown onto a wall and sticks on it. **(02 marks)**
- A bullet shot into a suspended block of wood and gets embedded into it and the two swing together after impact.

(Any two examples @ 1 mark)

(iii)



Horizontal motion;
$m_1 u_1 + m_2 u_2 = (m_1 + m_2) V \cos\theta$
$\therefore 2.5M \times 2.0 + 2.5M \times 0 = 5.0MV\cos\theta$
$\Rightarrow 5.0M = 5.0MV\cos\theta$
Or $\cos\theta = \frac{1}{v}$ .... (i)

Vertical motion: $2.5M \times 0 + 2.5M \times 1.5 = 5.0M V\sin\theta$ 01
$\Rightarrow 3.75M = 5.0??MV\sin\theta$

$$\Rightarrow \sin\theta = \frac{0.75}{v} \text{ .... (ii)}$$

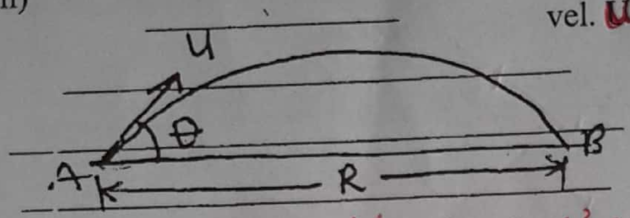
But $\sin^2\theta + \cos^2\theta = 1 \Rightarrow \left(\frac{0.75}{v}\right)^2 + \left(\frac{1}{v}\right)^2 = 1$

From which $v = 1.25 ms^{-1}$

In the direction $\theta = \sin^{-1}\left(\frac{0.75}{v}\right) = 36.9^o$ *(05 marks)*

(c) (i) Time of flight is the time taken by a projectile to cover its trajectory. through the point of projection on the same plane. *(01 mark)*

(ii) Consider a body projected a vel. U at an angle θ to the horizontal.



$y = ut\sin\theta - \frac{1}{2}gt^2$

At B; $O = u\sin\theta.T - \frac{1}{2}gT^2$, where T = time of flight.

$$\Rightarrow T = \frac{2u\sin\theta}{g} \text{ .... (i)}$$

The Range, $R = u\cos\theta.T$ .... (ii)

Dividing (i) by (2) gives: $\frac{T}{R} = \frac{2\tan\theta}{gT}$

$$\Rightarrow T = \left(\frac{2R\tan\theta}{g}\right)^{\frac{1}{2}}$$ *(03 marks)*

(iii) Range, $R = \frac{gT^2}{2\tan\theta}$; R is max. when $\theta = 45^o \Rightarrow \tan\theta = 1$

$$\therefore R\max = \frac{gT^2}{2} = \frac{9.81\times(3.5)^2}{2}$$

$$= 60.09m$$

(02marks)

Total = 20 marks

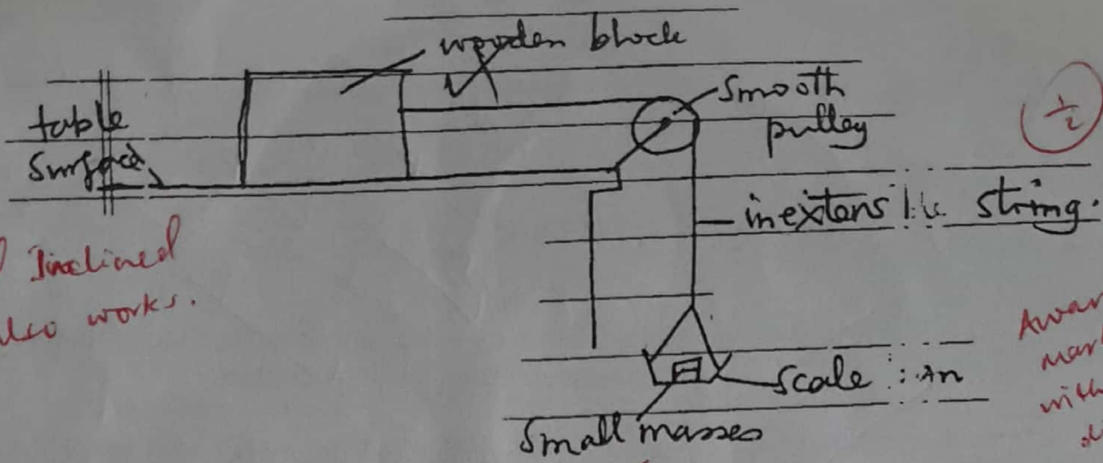
2. (a) (i) Static friction is the force that opposes relative motion of two surfaces in contact, which are at rest, but have a tendency to move. 01

(ii) - Solid surfaces have irregular molecular projections which form welded joints when two surfaces are placed into contact with each other.

- When the normal reaction is increased, the pressure at the welded joints increases.
- This leads to increased degree of interlocking of the irregular projections; and hence a bigger force (frictional) is required to cause motion of one surface relative to the other. *(03 marks)*

03

(b)



Method of Inclined plane also works.

$\frac{1}{2}$

Award of marks even without diagram.

- Small masses are added one at a time in the scale pan, and each time, the wooden block is given a slight push, until it moves at a constant velocity.
- The total mass m of the scale pan and its contents and the mass M of the wooden block are determined by measurement.
- The coefficient of kinetic friction μ is then obtained from: $\mu = \frac{m}{M}$

Limitation:

- Difficulty in knowing whether wooden block is moving at constant velocity. *(04 marks)*

(c) (i) Work – energy equation is $W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

Denied a mark without defining parameters.

Where W = work done by a force
m = mass of the body
v = final velocity
u = initial velocity of the body.

- Suppose a body of mass m initially moving with speed u is subjected to an accelerating force F such that its speed is increased to v in a distance S;

Then $S = \frac{v^2 - u^2}{2a}$, where a = acceleration.

- Work done by the force W = F.S

$$= F \times \frac{v^2 - u^2}{2a}$$

But F = ma

$$\Rightarrow W = ma.\frac{v^2 - u^2}{2a}$$

$$= \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

(03 marks)

(ii) u = 4.0ms^{-1}; s = 6.0m, m = 3.0kg; v = 0

The retarding force F = -ma $= -m\left(\frac{v^2 - u^2}{2s}\right)$

$$= -3.0\left(\frac{o^2 - 4.0^2}{2 \times 6.0}\right) = 4N$$

But $F = \mu R = \mu mg \Rightarrow \mu = \frac{F}{mg} = \frac{4}{3.0 \times 9.81}$

$= 0.136$ *(04 marks)*

(d) (i) Viscosity; - Is the friction force that opposes the relative motion between two fluid layers in contact.

Velocity gradient; - Is the change in velocity between molecular layers if a fluid separated by one metre.

layer / are

(02 marks)

(ii) - Viscosity in gases is due to momentum transfer between the neighbouring layers of gases.

- The viscosity is directly proportional to the average speed of the gas mols. And since the average speed of the gas mols increases with temp, ⇒ viscosity in a gas increases with increase in temp.

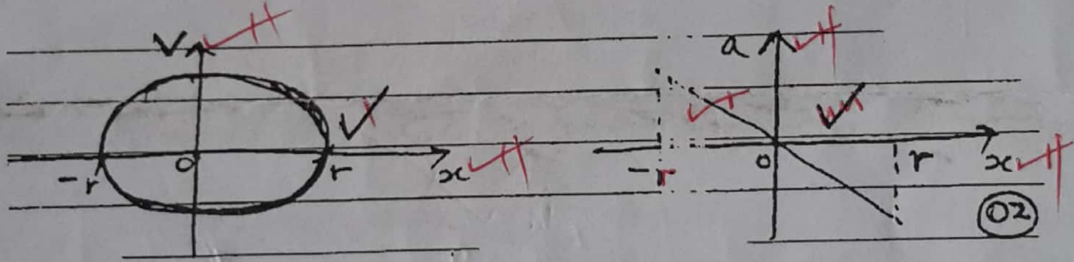
(03 marks)

Total = 20 marks.

3. (a) (i) Simple harmonic motion is the to and fro periodic motion of a body whose acceleration is directly prop. To its displacement from a fixed point, and is always directed towards the fixed pt.

(01 mark)

(ii)



(b) (i) - The ~~L~~Helical spring is clamped vertically by using the retort stand and a clamp.

- A known mass m is attached to the free end of the spring and is pulled downwards through a small distance and is released to oscillate.
- The time for 20 oscillations is obtained, and the time for one oscillations, T is determined.
- The expt. Is repeated for different values of m; and results tabulated to include T^2.
- A graph of T^2 against M is plotted and its slope s is calculated.
- The force constant K is then obtained from $K = \frac{4\pi^2}{S}$

04

(ii) – The mass of the spring not being negligible

- Improper clamping of the spring at the point of suspension
- Presence of viscosity or dissipative forces due to air
- Swaying or movement o the position of point of suspension or the stand not being firm.

swinging

03

- Error in timing.

(Any three @ 1 mark)

(c) m = 2kg, k = 100Nm^{-1}, r = 4cm = 0.04m

(i) Vmax = ~~rω~~ $= r\sqrt{\frac{k}{m}}$

$$\therefore V\max = r\sqrt{\frac{k}{m}} = 0.04\times\sqrt{\frac{100}{2}} = 0.28ms^{-1}$$ *(03 marks)*

(ii) When x = 2cm = 0.02m;

$$a = -w^2x$$

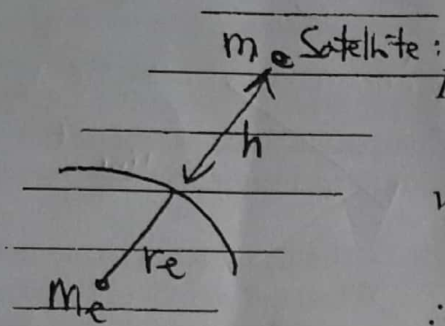
$$= -\left(\frac{k}{m}\right)\times 0.02 = -\frac{100}{2}\times 0.02$$

$$= -1.0ms^{-2}$$ *(02 marks)*

(d) (i) Geostationary orbit is a path in space of a satellite in which it has a period of 24 hours and appears to be at the same position relative to an observer on the earth's surface. *(01 mark)*

stationary

(ii)



$$F = \frac{GM_e m}{r^2} = \frac{mv^2}{r};$$

$$v = rw = r.\frac{2\pi}{T}$$

$$\therefore \frac{GM_e m}{r^2} = \frac{4\pi^2 \cancel{mr}}{T^2}$$ mr

$$\text{Or } r = \sqrt[3]{\frac{GM_e \cancel{m} T^2}{4\pi^2}} = \sqrt[3]{\frac{r_e^2 g.T^2}{4\pi^2}}$$

$$= \sqrt[3]{\frac{(6.4\times10^6)^2\times 9.81\times(24\times3600)^2}{4\times(3.14)^2}}$$

$$= 4.24\times10^7 m$$

$$\therefore h = r - r_e$$

$$= 4.24\times10^7 - 6.4\times10^6$$

$$= 3.6\times10^7 m$$ *(04 marks)*

Total = 20 marks

4. (a) (i) Rel. density is the ratio of the density of a substance to the density of water.

Or It is the ratio of the mass (weight) of any given vol. of a substance to the mass (weight) of an equal vol. of water.

4

(ii) - The weight of a solid object is measured in air using a spring balance and recorded as W_1.

- The object is completely in the immersed in water and its weight is recorded as W_2 and is immersed completely in the liquid whose rel. density is required and its weight W_3 is recorded.

- The rel. density of the $Liq. = \frac{W_1 - W_3}{W_1 - W_2}$ *(03 marks)*

Weight of water displaced = Weight of the floating solid.

$m_w g = m_s g$

(b) Mass of displaced water $= \ell_w V_w = 1000 \times 40 \times 10^{-4} \times x = 0.2$

Where x is the depth of which the solid floats.

$$\Rightarrow x = \frac{0.2}{1000 \times 40 \times 10^{-4}} = 0.05m$$

Mass of displaced mixture of Liq.

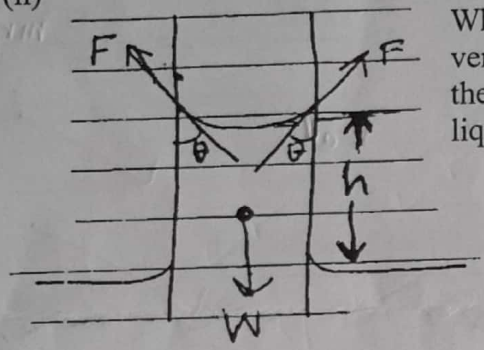
$= \ell_m V_m = \ell_m \times 40 \times 10^{-4} \times x = 0.3$

$\Rightarrow \ell_m \times 40 \times 10^{-4} \times 0.05 = 0.3$

From which $\ell_m = 1500kgm^{-3}$ *(04 marks)*

(c) (i) Surface tension; - Is the tangential force per metre that acts perpendicularly to one side of an imaginary ~~time~~ line drawn on a liquid surface. *(01 mark)*

(ii)



- The liquid stops rising in the cap. Tube When the weight of the raised column acting vertically downwards = vertical component of the upward forces exerted by the tube on the liquid.

ie. $F\cos\theta = W$, where $F = \frac{surface}{tension\ force}$

But $F = 2\pi r\gamma$ and $W = \pi r^2 h\rho g$

$\therefore 2\pi r\gamma \cos\theta = \pi r^2 h\rho g$

$$\Rightarrow h = \frac{2\gamma\cos\theta}{\rho r g}$$ *(04 marks)*

(d) r = 0.5cm, r = 1.0mm; $\gamma = 7.0 \times 10^{-2} Nm^{-1}$

Vol. of big drop $= \frac{4\pi r^3}{3} = \frac{4 \times 3.14 \times (5.0 \times 10^{-3})^3}{3}$

$= 5.23 \times 10^{-7} m^3$

Vol. of small droplet $= \frac{4\pi r'^3}{3} = \frac{4 \times 3.14 \times (1.0 \times 10^{-3})^3}{3}$

$= 4.0 \times 10^{-9} m^3$

$\therefore$ no of droplets formed; $n = \frac{5.23 \times 10^{-7}}{4.0 \times 10^{-9}} = 125$

Surface area of big drop $= 4\pi r^2 = 4 \times 3.14 \times (5.0 \times 10^{-3})^2$

$= 3.14 \times 10^{-4} m^2$

Surface area of the 125 droplets $= 125 \times 4\pi r'^2$

$= 125 \times 4 \times 3.14 \times (1.0 \times 10^{-3})^3$ units

$= 0.01257 m^2$

$\therefore$ Change in area $= 0.01257 - 3.14 \times 10^{-4}$

$= 1.23 \times 10^{-2} m^2$

$\therefore$ Work done $= \gamma \times$ Change in area

$= 7.0 \times 10^{-2} \times 1.23 \times 10^{-2}$

$= 8.6 \times 10^{-4} J$

(04 marks)

(e) - Introducing soap at the spot where the water surface is touched reduces the surface tension there.

- The resultant force is thus away from the spot and the powder is carried away from the spot towards the sides of the vessel.

(03 marks)

Total = 20 marks

SECTION B

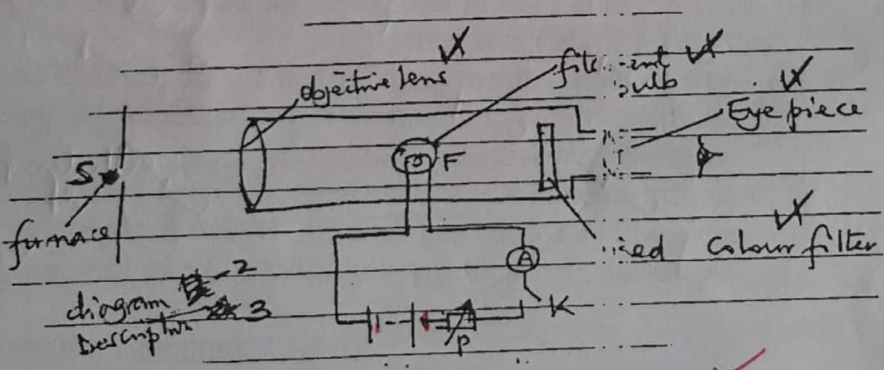
5. (a) (i) Thermometric property is a physical property of a substance which varies linearly and continuously with temp. and is constant at constant temp. *(01 mark)*

- Vol. of a fixed mass of gas at constant ~~vol.~~ pressure.
- Pressure of a fixed mass of gas at constant vol.
- Emf of a thermo couple
- Length of a liquid column in a cap. Tube
- Electrical resistance of a platinum wire. *(02 mark)*

(Any two @ 1 mark)

(ii) Absolute zero (OK); and is obtained when molecular motion of mols. Of a substance has ceased./ minimum kinetic energy.

(b) (i)



Any of parts for a working circuit.

- On closing the switch K, the eye piece E is focused at the filament F of the bulb
- The telescope is then directed to ~~force~~ focus the furnace S and light from it is focused by the objective lens on to the filament F
- The current through the filament is adjusted by using the rheostat P, until the brightness of the filament merges with that of the furnace; ie F becomes indistinguishable from the furnace
- The temp. of the furnace is then read from the ammeter A, previously calibrated in Kelvin.

(05 marks)

(ii) Advantage

- Can measure high temps (>1500°C)
- Direct reading

Disadvantage

- Cannot measure low temps. cannot measure rapidly changing temp. *(02 marks)*

(c) (i) Specific latent Lt of fusion of a substance is the ~~Lt~~ heat required to change the state of 1kg mass of a solid in to liquid at constant temp. *(01 mark)*

(ii) Latent Lt of fusion is used in only ~~breaking~~ weakening the strong inter molecular forces in the crystalline structure of the solid and some small work done against the atmosphere due to small increase in vol. whereas latent Lt of vaporization or separates the molecular further, break the intermolecular forces of attraction increasing the p.e of the molecules and energy is used to o work during the appreciable expansion against atmosphere pressure by the vapour. **(03 marks)**

(d) $m_w = 2kg : p = 98.5k\ Pa = 98.5\times10^3 Pa$

$\vartheta_s = 0.60 kgm^{-3}; l_v = 2.3\times10^3 kJkg^{-1}$

$= 2.3\times10^6 Jkg^{-1}$

Vol. of water, $V_1 = \frac{mass\ of\ water}{density\ of\ water} = \frac{2}{1000} = 0.002m^3$

Vol. of steam $V_2 = \frac{mass\ of\ water}{density\ of\ steam} = \frac{2}{0.60} = 3.333m^3$

But $W = P(V_2 - V_1) = 98.5\times10^3(3.333 - 0.002$

$= 3.28\times10^5 J$ **(04 marks)**

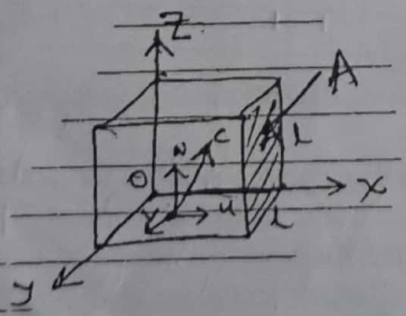
Total = 20 marks

6. (a) (i) An ideal gas is a gas in which inter molecular forces are negligible, and obeys Boyle's law perfectly. **(01 mark)**

(ii) - At high temp – the average k.e.s of the mols is high and this minimizes the inter molecular forces, and thus the forces become negligible $\Rightarrow$ gas behaves like an ideal gas.

- At low pressure – at a given temp; the no of mols colliding with the walls in a container is low, so mols will be spaced and their vol. will be negligible compared to the vol. of the vessel. Hence the gas will behave like an ideal gas. **(03 marks)**

(b)



Suppose a gas enclose in a cube of side l contains N molecules each of mass m.

Taking one mol. moving at a vel. C; which can be resolved into component u, v and w in the directions OX, OY and OZ directions respectively.

OX – direction:

Initial momentum = mu, and

Final momentum = -mu

$\therefore \Delta$ mom = mu – (-mu) = 2mu

Time of flight = $2l/u$

$\therefore$ Rate of change of mom $= \frac{2mu}{2l/u} = \frac{mu^2}{l}$ = force on A.

Total force due to the N molecules:

$$F = \frac{mu_1^{\,2}}{l} + \frac{mu_2^{\,2}}{l} + \ldots + \frac{mu_N^{\,2}}{l}$$

$$= \frac{m}{l}\left(u_1^{\,2} + u_2^{\,2} + \ldots + \frac{u_N^{\,2}}{\cancel{l}}\right)$$

$\therefore$ Pressure on $A = \frac{F}{A} = \frac{m}{l^3}\left(u_1^{\,2} + u_2^{\,2} + \ldots + u_N^{\,2}\right)$

Let $\bar{u^2} = \frac{u_1^{\,2} + u_2^{\,2} + \ldots + u_N^{\,2}}{N} \Rightarrow u_1^{\,2} + u_2^{\,2} + \ldots + u_N^{\,2} = N\bar{u^2}$

$$\therefore P = \frac{mN\bar{u^2}}{l^3}$$

For each mol; $c^2 = u^2 + v^2 + w^2 \Rightarrow \bar{c^2} = \bar{u^2} + \bar{v^2} + \bar{w^2}$

But $\bar{u^2} = \bar{v^2} = \bar{w^2} \Rightarrow \bar{c^2} = \bar{u^2} + \bar{u^2} + \bar{u^2} = 3\bar{u^2}$

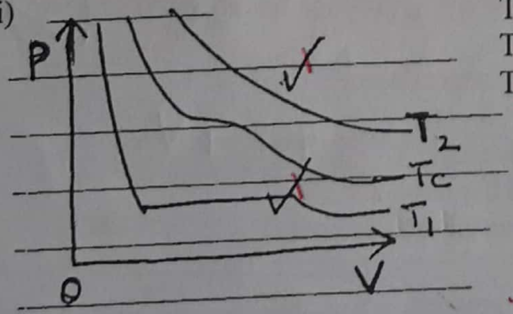
$$\therefore \bar{u^2} = \frac{1}{3}\bar{c^2}$$

$$\therefore P = \frac{mN}{l^3}.\frac{1}{3}\bar{c^2} = \frac{1}{3}\frac{mN}{l^3}\bar{c^2}$$

But $\frac{Nm}{l^3} = \vartheta \Rightarrow P = \frac{1}{3}\vartheta\bar{c^2}$ *(06 marks)*

(c) (i) Critical temp. is the temp. above which a gas cannot be liquidified however high the pressure is. *(01 mark)*

(ii)



T_1 - Below critical temp.
T_c - Critical temp 01
T_2 - Above critical temp.

(02 marks)

Must ~~identical~~ indicate ~~c~~critical temp — 01

$T_1 < T_c < T_2$. Give one mark for the shape.

(iii) $M_h = 1.66 \times 10^{-27}$kg, $M_o = 2.66 \times 10^{-26}$kg

From PV = $\frac{1}{3}M\bar{c^2} = RT$ for 1 mole

(d)

$$\Rightarrow \sqrt{\bar{c}^2} = \sqrt{\frac{3RT}{M}}$$

$$\therefore \sqrt{\bar{c}_h^2} = \sqrt{\frac{3RT}{M_h}} \text{ and } \sqrt{\bar{c}_o^2} = \sqrt{\frac{3RT}{M_o}}$$

$$\Rightarrow \frac{\sqrt{\bar{c}_h^2}}{\sqrt{\bar{c}_o^2}} = \sqrt{\frac{M_o}{M_h}} = \sqrt{\frac{2.66 \times 10^{-26}}{1.66 \times 10^{-27}}}$$

$= 4 : 1$ *(04 marks)*

(e) - When the temp. of a liquid is increased, the average k.e of its molecules increases.
- More molecules are able to escape and so the rate of evaporation increases
- The density of the vapour increases and this leads to an increase in the rate of condensation
- Equilibrium and saturation are re-established at a greater saturated vapour pressure. *(03 marks)*

Total = 20 marks

7. (a) (i) Coefficient of thermal conductivity is the rate of heat flow through a material per unit cross sectional area per unit temp. gradient. 01

(ii) - When one end of glasss is heated, the atoms therer gain k.e and vibrate with increased amplitudes; they will then collide with their neighbouring atoms and pass on some of their vibrational energy to these atoms.

thermal energy

- This will result into increase in amplitude of vibration of the atoms; they will in turn collide with the neighbouring atoms and pan on their energy. In this way, heat energy is propagated along the glass towards the colder end. *(03 marks)*

pass

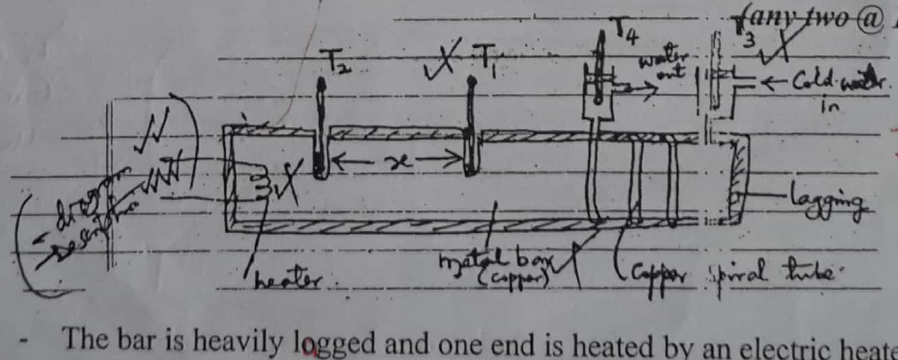
(iii) Rate of heat transfer depends on:
- Length of the conductor
- Cross – sectional area
- Temp. difference btn the ends
- Nature of the material (conductivity) *(01 mark)*

~~(any two @ 1 mark)~~

First two

Temperature gradient combines
- length of the conductor
- temperature difference at the ends

(b)



½ @ for any 4 parts.

- The bar is heavily logged and one end is heated by an electric heater
- Cold water is then passed through the copper spiral tube at a constant rate.
- Two temperature T_3 and T_4 record the entrance and exit temps. θ_3 and θ_4 respectively of the water

thermometers

- The thermometer T_1 and T_2 giving temps. θ_1 and θ_2 at a known separation x on the bar are inserted in holes containing mercury.
- The expt is made to ~~return~~ run until the four thermometer readings are constant
- They are read and recorded
- The mass m of water flowing through the tube in time t is measured
- The thermal conductivity K of copper is then obtained from:

$$K = \frac{x m_{t} c\,(\theta_4 - \theta_3)}{A\,(\theta_2 - \theta_1)}$$

Where A = area of cross section of the Bar, obtained from $A = \frac{\pi d^2}{4}$,

Where d = diameter of the bar c = s.h.c. of the water. *(06 marks)*

(c) $K_c = 385\,Wm^{-1}K^{-1}$, $K_b = 108\,Wm^{-1}K^{-1}$, $K_s = 50\,Wm^{-1}K^{-1}$

Let θ = temp. of junction

(i) From $Q_c = Q_b + Q_s$

$$\Rightarrow \frac{K_c A(100-\theta)}{l_c} = \frac{K_b A(\theta - 0)}{l_b} + \frac{K_s A(\theta - 0)}{l_s}$$

$$\frac{K_c(100-\theta)}{0.40} = \frac{K_b\theta}{0.10} + \frac{K_s\theta}{0.15}$$

$$\Rightarrow \frac{385A(100-\theta)}{0.40} = \frac{108A(\theta)}{0.10} + \frac{50A(\theta)}{0.15}$$

$$\frac{100K_c - K_c\theta}{0.40} = \frac{K_b\theta}{0.1} + \frac{K_s\theta}{0.15}$$

$$\Rightarrow 962.5(100-\theta) = 1080\theta + 333.3\theta$$

$$= 1413.3\theta$$

$$250K_c - 2.5K_c\theta = 10K_b + 2.5K_s\theta$$

From which $\theta = \cancel{4.5°C}$ 40.5°C *(05 marks)*

(ii) Heat current in the copper rod = rate of Lt flow

$$\theta = \frac{250K_c}{10K_b + \frac{20}{3}K_s + 2.5K_c}$$

$$= \frac{K_c A(100-\theta)}{l_c} = \frac{K_c A\left(100 - \frac{250K_c}{10K_b + 250K_s + 2.5K_c}\right)}{0.4}$$

$$= \frac{385 \times 2 \times 10^{-4} \times (100 - 40.5)}{0.4}$$

(02 marks)

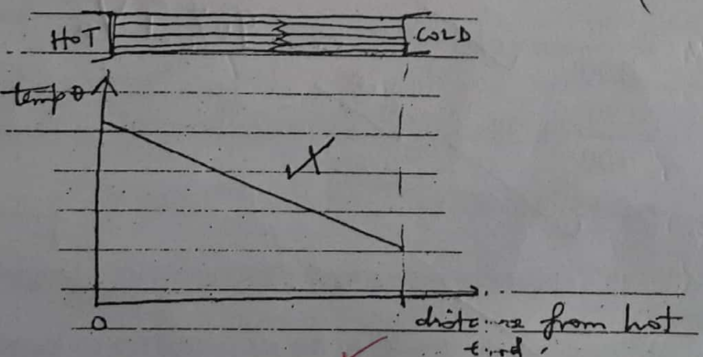
$$= \frac{300K_c}{3K_c + 8K_s + 12K_b}$$

$$= 11.5\,Js^{-1}$$

$$= 2\times10^{-4}K_c\left(100 - \frac{250K_c}{10K_b + 250K_s + 2.5K_c}\right)$$

$$\theta = \frac{150K_c}{6K_b + 4K_s + 1.5K_c}$$

(d)



- The temp. falls steadily or uniformly from the hot end.
- The heat loss from the sides is negligible and the same all along the bar.
- The lines of heat are parallel. *(02 marks)*

Total = 20 marks

SECTION C

8. (a) (i) X-rays are electromagnetic ~~rad n~~ radiations of short wave length (or high freq.) produced when fast moving electrons are stopped by matter. *(01 mark)*

Full mark.

(ii) - X-rays are produced ~~due to electron transition from higher energy levels to lower energy level~~ when fast moving electrons are stopping by matter whereas γ-rays are produced ~~when the molecules of an atom under nuclear fusion or fission.~~ due to spontaneous disintegration of unstable nuclei.

- X-rays have relatively longer wave length ~~than for~~ while γ-rays have shorter wave length.

Intensity of X-rays can be controlled while intensity of γ-rays cannot be controlled. *(02 marks)*

(b) (i) Shows - A line spectrum consisting of K- and L- series occurring at wavelengths of 0.500×10^{-10}m and 0.600×10^{-10}m respectively.

- A continuous spectrum with a definite cut-off wave length at 0.313×10^{-10}m. *(02 marks)*

(ii) From $\dfrac{hc}{\lambda \min} = eVa \Rightarrow h/e = \dfrac{\lambda \min Va}{c}$

$$= \frac{0.313\times10^{-10}\times40\times10^{3}}{3.0\times10^{8}}$$

$$= 4.17\times10^{-15}\,JsC^{-1}$$ *(03 marks)*

(iii) Increasing energy of the bombarding electrons leads to:

- A decrease in the cut-off wave length
- More characteristics lines like K_β, K_α and L_β, L_α appearing as the tube voltage is increased. *(02 marks)*

(c) Va = 35kV = 35 × 10^3V, I = 10m A = 10 × 10^{-3}A

(i) $I = ne \Rightarrow n = \dfrac{I}{e} = \dfrac{10\times10^{-3}}{1.6\times10^{-19}} = 6.25\times10^{16}s^{-1}$ electrons per second. *(03 marks)*

(ii) Rate of production of heat

$$= \frac{90}{100}\times n\times eVa$$ or 90% IVa

$$= \frac{90}{100}\times6.25\times10^{16}\times1.6\times10^{-19}\times35\times10^{3}$$

$$= 3.15\times10^{2}W$$ *(03 marks)*

(d) (i) Millikan's apparatus is surrounded in a constant – temp. bath in order:

- To maintain the density of the air so that the up thrust on the oil drops remains constant
- Changes in temp. may affect density of oil and so weight may change.
- To eliminate convection current. *(02 marks)*

(ii) - Since separation of plates is small, large drops may strike the lower plate without attaining terminal velocity.

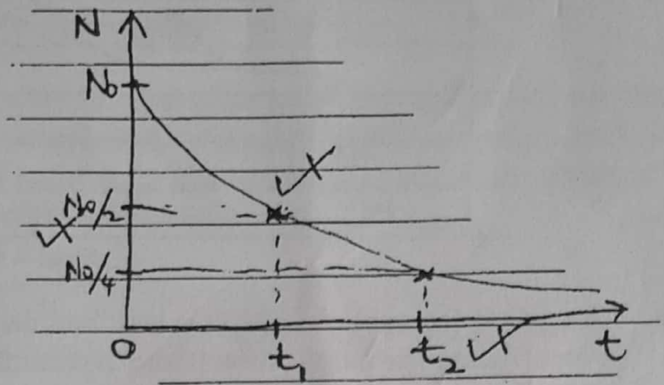
- Large drops require high voltage or p.d.s to be kept stationary. *(02 marks)*

9. (a) (i) Radioactive decay – Is the spontaneous disintegration of unstable nuclei of atoms accompanied by emission of α, β- particles and δ - rays or energy. to form a stable nuclei. *(01 mark)*

(ii) Half-life – Is the time taken for half the no. of radioactive atoms to decay or it is the time taken for the activity of a source to reduce to half of its original value. *(01 mark)*

(iii) Decay constant – Is the fractional no. of radioactive atoms that decay per second. *(01 mark)*

(b)



- Horizontal lines parallel to the time- axis are drawn at points $^{No}/_2$ and $^{No}/_4$ and the corresponding times t_1 and t_2 where the curve is cut are noted.
- The half-life $t_{\frac{1}{2}}$ is then calculated from: $t_{\frac{1}{2}} = \dfrac{t_1 + (t_2 - t_1)}{2}$
- Decay constant $\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$ $\lambda = \dfrac{\ln 2}{t_{1/2}}$ *(04 marks)*

(c) $t_{\frac{1}{2}} = 60$ days; No $= 1.0 \times 10^{20}$ atoms; $E_o = 8.0 \times 10^{-13}$J

(i) $A = \lambda N = \dfrac{0.693}{t_{\frac{1}{2}}} N_o e^{-\lambda t}$

$= \dfrac{0.693}{60} \times 1.0 \times 10^{20} e^{-\left(\frac{0.693}{60}\right) \times 120}$

$= 2.89 \times 10^{17}\ day^{-1}$ disintegrations per day.

or 3.3427×10^{12} disintegrations per second

or $N = N_o e^{-\lambda t}$

$= 1.0 \times 10^{20} e^{-\frac{\ln 2}{60} \times 120}$

$= 2.5 \times 10^{19}$ atoms *(04 marks)*

(ii) Total energy E = no. decayed $\times E_o$

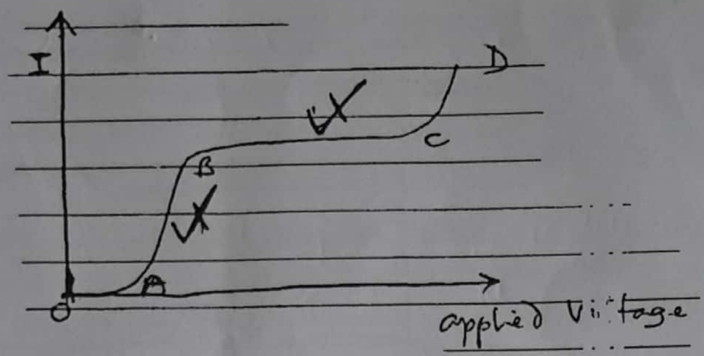
$$\therefore E = 1.0 \times 10^{20} \left(1 - e^{\frac{-0.693}{60} \times 120}\right) \times 8.0 \times 10^{-13}$$

$$= 6.0 \times 10^{7} J$$ *(03 marks)*

(d) (i) - Space charge – Is the large cloud number of electrons that gather close to the cathode as an almost stationary cloud of negative charge due to lack of sufficient energy to enable them reach the anode.

- Avalanche – Is a ~~collection of~~ large number of moving ion-pairs as a result of ~~violent~~ rapid collisions btn electrons and atoms as the former is accelerated towards the anode and a large no of electrons collects all along the anode wire. *(03 marks)*

(ii)



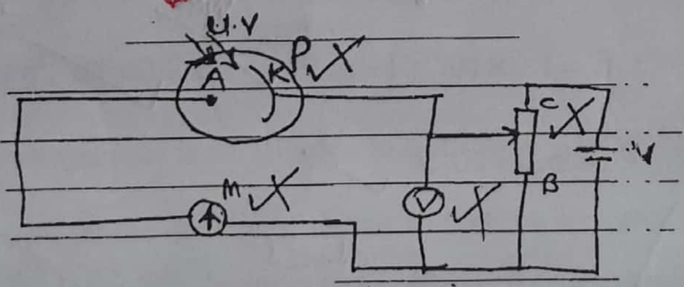
- Along OA, the applied voltage is less than the threshold voltage and there is insufficient gas amplication (there is recombination of ions-pairs) so no current pulses are detected.
- Along AB, the ~~magnificent~~ magnitude of any particular pulse depends on the strength of the initial ionization, which depends on the energy of the incident ionising particle. some ion pairs ~~re-continue~~ re-combine and current increase with applied voltage.
- Along BC; all ion-pair reach their respective destinations; no ~~recombination~~ occurs and current ~~probes~~ have the same amplitude or same current pulses are detected.
- Beyond C, quenching process is less and less effective and current increases uncontrollably. *(03 marks)*

Total = 20 marks

10. (a) (i) - Threshold freq – Is the frequency below which no photoelectric emission occurs however intense the incident radiation is.
- Work function – Is the minimum energy required to liberate an electron from a metal surface. *(02 marks)*

(ii) - When a metal surface is ~~radiated~~ irradiated by an electromagnetic radiation of high enough frequency, the electrons there absorbs the energy from the radiation as internal energy.
- If it is sufficient enough, they overcome the inward attraction by the atoms and are ~~ejected~~ as photo electrons. *(03 marks)*

(b)



02

- Monochromatic light (u.v) is made to illuminate the cathode k of a photocell P.
- The cathode is made positive with respect to the anode A.
- The p.d btn A and K is varied until the micro ammeter A reads zero.
- The voltmeter reading taken from the voltmeter is the stopping potential.

(05 marks)

(c) (i) When u.v falls on the zinc plate, the leaf falls instantly. This is because the electrons from the zinc plate are lost through photo electric emission; and the negative charge (electrons) will move from the leaf to the cap and to the zinc to replace the emitted electrons, thus no. of electrons down the GLE reduces thus reduces the force of repulsion btn the leaf and the zinc metal plate, then leaf falls.

(02 marks)

(ii) No effect is observed if infrared radiation falls on the zinc plate This is because infrared radiation has a frequency below the threshold required for photoelectric emission. *(02 marks)*

(iii) If u.v falls on the zinc plate connected to a positively charged plate, there will be no change in divergence of the leaf. This is because the electrons emitted by photoelectric emission are attracted back by the positively charged zinc plate. *(02 marks)*

(d) $\lambda_1 = 6.0\times10^{-7}m$ $\qquad \frac{1}{2}mv^2 \max = 4.0\times10^{-20}J$

$\lambda_2 = 5.5\times10^{-7}m$

From $hf = \dfrac{hc}{\lambda} = w_o + \frac{1}{2}mv^2;$

$$\frac{hc}{6.0\times10^{-7}} = w_o$$

Also; $\dfrac{hc}{5.5\times10^{-7}} = w_o + 4.0\times10^{-20}$

$$\Rightarrow \frac{hc}{5.5\times10^{-7}} = \frac{hc}{6.0\times10^{-7}} + 4.0\times10^{-20}$$

$$\Rightarrow h = 8.89\times10^{-34}\,Js$$

(04 marks)

Total = 20 marks

END