UACE Physics paper 1 set6 guide

1. (a)(i) What is projectile motion? (01 marks)
Projectile motion is motion of the body which after being given an initial velocity moves under the influence of gravity.
(ii) A bomb is dropped from an aeroplane when it is directly above a target at a height of 1402.5m. The aeroplane is moving horizontally with a speed 0f 500kmh^{-1}. Determine whether the bomb will hit the target. (05marks)
$Y = ut + ½ at^2$
$-1402.2 = 0 + ½ \times 9.81 \times t^2$
t = 16.9s
Horizontal velocity of the plane =500kmh^{-1} = $\frac{500 \ x\ 1000}{60\ x\ 60}$ = 138.89ms^{-1}
Distance of the bomb from the target = 138.89 x 16.9 = 2347.2m
Hence the bomb misses the target by 2347.2m

(b) (i) Define angular velocity. (01mark)
Angular velocity is the rate of change of angle for a body moving in a circular path.
(ii) A satellite is revolving around the earth in a circular orbit at an altitude of 6 x 105m where the acceleration due to gravity is 9.4 ms^{-2}. Assuming that the earth is spherical, calculate the period of the satellite. (03marks)

$Mg = mr\omega^2$
$g = \frac{4\pi^2 r}{T^2}$
$T = \sqrt{\left(\frac{4\pi^2(6.4\ x\ 10^6+6.0\ x\ 10^5)}{9.4}\right)}$ = 5.42 x 10^{3}s

(c) (i) State Newton's laws of motion (03marks)
- 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 of a body is directly proportional to applied force and takes place in the direction of the force
- For every action, there is an equal and opposite reaction

(ii) Explain how a rocket is kept in motion. (04marks)
Fuel is burst in a combustion chamber and exhaust gases are expelled at high velocity. This causes a large backward momentum. From the principle of conservation of linear momentum, an equal forward momentum is gained by the rocket.
Due to continuous combustion of the fuel, there is a large change in forward momentum which lead to the thrust, hence maintaining the motion of the rocket.
(iii) Explain why passengers in a bus are thrown backwards when the bus suddenly start moving (03marks)
Passengers are thrown backwards because of inertia. When the bus sets off the passenger tend to stay at rest because the force acts on the bus does not act on the passengers.

2. (a) (i) What is meant by Young's modulus? (03marks)

Young's Modulus is the ratio of tensile stress to tensile strain of a material

(ii) State Hooke's law (01mark)

Hooke's law states that the extension of a material is proportional to the stretching force provided the elastic limit is not exceeded.

(iii) Derive an expression for energy released in a unit volume a stretched wire in terms of stress and strain. (04marks)

Suppose a force, F, stretches the wire by extension x

Work done, W = average force x extension = $\frac{1}{2}Fx$ = stored energy

Energy stored per unit volume =$\frac{W}{AL}$; where AL is the volume of the wire

Hence energy store = $\frac{1}{2}\ x\ \left(\frac{F}{A}\right)\left(\frac{x}{L}\right) = \frac{1}{2}\ x\ stress\ x\ strain$

(b) A steel wire of length 0.6m and cross-section area 1.5 x $10^{-6}m^2$ is attached at B to a copper wire BC of length 0.39m and cross section area 3.0 x $10^{-6}m^2$. The combination is suspended vertically from a fixed point at A and supports a weight of 250N at C. find the extension in each of the wires, given that Young's Modulus for steel is 2.0 x $10^{11}Nm^{-2}$ and that of copper is 1.3 x $10^{11}Nm^{-2}$. (05marks)

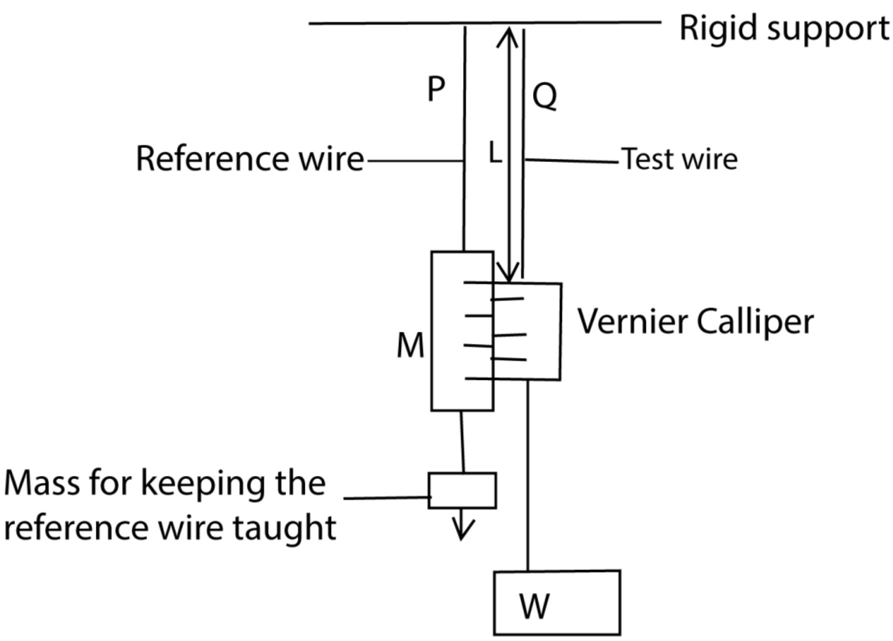
From e = $\frac{FL}{AE}$

For steel, $e_1 = \frac{250\ x\ 0.6}{1.5\ x\ 10^{-6}\ x\ 2.0\ x\ 10^{11}}$ = 5.0 x 10^{-4}m

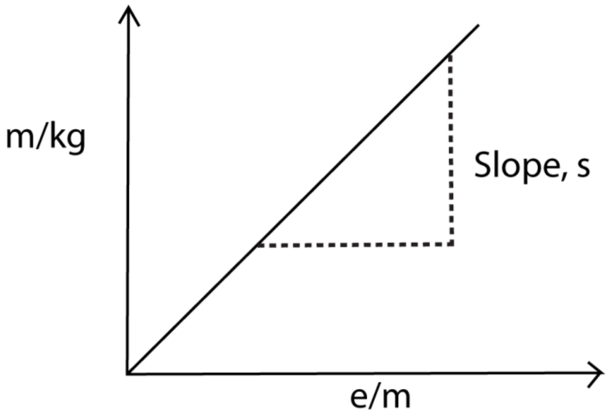
For copper, $e_2 = \frac{250\ x\ 0.39}{3.0\ x\ 10^{-6}\ x\ 1.3\ x\ 10^{11}}$ = 2.5.0 x 10^{-4}m

(c) With the aid of a labelled diagram, describe an experiment to determine the Young's Modulus of a steel wire (07marks)

Experiment to determine Young's Modulus for a metal wire



(i) Two thin, long wires of the same material and length P and Q are suspended from a rigid support.
(ii) P carries a scale M in mm and it's straightened by attaching a weight at its end.
(iii) Q carries a Vernier scale which is alongside scale M
(iv) Various loads are added to the test wire and corresponding extensions caused are read off from a vernier scale.
(v) The diameter (2r) of the wire is obtained by a micrometre screw gauge, and the cross section area of the wire A = $4\pi r^2$
(vi) A graph of mass (m) of the load against extension e is plotted



Young's modulus, Y = $\frac{gsL}{A}$

(d) Explain the term plastic deformation in metals (02marks)

During plastic deformation, some crystal planes slide over each other. The movement of dislocation takes place and on removing the stress, the original shape and size are not recovered due to energy loss in form of heat.

3. (a) Define work and energy (02marks)

Work is a product of force and distance moved in the direction of force.

Energy is the ability to do work

(b) Explain whether a person carrying a bucket of water does any work on the bucket while walking on a levelled road. (03marks)

There is no net force on the bucket in horizontal direction. The only force he exerts on the bucket is against the weight mg of the bucket perpendicular to the direction of motion. From work = Fcos90 = 0, there is no work done on the bucket

(c) A pump discharges water through a nozzle of diameter 4.5cm with speed of 62ms^{-1} into a tank 16m above the intake.

(i) Calculate the work done per second by the pump in raising the water if the pump is ideal. (04marks)

Total work done per second = P.E + K.E

= mgh + ½ mv^2

= $10^3\pi(2.25 \times 10^{-2})^2 \times 62(9.81 \times 16 + \frac{1}{2} x\ 62^2)$

= $2.05 \times 10^5 Js^{-1}$

(ii) Find the power wasted if the efficiency of the pump is 73% (02marks)

Efficiency = $\frac{P_{out}}{P_{in}} x\ 100 = 73$

$P_{in} = \frac{2.05\ x\ 10^5}{73}$ = 2.81×10^6W

Power lost = P_{in} - P_{out} = 2.81 x 10^6 – 2.05 x 10^5 = 7.6 x 10^4W

(iii) Account for the power loss in (c)(ii) (02marks)
Power is lost in overcoming friction and some is converted into sound and heat

(d) (i) State work-energy theorem. (01mark)

It states that work done by the net force acting on a body is equal to the change in its kinetic energy.

(ii) Prove the work-energy theorem for a body moving with constant acceleration. (03marks)

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

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

Work done = F x s but F = ma

$= ma\left(\frac{v^2 - u^2}{2a}\right)$

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

Therefore work done = change in kinetic energy

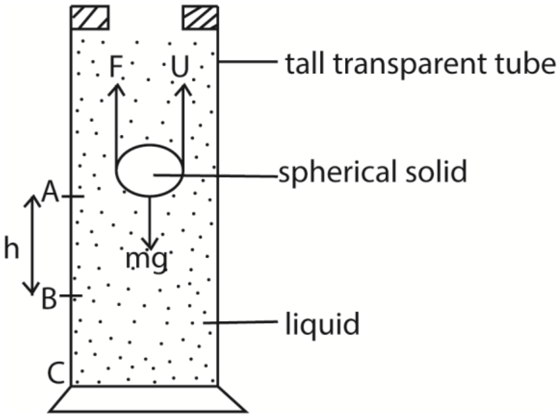
(e) Explain briefly what is meant by internal energy of a substance. (03marks)

The internal energy of a body or a substance is the total sum of kinetic energy and potential energy of the particles of a substance is the internal energy of a substance

4. (a) Define coefficient of viscosity and state its units. (02marks)
Coefficient of viscosity is the frictional force on unit area of a liquid in a region of unit velocity gradient. Units Pas or Nsm^{-2}

(b) Explain the origin of viscosity in air and account for the effect of temperature on it. (05marks)
In air, molecules are further apart and have negligible intermolecular forces. Therefore the molecules move randomly colliding with one another and continuously transferring momentum to the neighbouring layers. The transfer of momentum constitute viscosity of air. When the temperature increases the molecules move faster, their kinetic energy increases and make more frequent collision. This increases the transfer of momentum and lead to increase in viscosity.

(c) Describe, stating the necessary precautions an experiment to measure the coefficient of viscosity of a liquid using Stroke's law. (07marks)



- A liquid of known density, ρ, is put in a tall transparent glass with reference marks A and B, h metres apart
- A spherical solid of radius a and density, σ, is dropped into the liquid and time t taken to drop from A to B is determined.
- Terminal velocity, $v_0 = \frac{h}{t}$

  The coefficient viscosity, $\eta = \frac{2r^2(\sigma-\rho)g}{9v_0}$

  Assumptions

  The spherical solid moves with terminal velocity by the time it reaches A

  Precautions
  - The glass tube should be very wide compared to the diameter of the ball.
  - The point C should be far away from the top of the tube
  - Temperature is constant

(d) A steel ball bearing of diameter 8.0mm falls steadily through oil and covers a vertical height of 20.0cm in 0.56s. If the density of steel is7800kgm^{-3} and that of oil is 900kgm^{-3}, calculate the

(i) up thrust on the ball (03marks)

U = $\frac{4}{3}\pi r^3\rho g = \frac{4}{3}\ \pi\ x\ (4\ x\ 10^{-3})^3 x\ 900\ x\ 9.81$ = 2.37 x 10^{-3}N

(ii) viscosity of the oil (03marks)

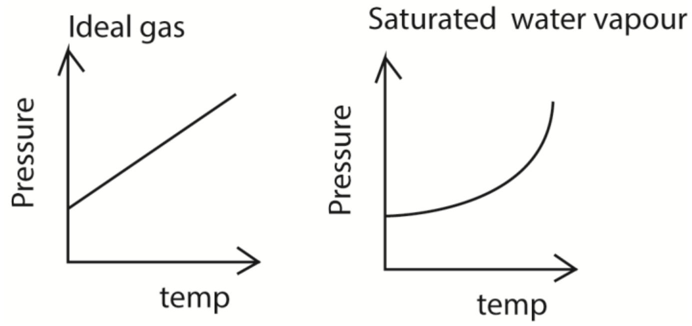
From $\eta = \frac{2r^2(\sigma-\rho)g}{9v_0}$

η = $\frac{2\left(4\ x\ 10^{-3}\right)^2\ x\ 9.81(7800-900)}{9\ x\ 0.357}$ = 0.674Nsm^{-2}

SECTION B

5. (a) (i) State two differences between saturated and unsaturated vapours. (02marks)
   - A saturated vapour pressure is one which is in dynamic equilibrium with its own liquid and an unsaturated vapour is one that is not in dynamic equilibrium with its own liquid.
   - A saturate vapour pressure does not obey gas laws whereas unsaturated vapour approximately obey gas laws.

   (ii) Sketch graphs of pressure against temperature for an ideal gas and for saturated water vapour originally at 0^{0}C (03marks)



(b) The specific heat capacity of oxygen at constant volume is 719$Jkg^{-1}K^{-1}$ and its density at standard temperature and pressure is 1.429kgm^{-3}. Calculate the specific heat capacity of oxygen at constant pressure (04marks)

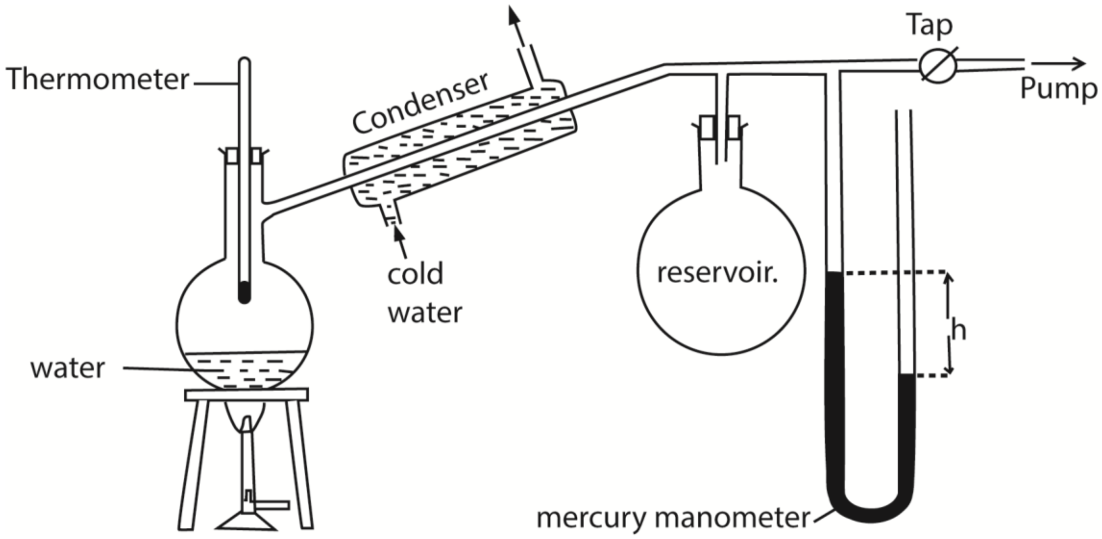
PV =mrT

$r = \frac{P}{T}\left(\frac{V}{m}\right) = \frac{1.01 \ x \ 10^5}{273 \ x \ 1.429}$ = 258.9$Jkg^{-1}K^{-1}$

$c_p - c_v = r$

c_p = 719 + 258.9 =977.9$Jkg^{-1}K^{-1}$

(c) (i) With the aid of a labelled diagram, describe an experiment to determine standard saturated vapour pressure of water. (05marks)



- The pressure of the air in R is shown by the mercury manometer; if its height is h, the pressure in mm mercury is P = H-h, where H is the barometer height.
- The tap is opened and the pressure above water varied using the pump to a suitable value.
- The tap is closed and water in the flask in heated until it boil.
- The temperature θ and difference in mercury levels, h, are noted and recorded.
- The saturated vapour pressure, P = ($H \pm h$) is calculated
- The procedure is repeated other values of θ and h
- A graph of P versus θ is plotted and the saturated vapour pressure at a particular temperature is obtained.

(ii) State how the experiment set up in (c) (i) may be modified to determine a saturated vapour pressure of above atmospheric pressure (01marks)

By replacing the vacuum pump with a bicycle pump

(d)(i) Define ideal gas (01mark)

An Ideal gas s one that obeys Boyle's law under all conditions

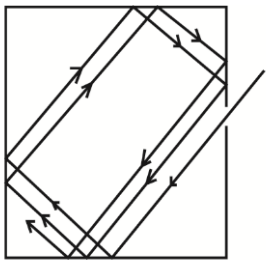
(ii) State and explain the conditions under which real gases behave as ideal gases. (04marks)

- At higher temperature, the intermolecular spacing increases and intermolecular forces become negligible
- At very low pressure, the gas occupies negligible volume of the container.

6. (a) (i) What is a black body?(01marks)

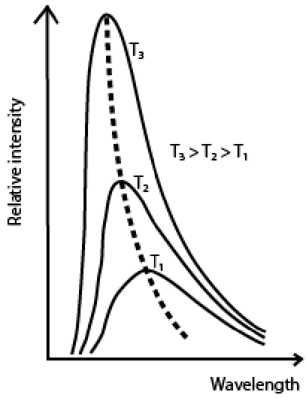
A black body is one which absorbs all the radiation that falls upon it, and reflects or transmits none.

(ii) Explain with the aid of a diagram how black body can be approximated. (03marks)



When radiation enters a black container through a hole, it undergoes multiple reflections. At each reflection, part of the radiation is absorbed. After several reflections, all the radiation is retained inside the container. Hence it approximates to a black body.

(iii) With the aid of sketch graphs explain the silent features of the spectral distribution of black body radiation (04 marks)



- For every wave length, relative intensity increases as temperature is increased.
- The wavelength at which maximum intensity occur shifts to the shorter wavelength as temperature is increased.
- λ_{max} is the wavelength of radiation emitted at maximum intensity/emission of a black body at a particular temperature.

(b) Give four properties of ultraviolet radiation. (02marks)

- produce ionization and florescence
- affect photographic plates
- produces photoelectric effect
- promotes chemical reaction
- can be reflected and refracted.

(c) Describe an experiment to compare the energy radiated by two surfaces at different temperatures (04marks)

- A metal cube whose sides have a variety of finishes; dull black, white, highly polished is filled with water and this water is kept boiling by a constant heat supply.
- A thermopile is made to face the various finishes of the cube at equal distances and each time the deflection on the galvanometer is noted.
- The deflection of the galvanometer is greatest when the thermopile is facing the dull-black surface and least when facing the highly polishes surface.
- This implies that the dull-black surface is a better radiator.

(d) (i) State Stefan's law. (01mark)

Stefan's law states that the total power radiated by a black body per unit surface area is proportional to the fourth power of its absolute temperature. i.e. $\frac{P}{A} \propto T^4$

(ii) The earth receives energy from the earth from the sun at the rate of 1.4 x 10^3Wm^{-2}. If the ratio of the earth's orbit to the sun's radius is 216, calculate the surface temperature of the sum. (05marks)

Power radiated by the sun = $4\pi r^2\sigma T^4$

Energy intensity = $\frac{4\pi r^2\sigma T^4}{4\pi R^2}$

$\therefore \frac{4\pi r^2\sigma T^4}{4\pi R^2} = 1.4\ x\ 10^3$

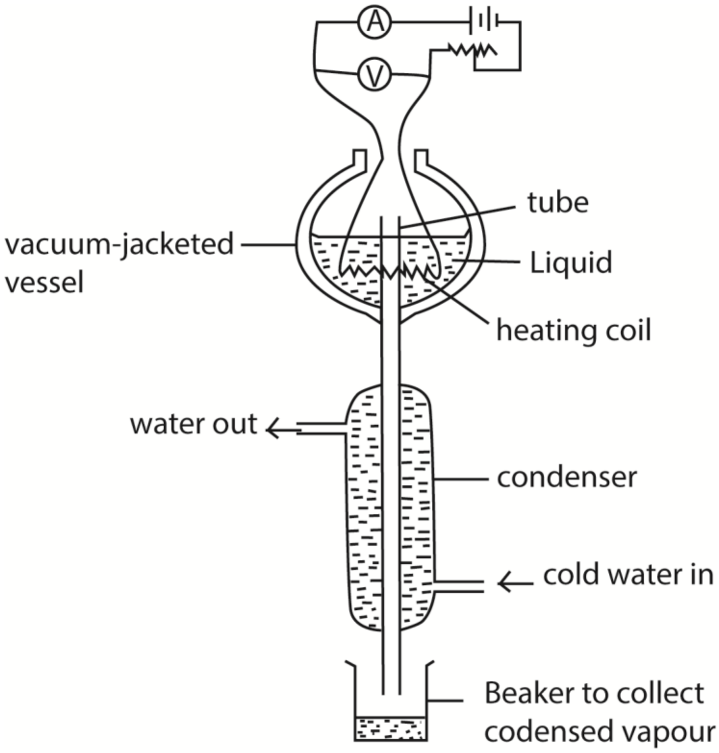
$T^4 = \frac{1.4\ x\ 10^3}{5.7\ x\ 10^{-3}}\left(\frac{R}{r}\right)^2 = \frac{1.4\ x\ 10^3}{5.7\ x\ 10^{-3}}\ x\ 216^2$

$T = 5.82x\ 10^3$ K

7. (a) Define specific latent heat of vaporization. (01mark)

Specific latent heat of vaporization is the amount of heat required to change 1kg mass of a liquid into vapour at constant temperature.

(b) With the aid of labelled diagram, describe an experiment to measure the specific latent heat of vaporization of a liquid using an electrical method. (07marks)



- Put the liquid whose specific latent heat of vaporization is required in a vacuum jacketed vessel as shown above.
- The liquid is heated to boiling point.
- The current, I, and voltage, V are recorded.
- The mass of liquid, m, condensed in time, t, is determined.
- Then IV = $\frac{m}{t}L + h$, where h is the rate of heat loss to the surroundings
- To eliminate, h, the experiment is repeated for different values of I' and V' and the mass of the liquid, m' condensed in tie t is determined.
- Again I'V' = $\frac{m\prime}{t}L + h$

  Latent heat of vaporization, L =$\frac{(I'V'-IV)t}{(m'-m)}$

(c) Explain the effect of pressure on the boiling point of a liquid. (02marks)

- Since a liquid boils when its saturated vapour pressure is equal to external pressure.
- Increasing the external pressure increases the boiling point of a liquid because the liquid has to be heated to a higher temperature to make its saturated vapour pressure equal to external pressure

(d) A liquid of specific heat capacity 2.8 x 10^3Jkg^{-1}K^{-1} and specific latent heat of vaporization 9.00 x 10^5Jkg is contained in a flask of heat capacity 800JK^{-1} at a temperature of 32^{0}C. An electric heater rated 1kW is immersed in 2.5kg of the liquid and switched on for 12 minutes, calculate the amount of liquid that boiled off, given that the boiling point of the liquid is 80^{0}C. (06marks)

Heat supplied by the heater = mcθ + Cθ + m_1L

1000 x 12 x 60 = 2.5 x 2.8 x 10^3(80-32) + 800 x (80- 32) + 9.00 x $10^5$$m_1$

Mass of the liquid evaporates, m_1 = 0.384kg

(e) (i) Two thermometers are used to measure the temperature of a body. Explain why the temperatures may be different. (02marks)

Because thermometric properties vary differently with temperature and only agree at fixed points.

(ii) A platinum resistance thermometer has a resistance of 5.42Ω at the triple point of water. Calculate the resistance at a temperature of 50.0^{0}C. (02marks)

T = $\frac{R_T}{R_{tr}}$ x 273.16

(273 + 50) = $\frac{R_{50}}{5.42}$ x 273.16

R_{50} = 6.41Ω

SECTION C

8. (a) State Rutherford's model of the atom. (02marks)

The positive charge of an atom and nearly all the mass is concentrated in a small volume at the center. Electrons are in motion in circular orbits around the nucleus and the volume of the atom is accounted for by the electron cloud.

(b) Explain how Bohr's model of the atom addresses the two main failures of Rutherford's model. (07marks)

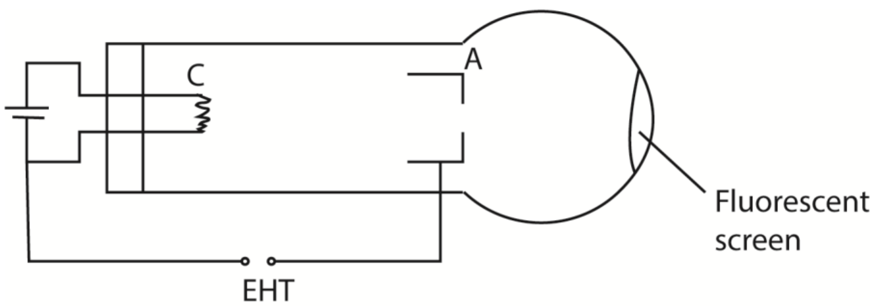
Orbiting electrons experience centripetal acceleration. Therefore they continuously emit electromagnetic radiation hence would lose energy. This therefore implies that the electrons would spiral towards the nucleus and the atom ceases to exist. Yet the atom is stable Thus Rutherford model cannot explain the stability of the atom.

Since electron continuously accelerating around the nucleus, a continuous emission spectra should be emitted by the atom. However experimental observation reveals that it is atomic emission spectrum

From Bohr's model, electrons move around the nucleus in circular orbits. In these orbits the electron does not radiate energy. Electromagnetic radiation is emitted when the electron makes a transition between orbits

The electron can only move in allowed orbits in which their angular momentum is equal to $\frac{nh}{2\pi}$

(c) With the aid of a labelled diagram, describe how cathode rays are produced. (05marks)



Hot Cathode C produces electrons by thermionic emission. The electrons are accelerated by p.d between cathode C and anode A

(d) (i) What is binding energy of a nucleus? (01mark)

Binding energy is the energy released when a nucleus is formed from its components (protons and neutrons)

(ii) Calculate the energy in MeV released by fusing four protons to form an alpha particle and two beta particles.

Mass of beta particle = 0.000549u

Mass of hydrogen atom = 1.007825u

Mass of helium atom = 4.002664u

[1u = 931MeV] (05marks)

Solution

$4{}_{1}^{1}H \rightarrow {}_{2}^{4}He + 2{}_{-1}\beta + Q$

Mass of the reactant = 4 x 1.00782 = 4.031300

Mass of the products = 4.002664 + 2 x 0.000549= 4.003762

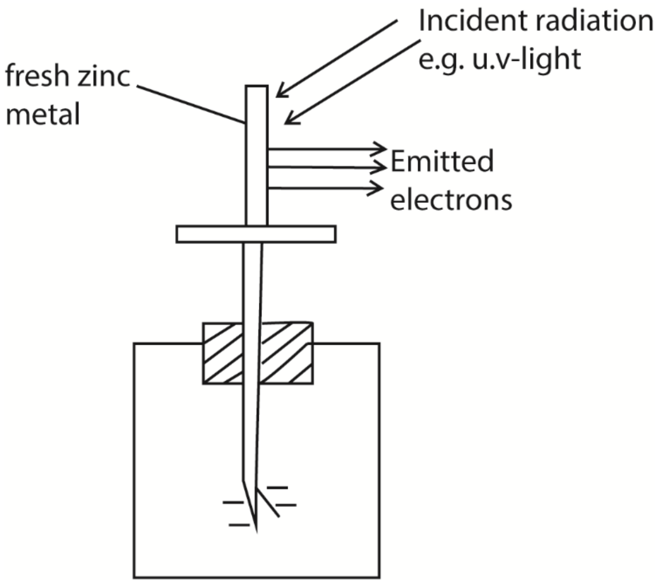
Decrease in mass= 4.0031300 - 4.003762 =0.027538U

= 0.027538 x 931

= 25.64MeV

9. (a) What is photo electric emission? (01mark)
Is the emission of electrons from a clean surface of a metal when irradiated by electromagnetic radiation of light

(b)(i) Describe an experiment to demonstrate photo electric effect. (04marks)



- Freshly cleaned zinc plate is placed on top of a negatively charged electroscope.
- Ultraviolet radiation is directed onto the zinc plate
- The leaf gradually falls indicating the electroscope has lost charge which are electrons.

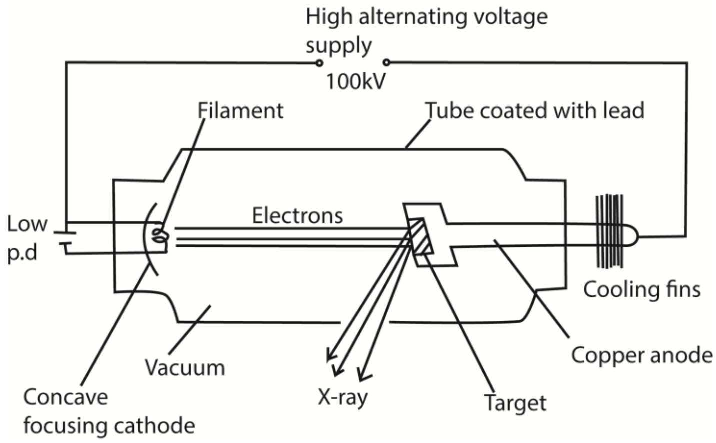
(ii) When a clean surface of a metal in a vacuum is irradiated with light of wave length 5.5 x 10^{-7}m, electrons just emerge from the surface. However when light of wavelength 5 x 10^{-7}m is incident on the metal surface, electrons are emitted each with energy 3.62 x 10^{-20}J. Find Plank's constant. (04marks)

K.E = $\frac{hc}{\lambda} - \frac{hc}{\lambda_0}$

3.62 x 10^{-20} = $h\ x\ 3\ x\ 10^{8} \left(\frac{1}{5\ x\ 10^{-7}} - \frac{1}{5.5\ x\ 10^{-7}}\right)$

$\therefore h = 6.64\ x\ 10^{-34} Js$

(c) (i) With the aid of a labelled diagram, describe an X-ray tube and how X-rays are produced. (05marks)



Mode of operation

- The filament is heated by a low voltage supply and the electrons are emitted by thermionic emission.
- The concave focusing cathode focuses the electrons from the filament onto the target.
- These electrons are accelerated towards the anode by the high voltage between the filament and the Anode.
- When the electrons (cathode rays) strike the metal target, about only 1% their kinetic energy is converted to X-rays and the 99% of their kinetic energy is converted to heat, which is conducted away by the cooling fins.

(ii) Describe how the intensity and quality of X-rays is controlled in an X-ray tube. (02marks)

- Intensity of X-rays is controlled by varying the filament current
- Quality of X-rays is controlled by the high voltage

(d) An X-ray tune operates at 1.5 x 10^{-3}V and the current through it is 1.0 x 10^{-3}A.

Find the

(i) number of electrons crossing the tube per second. (02marks)

n = $\frac{I}{e}$ = $\frac{1.0\ x\ 10^{-3}}{1.6\ x\ 10^{-19}}$ = 6.15 x 10^{15}

(ii) kinetic energy gained by electron traversing the tube (02marks)

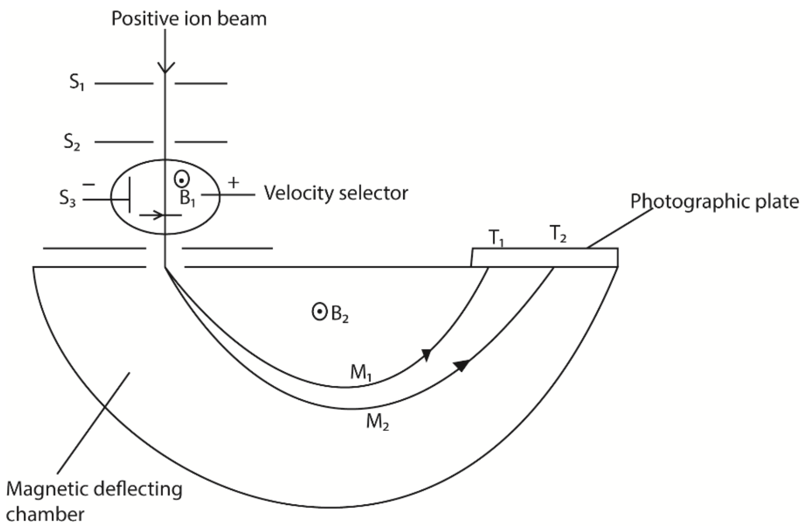
K.E = eV 1.6 x 10-19 x 1.5 x 10^{-3} = 2.4 x 10^{-16}J

10. (a)(i) What is specific charge? (01mark)
Specific charge is the ratio of charge to mass of a particle

(ii) State the **unit** of specific charge (01mark)

Unit = Ckg^{-1}

(iii) Describe with the aid of a diagram how the specific charge of positive ions can be determined using a mass spectrometer. (06marks)



T_1 and T_2 are tracers on photographic plate, S_1, S_2 and S_3 are slits

Mode of Action

- Positive ions are produced in a discharge tube and admitted as a beam through slits S_1 and S_2.
- The beam then passes between insulated plates P, Q, connected to a battery, which create an electric field of intensity E.
- A uniform magnetic field B_1, perpendicular to E is applied over the region of the plates and all ions, charge e with the same velocity, v given by $B_1ev = Ee$ will then pass undeflected through the plates and through a slit S_3.
- The selected ions are deflected in a circular path of radius r by a uniform perpendicular magnetic field B_2 and an image is produced on a photographic plate as shown.
  In this case
  $$\frac{mv^2}{r} = B_2ev$$
  $$\therefore \frac{m}{e} = \frac{rB_2}{v}$$

  But for the ions selected v = $\frac{E}{B_1}$ from above

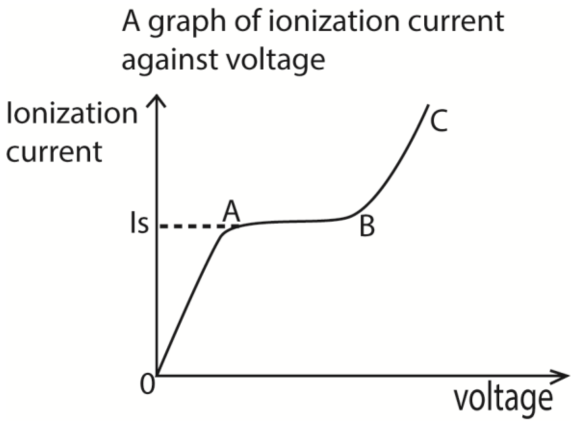
Specific charge, $\frac{e}{m} = \frac{E}{rB_2B_1}$,

(b) A beam of strongly ionized carbon atoms passes undeflected through a region of crossed magnetic and electric field of 0.10T and $1.0 \times 10^4 NC^{-1}$ respectively. When it enters a region of uniform magnetic field, it is deflected through an arc of radius 0.75m. Calculate the magnetic flux density of this magnetic field. (Mass of carbon atom = 2.0 x 10^{-26}kg) (05marks)

$B_1qv = qE$, $v = \frac{E}{B_1}$ and $B_2qv = \frac{mv^2}{R}$

$\therefore B_2 = \frac{mE}{qRB_1} = \frac{2.0\ x\ 10^{-26}\ x\ 1.0\ x\ 10^4}{1.6\ x\ 10^{-19}\ x\ 0.75\ x\ 0.1} = 0.0167T$

(c) (i) Draw a graph to illustrate the variation of ionization current and p.d across an ionization chamber and explain its features. (03marks)



Region OA:

Current detected increases gradually but p.d is not large enough to prevent recombination of the ions.

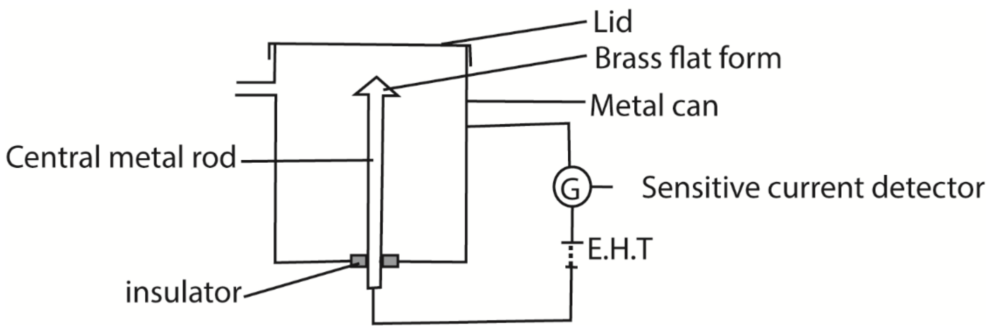
Region AB. (saturation region)

Current is almost constant, all ions reach the electrode before recombination but there is no secondary ionization.

Region BC (gas amplification)

Current increases rapidly for small increase (change) in p.d. because secondary ionization takes place due to primary ions being produced. This implies many ion pairs, thus a larger current detected.

(ii) Explain how ionization chamber can be used to detect ionization radiation (04marks)



- A radiation source on the brass flat form causes ionization of air in the chamber producing electrons and positive ions.
- The electrons move to the metal can and positive ions drift to the central metal rod.

- Movement of the ions to the electrodes causes discharge and current pulse flows in external circuit.
- The current sensitive detector detects current.
- The magnitude of current detected shows the extent to which ionization takes place.

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