UACE Physics paper 1 2006 Guide Time 2½ marks

Instructions the candidates:

Answer **five** questions, including at least **one**, but **not more than two** from each sections **A, Band C**.

Any additional question(s) answered will not be marked.

Non programmable scientific calculators may be used.

Assume where necessary

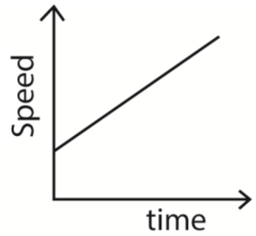
Acceleration due to gravity, g	$9.81ms^{-2}$
Electron charge, e	$1.6 x10^{-19}C$
Electron mass	$9.11 \times 10^{-31}kg$
Mass of the earth	$5.97 \times 10^{24}kg$
Plank's constant, h	$6.6 \times 10^{-34}Js$
Stefan's-Boltzmann's constant, σ	$5.67 \times 10^{-8}Wm^{-2}K^{-1}$
Radius of the earth	6.4 x 106m
Radius of the sun	$7 \times 10^{8}m$
Radius of the earth's orbit about the sun	$1.5 \times 10^{11}m$
Speed of light in the vacuum, c	$3.0 \times 108ms^{-1}$
Thermal conductivity of copper	$390Wm^{-1}K^{-1}$
Thermal conductivity of aluminium	$210Wm^{-1}K^{-1}$
Specific heat capacity of water	$4.200Jkg^{-1}K^{-1}$
Universal gravitational constant	$6.67 \times 10^{-11}Nm^{2}Kg^{-2}$
Avogadro's number, N_A	$6.02 \times 10^{23}mol^{-1}$
Surface tension of water	$7.0 \times 10^{-2}Nm^{-1}$
Density of water	$1000kgm^{-3}$
Gas constant, R	$8.31Jmol^{-1}K^{-1}$
Charge to mass ratio, e/m	$1.8 \times 10^{11}Ckg^{-1}$
The constant, $\frac{1}{4\pi\varepsilon_0}$	$9.0 \times 10^{9}F^{-1}m$
Faraday's constant, F	$9.65 \times 10^{4}Cmol^{-1}$

SECTION A

1. (a)(i) What is meant by uniformly accelerated motion? (01marks)

   Uniformly accelerated motion is one for which velocity increases by equal amounts in equal successive time interval

   (ii) Sketch the speed against time graph for a uniformly accelerated body. (01mark)



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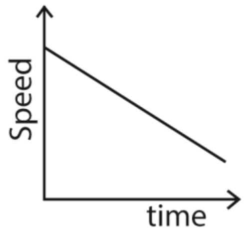


   (iii) Derive the expression: S = ut + ½ at^2, for the distance, S, moved by a body which is initially travelling with speed u and is uniformly accelerated for time t.

   $s = \left(\frac{u+v}{2}\right) t$ but v = u + at

   $s = \frac{(u+u+at)t}{2}$

   = ut + $\frac{1}{2}at^2$

(b) A projectile is fired horizontally from the top of a cliff 250m high. The projectile lands 1.414×10^3m from the bottom of the cliff. Find the

(i) initial speed of the projectile. (05marks)

From y = u_yt + $\frac{1}{2}at^2$

-250 = 0 - $\frac{1}{2}$ x 9.81 x t^2;

t = 7.14s

Horizontally, x = u_xt

1.414×10^3 = 7.14u_x

u_x = 198ms^{-1}

(ii) velocity of the projectile just before it hits the ground. (05marks)

v_y = u_y + at

= 0 – 9.81 x 7.14 = 70ms^{-1}

v = $\sqrt{u_x^2 + u_y^2}$ = $\sqrt{198^2 + -70^2}$ 210ms^{-1}

θ = $tan^{-1}\left(\frac{70}{198}\right)$ = 19.5^0 to the horizontal

(c) Describe an experiment to determine the centre of gravity of a plane sheet of material having irregular shape (04marks)

- three holes are drilled around the edge of the sheet of irregular object.

- The cardboard is suspended from a pin through one of the holes. When the cardboard is freely suspended, a plumb line is suspended from the same pin.
- A line is drawn to mark the line where the plumb line passes.
- The procedure is repeated for the other two holes.
- The point of intersection of the three line is the centre of gravity

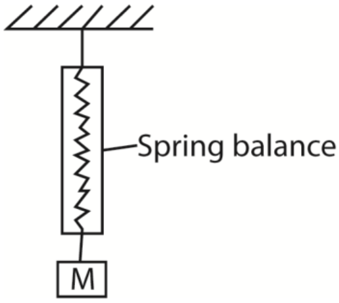
2. (a) (i) Define force and power. (02marks)

   A force is something that changes of tends to change a body's state of rest or uniform motion in straight line.

   Power is the rate of doing work

   (ii) Explain why more energy is required to push a wheel barrow uphill than on a level ground. (03mark)

   (b)



   A mass, M, is suspended from a spring balance as shown in the figure above. Explain what happens to the reading of the spring balance when the setup is raised slowly to a very high height above the ground. (02marks)

   On a level ground, work is only done against frictional force, while when moving uphill work is done against friction force and gravity. As the setup is raised to a greater height, acceleration due to gravity decrease; so the weight of M decreases, therefore the reading of the spring balance also decreases.

   (c) (i) State the work-energy theorem (01mark)

   Work done by the resultant force on the body is equal in kinetic energy of the body

   (ii) A bullet of mass 0.1kgmoving horizontally with a speed of 420ms^{-1} strikes a block of mass 2.0kg at rest on a smooth table and becomes embedded in it. Find the kinetic energy lost if they move together. (04marks)

   $m_1u_1 = (m_1 + m_2)v$

   $0.1 \times 420 = 2.1v$

   $v = 20ms^{-1}$

   loss in K.E $= \frac{1}{2}m_1u^2 - \frac{1}{2}(m_1 + m_2)v^2$

   $= \frac{1}{2}\ x\ 0.1\ x\ 420^2 - \frac{1}{2}\ x\ 2.1\ x\ 20^2$

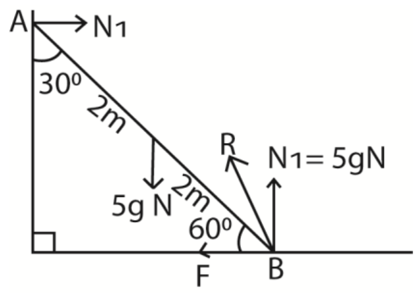
   = 8400J

   (d) State the condition for equilibrium of a rigid body under the action of coplanar forces. (02marks)

- the sum of forces acting in any one direction is equal to the sum of forces acting in the opposite direction (the resultant force on the body = 0)
- the sum of clockwise moments about any point is equal to the sum of anticlockwise moments about the same point.

(e) A 3m long ladder rests at an angle 60^0 to the horizontal against a smooth vertical wall on a rough ground. The ladder weighs 5kg and its centre of gravity is one- third from the bottom of the ladder.

(i) Draw a sketch diagram to show the forces acting on the ladder. (02marks)



(ii) Find the reaction of the ground on the ladder (04marks)

Taking moments about A;

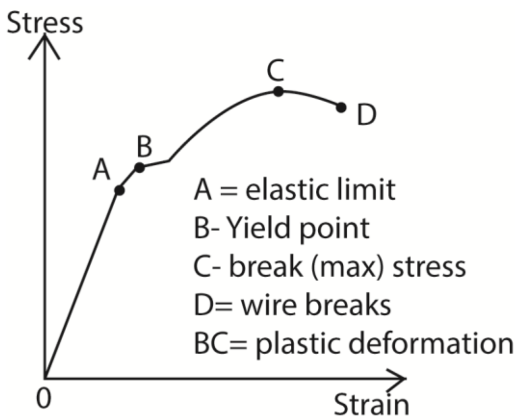
F x $3\cos30^0$ + 5g x $2\sin 30^0$ = 5g x $3\sin 30^0$

F = 9.44N

R = $\sqrt{9.44^2 + (3\ x\ 9.91)^2}$ = 49.95N

$\theta = \ tan^{-1}\left(\frac{9.44}{49.05}\right)$ = 10.9^0 to the vertical

3. (a) (i) Define stress and strain (02marks)
   Stress is force per unit area.
   Strain is force per unit length
   (ii) Determine the dimensions of Young's modulus. (03marks)
   Y = $\frac{stress}{strain} = \frac{F}{A} \div \frac{e}{e} = \frac{MLT^{-2}}{L^2}\ x\ \frac{L}{L}$ = $ML^{-1}T^{-2}$
   (b) Sketch a graph of stress versus strain for a ductile material and explain its features. (06marks)



- OA – stress is proportional to strain and the material regains its length

- AB - stress is not proportional to strain but the material regains its length
- Beyond B the material becomes permanently stretched
- CD the material undergoes plastic deformation
- Beyond D the material breaks

(c) A steel wire of cross section area $1mm^2$ is cooled from a temperature of 60^0C to 15^0C. Find the:

(i) strain (02marks)

Strain = $\alpha\Delta\theta$ = 1.1x 10-5 x (60 – 15) = 4.95×10^{-4}

(ii) force needed to prevent it from contracting. (03marks)

[Young's Modulus= $2.0 \times 10^{11}Pa$, Coefficient of linear expansion of steel = $1.1 \times 10^{-5}K^{-1}$]

Force = AYstrain

$= 10^{-6} \times 2 \times 10^{11} \times 4.95 \times 10^{-4}$

= 99N

(d) Explain the energy changes which occur during plastic deformation (04marks)

During plastic deformation, molecular separation increase leading to a gain in elastic potential energy and heat is evolved. This heat is not recoverable when stress is reduced to zero.

4. (a) (i) State Archimedes' Principle. (01mark)

Archimedes' Principle states that when a body is fully or partially immersed in a fluid, it experiences an up thrust equal to the weight of the fluid displaced.

(ii) Describe an experiment to determine the relative density of an irregular solid which floats in water

- Weigh the solid in air = W
- Attach a sinker to irregular solid and weigh them when the solid is outside but the sinker immersed in water = W_1
- Weigh the solid and the sinker when the both completely immersed in water= W_2.
- Upthrust on irregular solid in water = $W_1 - W_2$

  Relative density = $\frac{W}{W_1 - W_2}$

(iii) A block of wood floats at an interface between water and oil with 0.25 of its volume submerged in oil. If the density of the wood is $7.3 \times 10^2kgm^{-2}$, find the density of oil. (04marks)

From mass = volume x density

Mass of water displaced = 0.75V x 1000 where V = volume of wood

Mass of oil displaced = 0.25Vρ where ρ = density of oil

Mass of water displaced + mass of oil displaced = mass of wood

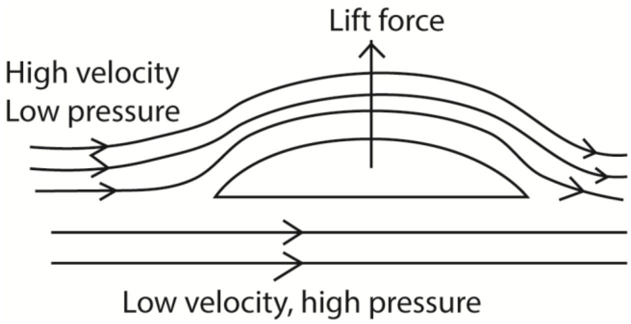
$0.75V \times 1000 + 0.25V\rho = 7.3 \times 10^2V$

$\rho = -80kgm^{-3}$

(b) (i) State Bernoulli's Principle. (04marks)

For non- viscous incompressible fluid, flowing steadily, the sum of the pressure, kinetic energy and potential energy per unit volume is constant.

(ii) Explain the origin of the lift force on the wings of an aeroplane at take-off. (04marks)



- Air flows above the wing of a plane at high velocity hence low pressure.
- Below the wings, air flows at low velocity and hence high pressure.
- The difference in pressure cause a lift force, therefore net upward force.

(c) Water flowing in a pipe on the ground with a velocity of $8ms^{-1}$ and at gauge pressure of 2.0×10^5Pa is pumped into a water tank 10m above the ground. The water enters the tank at a pressure of 1.0×10^5Pa. Calculate the velocity with which the water enters the tank. (03marks)

From P + $\frac{1}{2}\rho v^2 + \rho gh = constant$ where P = atmospheric pressure+ gauge pressure

$3\ x\ 10^5 + \frac{1}{2} x\ 10^3\ x\ 8^2 + 0 = 1x\ 10^5 + \frac{1}{2} x\ 10^3\ x\ v^2 + 10^3\ x\ 9.81\ x\ 10$

V = $16.4ms^-1$

(d) Describe how terminal velocity can be measured. (04marks)

- A viscous fluid is filled in a tall jar
- A spherical ball is dropped centrally into the fluid and time t taken by the ball to fall through known distance, d, between known points is determined.
- Terminal velocity, $v_0 = \frac{d}{t}$
- The experiment is repeated to obtain average value.

SECTION B

1. (a) Define saturated vapour pressure (S.V.P) (01mark)

Saturated vapour pressure in the one in dynamic equilibrium with its own liquid

(b) Use the kinetic theory of matter to explain the following observations

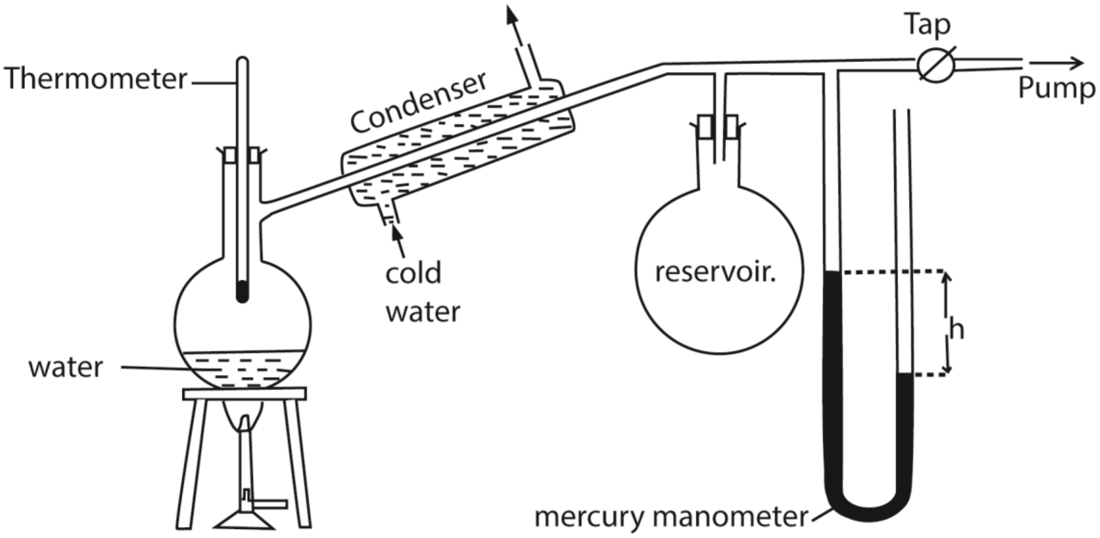
(i) saturated vapour pressure of a liquid increases with temperature. (03marks)

Increase in temperature increases the kinetic energy of the liquid molecules and the rate of evaporation increases. Therefore the pressure of the vapour rises. As the rate at which the molecules bombard the liquid surface increases, dynamic equilibrium is restored at a higher saturated vapour pressure.

(ii) saturated vapour pressure is not affected by decrease in volume at constant temperature. (03marks)

A decrease in volume leads to momentary increase in the density of the vapour. The rate of condensation increase than the rate of evaporation. As the density of the vapour falls the rate of condensation also falls. Dynamic equilibrium is re-established to original values of density and pressure of vapour. Therefore no increase in saturated vapour pressure.

(c) Describe how saturated vapour pressure of a liquid at various temperatures can be determined. (07marks)



- 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.

(d) (i) State Dalton's law of partial pressures (01mark)

Daltons law of partial pressures states that the pressure of a mixture of gases that do not react chemically is the sum of partial pressures of its components.

(ii) A horizontal tube of uniform bore, closed at one end, has some air trapped by a small quantity of water. The length of the enclosed air column is 20cm at 12^0C.

Find stating any assumptions made, the length of air column when the temperature is raised to 38^0C.

[S.V.P of water at 12^0C and 38^0C are 10.5mmHg and 49.5mmHg respectively.

Atmospheric pressure = 75cmHG] (05marks)

T_1 = 273 + 12 = 285K, T_2 = 273 + 38 = 311K; P_1 = 750 – 10.5 = 739.5mmHg, P_2 = 750-49.5 = 700.5mmHg

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{739.5\ x\ 20A}{285} = \frac{700.5\ x\ hA}{311}$$

h = 23.04cm

Assumption: the tube does not expand when the temperature increases.

2. (a) (i) Define specific heat capacity of a substance. (01mark)

Specific heat capacity is the energy required to raise the temperature of 1kg mass of a substance by 1K.

(ii) State three advantages of the continuous flow method over the method of mixtures in determination of the specific heat capacity of a liquid. (03marks)

- The heat capacity of the apparatus is not required.
- Heat loss is eliminated in the calculation
- Resistance thermometer can be used.
- Temperatures are read at leisure

(b) In a continuous flow experiment, a steady difference of temperature of 1.5^0C is maintained when the rate of liquid flow is $4.5gs^{-1}$ and the rate of electrical heating is 60.5W. On reducing the liquid flow rate to $1.5gs^{-1}$, 36.5W is required to maintain the same temperature difference.

Calculate the

(i) Specific heat capacity of the liquid. (04marks)

$P = \frac{m}{t}c\theta + h$

$60.5 = 4.5 \times 10^{-3} \times c \times 1.5 + h$ ………… (i)

$36.5 = 1.5 \times 10^{-3} \times c \times 1.5 + h$ ………… (ii)

Subtracting (ii) from (i)

$24 = 3 \times \times 10^{-3} \times c \times 1.5$

c = 5,333Jkg

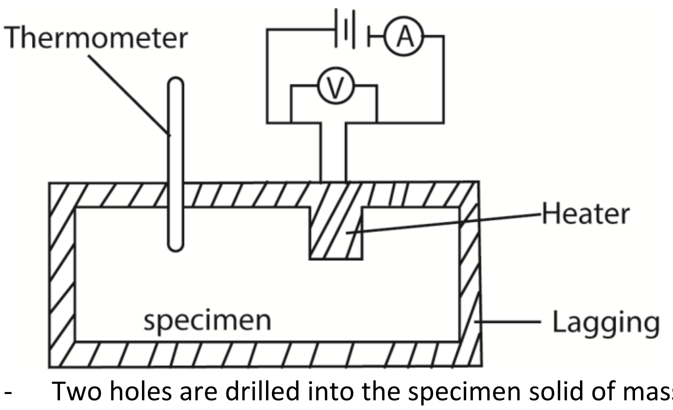
(ii) Rate of heat loss to the surroundings (03marks)

Substituting c in (i)

$60.5 = 4.5 \times 10^{-3} \times 5333 \times 1.5 + h$

h = 24.5W

(c) (i) Describe an electrical method for determination of the specific heat capacity of a metal. (06marks)



- Two holes are drilled into the specimen solid of mass m.
- A thermometer is inserted in one of the holes and an electric heater into the other hole. The holes are then filled with a good conducting fluid, e.g. oil to ensure thermal contact.
- The apparatus is insulated and initial temperature θ_0 is recorded.
- The heater is switched on at the same time a stop clock is started.
- The steady values of ammeter reading, I and voltmeter reading, V are recorded.
- After considerable temperature rise, the heater is switched off and stop clock stopped.
- The highest temperature θ_1 recorded and time t taken noted.
- The specific heat capacity, c, of the conducting solid is calculated from

$c = \frac{IVt}{m(\theta_1 - \theta_0)}$

(ii) State the assumptions made in the above experiment. (02marks)

- All heat supplied by the heater is gained by the metal block
- The volume of the metal does not change.

(iii) Comment about the accuracy of the results of the experiment in (c)(i) above. (01marks)

The value of specific heat capacity is accurate as long as there is not heat losses to the surrounding.

3. (a)(i) Define thermal conductivity. (01mark)

Thermal conductivity is the rate of heat flow per unit cross section area per unit temperature gradient.

(ii) Explain the mechanism of heat transfer in metals (03marks)

When one end of a metal is heated, the metal atoms again energy and their vibration increase. These collide with the neighboring atoms giving them some of the energy. The neighboring atoms also vibrate with higher amplitudes and collide with their neighboring atom to which they give some of their energy. In this way heat is transferred from atom to atom.

Secondly, electrons gain kinetic energy and move and collide other electrons and atom delivering heat energy.

(b) Two brick walls each of thickness 10cm are separated by an air-gap of thickness 10cm. the outer faces of the brick walls are maintained at 20^0C and 5^0C respectively.

(i) Calculate the temperatures of the inner surfaces of the walls. (06marks)

From $\frac{\Delta Q}{\Delta t} = kA\frac{\Delta\theta}{\Delta x}$

$$k_bA\ \frac{(20-\theta_1)}{0.1} = k_aA\ \frac{(\theta_1-\theta_2)}{0.1} = k_bA\ \frac{(\theta_2-5)}{0.1}$$

$$0.6A\ \frac{(20-\theta_1)}{0.1} = 0.2A\ \frac{(\theta_1-\theta_2)}{0.1} = 0.6A\ \frac{(\theta_2-5)}{0.1}$$

$$\theta_1 = 19.5^0\ and\ \theta_2 = 5.5^0C$$

(ii) Compare the rate of heat loss through the layer of air with that through a single brick wall. (03marks)

The rate of heat loss from a single brick wall is higher than that of the air because a brick is a better conductor.

[Thermal conductivity of air is $0.02Wm^{-1}K^{-1}$, and that of bricks is $0.6Wm^{-1}K^{-1}$]

(c)(i) State Stefan's law of black body radiation. (01mark)

The total energy radiated by a black body per unit area of the surface per unit time is proportional to the fourth power of the body's absolute temperature.

(ii) The average distance of Pluto from the sun is about 40 times that of the Earth from the sun. If the sun radiated as a black body at 600K, and is 1.5×10^{11}m from the Earth, Calculate the temperature of Pluto. (06marks)

Power radiated by the sun = $4\pi r_s^2\sigma T_s^4$

Power radiated by Pluto =$\frac{\pi r_p^2}{4\pi R^2}$ $x\ 4\pi r_s^2\sigma T_s^4$

Power radiated by Pluto assuming it is a black body = $4\pi r_p^2\sigma T_p^4$

At equilibrium, $4\pi r_p^2\sigma T_p^4$ = $\frac{\pi r_p^2}{4\pi R^2}$ $x\ 4\pi r_s^2\sigma T_s^4$

T_p = $\left(\frac{T_s^4 r_s^2}{4R^2}\right)^{\frac{1}{4}}$ = $\left(\frac{6000^4 x\left(7\ x\ 10^8\right)^2}{4\ x\ (40\ x\ 1.5\ x\ 10^{11})}\right)^{\frac{1}{4}}$ = 45.8K

SECTION C

1. (a) (i) What is a photon? (01mark)
   A photo is a packet of energy that is carried by electromagnetic radiation equal to hf where h id Plank's constant and f is the frequency of the radiation

   (ii) Explain, using quantum theory, the experimental observation on the photoelectric effect. (06marks)

   Observations:

   - Photoelectric effect starts at the instant metal surface receives radiation
   - The photocurrent is proportional to the intensity of radiation
   - The maximum kinetic energy of photoelectrons is proportional to the frequency of the incident radiation and is independent of the intensity of the radiation.
   - For a given metal surface, there exist a minimum frequency below which photoelectric emission occurs regardless of the intensity of the radiation

Explanation

- According to the quantum theory, radiation is emitted and absorbed in quanta.
- When a single quantum (photon) interacts with an electron on a metal surface, it gives it all or none of its energy implying that only one electron absorbs the energy of a photon. Therefore the number of photo-electrons is proportional to the number of incident photons (intensity of radiation) of energy.
- Part of this energy is used to overcome attraction of the electron by the metal surface and the rest is kinetic energy of the emitted electrons.
- Minimum energy is required to emit an electron, and thus there is minimum frequency of a radiation that emit electrons since the energy of a radiation is proportional to frequency.

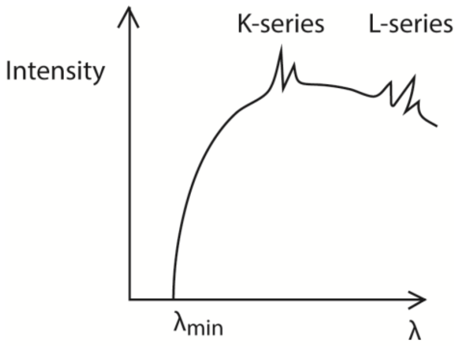
(iii) When light of wavelength 450nm falls on a certain metal, electrons of maximum kinetic energy 0.76eV are emitted. Find the threshold frequency for the metal. (04marks)

$$hf_0 = \frac{hc}{\lambda} - kinetic\ energy$$

6.6 x 10^{-34} x $hf_0 = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{450 \times 10^{-9}} - 0.76 \times 1.6 \times 10^{-19}$

f_0 = 4.83 x 10^{14}Hz

(b) Explain, using suitable sketch graph, how X-ray spectrum in an X-ray tube are formed. (06marks)



The spectrum consists of two major components, i.e. the continuous (background) spectrum and the very sharp line spectrum superimposed onto the background spectrum.

The continuous spectrum is produced when electrons make multiple collisions with the target atoms in which they are decelerated. At each deceleration, X-rays of differing wavelength are produced.

The shortest Wavelength X-rays are produced when electrons lose all their energy as X-ray photon in a single encounter with the target atoms. The wavelength of the X-rays at this point is known as the cut off wavelength. At cut off wavelength, energy in an X-ray photon equals kinetic energy of the electron;

i.e. hf = eV or $\frac{hc}{\lambda_{max}} = eV$ where V = p.d

The line spectrum

At high tube voltages, the bombarding electrons penetrate deep into the target atoms and knock out electrons from inner shell. The knocked out electrons occupy vacant spaces in higher unfilled shells putting the atom in excited state and making them unstable.

Transition of an electron from higher to lower energy levels results in an emission of X-ray photon of energy equal to energy difference between the energy levels.

If the transition ends in the K-shell, it produces K-series and if the transition ends in L-shell. It produces L-series.

(c) A beam of X-rays of wavelength 8.42 x 10^{-11}m is incident on a sodium chloride crystal of interplanar separation 2.82 x 10^{-10}m. Calculate the first order of diffraction angle. (03marks)

From 2dsinθ = nλ

$\theta = sin^{-1}\left(\frac{1 \, x \, 8.42 \, x \, 10^{-11}}{2 \, x \, 2.82 \, x \, 10^{-10}}\right) = 8.58^0$

2. (a) (i) A beam of electrons, having a common velocity, enters a uniform magnetic field in a direction normal to the field. Describe and explain the subsequent path of the electrons (04marks)

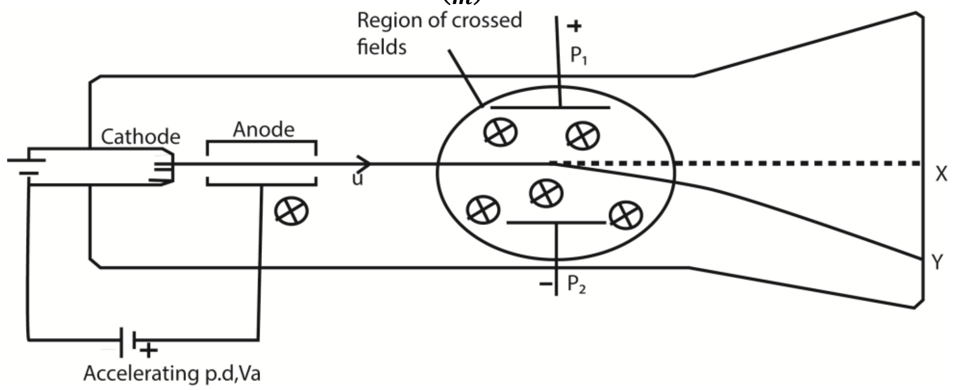
The electrons will describe a circular path, since they experience a magnetic force (F = Bev) at right angle to their direction of motion and to the field. This provides a centripetal force.

(ii) Explain whether a similar path would be followed if a uniform electric field were substituted for magnetic field (01mark)

The electrons experience an electric force (F= eE) in direction opposite that of magnetic field. Thus causes them to describe a parabolic force

(b) Describe an experiment to measure the ratio of the charge to mass of an electron (07marks)

Determination of Specific Charge $\left(\frac{e}{m}\right)$ of an electron: (J.J Thomson's Method)



- The electrons are produced thermionically by a hot filament cathode and are accelerated towards a cylindrical anode and pass through it.
- The small hole on the anode confines the electrons to a narrow beam.
- When both the electric field and the magnetic field are off, the electrons reach the screen at X and cause fluorescence.
- If the velocity of the electrons on emerging from the anode is u then

  $eVa = \frac{1}{2}mu^2$

  ⇨ $\frac{e}{m} = \frac{u^2}{2Va}$ ……………………………………… (i)

  Where Va is the accelerating voltage between the cathode and anode.

- The magnetic field is switched on and the beam is deflected to position Y.
- In order to bring the beam back to the original position X, the electric field is switched on and adjusted until the beam is at X again.
- This implies that The magnetic force = the electric force

  $Beu = eE$

  $\therefore u = \frac{E}{B}$ ……………………………… (ii)

  Substituting eqn. (ii) in (i)

$\frac{e}{m} = \frac{E^2}{2B^2Va}$ but E = $\frac{V}{d}$

$\therefore \frac{e}{m} = \frac{V^2}{2B^2d^2Va}$ where, V is the p.d between the plates at separation of d apart

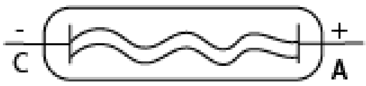
(c) Electrodes are mounted at opposite ends of low pressure discharge tube and a potential difference of 1.20kV applied between them. Assuming the electrons are accelerated from rest, calculate the maximum velocity which they could acquire. [Specific electron charge =-1.76 x 10^{11} Ckg^{-1}) (02marks)

From $\frac{1}{2}mv^2 = eV$

$$v = \sqrt{\frac{2eV}{m}} = \sqrt{2x\ 1.7\ x\ 10^{11}\ x1.2\ x\ 10^3} = 2.06 \text{ x } 10^7 ms^{-1}$$

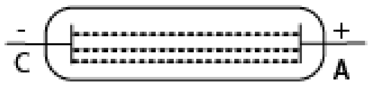
(d) (i) Give an account of the stages observed when an electric discharge passes through a gas at pressure varying from atmospheric to about 0.01mmHg as air is pumped out when the p.d across the tube is maintained at extra high tension. (05marks)

At pressure ≈ 10mmHg



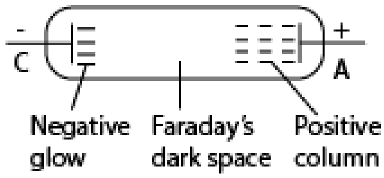
A discharge of blue streamer

At pressure ≈ 2mmHg

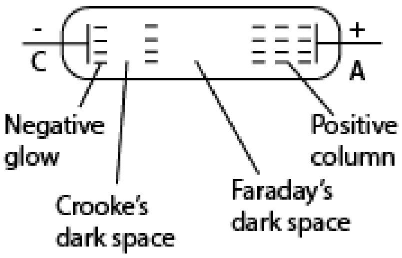


A long luminous column appears from the anode the cathode (the positive or pink column)

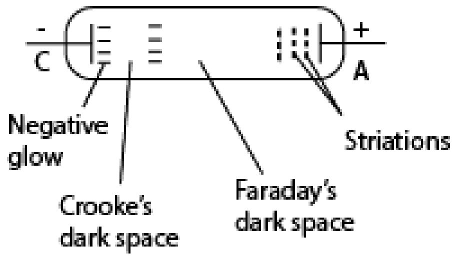
At pressure ≈ 1mmHg



At pressure ≈ 0.5mmHg



At pressure ≈ 0.05mmHg



At pressure ≈ 0.01mmHg
the poositive column striations and negative glow disappear.
Crookes dark region fille the tube
A Stream of visible particles is emitted from the cathode
the entire tube fluoresces

(ii) State two disadvantages of discharge tubes when used to study cathode rays. (01mark)

- A gas is needed at very low pressure which may not be easy to achieve practically.
- A very high p.d is needed across tube which may not be safe to handle
- X-rays may be produced and these are unsafe.

3. (a) (i) What is meant by half-life of a radioactive material? (01mark)
   - Half-life is the time taken for the activity of a material to decrease to half its original value.

(ii) Given the radioactive law, $N_t = N_0e^{-\lambda t}$, obtain the relationship between λ and half-life $T_{\frac{1}{2}}$ (02marks)

$In\frac{N_0}{N} = \lambda t$ at t =$T_{\frac{1}{2}}$, N = $\frac{N_0}{2}$

$$\Rightarrow \; In\frac{N_0}{\frac{N_0}{2}} = \lambda T_{\frac{1}{2}}$$

$$\lambda = \frac{In2}{T_{\frac{1}{2}}}$$

(iii) What are radioisotopes? (01mark)

Radioisotope are radioactive atoms of the same element having the same atomic number but different atomic mass

(iv) The radioisotope ${}^{90}_{38}Sr$ decays by emission of β-particles. The half-life of the radioisotope is 28.8years. Determine the activity of 1g of the isotope (05marks)

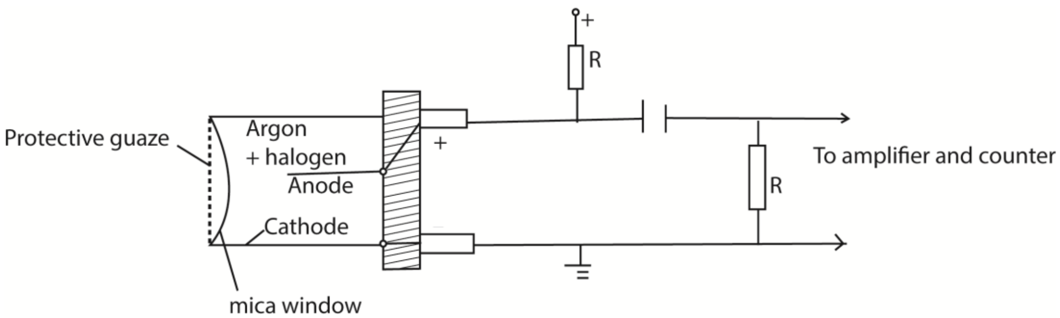
Activity, A = λN, where N = $\frac{N_{AM}}{M}$ and $\lambda = \frac{In2}{T_{\frac{1}{2}}}$

Activity, A = $\frac{In2}{28.8\ x\ 365\ x\ 24\ x\ 3600\ x\ 1}$ = 7.63 x $10^{-10}s^{-1}$

(b) (i) With aid of a diagram describe the structure and action of Geiger-Muller tube. (06marks)

The GMT is used to detect the presence of X- rays, Gamma rays, beta particles and if the window of the tube used is very thin, it detects even alpha particles.

Structure



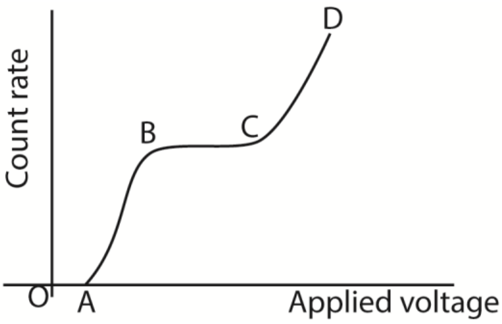
The thin mica window allows the passage and detection of the weak penetrating alpha particles. The GM tube is first evacuated then filled with Neon, Argon plus Halogen gas which is used as a quenching agent.

Mode of operation

Mode of operation

- When an ionizing particle enters the tube through the window, argon atoms are ionized.
- The electrons move to the anode while the positive ions drift to the cathode.
- A discharge occurs and the current flows in the external circuit.
- A p.d is obtained across a large resistance, R which is amplified and passed to the scale.
- The magnitude of the pulse registered gives the extent to which ionization occurred.

(ii) Sketch the current –voltage characteristic of the Geiger- Muller tube and explain its main features. (03marks)



OA – the operating voltage is not enough to attract the ions to the respective electrodes and hence the counter registers no reading. This voltage (i.e. at A) is called the threshold voltage.

AB – the applied p.d not enough to attract all electrons; hence increasing the p.d increases the number of electrons being attracted and hence increase in counter rate.

BC – here the count rate is constant. This is called the plateau region.

- Between BC, all the negative ions are able to reach the anode because the operating voltage is large enough to attract them.

- Full avalanche is obtained along the entire length of the anode.

- Here the tube is said to be operating normally.

CD: - The count rate increases rapidly because the quenching process becomes ineffective and eventually a continuous discharge occurs which might damage the tube.

(iii) Identify, giving reasons, the suitable range in (b) (ii) of operation of the tube (02marks)

The suitable region is BC, in this range, every particle which produces ionization is detected.

Compiled by Dr. Bbosa Science