UACE Physics paper 1 2009 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) Define the term impulse (01mark)

Impulse is the product of force and time for which the force acts.

(ii) 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

(b) A bullet of mass 10g travelling horizontally at a speed of 100ms^{-1} strikes a block of wood of mass 900g suspended by a light vertical string and is emended in the block which subsequently swings freely. Find the

(i) vertical height through which the block rises. (04marks)

From mu =(m + M)v

$10 \times 10^{-3} \times 100 = (10 \times 10^{-3} + 900 \times 10^{-3})v$

$v = 1.1ms^{-1}$

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

$0 = 1.1^2 – 2gh$

$h = 6.2 \times 10^{-2}m$

(ii) Kinetic energy lost by the bullet (03marks)

K.E lost = K.E before collision – K.E after collision

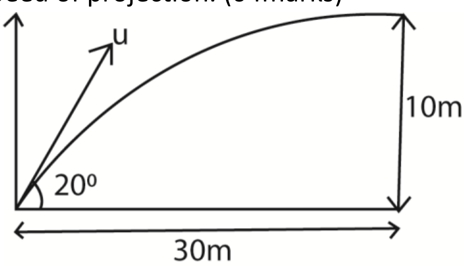
$= \frac{1}{2}\ x\ 10x\ 10^{-3}\ x\ 100^2 - \frac{1}{2}\ x\ 910\ x\ 10^{-3}x\ 1.1^2$ =49.45J

(c) Explain the terms time of flight and range as applied to projectile motion. (02marks)

- Time of flight is the time taken by the projectile to move from the point of projection to the point where it lands on a plane through the point of projection.
- Range is the horizontal distance from the point of projection to appoint where the projectile lands along the plane through the point of projection.

(d) A stone is projected at an angle of 20^0 in horizontal and just clears a wall which is 10m high and 30m from the point of projection. Find the

(i) speed of projection. (04marks)



Using y= xtanα + $\frac{gx^2 sec\alpha}{2u^2}$

$10 = 30\tan 20^0 - \frac{9.81\ x\ 30^2\ \sec 20^0}{2u^2}$

$u = 71.5ms^{-1}$

(ii) Angle which the stone makes with the horizontal as it clears the wall. (03marks)

u_x = 71.5cos 20 = 67.188ms^{-1}

u_y = 71.5sin20 – 9.81 x $\frac{30}{71.5cos20}$ = 20.07ms^{-1}

tan θ = $\frac{20.07}{67.188}$

θ = 16.6^0

2. (a) Define the following terms
   (i) Velocity
   Velocity is the rate of change of displacement with time
   (ii) Moment of a force
   Moment of force is the product of the force and perpendicular distance from the point to the point of action of the force.

(b) (i) A ball is projected vertically up wards with a speed of 50ms^{-2}.on return it passes a point of projection, and falls and falls 78m below. Calculate the total time taken. (05marks)

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

-78 = 50t - $\frac{1}{2}x\ 9.81\ x\ t^2$; t = 11.57s

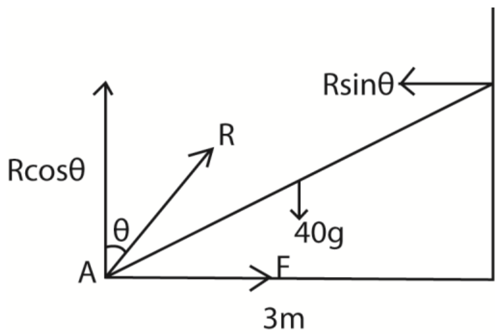
(ii) State energy changes that occurred during the motion of the ball in (b)(i) above. (03marks)

K.E →P.E + K.E → P.E → P.E + K.E → K.E → sound + heat

(c) (i) State the conditions required for mechanical equilibrium to be attained. (02marks)

The algebraic sum of moments of all forces about a point is zero

(ii) A uniform ladder of mass 40kg length 5m, rests with its upper end against a smooth vertical wall and with its lower end at 3m from the wall on a rough ground. Find the magnitude and direction of the force exerted at the bottom of the ladder. (06marks)



Rcosθ= 40g …………………. (i)

Taking moments about A

4Rsinθ = 40g x $\frac{3}{2}$

Rsinθ = 15g…………………… (ii)

By squaring Eqn. (i) and Eqn. (ii) and adding them;

$R^2Cos^2θ + R^2sin^2θ = 1600g^2 + 225g^2$

R = 42.72g = 42.72 x 9.81 = 420N

Eqn. (ii) ÷ Eqn. (i)

tan θ = $\frac{15g}{40g}$ = 0.375

θ = 20.60

∴ the force at the bottom = 420N at an angle 20.6^0 to the vertical

(d) State four instances where increasing friction is useful. (02marks)

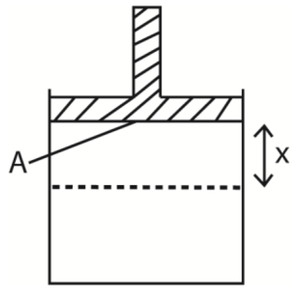
- Walking
- Sharpening of blades
- Lighting a match
- Braking of vehicles.

3. (a) What is meant by simple harmonic motion? (01mark)
Simple harmonic motion is a motion whose acceleration is directly proportional to the displacement from a fixed point and is directed towards the fixed point.

(b) A cylindrical vessel of cross-section area A, contains air of volume V, at pressure, P, trapped by frictionless air tight piston of mass, M. the piston is pushed down and released.

(i) If the piston oscillates with simple harmonic motion, show that its frequency, f, is given by

$$f = \frac{A}{2\pi}\sqrt{\frac{P}{MV}} \text{ (06marks)}$$



P = $\frac{F}{A}$; F = PA = mg where m = mass of the piston pushed through a small distance, dx.
Restoring force, Fr = (P_2A – mg)
=> -(P_2A – mg) = ma
- (P_2A – PA) = ma ……………….. (i)
From Boyles's law
$P_1V_1 = P_2V_2$ = PV
=> P_2(V-Ax) = PV
$P_2 = \frac{PV}{V-Ax}$
∴ -PA$\left(\frac{V}{V-Ax} - 1\right)$ = -PA$\left(\frac{Ax}{V-Ax}\right)$ = ma

For small x; ma = -$\left(\frac{PA^2x}{V}\right)$ => a = -$\left(\frac{PA^2}{mV}\right)x$;

Compare with a = $-\omega^2 x$ for S.H.M

⇨ $\omega^2 = \left(\frac{PA^2}{mV}\right)$ => $\omega = \sqrt{\frac{PA^2}{mV}} = 2\pi f$

⇨ $f = \frac{A}{2\pi}\sqrt{\frac{P}{mV}}$

(ii) Show that the expression for f, in (b)(i) is dimensionally correct. (03marks)

$[f] = \left[\frac{A}{2\pi}\sqrt{\frac{P}{mV}}\right]$

[L.H.S] = T^{-1}

[R.H.S] = $\sqrt{\frac{L^4ML^{-1}T^{-2}}{ML^3}} = T^{-1}$

[L.H.S] = [R.H.S]

Hence the equation is dimensionally correct

(c) A particle executing simple harmonic motion vibrates in a straight line. Given that the speeds of the particle are $4ms^{-1}$ and $2ms^{-1}$ when the particle is 3cm and 6cm respectively from the equilibrium, calculate the

(i) amplitude of oscillation. (03marks)

From $V^2 = \omega^2(a^2 - x^2)$

$16 = \omega^2(a^2 - (3 \times 10^{-2})^2)$ ………………… (i)

$4 = \omega^2(a^2 - (6 \times 10^{-2})^2)$ ………………… (ii)

From equations (i) and (i)

a = 6.7cm

ω = 66.67rads-1

(ii) frequency of the particle. (03marks)

From ω = 2πf

$f = \frac{66.67}{2\pi} = 10.6s^{-1}$

(d) Give two examples of oscillatory motion which approximate to simple harmonic motion and state the assumption made in each case. (04marks)

- Swing of a suspended pendulum bod
- Vibration of a loaded spring

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

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

(ii) Use Archimedes' Principle to derive an expression for resultant force on a body of weight, W, and density, σ, totally immersed in a fluid of density, ρ. (04marks)

Up thrust (U) = weight of fluid displaced

= mg

= Vρg

Resultant force Fr = W – Vρg but $V = \frac{W}{\sigma g}$

$\therefore Fr = W - \frac{W\rho g}{\sigma g} = W\left(1 - \frac{\rho}{\sigma}\right)$

(b) A tube of uniform cross sectional area of 4 x $10^{-3}m^2$ and mass 0.2kg is separately floated vertically in water of density 1.0 x 10^3kgm^{-3} and in oil of density 8.0 x 10^2kgm^{-3}. Calculate the difference in the lengths immersed (04marks)

m = PV = ρAL

For water, $L_w = \frac{m}{A\rho} = \frac{0.2}{1000\ x\ 4\ x\ 10^{-3}} = 0.05m$

For oil, $L_o = \frac{m}{A\rho} = \frac{0.2}{800\ x\ 4\ x\ 10^{-3}} = 0.0625m$

Difference in length = 0.0625 – 0.05 = 0.0125m

(c) (i) Define surface tension in terms of work (01mark)

Surface tension is the work done to increase the surface area of a liquid under isothermal conditions.

(ii) Use the molecular theory to account for surface tension of a liquid. (04marks)

- Liquid molecules attract each other.
- The molecules within the body of the liquid (bulk) molecules is attracted equally by neighbors in all direction, hence, the force on the bulk molecules is zero,
- For a surface molecules, there is a net inward force because there are no molecules above the surface to attract them equally.

- To the surface, work must be done against the inward attractive force, hence, a molecule in the surface of a liquid has a greater potential energy than a molecule in the bulk. The potential energy stored inmolecules at the surface is called free surface energy or surface tension.

- Due to the attractive forces experienced by surface molecules due to their neighbours put in a state of tension; the liquid surface behave as a stretched skin.

(iii) Explain the effect of increasing temperature of a liquid on its surface tension. (04marks)

When a liquid is heated, the average kinetic energy of its molecules increase. So the intermolecular of attraction decrease because molecules spend less time in the neighbourhood of a given molecule. At the same time, more molecule enter the liquid surface which lowers the potential energy of the surface thereby lowering the surface tension.

(iv) Calculate the excess pressure inside a soap bubble of diameter 3.0cm if the surface tension of the soap solution is $2.5 \times 10^{-2}Nm^{-1}$. (02marks)

Excess pressure = $\frac{4\gamma}{r} = \frac{4 \times 2.5 \times 10^{-2}}{1.5 \times 10^{-2}}$ = 6.67Pa

SECTION B

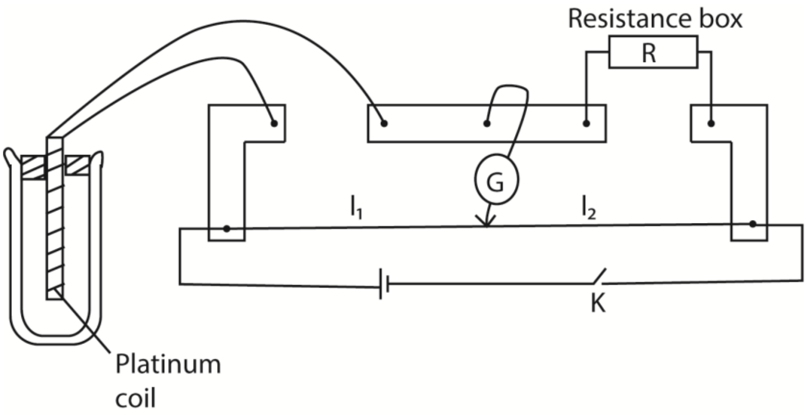
5. (a) (i) Define the term thermometric property. (01mark)

Thermometric property is a physical property that vary uniformly and continuously with temperature.

(i) State two thermometric properties. (01mark)

- Volume of constant mass of a gas at constant pressure
- Pressure of a gas at constant volume
- Electrical resistance of a platinum wire
- e.m.f of a thermocouple

(ii) With the aid of a labelled diagram, describe how the room temperature can be measured using uncalibrated resistance thermometer. (06marks)



- Place the resistance thermometer in a funnel with crushed ice and leave it for some time.
- Close the switch and obtain a balance point by adjusting the resistance box,
- Determine the resistance R_0 at 0^0C from $R_0 = \left(\frac{l_1}{l_2}\right)R$
- Transfer the resistance thermometer a beaker containing boiling water and after some time, determine resistance R_{100}.
- Place the resistance thermometer in water at room temperature and determine resistance R_θ.
- Temperature of the room temperature, θ = $\left(\frac{R_\theta - R_0}{R_{100} - R_0}\right) x\ 100^0C$

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

Specific heat capacity is the amount of heat required to raise the temperature of 1kg mass of a substance by 1K of 1^0C.

(ii) Hot water at 85^0C and cold water 10^0C are ran into a bath at a rate of $3.0 \times 10^{-2}m^3min^{-1}$ and V, respectively. At the point of filling the bath, the temperature of the mixture of water 40^0C. Calculate the time taken to fill the bath is its capacity is $1.5m^3$.

$V\rho tC(40 - 10) = 3.0 \times 10^{-2}\rho tC(85 - 40)$

$30V = 3.0 \times 10^{-2} \times 45$

$V = 4.5 \times 10^{-2} m^3 min^{-1}$

At time of filling; total volume = volume of hot water + volume of cold water.

$1.5 = 4.5 \times 10^{-2} \times t + 3.0 \times 10^{-2} \times t$

Time, t = 20minutes.

(c) The specific latent heat of fusion of a substance is significantly different from its specific latent heat of vaporization at the same pressure. Explain how the difference arises. (04marks)

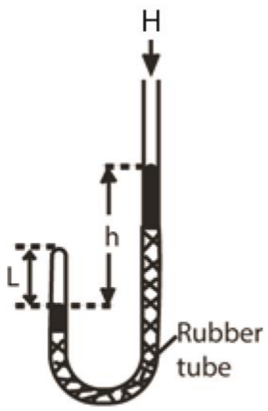
During evaporation, more energy is need to break intermolecular forces of attraction to form a gas and work done is done against atmospheric pressure by the expanding gas.

During fusion, energy is supplied to weaken the molecular bonds in solids accompanied by a small increase in volume. This implies negligible work done against atmospheric pressure.

(d) Explain in terms of specific heat capacity why water is used in a car radiator other than any other liquid. (02mark)

Water has very high specific heat capacity, hence high amount of heat lead to small increase in temperature of water compared to the change in temperatures in equal masses other liquids with low specific heat capacities.

6. (a) (i) state Boyles law. (01mark)
Boyle's law states that the pressure of a fixed mass of a gas at constant temperature is inversely proportional to the volume of the gas.
(ii) Describe an experiment that can be used to verify Boyles' law. (06marks)



- air in the closed limb of a U-tube barometer as shown above
- mercury is poured to a height, h, and the length of the air column, L is noted.
- the length h is varied to obtain different sets of values of h and L
- Pressure of the gas is calculated from $P = (H + h)\rho g$ where H= height of barometer corresponding to atmospheric pressure, ρ = density of mercury, g = acceleration due to gravity. Note that h can be positive or negative.
- If A is the cross section area, $V = AL$
- Values of h, L, P, V and 1/V are tabulated

- A plot of P against 1/V gives a straight line through the origin which verifies Boyle's law.

(b) Explain the following observations using the kinetic theory.

(i) A gas fills any container in which is it placed and exerts pressure on its walls. (03marks)

A gas contains molecules with negligible intermolecular forces and free to move in all directions. As they move, they collide with each other and with the walls of the container. The unrestricted movements make them to fill the available space and collisions with the walls contributes to the pressure exerted on the wall.

(ii) The pressure of a fixed mass of a gas rises when temperature is increased at constant volume. (02 marks)

When the temperature of a gas increases, the kinetic energy of the gas molecules increases. This increases the frequency and force of collision against the wall leading to increase in pressure.

(c) (i) What is meant by a reversible process. (01marks)

A reversible process in one that takes place in reverse direction through the same values of pressure, volume and temperature in small changes or steps.

(ii) State the conditions necessary for isothermal and adiabatic processes to occur, (04marks)

Isothermal process occurs at constant temperature and therefore the gas must be enclosed in thin walled container placed in a temperature reservoir and occurs slowly.

Adiabatic process requires no heat input or out and therefore should occur rapidly in well insulated container like a thermos flask.

(d) A mass of an ideal gas of volume 200cm^3 at 144K expands adiabatically to a temperature of 137K. Calculate its new volume. (Take γ =1.40)

$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$

$\gamma = \frac{2100}{1500} = 1.40$

⇨ $144(200)^{1.4-1} = 137(V)^{1.4-1}$

V = 226.5cm^3

7. (a) Define thermal conductivity. (01mark)

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

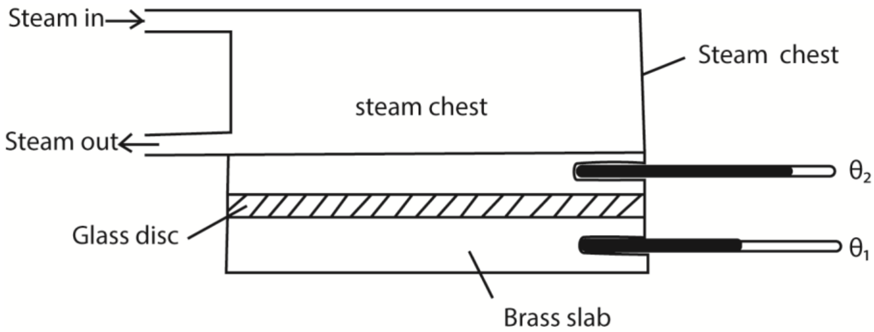
(b)(i) Explain the mechanism of thermal conduction in nonmetallic solids. (03marks)

In solids the atoms are loosely packed and have strong intermolecular forces as they vibrate within a fixed lattice. When one end is heated, the atoms vibrate with bigger amplitudes, collide with the neighboring atoms and lose their vibration energy to them. These also vibrate more vigorously and collide and lose their vibration energy to them. In this way, heat is propagated throughout the solids.

(ii) Why are metal better thermal conductors than nonmetallic solids? (02marks)

In metals there are free electrons which gain kinetic energy when heat and move faster and for a longer distance to pass over their energy to other atoms they collide with. This occurs in addition to the transfer of heat by vibrating atoms as it occurs in nonmetallic solids.

(c) With the aid of a diagram, describe an experiment to determine the thermal conductivity of a poor conductor. (06marks)



- Glass s cut in form of a thin disc of cross section area, A and thickness, x.
- The disc is sandwiched between a steam chest and brass slab of mass, m and specific heat capacity, c.
- Steam is passed through the chest until the thermometers register steady temperatures, θ_1 and θ_2.
- Then, $\frac{\theta}{t} = kA\left(\frac{\theta_2 - \theta_1}{x}\right)$
- The glass disc is removed and brass slab is heated directly by steam chest, until its temperature is about 10^0C above θ_1.
- Steam chest is removes and the top of the glass slab is covered by the glass disc.
- The temperature of the slab is recorded at suitable time interval until its temperature is about 10^0C below θ_1.
- A graph of temperature against time is plotted and its slope s determined at θ_1

$$\frac{\theta}{t} = mcs$$

$$\therefore\ kA\left(\frac{\theta_2 - \theta_1}{x}\right) = mcs$$

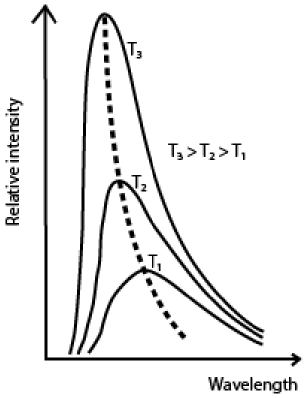
$$k = \frac{mcsx}{A(\theta_2 - \theta_1)} \text{ but A} = \frac{\pi D^2}{4}$$

$$\therefore k = \frac{4mcsx}{\pi D^2(\theta_2 - \theta_1)}$$

(d) (i) What is meant by a black body? (01mark)

A black body is one that absorbs all incident radiations on it, transmits and reflects none.

(ii) Sketch curves showing the spectral distribution of energy radiated by a black body at three different temperatures. (02marks)



(iii) Describe the main features of the curves you have drawn in (d)(ii) (02marks)

- 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.

(e) A small blackened solid copper sphere of radius 2cm is placed in an evacuated enclosure whose wall are kept at 100^0C. Find the rate at which energy must be supplied to the sphere to keep its temperature at 127^0C. (03marks)

$P = \sigma A(T_2^4 - T_1^4)$

$= \sigma 4\pi r^2(T_2^4 - T_1^4)$

$= 5.67 \times 10^{-8} \times 4\pi (2 \times 10^{-2})^2(400^4 - 372^4)$

$= 1.78W$

SECTION C

8. (a) State four differences between cathode rays and positive rays (02marks)

Cathode ray	Positive ray
Negatively charged	Positively charged
Produce X-rays on striking matter	Do not produce x-ray on striking matter
Deflected towards anode and north pole of the magnet	Deflected towards cathode and south pole of the magnet

(b) An electron having energy of 4.5×10^2eV moves at right angles to a uniform magnetic field of flux density 1.5×10^{-3}T. Find the

(i) radius of the path followed by the electron. (04marks)

$$\frac{1}{2}m_e v^2 = eV$$

$$u = \sqrt{\frac{2eV}{m_e}}$$

$$Beu = \frac{m_e u^2}{r} \Rightarrow r = \frac{m_e u}{eB}$$

$$r = \frac{1}{B}\sqrt{\frac{2m_e V}{e}} \text{ but } \frac{e}{m_e} = 1.8 \times 10^{11}$$

$$\therefore r = \frac{1}{1.5 \times 10^{-3}}\sqrt{\frac{2 \times 450}{1.8 \times 10^{11}}} = 4.71 \times 10^{-2}\text{m}$$

(ii) period of the motion. (03marks)

$$T = \frac{2\pi r}{u} = 2\pi r\sqrt{\frac{m_e}{2eV}} = 2\pi \times 4.71 \times 10\text{-}2\sqrt{\frac{1}{2} \times \frac{1}{1.8 \times 10^{11}} \times \frac{1}{450}} = 2.32 \times 10^{-8}\text{s}$$

(c) (i) Define the term Avogadro constant and Faraday constant (02marks)

Avogadro constant is the number of atoms or molecules in one mole of a substance.

Faraday's constant is the quantity of charge required to deposit one mole of a monovalent element.

(ii) Use the Avogadro constant and Faraday constants to calculate the charge on anion of monatomic element. (03marks)

Charge = $\frac{F}{N_A} = \frac{96500}{6.02 \, x \, 10^{23}}$ = 1.6 x 10^{-19}C

(d) Explain the meaning of the following terms as applied to a Geiger-Muller tube.

(i) threshold potential difference (02marks)

Threshold p.d is the minimum p.d below which no pulse can be detected. This is because there is no sufficient gas amplification.

(ii) Dead time (02marks)

Dead time is the time ions take to travel towards the cathode before the electric field at the cathode returns to level large enough for an avalanche to start. Ionizing particles arriving within this time will not be detected.

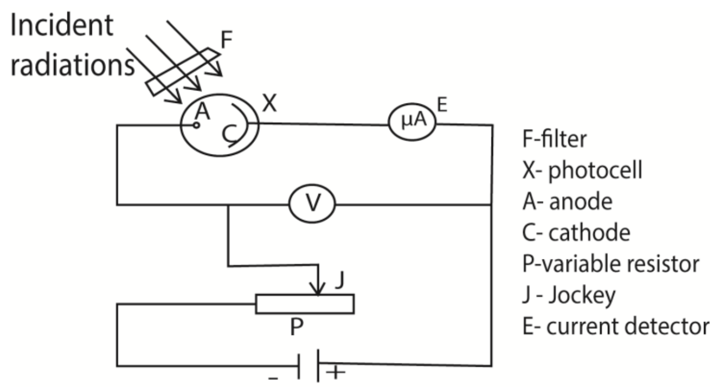
(iii) A quenching agent (02marks)

A quenching agent is a gas or vapour inside a Geiger-Muller tube to ensure that only one pulse is produced by each ionizing particle that enter the tube. It slows down the positive ions and prevent further ionization.

9. (a) State the laws of photoelectric effect (04marks)

- The time lag between irradiation of the metal surface and emission of the electrons by the metal surface is negligible.
- For a given metal, surface there is a minimum value of frequency of radiation called threshold frequency (f_0) below which no photo electrons are emitted from the metal however intense the incident radiation may be.
- The number of photoelectrons emitted from the surface per second is directly proportional to the intensity of incident radiation for a particular incident frequency
- The K.E of the photoelectrons emitted is independent of the intensity of the incident radiation but depends only on its frequency

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



- An evacuated electric cell X that has inside it a photo-emissive metal cathode, C of large surface area and an anode A for collecting the electron produced
- A is made negative in potential relative to C.
- The photoelectrons emitted from C when illuminated with a suitable beam experience a retarding potential.
- The p.d V is increased negatively until the current become zero and the stopping potential Vs is noted from the voltmeter.

(c) A 100mW beam of light of wavelength 4.0×10^{-7}m falls on caesium surface of a photocell.

(i) How many photons strike the caesium surface per second? (03marks)

$$P = \frac{nhc}{\lambda} \Rightarrow n = \frac{P\lambda}{hc} = \frac{100 \, x \, 10^{-3} \, x \, 4.0 \, x \, 10^{-7}}{6.6 \, x \, 10^{-34} \, x \, 3.0 \, x \, 10^{8}} = 2.02 \times 10^{17}$$

(ii) If 65% of the photons emit photoelectrons, find the resulting photocurrent. (03marks)

$$65\% \text{ of } n = \frac{65}{100} \, x \, 2.02 \, x \, 10^{17}$$

$$I = ne = \frac{65}{100} \, x \, 2.02 \, x \, 10^{17} x \, 1.6 \, x \, 10^{-19} = 2.1 \times 10^{-2} A$$

(iii) Calculate the kinetic energy of each photon if the work function of caesium is 2.20eV. (03marks)

$$hf = w_o + \frac{1}{2}mv^2$$

$$K.E = \frac{6.6 \, x \, 10^{-34} \, x \, 3.0 \, x \, 10^{8}}{4 \, x \, 10^{-7}} - 2.2 \, x \, 1.6 \, x \, 10^{-19} = 1.43 \times 10^{-19} J$$

(d) Distinguish between continuous and line spectra in an X-ray tube. (02marks)

Continuous spectrum is produced by multiple collision of electrons with target atoms.

Line spectrum is a result of electron transition from higher to lower energy levels.

10. (a) (i) Explain the observation made in the Rutherford α-particle scattering experiment. (06marks)
- Most alpha particle passed through metal foil undeflected. This is because most space in an atom is empty.
- A few alpha particles are deflected through small angles less than 900. This is because the positive alpha particle are repelled by the positive nucleus of the gold atom.
- Very few particles are scattered through large angle greater than 900. This is because the chances of head-on collision are very minimal. This implies the nucleus occupies a small portion of the available space.

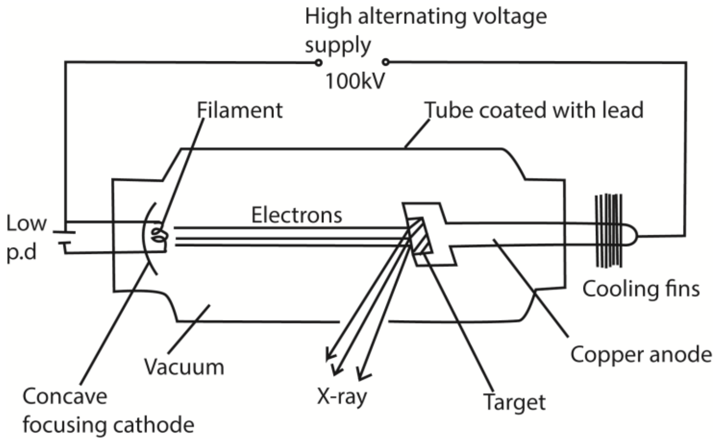
(ii) Why is a vacuum necessary in this experiment? (01mark)

- To enable the alpha particle to reach the detector.

(b) Distinguish between excitation and ionization energies of an atom. (02marks)

- **Excitation energy** is the energy required to remove an electron from an atom in its ground state to a higher energy level.
- **Ionization energy** is the energy required to remove an electron from an atom in its ground state that is completely lost

(c) Draw a labelled diagram showing the main components of an X-ray tube (03marks)



(d) An X-ray tube is operated at 50kV and 20mA. If 1% of the total energy supplied is emitted as X-radiation, calculate the

(i) maximum frequency of emitted radiation (03marks)

$eV = hf_{max}$

$1.6 \times 10^{-19} \times 50 \times 10^{3} = 6.6 \times 10^{-34} \times f_{max}$

$f_{max} = 1.21 \times 10^{19}$Hz

(ii) rate at which heat must be removed from the target in order to keep it at a steady temperature. (03marks)

Power supplied = IV = $20 \times 10^{-3} \times 50 \times 10^{3} = 1000$W

Power converted to heat and removed = $\frac{99}{100} x\ 1000 = 990W$

(e) A beam of X-ray of wavelength 0.2nm is incident on a crystal at glancing angle 30^0. If the interplanar separation is 0.20nm, find the order of diffraction. (02marks)

$2d\sin\theta = n\lambda$

$2 \times 2 \times 10^{-10}\sin 30 = n \times 10^{-10}$

n = 1