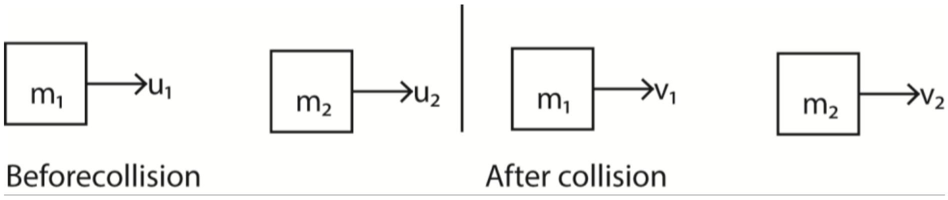
UACE Physics paper 1 set10 guide

1. (a) (i) State the law of conservation of linear momentum. (01mark)
   The law of conservation of linear momentum states that for a system of interacting bodies, their total momentum remains constant provided there is no external force acting.
   (ii) Use Newton's law to derive the law in (a) (i) (04marks)



During collision, each body exerts a force of impact on each other according to Newton's second law of motion.

Let I be the I impulse on A, then the impulse on B = -I.

$I = M_1v_1 - m_1u_1$ .... (i)

$-I = m_2v_2 - m_2u_2$ .... (ii)

Equation (i) + equation (ii)

$0 = M_1v_1 - m_1u_1 + m_2v_2 - m_2u_2$

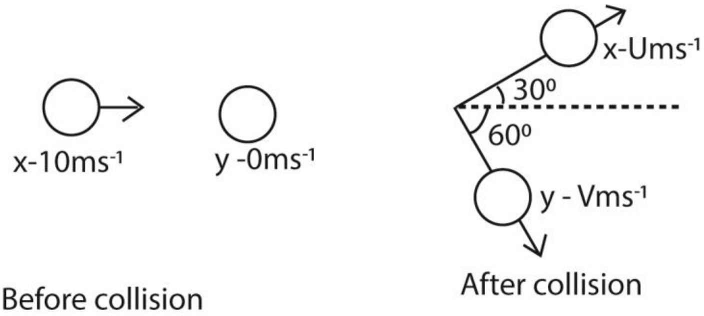
$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

(b) Distinguish between elastic an inelastic collision (01mark)

- During an elastic collision, the interacting bodies separate after interaction and there is conservation of total kinetic energy.
- During inelastic collision, there is bouncing after interaction and there is loss of kinetic energy.

(c) An object X of mass M, moving with a velocity of $10ms^{-1}$ collides with a stationary object Y of equal mass. After collision, X moves with a speed u at an angle 30^0 to the initial direction, while Y, moves with a speed V at angle 90^0 to the new direction of X.

(i) Calculate the speeds U and V (05marks)



Applying the law of conservation of linear momentum in horizontal direction

m x 10 = mUcos 30^0 + mVcos60^0

10 = U$\frac{\sqrt{3}}{2}$ + $\frac{V}{2}$ …………………………………………………………… (i)

Applying the law of conservation of linear momentum in vertical direction

m x 0 = mUsin30^0 – mVsin60^0

0 = $\frac{U}{2} - V\frac{\sqrt{3}}{2}$

U = V$\sqrt{3}$ ……………………………………………………………… (ii)

Eqn. (i) and Eqn. (ii)

U = 8.66ms^{-1}

V = 5ms^{-1}

(ii) Determine whether the collision is elastic or not. (03marks)

Kinetic energy before = $\frac{1}{2}m\ x\ 10^2$ = 50mJ

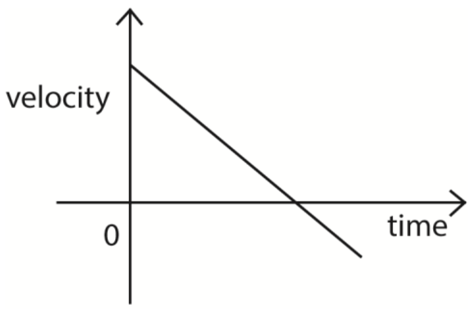
Kinetic energy after collision= $\frac{1}{2}m\ x\ 5^2 + \frac{1}{2}m\ x\ 8.66^2$ = 50mJ

Since kinetic energy is conserved, the collision is elastic.

(d) (i) Define uniform acceleration. (01mark)

Uniform acceleration is the a constant rat of change of velocity

(ii) With the aid of a velocity-time graph, describe the motion of a body projected vertically upwards. (03marks)



When a body is projected vertically upwards with velocity, V, it undergoes uniform retardation, g. At maximum height, the velocity becomes zero. It then accelerated uniformly downwards.

(iii) Calculate the range of a projectile which is fired at an angle of 45^0 to the horizontal with a speed of 20ms^{-1}. (02marks)

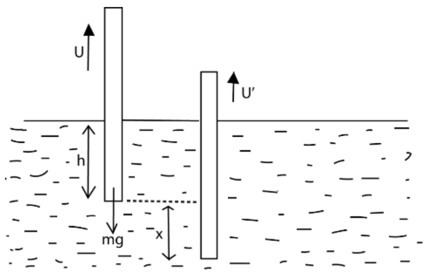
R = $\frac{u^2 sin2\theta}{g} = \frac{20^2\ x\ sin90}{9.81}$ = 40.77m

2. (a)(i) State Archimedes' principle. (01mark)
Archimedes' Principle state that when a body is wholly or partially immersed in a fluid, it experiences an up thrust equal to the weight of the fluid displaced.
(ii) A solid weighs 20.0g in air, 15.0g in water and 16.0g in a liquid, R. Find the density of R (03marks)
Mass of displaced water = 20.0 – 15.0 = 5.0g
Mass of liquid displaced = 20.0 – 16.0 = 4.0g
Relative density of the liquid = $\frac{4}{5} = 0.8$
(b) (i) What is meant by simple harmonic motion? (01 mark)
Simple harmonic motion is a periodic motion where the acceleration is always directed towards a fixed point and is proportional to the displacement from that point.

(ii) Distinguish between damped and forced oscillations (02marks)

- Damped oscillation are oscillation in which the amplitude of oscillating system gradually decrease to zero due to the presence of dissipative forces like air resistance
- Forced oscillation are those whose continuity is maintained by periodic input of energy.

(c) A cylinder of length, L, and cross section area A and density σ floats in a liquid of density, ρ. The cylinder is pushed down slightly and released.
(i) show that it performs simple harmonic motion. (05marks)



At equilibrium position, the body sinks to a height, h, below the liquid surface
Up thrust = weight of the body
But U = Ahρg
mg = ALσg ……………………………………..(i)
A is the cross section area of a cylinder
When a body is displaced through a distance, x, and released,
Up throust = (h + x) Aρg

Resultant force = mg - (h + x) Aρg

But, m = Ahρ = ALσ
h = $\frac{L\sigma}{\rho}$

Ahρa = Ahρg – Ahρg – Aρgx
a = $\frac{-A\rho gx}{Ah\rho}$ = $\frac{-gx}{h}$
substituting for h
$a = -\frac{\rho g}{\sigma L}x = -kx$ hence simple harmonic motion

(ii) Derive the expression for period of the oscillation. (02marks)

$\omega = \sqrt{\frac{\rho g}{\sigma L}}$ but $T = \frac{2\pi}{\omega}$

$T = 2\pi\sqrt{\frac{\sigma L}{\rho g}}$

(d) A spring of force constant $40Nm^{-1}$ is suspended vertically. A mass of 0.1kg suspended from the spring is pulled down a distance of 5mm and released. Find the

(i) period of the oscillation (02marks)

$\omega = \sqrt{\frac{k}{m}}$ but $T = \frac{2\pi}{\omega}$

$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{0.1}{40}} = 0.314s$

(ii) maximum acceleration of the mass (02marks)

$\omega^2 = \frac{k}{m} = \frac{400}{0.1} = 400$

$a_{max} = \omega^2 x = 400 \times 5 \times 10^{-3} = 2ms^{-2}$

(iii) net force acting on the mass when it is 2mm below the centre of oscillation. (02marks)

$F = kx = 40 \times 2 \times 10^{-3} = 0.08N$

3. (a) Define viscosity of a fluid (01mark)

Viscosity is the frictional force between layers of a liquid.

(b) (i) Derive an expression for terminal velocity attained by a sphere of density, σ, and radius, a, falling through a fluid of density, ρ and viscosity, η. (05marks)

At terminal velocity, mg = U + F

⇨ $\frac{4}{3}\pi a^3\sigma g = \frac{4}{3}\pi a^3\rho g - 6\pi a\eta v_0$

$v_0 = \frac{2ga^2(\sigma - \rho)}{9\eta}$ where;

σ = density of the sphere

ρ = density of the liquid

η = viscosity of the fluid

g = acceleration due to gravity

v0 = terminal velocity

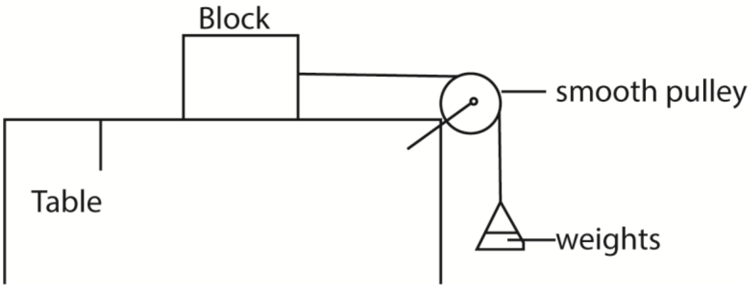
(ii) Explain the variation of viscosity of a liquid with temperature. (02marks)

As temperature increases, the separation of molecules increase and the intermolecular forces decrease leading to the decrease in viscosity.

(c) (i) State the laws of friction. (02marks)

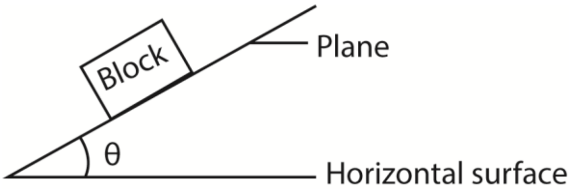
- The frictional force between two surfaces opposes their relative motion.
- The frictional force is independent of the area of contact of the given surfaces when the normal reaction is constant,
- The limiting frictional force is proportional to the normal reaction for the case of static friction. The frictional force is proportional to the normal reaction for the case of kinetic (dynamic) friction, and is independent of the relative velocity of the surfaces.

(ii) With the aid of a well labelled diagram, describe an experiment to determine the coefficient of kinetic friction between two surfaces. (05marks)



- A block of mass m is placed on a flat table and connected to a scale pan as shown in the diagram above.
- Small weights are added in bits on to the scale pan until the block just starts to move. The total weight of the scale pan and weights added is obtained, W_f.
- The coefficient of static friction, $\mu = \frac{W_f}{mg}$

Alternative method



- A block is placed on horizontal plane. The plane is tilted gently until the block just start to slide
- The angle of tilt θ is measured
- The coefficient of static friction, $\mu = \tan\theta$

(d) A body slides down a rough plane inclined at 30^0 to horizontal. If the coefficient of kinetic friction between the body and the plane is 0.4, find the velocity after it has travelled 6m along the plane. (05marks)

From $ma = mg\sin\theta - \mu mg\cos\theta$

$a = 9.81\sin 30 - 0.4 \times 9.81 \times \cos 30 = 1.5ms^{-2}$.

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

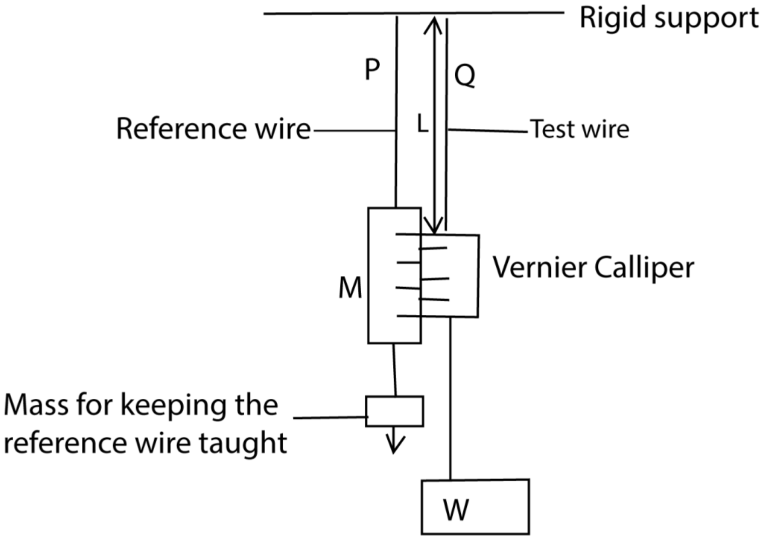
$v^2 = 0 + 2 \times 1.5 \times 6$

$v = 4.243ms^{-1}$

4. (a) (i) Describe the terms tensile stress and kinetic strain as applied to a stretched wire. (02marks)
   - Tensile stress is the ratio of the stressing force applied on the wire to the cross sectional area of the wire.
   - Tensile strain is the ratio of extension in a wire to original length of the wire.

   (ii) Distinguish between elastic limit and proportional limit. (02marks)
   - Elastic limit s the point beyond which a material does not regain its original length and shape when the load is removed.
   - Proportional limit is a point beyond which the extension of a material is not proportional to the applied force or load.

   (b) With the aid of a labelled diagram, describe an experiment to investigate the relationship between tensile stress and tensile strains of a steel wire. (07marks)



(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) The strain, $\frac{e}{l_0}$ and stress, $\frac{F}{A}$ are obtained
(vii) The procedure is repeated for different values of F and e
(viii) A graph of stress against strain is plotted. From the graph it is found that in the first part stress is proportional to strains up to a certain point beyond which it not proportional.

(c)(i) A load of 60N is applied to a steel wire of length 2.5m and cross sectional area of $0.22mm^2$. If Young's Modulus for steel is 210GPa, find the expansion produced. (03marks)

$\Delta t = \frac{FL}{AE} = \frac{60\ x\ 2.5}{(0.22\ x\ 10^{-6} x\ 210\ x\ 10^{9})} = 3.25 \times 10^{-3}$m

(ii) If the temperature rise of 1K causes a fractional increase of 0.001%, find the change in length of a steel wire of length 2.5 when the temperature increases by 4K. (03marks)

1K causes an extension of $\frac{2.5\ x\ 0.001}{100}$

4K causes an extension of $\frac{2.5\ x\ 0.001}{100}\ x\ \frac{4}{1} = 1\ x\ 10^{-4}$m

(d) The velocity, V, of a wave in a material of Young's Modulus, E and density, ρ, is given by $V = \sqrt{\frac{E}{\rho}}$. Show that the relationship is dimensionally correct. (03marks)

LHS, [V] = LT^{-1} ……………………………………………… (i)

Since [E] = $ML^{-1}T^{-2}$ and [ρ] = ML^{-3}

⇨ RHS = $\left[\frac{ML^{-1}T^{-2}}{ML^{-2}}\right]^{\frac{1}{2}}$ = LT^{-1} …………………. (ii)

From eqn. (i) and eqn. (ii) the relation is dimensionally consistent.

SECTION B

5. (a) (i) Define the term specific heat capacity and internal energy and state their units. (03marks)

Specific heat capacity is the amount of heat required to raise the temperature of 1kg mass of a substance by 1K of 1^0C.
Internal energy is the total of the kinetic energy of atoms and molecules and the parallel potential energy due to mutual interactions of these atoms. Units: joules.

(ii) Why is the distinction between specific heat capacity at constant pressure and that at constant volume important for gases, but less important for solids and liquids? (04marks)

The volume of solids and liquids change very little when heated at constant pressure compared with volume changes for gas for the same temperature changes. Thus solid and liquids do very little work against atmospheric pressure. This implies that there is very little difference in energy when they expand and when they are allowed to expand.

(b) Explain why the temperature of a liquid does not change when the liquid is boiling? (02marks)

When the liquid boils, there is change in a state to vapour and all the heat supplied is used to do work by breaking the molecular bonds of the liquid. The temperature will not change until all the bonds broken.

(c) One kilogram of water is converted to steam at a temperature of 100^0C and a pressure of 1.0×10^5Pa. If the density of steam is $0.58kgm^{-3}$ and specific heat of vaporization of water is $2.3 \times 10^6 Jkg^{-1}$, calculate the

(i) external work done (04marks)

Volume of 1kgof steam = $\frac{m}{\rho} = \frac{1}{0.58}$ = $1.724m^3$

Volume of 1kgof steam = $\frac{m}{\rho} = \frac{1}{1000}$ = $0.001m^3$

Change in volume = 1.724 – 0.001 = $1.723m^3$

Work = pdV = $1.0 \times 10^5 \times 1.723 = 1.723 \times 10^5$J

(ii) internal energy (03marks)

$\Delta u = \Delta Q - \Delta w$

$= 2.3 \times 10^6 - 1.723 \times 10^5$

$= 2.13 \times 10^6$J

(d) Explain why the specific latent heat of fusion and specific latent heat of vaporization of a substance at the same pressure are different. (04marks)

Change from solid to liquid, intermolecular bonds are weakened and there is a small increase in volume. This implies there negligible change in volume and thus little work done against atmospheric pressure.

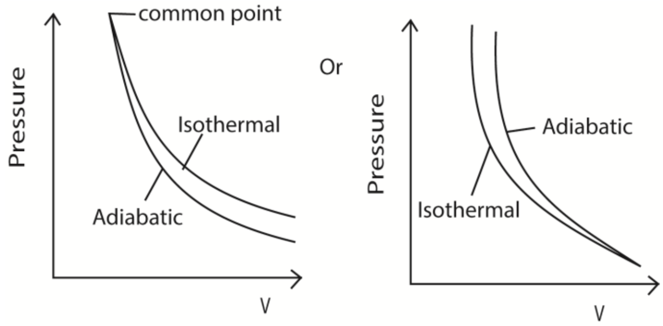
During vaporization, a lot of heat is required to break molecular bonds in a liquid and to enable expansion to larger volume of a gas against atmospheric pressure.

6. (a) (i) Explain the difference between isothermal and adiabatic expansion of a gas. (02marks)

Isothermal expansion takes place at constant temperature.

Adiabatic expansion takes place at constant heat.

(ii) Using same axes and point, sketch graphs of pressure versus volume for fixed mass of a gas undergoing isothermal and adiabatic changes. (03marks)



(b) Show that work, W, done by a gas which expands reversibly from V_0 to V_1 is given by

$W = \int_{V_0}^{V_1} \rho dv$ (04marks)

If the piston is moved through a small distance dx, so that the pressure P is constant then

dw = Fdx

but F = PA; => dw = PAdx; also, Adx = dv

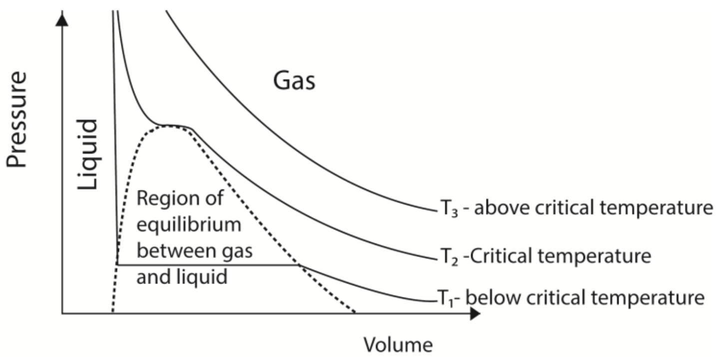
$\therefore dw = Pdv$

=> W = $\int_{v_0}^{v_1} Pdv$

(c) (i) State two differences between real and ideal gases (02marks)

Real gas	Ideal gas
Intermolecular force are appreciable	Intermolecular forces are negligible
Volume of molecules compared to the volume of the container is not negligible	Volume of molecules compared to the volume of container is negligible
Obey Boyle's law at high temperature and very low pressure	Obey Boyle's law at all temperatures and pressures.

(ii) Draw a labelled diagram showing P-V isothermals for a real gas above and below the critical temperature. (03marks)



- Above the critical temperature a gas obeys Boyle's law.
- Below the critical temperature a gas exist as unsaturated vapour at low pressure when the pressure is increase it condenses until all the gas is turned into a liquid.

(d) Ten moles of a gas, initially at 27^0C are heated at constant pressure of 1.01 x 10^5Pa and volume increased from $0.25m^3$ to $0.375m^3$. Calculate the increase in internal energy.
[Assume $C_p = 28.5Jmol^{-1}K^{-1}$] (06marks)

T_1 = 270C = 300K

Using $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{0.250}{300} = \frac{0.375}{T_2}$; T_2 = 450K

$\Delta T = 450 - 300 = 150K$

ΔQ = ΔU + Δw

$nC_p\Delta T = nC_v\Delta T + nR\Delta T$

$nC_v\Delta T = nC_p\Delta T - nR\Delta T$

= 10 x 28.5 x 150 – 10 x 8.31 x 150

= 3.03 x 10^4J

7. (a) What is meant by the following?

(i) Conduction

Conduction is the process of heat transfer through a substance from a region of high temperature to a region of low temperature without bulk movement of the medium; mainly by collision between atoms that vibrate about equilibrium positions.

(ii) Convection

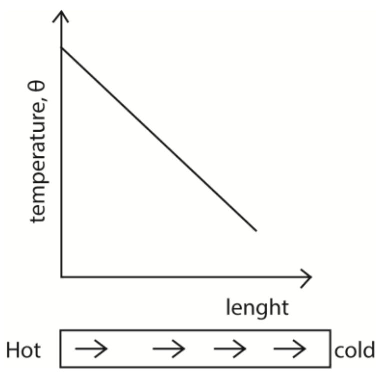
Convection is a process of heat transfer in fluids from a region of high temperature to a region of low temperature, due to movement of the medium. Heated fluid become less dense and rises up and is replaced by cold denser fluid.

(iii) Greenhouse effect (06marks)

Solar radiation of short wavelengths is absorbed by the earth's surface. The earth radiates long wavelength radiations which are trapped by the atmosphere leading to global warming.

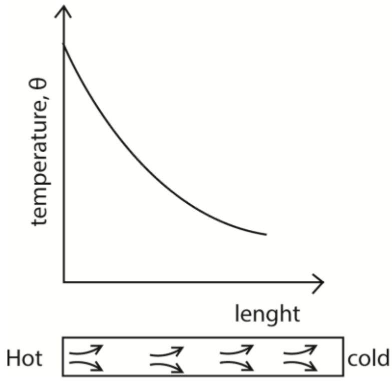
(b) One end of a long copper bar is heated in a steam chest and the other end is kept cool by current of circulating water. Explain with the aid of sketch graphs, the variation of temperature along the bar, when steady state has been attained if the bar is

(i) lagged (02marks)



The rate of heat flow along the bar is constant since heat loss is negligible.

(ii) exposed to the surrounding (02marks)

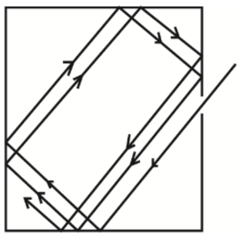


The rate of heat flow decrease with length due to heat losses

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

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

(ii) Describe how a black body can be approximated in practice. (04marks)

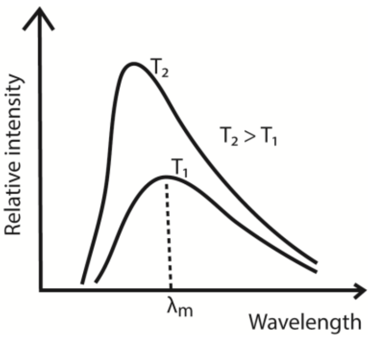


When radiation enters a black container through a hole, it undergoes multiple reflections. At each reflection, part of the radiation is absorbed. After several reflections, all the radiation is retained inside the container. Hence it approximates to a black body.

(d) (i) State Prevost's theory of heat exchange. (01mark)

A body at constant temperature is in of dynamic equilibrium with its surroundings. The rate of radiation being equal to the rate of absorption.

(ii) Sketch the variation with wavelength of the intensity of radiation emitted by a black body at two different temperatures. (01mark)



- 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 cube of side 1.0cm has a grey surface that emits 50% of the radiation emitted by a black body at the same temperature. If the cube's temperature is 700^0C, calculate the power radiated by the cube. (03marks)

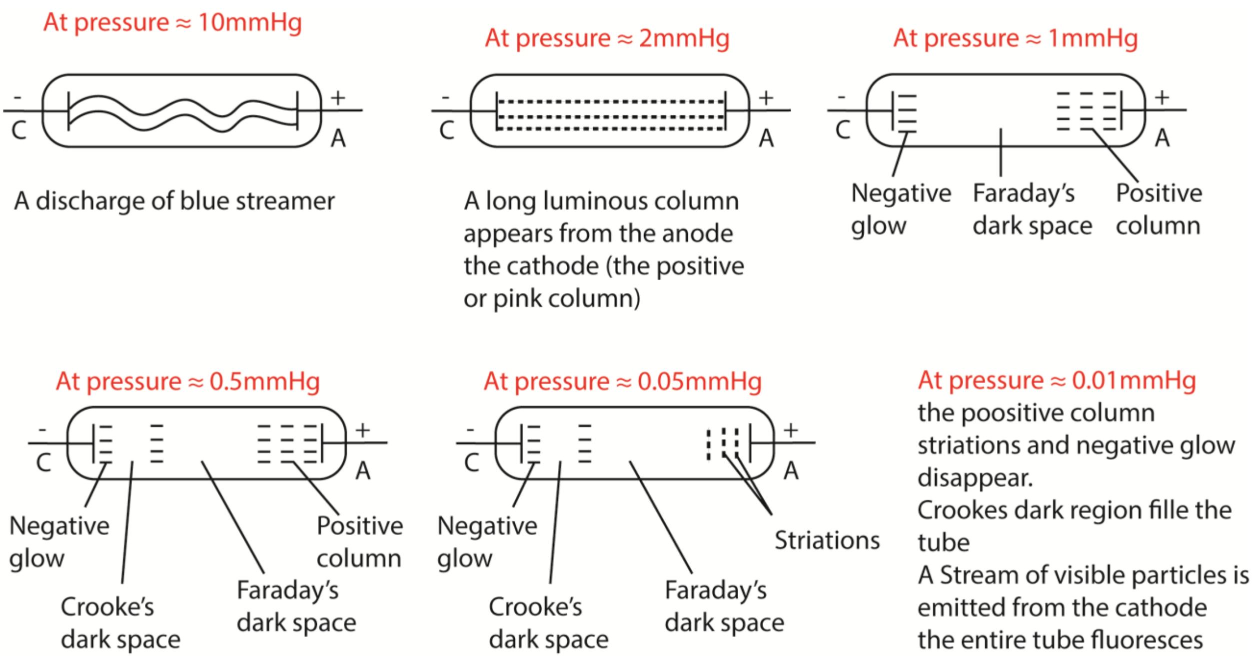
$P = \sigma A T^4$

T = 700 + 273 = 973K

$\therefore P = 0.5 \times 5.67 \times 10^{-8} \times (6 \times 10^{-4}) \times 973^4 = 15.25W$

SECTION C

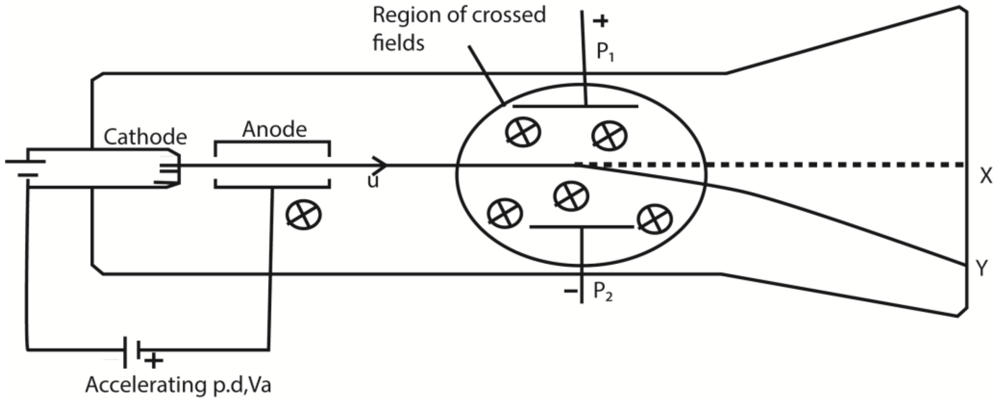
8. (a) (i) With the aid of a labelled diagram, describe what is observed when a high tension voltage is applied across a gas tube in which pressure is gradually reduced to vary low value. (05marks)



(ii) Give two applications of discharge tubes. (01mark)

- Making mercury lamps, sodium lamps
- Neon signs
- Florescent tubes

(b) Describe Thomson's experiment to determine the specific charge of an electron. (06marks)



- 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

  ∴u = $\frac{E}{B}$ ………………………………(ii)

  Substituting eqn. (ii) in (i)

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

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

(c) In a Millikan's experiment, a charged oil drop of radius 9.2 x 10^{-7}m and density 800kgm^{-3} is held stationary in an electric field of intensity 4.0 x 10^4Vm^{-1}.

[Density of air = 1.29kgm^{-3}, coefficient of viscosity of air = 1.8 x 10^{-5}Nsm^{-1}]

(i) How many electron charges are on the drop? (04marks)

mg = U + Eq

$\frac{4}{3}\pi r^3\rho g = \frac{4}{3}\pi r^3\sigma g$ + Eq

q = $\frac{\frac{4}{3}\pi r^3(\rho - \sigma)g}{E} = \frac{\frac{4}{3}\pi\ x\ (9.2\ x\ 10^{-7})^3(800 - 1.29)x\ 9.81}{4\ x\ 10^4} = 6.39\ x\ 10^{-19}$

n = $\frac{q}{e} = \frac{6.39\ x\ 10^{-19}}{1.6\ x\ 10^{-19}}$ =4

(ii) Find the electric field intensity that can be applied vertically to move the drop with velocity $0.005ms^{-1}$ upwards.

Mg + Fv = U + Eq

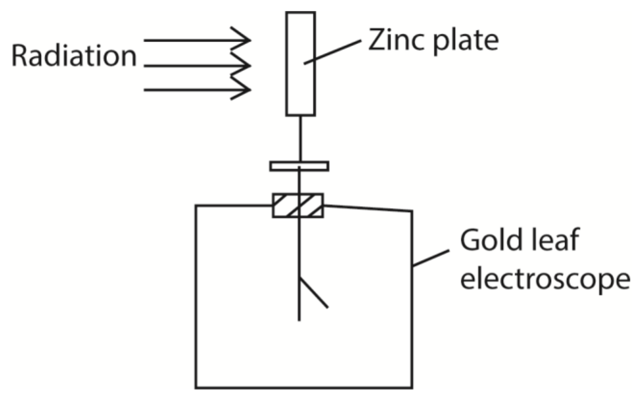
$$E = \frac{mg-U+Fv}{q} = \frac{\frac{4}{3}\pi r^3(\rho-\sigma)g+Fv}{q} = \frac{\frac{4}{3}\pi r^3(\rho-\sigma)g+6\pi\eta r v_0}{q}$$

$$= \frac{\frac{4}{3}\pi\ x\ (9.2\ x\ 10^{-7})^3(800-1.29)x\ 9.81\ x\ 6\pi\ x\ 1.8\ x\ 10^{-5}\ x\ 9.2\ x\ 10^{-7}\ x\ 0.005}{1.6\ x\ 10^{-19}}$$

$= 2.48 \times 106Vm^{-1}$

9. (a) Explain what is meant by photoelectric effect. (02marks)
Emission of electrons from clean metal surface struck by electromagnetic radiations of high energy.

(b)



Ultraviolet and infrared radiations are directed in turns on to a zinc plate which is attached to a gold leaf electroscope as shown in the figure above

Explain that happens when

(i) Ultraviolet radiation falls on the zinc plate (02marks)
Electrons will be emitted and a net positive charge will be left on the zinc plate. Both the plate and the leaf acquire a positive charge and the leaf diverge.

(ii) Infrared falls on the zinc plate. (01mark)
Infrared has low frequency, therefore no electrons will be emitted from the zinc plate and the leaf will not diverge.

(iii) The intensity of each radiation is increased. (02marks)
In case of ultraviolet, more electrons will be emitted per second and the leaf diverges rapidly
In case of infrared, the leaf does not diverge because the frequency is low

(c) An X-ray of wavelength 10^{-10}m is required for the study of its diffraction in a crystal. Find the least accelerating voltage to be applied on an X-ray tube in order to produce these X-rays. (04marks)

E = $h\frac{c}{\lambda} = 6.6 \ x\ 10^{-34}\ x\ \frac{3\ x\ 10^{8}}{10^{-10}}$ = 1.98 x 10^{-15}J

Energy of electron = eV = 1.98 x 10^{-15}J

$$V = \frac{1.98\ x\ 10^{-15}}{1.6\ x\ 10^{-19}} = 1.24 \text{ x } 10^{4}V$$

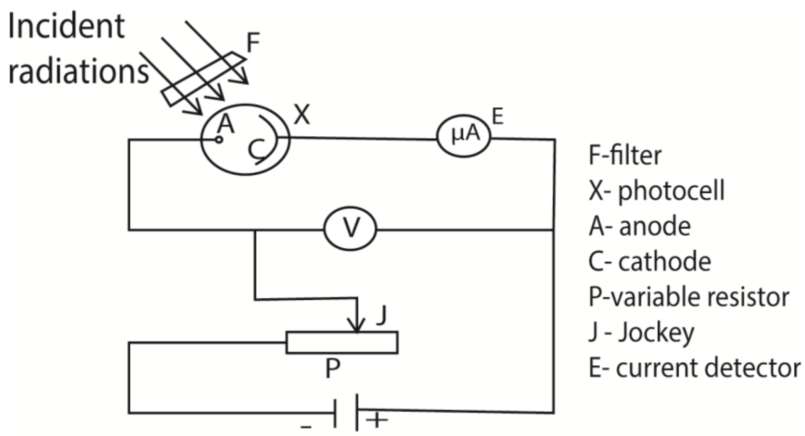
(d) Sodium has a work function of 2.0eV and is illuminated by radiation of wavelength 150nm. Calculate the maximum speed of the emitted electrons. (04marks)

K.E = $h\frac{c}{\lambda e} - w_0$

$$\frac{1}{2}\ x\ 9.11\ x\ 10^{-31}v^2 = \left(\frac{6.6\ x\ 10^{-34}}{1.6\ x\ 10^{-19}}\ x\ \frac{3\ x\ 10^{8}}{150\ x\ 10^{-9}} - 2.0\right)\ x1.6\ x\ 10^{-19}$$

v = 1.48 x 10^{6}ms^{-1}

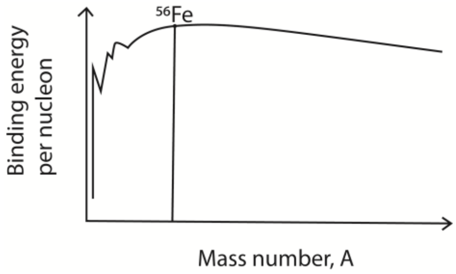
(e) With the aid of a well labelled diagram, describe how stopping potential of a metal can be measured. (05marks)



- 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.

10. (a) (i) What is meant by mass defect? (01marks)
Mass defect is the is the difference in sum of mass of the components of the nucleus and the mass of the nucleus

(ii) Sketch a graph showing how binding energy per nucleon varies with mass number and explain its features. (03marks)



Binding energy increases rapidly from mass number=1 to a peak of mass number, A = 56 and then decreases gradually.

(iii) Find the binding energy per nucleon of $^{56}_{26}Fe$ given that

Mass of 1 proton = 1.007825u

Mass of 1neutron = 1.008665u

[1u = 931MeV) (03marks)

Solution

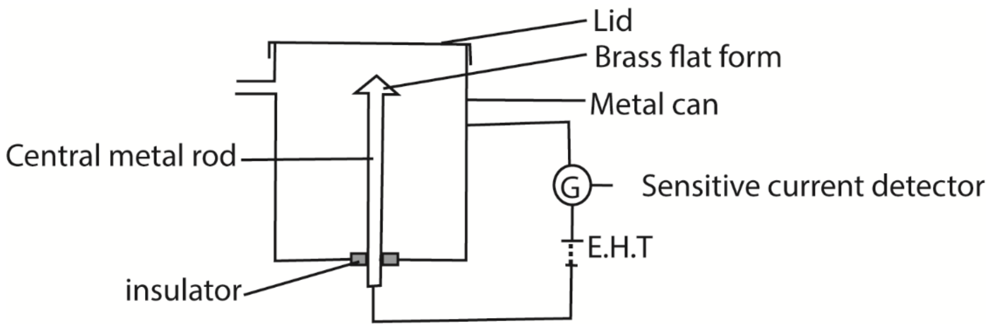
Binding energy = (26 x 1.007825 + 30 x 1.008665 - m_f)U

where mf is the mass of the nucleus of Fe-56

Binding energy = (56.4634- m_f) x 931eV

Binding energy per nucleon = $\frac{(56.4634 - m_f)\ x\ 931}{56}$eV

(b) With the aid of a diagram, explain how an ionization chamber works (06marks)



- 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.

(c) (i) Show that an alpha particle collides head on with an atom of atomic number, Z, the closest distance of approach to the nucleus X_0 is given by

$X_0 = \frac{ze^2}{\pi\varepsilon_0 mv^2}$

Where

e is electronic charge

ε_0 is permittivity of fee space

m is mass of alpha particle

v is initial speed of alpha particle (04marks)

charge on ^4_2He = 2e

charge on atomic nucleus = Ze

kinetic energy of $^4_2He = \frac{1}{2}mv^2\ where\ v$= speed of collision

Electrostatic potential energy = $\frac{1}{4\pi\varepsilon_0}\ x\ \frac{(Ze)(2e)}{X_0}$

At closest distance x0 of approach;

Kinetic energy = electrostatic potential energy

$\frac{1}{2}mv^2 = \frac{2Ze^2}{4\pi\varepsilon_0 x_0}$

$x_0 = \frac{Ze^2}{\pi\varepsilon_0 v^2}$

(ii) In a head on collision between an alpha particle and a gold nucleus, the minimum distance of approach is 5 x 10^{-14}m. Calculate the energy of alpha particle (in MeV)

[atomic number of gold= 79]

Kinetic energy = $\frac{1}{2}mv^2 = \frac{2Ze^2}{4\pi\varepsilon_0 x_0} = \frac{9\ x\ 10^9\ x\ 2\ x\ 79\ x\ (1.6\ x\ 10^{-19})^2}{5\ x\ 10^{-15}}$ = 7.28 x 10^{-13}J =4.55MeV

Compiled by Dr. Bbosa Science