UACE Physics paper 1 set 5 guide

1. (a) (i) what is meant by conservative force? (01mark)

Conservative force are forces for which the work done in moving a body around a closed path is zero.

Or

Conservative force is the one for which the work done in moving a body from one point to another is independent of the path taken.

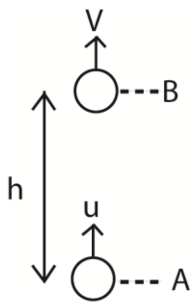
(ii) Give two examples of conservative forces. (01mark)

- Gravitational force, magnetic force, electric force, elastic force

(b) (i) State the law of conservation of mechanical energy. (01mark)

The sum of kinetic energy and potential energy is constant in the absence of dissipative forces.

(ii) A body of mass, m, is projected vertically upwards with speed, u. show that the low of conservation of mechanical energy is obeyed throughout its motion. (05marks)



At A, K.E $=\frac{1}{2}mu^2$, P.E = 0

Total energy at A = K.E + P.E = $\frac{1}{2}mu^2 + 0 = \frac{1}{2}mu^2$

At B, K.E = $\frac{1}{2}mv^2$; P.E = mgh

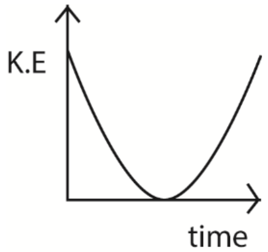
Total energy at B, = $\frac{1}{2}mv^2$ + mgh

But $v^2 = u^2 - 2gh$

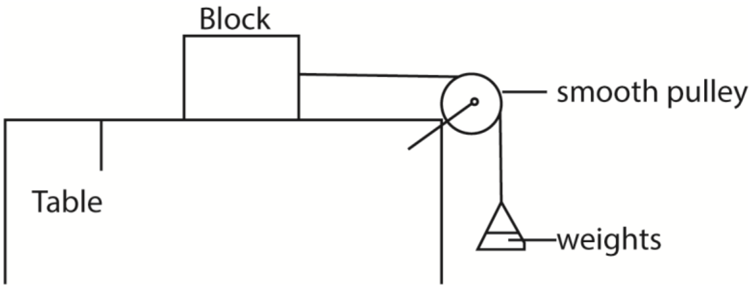
Total energy at B = $\frac{1}{2}m(u^2 - 2gh) + \text{mgh} = \frac{1}{2}mu^2$

∴Total energy at A = total energy at B

(iii) Sketch a graph showing variation of kinetic energy by the body with time. (01 mark)

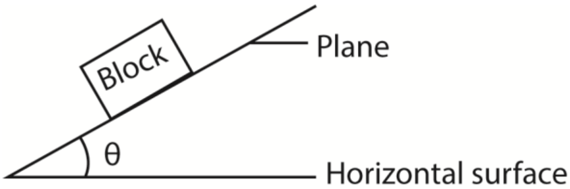


(c) (i) Describe an experiment to measure the coefficient of static friction. (04marks)



- 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, μ = $\frac{W_f}{mg}$

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, μ = tanθ

(ii) State two disadvantages of friction. (01mark)

- Wastes energy
- Causes wear and tear
- Causes noise
- Generates unnecessary heat

(d) A bullet of mass 20g moving horizontally strikes and get embedded in a wooden block of mass 500g resting on a horizontal table. The block slides through a distance of 2.3m before coming to rest. If the coefficient of kinetic friction between the block and table is 0.3, calculate

(i) friction force between the block and the table. (02marks)

F = μmg = 0.3 x 0.52 x 9.81 = 1.53N

(ii) velocity of the bullet just before it strikes the block. (04marks)

F = ma

- 1.53 = 0.52a

a = -2.94ms^{-2}

$V^2 = u^2 - 2as$

0 = v_1^2- 2 x 2.94 x 2.3

$v_1 = 3.68ms^{-1}$

Mu = (m +m_1)v_1

0.02u = 0.502 x 3.68

u = 95.7ms^{-1}

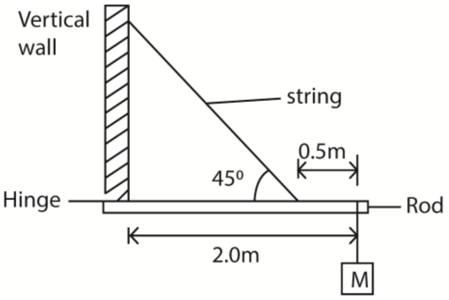
2. (a) (i) State the principle of moments. (01mark)

When a body is in mechanical equilibrium, the sum of clockwise moments about any point is equal to the sum of anticlockwise moments about the same point

(ii) Define the terms centre of gravity and uniform body. (02marks)

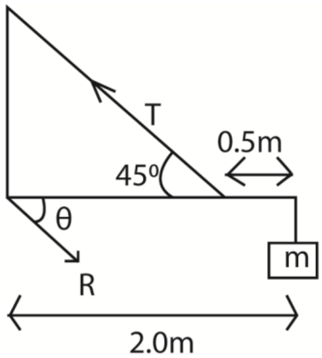
- Centre of gravity is the point where the resultant force on the body due to gravity acts.
- A uniform body is one whose centre of gravity is the same as the geometrical centre.

(b) Figure below shows a body, M of mass 20kg supported by a rod of negligible mass horizontally hinged to a vertical wall and supported by a string fixed at 0.5m from the other end of the rod.



Calculate the

(i) Tension in the string (03marks)



$T\sin 45 \times 1.5 = 20 \times 9.81 \times 2$

$T = 370N$

(ii) Reaction of the hinge (03marks)

$R\cos\theta = 370\cos 45$ ……………..(i)

Taking moments about O

$R\sin\theta \times 1.5 = 20 \times 9.81 \times 0.5$ …. (ii)

Eqn. (i) and (ii)

$\theta = 14^0$

(iii) Maximum additional mass which can be added to the mass of 20kg before the string can break given that the string cannot support a tension of more than 500N. (02marks)

Taking moments about the hinge

$500\sin 45 \times 1.5 = X \times 9.81 \times 2$

$X = 27kg$

extra mass = 27 – 20 = 7kg

(c) (i) Define Young's modulus. (01marks)

Young's modulus is the ratio of tensile stress to tensile strain

(ii) Explain the precautions taken in determinations of Young's modulus of a wire. (06marks)

- After each reading, the load is removed to check that the wire returns to its original length, to ensure that elastic limit is not exceeded.
- Long wires are used to achieve measurable expansion
- Thin wires are used to produce high tensile stress
- Identical wires are used to eliminate error of expansion or contraction due to changes in temperature.

(iii) Explain why a piece of rubber stretches much more than a metal wire of the same length and cross section (02marks)

Rubber consist of coiled molecules while metal does not. When load is applied to rubber, the molecules uncoil leading to a larger extension

3. (a) State Kepler's laws of planetary motion (03marks)
- Planets resolve in elliptical orbits with the sun at the focus.
- The imaginary line joining the sun to any planet sweeps out equal areas in equal time intervals
- The square of the period of revolution of a planet is proportional to the cube of the mean distance from the sun to planet

(b) (i) what is a parking orbit? (01mark)

A parking orbit is the path in space followed by a satellite whose period of revolution is equal to the period of rotation of the earth.

(ii) Derive an expression for the period, T, of a satellite in a circular orbit of radius, r, above the earth in terms of mass of earth, m, gravitational constant, G and r. (04marks)

$\frac{GmM_S}{r^2} = M_S r\omega^2$ but ω = $\frac{2\pi}{T}$

$\frac{Gm}{r^2} = r\left(\frac{4\pi^2}{T^2}\right)$

T = $2\pi\sqrt{\frac{r^3}{Gm}}$

(c) (i) A satellite of mass 200kg is launched in a circular orbit at a height of 3.59×10^7m above the earth's surface. Find the mechanical energy of the satellite. (03marks)

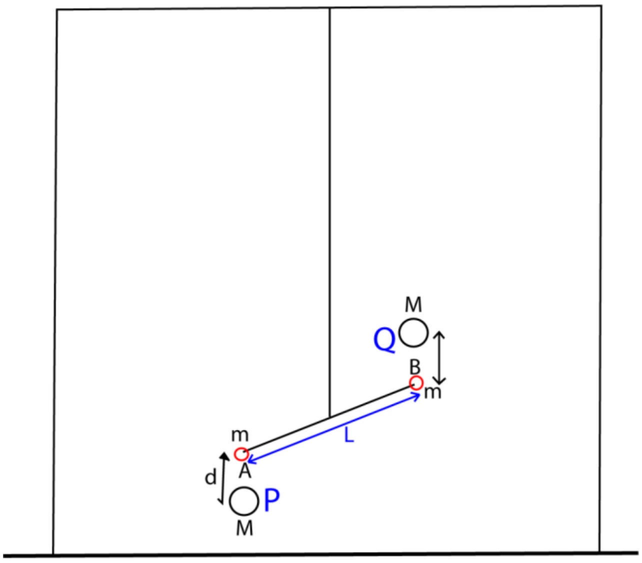
M.E = $\frac{-GMm}{2r}$ = $\frac{-6.67 \, x \, 10^{-11} \, x \, 5.97 \, x \, 10^{24} \, x \, 200}{2(3.59 \, x \, 10^{7}+6.4 \, x \, 10^{6})} = -9.41 \, x \, 10^{8}$

(ii) Explain what will happen to the satellite if its mechanical energy was reduced. (03marks)

When mechanical energy, M.E = $\frac{-GMm}{2r}$; is reduced, the satellite falls to orbit of smaller radius

(d) Describe laboratory method of determining the universal gravitational constant, G. (06marks)

Determining gravitational constant



- Two equal lead spheres A and B each of mass, m, are attached to end of a bar AB of length, L.
- The bar AB is suspended from a ceiling.
- Large spheres P and Q are brought towards A and B respectively from the opposite side
- Large spheres P and Q altered small spheres A and B respectively by equal and opposite gravitational forces give rise to gravitational torque, F, which in turn twist the suspended through angle θ.
- A resting torque of the wire opposes the twisting of the wire from equilibrium position

  Then

  F = Cθ $=\frac{GMm}{d^2}$

  G = $\frac{C\theta d^2}{MmL}$

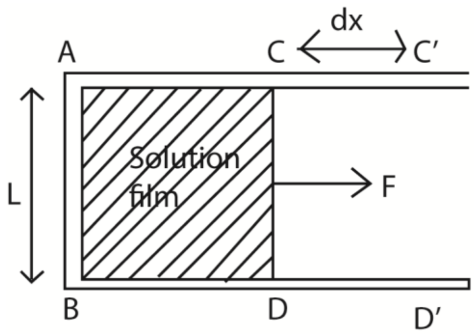
  Where

  d = distance between the centre of A and P or B and Q.

  C = the twisting couple per unit twist (θ = 1)

4. (a) (i) Distinguish between surface tension and surface energy (01mark)
   - Surface tension is a force per unit length acting at right angle to one side of an imaginary line drawn in the liquid surface
   - Surface energy is the work done in increasing area of the surface by 1m2 under isothermal conditions.

   (ii) Show the surface energy and surface tension are numerically equal. (03marks)



- F a wire frame ABCD is put in a solution of surface tension γ and a film of the solution forms on ABCD; and if a force F is used to extend the film to ABC'D' ;
- Then surface tension, γ = $\frac{F}{2L}$
- Surface energy, σ = $\frac{Fdx}{2Ldx} = \frac{2\gamma Ldx}{2Ldx}$ = γ

  ∴ Surface energy, σ = surface tension, γ

(iii) Explain why water dripping out of a tap does so in spherical shapes. (03marks)

For any given volume, a sphere is a shape that offer minimum surface area and therefore the most stable

(b) Two soap bubbles of radius 2.0cm and 4.0cm respectively coalesce under isothermal conditions. If the surface tension of the soap solution is 2.5x $10^{-2}Nm^{-1}$, calculate the excess pressure inside the resulting soap bubble. (04marks)

$2(\pi r_1^2) + 2(\pi r_2^2) = 2(\pi R^2)$

$R = \sqrt{r_1^2 + r_2^2)} = \sqrt{2^2 + 4^2}$ = 4.47 cm

$P_1 - P_0 = \frac{4\gamma}{R} = \frac{4\ x\ 2.5\ x\ 10^{-2}}{4.47\ x\ 10^{-2}}$ 2.24Pa

(c) (i) State Bernoulli's principle (0marks)

Bernoulli's Principle states that for a streamline motion of an incompressible non viscous fluid, the sum of pressure at any point and kinetic energy per unit volume is always constant.

(ii) Explain how wind at a high speed over the roof of a building can cause the roof to be ripped off the building. (03marks)

Wind blowing at a high speed over the roof of a building causes pressure above the roof to decrease below the pressure in the building where the wind is slow. This difference in pressure causes a resultant force that pushes the roof off the building.

(iii) An aeroplane has a mass of 8,000kg and wing area of 8.0m^2. When moving through still air, the ratio of its velocity to that of the air above its wings is 0.25. At what velocity will the aeroplane be able to just lift off the ground? (Density of air = 1.3kgm^{-3})

- Minimum force to lift an aeroplane = 8000 x 9.81 = 78480N
- If v is the velocity of the aeroplane, then velocity of air below the wings v_b = v.
- Velocity of the air above the aeroplane = va= $\frac{v}{0.25} = \frac{v_b}{0.25}$ or v_a = 4v
- From Bernoulli's Principle, $P_b + \frac{1}{2}\rho v_b^2 = P_a + \frac{1}{2}\rho v_a^2$

  $P_b - P_a = \frac{1}{2}\rho\left(v_a^2 - v_b^2\right) = \frac{1}{2}\ x\ 1.3\ ((4v)^2 - v^2)$ = 9.75v^2

  But force = pressure x area

⇨ 78480 = 9.75v^2 x 8

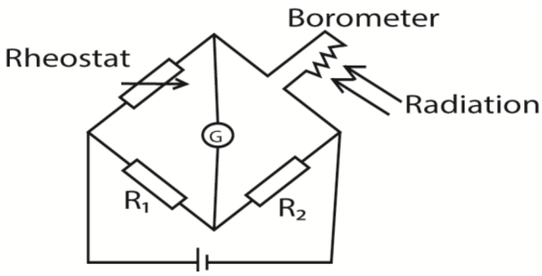
v = 31.72ms^{-1}

SECTION B

5. (a) (i) State four desirable properties a material must have to be used as a thermometric substance. (02marks)
    - The property must vary linearly with temperature
    - The property must vary continuously with temperature
    - The property must be easily measurable
    - The property must be safe to handle

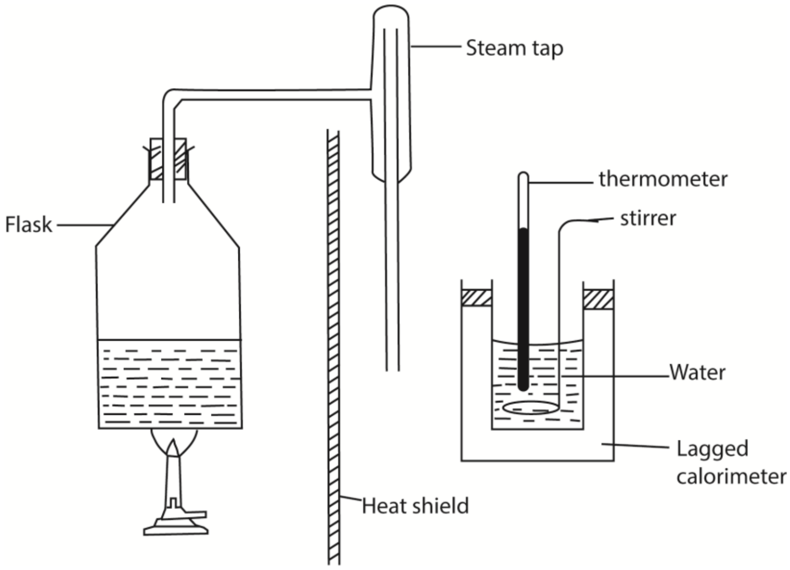
   (ii) State why scales of temperature based on different thermometric properties may not agree. (01mark)
   It is because different thermometric properties vary differently with temperature but only agree at the fixed points.

   (b) With the id of diagram explain how a bolometer is used to detect thermal radiation. (06marks)



The bolometer strip is connected to Wheatstone bridge circuit above. The rheostat is adjusted until the galvanometer shows no deflection. When the radiations fall on the strip, they are absorbed and its temperature rises leading to an increase in resistance. The galvanometer deflects showing the presence of radiations.

   (c) Describe, with the aid of a diagram an experiment to determine specific heat of vaporization of steam using the method of mixtures. (07marks)



- The initial temperature θ_0 and mass, m of water in the calorimeter are measured
- Steam from boiling water is passed into water in a calorimeter and after a reasonable temperature rise, flow of steam is stopped and final temperature, θ_f is recorded.

- Mass m_2 of water in the calorimeter is then taken
- The mass of steam condensed, $m_s = (m_2 - m)$
  Given that the heat capacity of the calorimeter= C
  Heat gained by steam = heat gained by water and calorimeter
  $m_s c_v + m_s c(100 - \theta_f) = (m_2 - m)c(\theta_f - \theta_0) + C(\theta_f - \theta_0)$
  c_v = specific latent heat of vaporization
  c= specific heat capacity of water

(d) A 600W electricity heater is used to raise the temperature of a certain mass of water in a thermos flask from room temperature to 80^0C. The same temperature rise is obtained when seam from a boiler is passed into an equal mass of water at room temperature in the same time. If 16g of water were being evaporated every minute in the boiler, find the specific latent heat of vaporization of steam, assuming no heat losses. (04marks)

Rate of evaporation = 0.016kg per minute

$= \frac{0.016}{60}$ kgs^{-1}

Let Lv be specific latent heat of vaporization

$P = mL_v + mc\theta$

$600 = \frac{0.016}{60} c_v + \frac{0.016}{60}\ x\ 4200\ x\ (100 - 80)$

$L_v = 2.2$ x 106Jkg^{-1}

6. (a) Define the following

(i) Absolute zero (01marks)

It is the temperature attained when molecules slow down and acquire the least possible energy

(ii) Cooling correction (01marks)

It is the temperature added to experimentally observed maximum temperature to cater for heat lost to the surroundings.

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

Dalton's law of partial pressures states that the total pressure of a mixture of gases that do not react chemically is equal to the sum of partial pressures

(ii) Using the expression $p = \frac{1}{3}\rho\overline{c^2}$, where ρ is the pressure of a gas of density ρ and mean square speed c^2, derive Daltons law of partial pressures for two gases. (05marks)

$P = \frac{1}{3} N \frac{m}{V} \overline{c^2} = \frac{2}{3} N \left(\frac{1}{2} m\overline{c^2}\right)$

For gas 1, $P_1V_1 = \frac{2}{3} N_1 \left(\frac{1}{2} m_1 \overline{c_1^2}\right)$

$\Rightarrow N_1 = \frac{3}{2} P_1 V_1 . \frac{1}{K_1}$

Similarly for gas 2

$N_2 = \frac{3}{2} P_2 V_2 . \frac{1}{K_2}$

For a mixture of gases, $N = \frac{3}{2} PV . \frac{1}{K}$; but $N = N_1 + N_2$

$\frac{3}{2} PV . \frac{1}{K} = \frac{3}{2} P_1 V_1 . \frac{1}{K_1} + \frac{3}{2} P_2 V_2 . \frac{1}{K_2}$

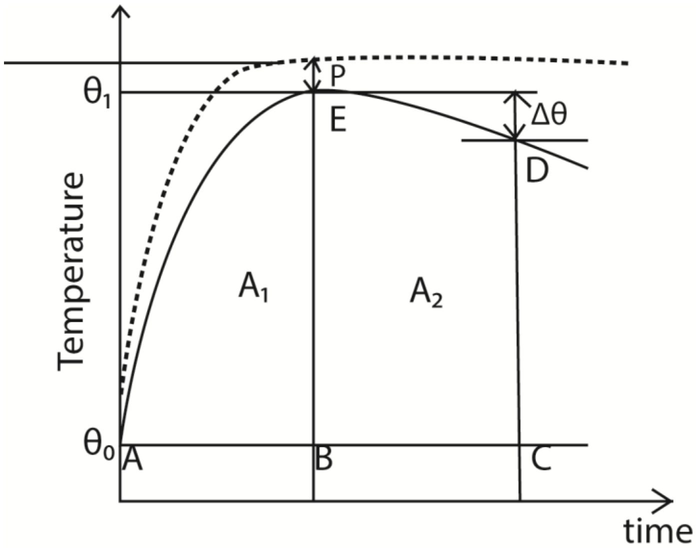
Since temperature is constant, $K_1 = K_2 = K$

- $PV = P_1V_1 + P_2V_2$

- But $V = V_1 = V_2$
- $\therefore P = P_1 + P_2$

(c) Explain clearly the steps taken to determine the cooling correction when measuring the specific heat capacity of a poor conductor by the method of mixtures. (07marks)

- Pour a liquid in a calorimeter and place it on a table
- Place a thermometer into the liquid and after sometime, record the temperature of the surroundings, θ_0.
- Gently place a hot solid into the liquid and stir.
- Record the temperature of the mixture at suitable interval until the temperature of the mixture has fallen by about 1^0C below the observed maximum temperature, θ_1.
- Plot a graph of temperature against time



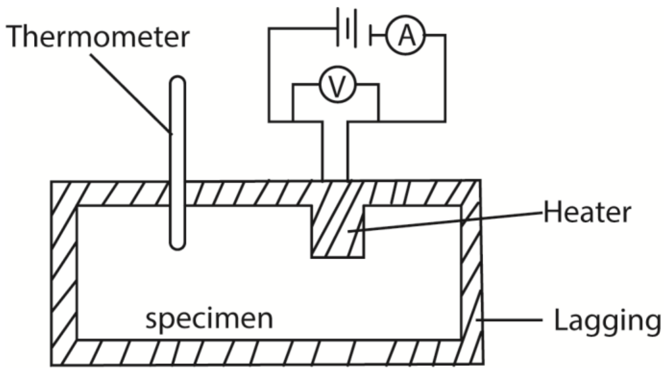
- The broken line shows how we would expect the temperature to rise if no heat were lost and the difference, P, between the plateau of this imaginary curve, and the crest of the experimental curve, E. is known as the 'cooling correction'
- Draw a line AC through θ_0 parallel to the time axis.
- Draw a line BE through θ_1 parallel to the temperature axis.
- Draw a line CD beyond BE parallel to the temperature axis and note $\Delta\theta$
- Estimate the area A_1 and A_2 under the graph by counting the square on the graph paper
- Cooling correction, P s given by the graph

  Cooling correction, P = $\frac{A_1}{A_2}\ x\ \Delta\theta$^{0}C

7. (a) Define thermal conductivity of material and state its units. (02marks)

Thermal conductivity is the rate of heat flow per unit area of cross section area per temperature gradient. Units are $Wm^{-1}K^{-1}$

(b) Describe an experiment to determine the thermal conductivity of copper. (06marks)

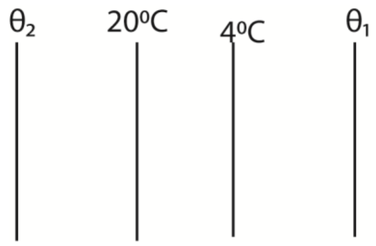


- Two holes are drilled into the specimen solid of copper of mass m.
- A thermometer is inserted in one of the holes and an electric heater into the other hole. The holes are then filled with a good conducting fluid, e.g. oil to ensure thermal contact.
- The apparatus is insulated and initial temperature 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 = $\frac{IVt}{m(\theta_1 - \theta_0)}$

(c) A double glazed window has two glasses each of thickness 4.0mm separated by a layer of air of thickness 1.5mm. If the two inner air-glass surfaces have steady temperature of 20^0C and 4^0C respectively. Find the

(i) temperatures of the outer air-glass surfaces (03marks)



$$\frac{Q}{t} = \frac{0.72A(\theta_2 - 20)}{4\ x\ 10^{-3}} = \frac{0.025A(20 - 4)}{1.5\ x\ 10^{-3}} = \frac{0.72A(4 - \theta_1)}{4\ x\ 10^{-3}}$$

$\theta_2 = 21.48^0C$; $\theta_1 = 2.52^0C$

(ii) the amount of heat that flows across an area of the window of $2m^2$ in 2hours.

$\frac{Q}{t} = \frac{0.025\ x\ 16\ x\ 2}{1.5\ x\ 10^{-3}}$ = 533.3Js^{-1}

Heat flow in two hours = 533.3 x 2 3600 = 3.84 x 10^6J

[Conductivity of glass = 0.72$Wm^{-1}k^{-1}$ and that of air = 0.025$Wm^{-1}K^{-1}$]

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

A black body s one that absorbs all incident radiation falling on it and transmits or reflects none.

(ii) Explain how a welder can protect the eyes from damage. (03marks)

A welder puts on dark shades that absorb ultraviolet light which damages the eyes.

(iii) Calculate the wavelength of the radiation emitted by a black body at 6000K

[Wen's displacement constant = 2.9×10^{-3}mK] (02marks)
$\lambda T = 2.9 \times 10^{-3}$
$6000\lambda = 2.9 \times 10^{-3}$
$\lambda = 4.8 \times 10^{-7}$m

SECTION C

8. (a) (i) Define Avogadro's constant and Faraday's constant. (02marks)
Avogadro's constant is the number of atoms in one mole of substance.
Faradays constant is the charge required to liberate one mole of monovalent ions during electrolysis.

(ii) Show that the charge carried by a monovalent ion is 1.6×10^{-19}C. (02marks)

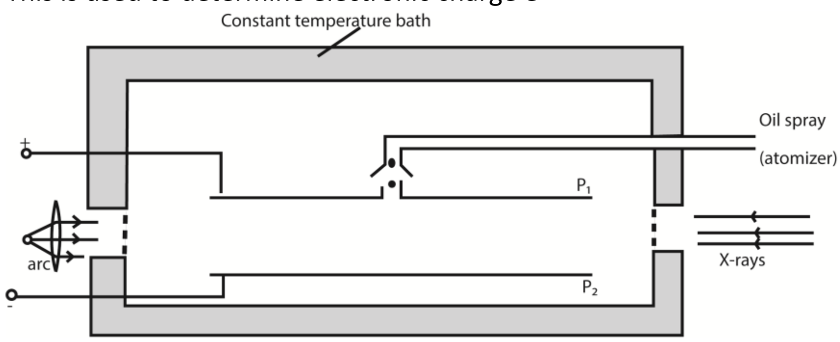
1F = nq (q = electronic charge)

$q = \frac{96500}{6.02 \; x \; 10^{23}} = 1.6\text{x } 10^{-19}$C

(b) With the use of a labelled diagram, describe Millikan's oil drop experiment for the determination of the charge of an electron. (07marks)

Millikan's Oil drop experiment

This is used to determine electronic charge e



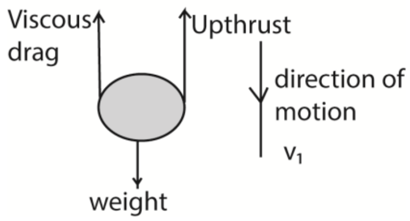
Procedure

- Set up of the apparatus is as shown above
- Oil drops are introduced between the plates P_1 and P_2 by spraying using the atomizer.
- These oil drops are charged in the process of spraying by friction but the charge may be increased further ionization due to X-rays.
- The oil drops are strongly illuminated by an intense light from the arc lamp so that they appear as bright spots when observed through a low power microscope.
- With no electric field between the plates, record the time t_1 taken for drop to fall from P_1 to P_2.
- The electric field between the plates is turned on and adjusted so that the drop becomes stationary.

Case 1

With no electric field, the oil drop falls with a uniform velocity v_1 called terminal velocity

Forces of falling oil drop



Weight = Upthrust + viscous drag ……………………………… (i)

= volume of the oil drop x density x gravity

= $\frac{4}{3}\pi r^3 \rho g$ (ρ = density of oil, r = radius of oil drop)

Upthrust = weight of air displaced by oil drop

= volume of the air displaced by oil drop x density x gravity

= $\frac{4}{3}\pi r^3 \sigma g$ (σ = density of air)

Viscous drag = $6\pi r\eta v_1$ (From strokes' law)

From 1

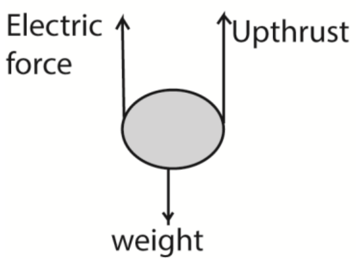
$\frac{4}{3}\pi r^3 \rho g = \frac{4}{3}\pi r^3 \sigma g + 6\pi r\eta v_1$ …………………… (ii)

$r = \left[\frac{9\eta v_1}{2g(\rho-\sigma)}\right]^{\frac{1}{2}}$

Case 2

When the electric field is applied so that the drop is stationary, the drop has no velocity and no acceleration.

Forces of stationary oil drop



Weight = Upthrust + electric force

$\frac{4}{3}\pi r^3 \rho g = \frac{4}{3}\pi r^3 \sigma g + qE$ …………………… (iii)

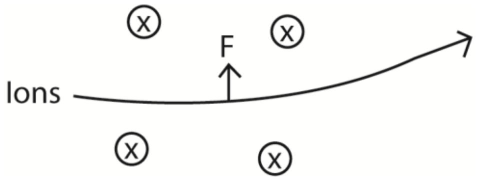
From (ii) and (iii)

q = $\frac{6\pi r\eta v_1}{E}$ but E = $\frac{V}{d}$

Substituting for r

q = $\frac{6\pi\eta d v_1}{V}\left[\frac{9\eta v_1}{2g(\rho-\sigma)}\right]^{\frac{1}{2}}$

(c) A beam of positive ions moving with velocity v enters a region of a uniform magnetic field density B with the velocity at right angles to the field B. By use of a diagram, describe the motion of ions. (03marks)



Magnetic force, F = BQV acts on the ions. The force is perpendicular to both B and V according to Fleming's rule. The ion describe a circular path of radius, r, given by

BQV = $\frac{mV^2}{r}$

r = $\frac{mV}{BQ}$ where Q is the charge on the ions.

(d) A charged oil drop of density 880kgm^{-3} is held stationary between two parallel plates 6.0mm apart held at a potential difference of 10^3V. When the electric field is switched off, the drop is observed to fall a distance of 2.0mm in 35.7s. (Viscosity of air = 1.8 x 10^{-5}Nsm^{-2}, Density of air = 1.29kgm^{-3}).

(i) Calculate the radius of the drop. (03marks)

$V_0 = \frac{2 \, x \, 10^{-3}}{35.7}$ = 5.6 x 10^{-5}ms^{-1}

r = $\left(\frac{9\eta V_0}{2g(\rho - \sigma)}\right)^{\frac{1}{2}} = \left(\frac{9 \, x \, 1.8 \, x \, 10^{-3} \, x \, 5.6 \, x \, 10^{-5}}{2 \, x \, 9.81 \, (880-1.29)}\right)^{\frac{1}{2}}$ = 7.254 x 10^{-7}m

(ii) Estimate the number of excess electrons on the drop. (03marks)

Q = $\frac{4\pi r^3 g}{3E}(\rho - \sigma) = \frac{4\pi r^3 gd}{3V}$

$$= \frac{4\pi \, (7.254 \, x \, 10^{-7})^3 \, x \, 9.81 \, x \, 6 \, x \, 10^{-3}}{3 \, x \, 103}(880 - 1.29)$$

= 8.029 x 10^{-19}C

Q = ne

n = $\frac{8.026 \, x \, 10^{-19}}{1.6 \, x \, 10^{-19}}$ 5

9. (a) (i) State the laws of photoelectric emission (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

(ii) Explain briefly one application of photoelectric effect. (04marks)

Use in a photocell in a burglar alarm: when an intruder intercepts infrared radiation incident on the photocell, the flow of current is interrupted. The alarm is set off

(b) In a photoelectric set up. A point source of light of power 3.2 x 10^{-3}W emits mono-energetic photons of energy 5.0eV. The source is located at a distance of 0.8m from the center of a stationary metallic sphere of work function 3.0eV and radius 8.0 x 10^{-3}m. The efficiency of photoelectron emission is one in every 10^{6} incident photons.

Calculate

(i) Number of photoelectrons emitted per second. (04marks)

The number of photons emitted per second by the lamp = $\frac{3.2\ x\ 10^{-3}}{5.0\ c\ 1.6\ x\ 10^{-19}}$ = 4.0 x 10^{15}

Photons incident on the sphere = $\frac{4.0\ x\ 10^{15}\ x\ \pi\ x\ (8.0\ x\ 10^{-3})^{2}}{4\pi\ x\ 0.8^{2}}$ = 1.0 x 10^{11} photons

Number of electrons emitted per second = $\frac{10^{11}}{10^{6}}$ = 10^{5}

(ii) Maximum kinetic energy in joules, the photo electrons. (02marks)

Maximum kinetic energy = 5- 3 = 2eV = 2 x 1.6 x 10^{-19} = 3.2 x 10^{-19}J

(c) (i) State Bragg's law of X-ray diffraction (01marks)

It states that for constructive interference of diffracted X-rays to occur, the path difference s an integral multiple of the wavelength of the X-ray.

Or

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

Where d = interatomic spacing

θ = glancing angle

λ = wavelength of X-rays

n = integral number

(ii) Show that density, ρ, of a crystal can be given by

$\rho = \frac{Msin^{3}\theta}{125N_{A}(n\lambda)^{3}}$

where θ is the glancing angle, n, is the order of diffraction, λ is the X-ray wavelength and M is the molecular weight of the crystal. (05marks)

Density, $\rho = \frac{M}{V}$

Volume of crystal molecule with interatomic spacing d= d^{3}

1mole weight M g

∴ 1 molecule weigh $\frac{M\ x\ 10^{-3}}{N_{A}}$

Density of a molecule, $\rho = \frac{M\ x\ 10^{-3}}{N_{A}d^{3}}$

From Bragg's law, $d = \frac{n\lambda}{2\sin\theta}$

$\rho = \frac{M\ x\ 10^{-3}}{N_{A}\left(\frac{n\lambda}{2\sin\theta}\right)^{3}} = \frac{Msin^{3}\theta}{125N_{A}(n\lambda)^{3}}$

10. (a) With reference to a Geiger-Muller tube, define the following

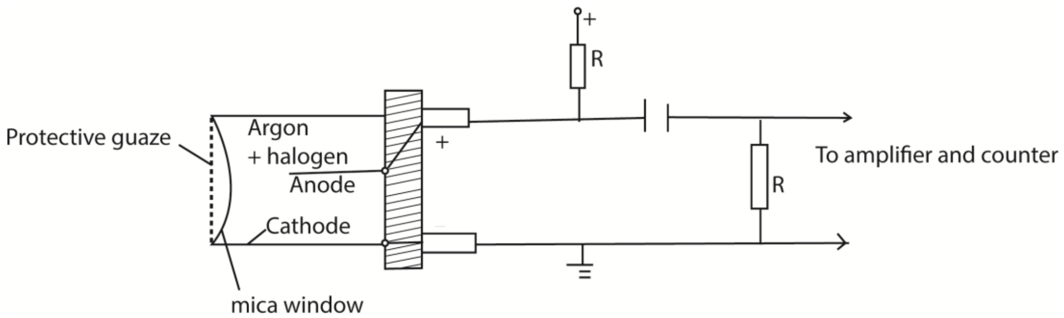
(i) quenching agent (01mark)

It is a halogen gas placed in a Geiger-Muller tube to prevent positive ions from causing the release of electrons from the cathode.

(ii) back ground count rate (01mark)

It is the activity detected by the GM tube in absence of the radioactive source.

(b) (i) With the aid of a labelled diagram, describe the operation of a Geiger-Muller (GM) tube (06marks)



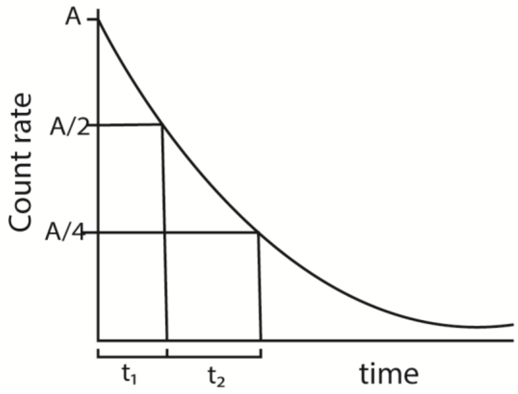
The thin mica window allows the passage and detection of the weak penetrating alpha particles. The GM tube is first evacuated then filled with Neon, Argon plus Halogen gas which is used as a quenching agent.

Mode of operation

- 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) Explain how the half-life of a short lived radioactive source can be obtained by use of a Geiger-Muller tube. (04marks)

- Switch on the GM-tube, note and record the background count rate, A.
- Place a source of ionizing radiation near the GM-window.
- Note and record the count rate recorded the count rate at equal intervals.
- For each count rate recorded subtract the background count rate to get the true rate.
- Plot a graph of the count rate against time.



Find time t_1 taken for the activity to reduce to A/2 and t_2 taken for activity to reduce to A/4 from A/2

Half-life = $\frac{1}{2}(t_1 + t_2)$

(c) A radioactive isotope ${}^{32}_{15}P$ which has a half-life of 14.3days, disintegrates to form a stable product. A sample of the isotope is prepared with initial activity of 2.0 x $10^6 s^{-1}$. Calculate the

(Assume $N = N_0e^{-\lambda t}$)

(i) the number of ^{32}P atoms present (03marks)

Activity, $A_0 = \lambda N_0$ but $\frac{0.693}{t_{\frac{1}{2}}}$

$$2.0 \times 10^6 = \frac{0.693\ x\ N_0}{14.3\ x\ 24\ x\ 60\ x\ 60}$$

$N_0 = 3.56x\ 10^{12}$ atoms

(ii) activity after 30 days (03marks)

From $In\frac{A_0}{A} = \lambda t$ where $\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

$$\text{In}\frac{2\ x\ 10^6}{A} = \frac{0.693\ x\ 30\ x\ 24\ \ x\ 60\ x\ 60}{14.2\ x\ 24\ x\ 60\ x\ 60}$$

$A = 4.67 \times 10^5 s^{-1}$

(iii) number of ^{32}P atoms after 30 days (02marks)

Activity, $A = \lambda N$

$4.67 \times 10^5 = \frac{0.693\ x\ N}{14.2\ x\ 24\ x\ 60\ x\ 60} = 3.49 \times 10^{12}$ atoms

Number of atoms $N = 8.3$ cx 10^{11}

Compiled by Dr. Bbosa Science