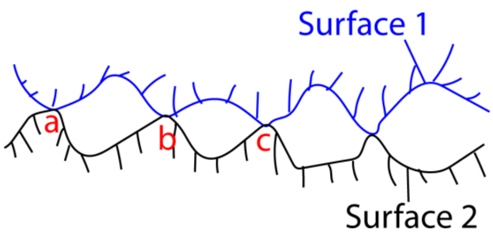
# UACE Physics paper 1 set7 guide

**SECTION A**

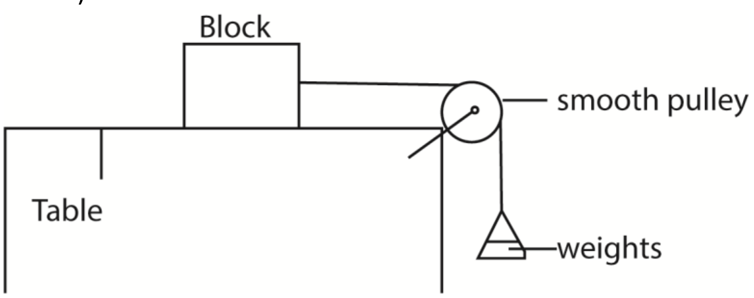
1. (a) Using the molecular theory, explain the laws of friction between solid surfaces. (06marks)
   - Surfaces have very small projections that form contact and welded to each other due to high pressure when the surfaces are in contact; such as at point a, b, c below.




These welding have to be broken for relative motion to occur. This explains the fact that friction oppose motion between the surfaces in contact.

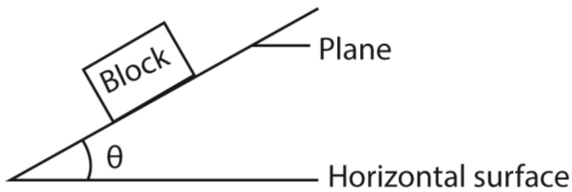
   - When the area between the surfaces is changes, the actual area of contact remains constant as long as there is no change in normal reaction and thus friction remains unchanged. This explains the fact that friction is independent of area of contact provided normal reaction is constant.
   - Increase in normal reaction increases the pressure at the welded points. This increases the actual area of contact to support bigger load. Therefore friction is proportional to normal reaction.

(b) With the aid of a labelled diagram, describe how the coefficient of static friction for an interface between a rectangular block of wood and a plane surface can be determined. (06marks)



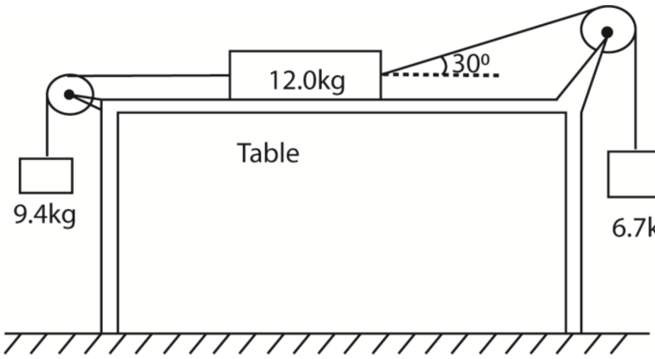

- A block of mass m is placed on a flat table and connected to a scale pan as shown in the diagram above.
- Small weights are added in bits on to the scale pan until the block just starts to move. The total weight of the scale pan and weights added is obtained, $W_f$.
- The coefficient of static friction,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

Alternative method



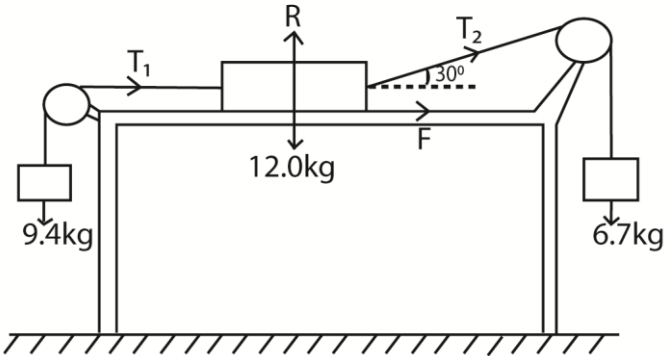
- A block is placed on horizontal plane. The plane is tilted gently until the block just start to slide
- The angle of tilt θ is measured
- The coefficient of static friction, $\mu = \tan\theta$

(c) The diagram below shows three masses connected by inextensible strings which pass over smooth pulleys. The coefficient of friction between the table and the 12.0kg mass is 0.25.




If the system is released from rest, determine the

(i) Acceleration of the 12.0kg mass (05marks)




$9.4g - T_1 = 9.4a$ ………………………… (i)

$T_1 - T_2\cos 30^0 - F = 12a$ ……………… (ii)

$T_2 - 6.7g = 6.7a$ ………………………… (iii)

$F = \mu R = 0.25(12g - T_2 \times 0.5) = 3g - \frac{T_2}{8}$

$a = 0.53ms^{-2}$

(ii) Tension in each string (03marks)

$T_2 = 6.7a + 6.7g = 6.7(0.53 + 9.81) = 69.3N$

$T_1 = 9.4g - 9.4a = 9.4(9.81 - 0.53) = 87.2N$

2. (a) Define terminal velocity (01mark)

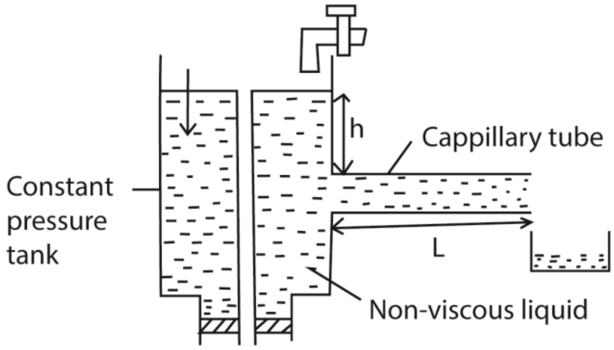
Terminal velocity is the maximum velocity attained by a body falling through a viscous fluid.

(b) Explain laminar flow and turbulent flow (03marks)

Laminar flow is the type of flow where equidistant layers of fluid from the axis of flow have the same velocity flow line are parallel to the axis of flow and the flow is orderly.

Turbulent flow is the type of flow where equidistant layers of a fluid from the axis of flow have varied velocities. The flow lines are not parallel and the flow is disorderly.

(c) Describe an experiment to measure the coefficient of viscosity of water using Ponselle's formula. (07marks)




- the liquid of density, ρ, passes slowly from a constant head tank through a capillary tube of length, l and radius r.
- for a height, h, of the tube, the volume V is collect in time t.
- the flow rate R = $\frac{V}{t}$ is calculated
- the experiment is repeated for different value of V and h.
- a graph of R against h is plotted and slope S is obtained

For steady flow, $S = \frac{\pi r^4 P}{8\eta l}$

But P = hρg

$r = \frac{d}{2}$

$$S = \frac{\pi\left(\frac{d}{2}\right)^4 P}{8\eta l}$$

$$\eta = \frac{\pi\left(\frac{d}{2}\right)^4 h\rho g}{8Sl}$$

(d) (i) State Bernoulli's principle (01 mark)

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

(ii) Explain why a person standing near a railway line is sucked towards the railway line when a fast moving train passes. (03marks)

Between the man and the train, the velocity of air is increased due to the motion of the train resulting in a decrease in pressure according to Bernoulli's Principle. Behind the man, the flow velocity is lower and pressure is higher. This results in a resultant force towards the train, hence the man is sucked in

(e) A horizontal pipe of cross sectional area $0.4m^2$, tapers to a cross section area of $0.2m^2$. The pressure at the large section of the pipe is $8.0 \times 10^4 Nm^{-2}$ and the velocity of water through the pipe is $11.2ms^{-1}$. If the atmospheric pressure is $1.01 \times 10^5 Nm^{-2}$, find the pressure at the small section of the pipe. (05marks)

$A_1V_1 = A_2V_2$

$0.4 \times 1.2 = 0.2 \times V_2$

$V_2 = 2.4ms^{-1}$

$P_1 + \frac{1}{2}\rho V_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho V_2^2 + \rho g h_2$

Since h1 = h2

$P_1 + \frac{1}{2}\rho V_1^2 = P_2 + \frac{1}{2}\rho V_2^2$

$8.0 \times 10^4 + \frac{1}{2} x\ 10^3\ x\ 1.2^2 = P_2 + \frac{1}{2}\ x\ 10^3 x\ 2.4^2$

P2 = 7.784 x $10^4$Pa

3. (a) (i) State the law of conservation of linear momentum (01mark)

If no external force acts on a system of colliding objects, the total momentum of the objects in a given direction before collision is equal to the total momentum in the same direction after collision

(ii) A body explodes and produces two fragments of mass m and M. is the velocities of the fragments are u and v respectively. Show that the ratio of the kinetic energies of the fragments is

$\frac{E_1}{E_2} = \frac{M}{m}$ where $E_1$ is the kinetic energy of m and $E_2$ is the kinetic energy od M.

$E_1 = \frac{1}{2}mu^2$ and $E_2 = \frac{1}{2}Mv^2$

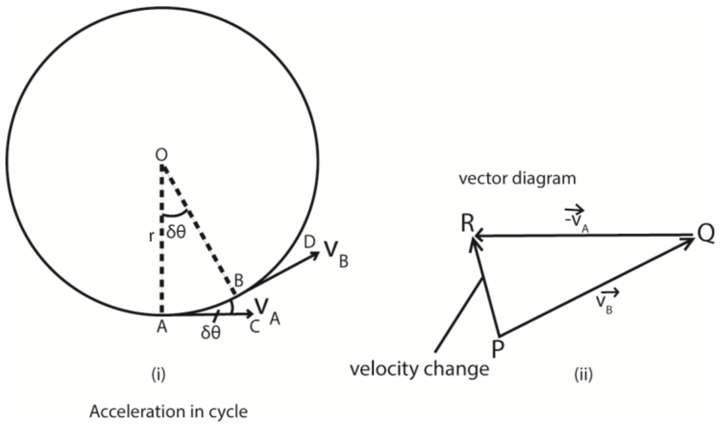
From the principle of conservation of linear momentum mu = -MV

v = $\frac{-mu}{M}$

$E_2 = \frac{1}{2}M\left(\frac{-mu}{M}\right)^2 = \frac{1}{2}Mx\ \frac{m^2u^2}{M^2} = \frac{1}{2}mu^2\ x\ \frac{m}{M} = E_1\frac{m}{M}$

$\frac{E_1}{E_2} = \frac{M}{m}$

(b) Show that the centripetal acceleration of an object moving with constant velocity, v, in a circle of radius, r is$\frac{v^2}{r}$. 904marks)




The velocity change from A to B = $v_B - v_A$ or $v_B + (-v_A)$.

In figure 2(ii) above, PQ represents $v_B$ in magnitude (v) and direction BD; QR represents $-v_A$ in magnitude (v) and direction (CA).

Velocity change = $v_B + (-v_A)$ = PR

When δt is small, the angle AOB or δθ is small;
Also angle PQR equal to δθ is small

PR or acceleration then points toward O, the centres of the circle.

a = $\frac{velocity\ change}{time} = \frac{PR}{\delta t} = \frac{v\delta\theta}{\delta t}$

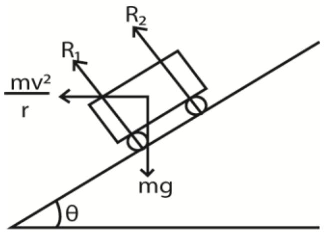
but $\frac{\delta\theta}{\delta t}$ =ω and v = rω

a = rω x ω = rω$^2$ but ω = $\frac{V}{r}$

- a = $\frac{v^2}{r}$

(c) A car of mass 1000kg moves round a banked track at constant speed of 108kmh$^{-1}$. Assuming the total reaction at the wheels is normal to the track, and the radius of curvature of the truck is 100m, calculate the:

(i) angle of inclination of the track to the horizontal (04marks)




Frθm tanθ = $\frac{v^2}{rg}$

v = 108kmh$^{-1}$ = $\frac{108\ x 1000}{60\ x\ 60} = 30ms^{-1}$

tan θ = $\frac{30^2}{100\ x\ 9.81}$

θ = 42.5$^0$

(ii) reaction at the wheels (02marks)

From ($R_1$ + $R_2$) sinθ = $\frac{mv^2}{r}$

=> $R_1$ + $R_2$ = $\frac{mv^2}{r sin\theta}$ = $\frac{1000\ x\ 30^2}{100 \sin 42.5^0}$ = 1.33 x 10$^4$N

(d) (i) Define uniformly accelerated motion (01mark)

Uniformly accelerated motion is where velocity changes by the same amount in the same time interval

(ii) A train starts from rest at station A and accelerates at 1.25ms$^{-2}$ until it reaches a speed of 20ms$^{-1}$. It then travels at this steady speed for a distance of 1.56km and then decelerates at 2ms$^{-2}$ to come to rest at station B. Find the distance from A to B. (04marks)

For accelerated motion using $v^2 = u^2 + 2as$

$20^2 = 0^2 + 2(1.25)s$

s = 160m

For deceleration:

$0 = 20^2 - 2 \times 2 \times s$

s = 100m

Total distance = 160 + 1560 + 100 = 1820m

4. (a)(i) State Kepler's laws of planetary motion. (03marks)

 - Planets describe ellipses about the sun as one focus
 - The imaginary line joining the sum and planet sweeps out equal areas in equal time intervals
 - The square of the periodic time of revolution of planets about the sun are proportional to the cubes of their mean distance from the sun

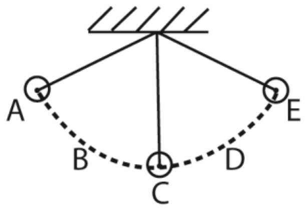
(ii) Estimate the mass of the sun, if the orbit of the earth around the sun is circular. (04marks)

$M = \frac{4\pi^2 r^3}{GT^2} = \frac{4\pi^2 x\,(1.5\,x\,10^{11})^3}{6.67\,x\,10^{-11}\,x\,(365\,x\,24\,x\,60\,x\,60)} = 2.0 \times 10^{30}$kg

(b) Explain Brownian motion (03marks)

Continuous random and haphazard (zig-zag) motion of fluid particles caused by repeated collision of particles exerting a resultant force on each other which changes in magnitude and direction.

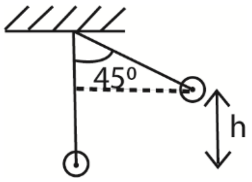
(c) Explain the energy changes which occur when a pendulum is set into motion. (03marks)




Potential energy at A → Kinetic + potential energy at B → kinetic at C → Kinetic + potential energy at D→ potential energy at E

(d) A simple pendulum of length 1m has a bob of mass 100g. It is displaced from mean position A to position B so that the string makes an angle of $45^0$ with the vertical. Calculate the

(i) maximum potential energy of the bob. (03marks)




h = 1 – cos 45 = 0.293

P.E = mgh = 0.1 x 9.81 x 0.293 = 0.287J

(ii) velocity of the bob when the string makes an angle of $30^0$ 2ith the vertical. [Neglect air resistance]

Height of the ball when the string makes 300 = 1 – cos 30 = 0.134

Potential energy at this point = mgh = 0.1 x 9.81 x 0.134 = 0.122J

Kinetic energy = change in potential energy = 0.287 – 0.122 = 0.165J

Let the velocity be v

$$\Rightarrow \frac{1}{2}\, x\ 0.1\ x\ v^2 = 0.165$$
$$v = 1.8ms^{-1}$$

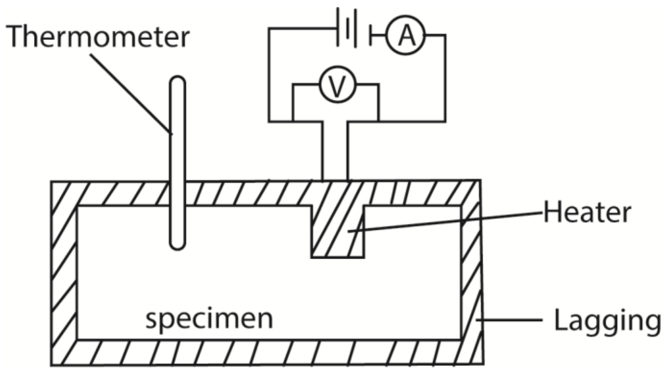
**SECTION B**

5. (a) Define

(i) Specific heat capacity (01mark)
Specific heat capacity is the amount of heat required to rise the temperature of 1kg mass of a substance by 1K.

(ii) Specific latent heat of vaporization of a liquid. (01 mark)
Specific latent heat of vaporization is amount of heat required to convert 1kg of a liquid substance at its boiling point into vapor at constant temperature.

(b) With the aid of a labelled diagram, describe the electrical method of determining the specific heat capacity of a solid (07marks)




- 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 $\theta_0$ 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 $\theta_1$ 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) An electrical heater rated 48W, 12V is placed in a well-insulated metal of mass 1.0kg at a temperatures of $18^0$C. When power is switched on for 5minutes, the temperature of the metal rises to $34^0$C. Find the specific heat capacity of the metal (04marks)

Heat supplied by the heater, IVt = mcθ

48 x 5 x 60 = 1 x c x (34-18)

Specific heat capacity, c = 900Jkg$^{-1}$K$^{-1}$

(d) (i) State Newton's law of cooling (01marks)

The rate of loss of heat is proportional to the excess temperature over the surroundings under conditions of forced convection.

(ii) Use Newton's law of cooling to show that $\frac{d\theta}{dt} = -k(\theta - \theta_R)$

Where $\frac{d\theta}{dt}$ is the rate of fall of temperature and $\theta_R$ is the temperature of the surrounding.

From the above law, $\frac{dQ}{dt} \propto (\theta - \theta_R)$

=> $\frac{dQ}{dt} = k(\theta - \theta_R)$

But $\frac{dQ}{dt} = mc\frac{d\theta}{dt}$

=> $\frac{d\theta}{dt} = k(\theta - \theta_R)$

Since for a given body, m and c are constant.

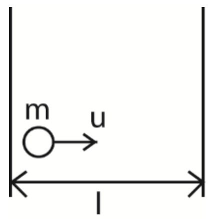
(e) Explain why evaporation causes cooling. (03marks)

During evaporation the most energetic molecules at the liquid surface escape leaving molecules with low kinetic energy. Since mean kinetic energy of molecules is directly proportional to absolute temperature, the liquid cools.

6. (a) The pressure, P, of an ideal gas is given by P= $\frac{1}{3}\rho\overline{c^2}$, where ρ is the density of the gas and $\overline{c^2}$ its mean square speed.

(i) Show clearly the steps taken to derive this expression (06marks)

Consider a molecule of mass, m, moving in a cube of length, l and velocity, u.




Change in momentum = mu - $^{-}$mu = 2mu

Rate of change of momentum = $\frac{2mu}{t}$

Time, t, between collision = $\frac{2l}{u}$

$F_1 = 2mu \div \frac{2l}{u} = \frac{mu^2}{l}$

For N molecules, force on the wall,

$F = \frac{mu_1^2}{l} + \frac{mu_2^2}{l} + \frac{mu_3^2}{l} + \cdots + \frac{mu_N^2}{l}$

Pressure, $P = \frac{F}{A} = \frac{m}{l^3}(u_1^2 + u_2^2 + u_3^2 + \cdots + u_N^2)$ since $A = l^2$

$$\overline{u^2} = \frac{u_1^2 + u_2^2 + u_3^2 + \cdots + u_N^2}{N}$$

$$N\overline{u^2} = u_1^2 + u_2^2 + u_3^2 + \cdots + u_N^2$$

$$\therefore P = \frac{Nm\overline{u^2}}{l^3} = \rho\overline{u^2};\ since\ \rho = \frac{Nm}{l^3}$$

$\overline{c^2} = \overline{u^2} + \overline{v^2} + \overline{w^2}$ and $\overline{u^2} = \overline{v^2} + \overline{w^2}$

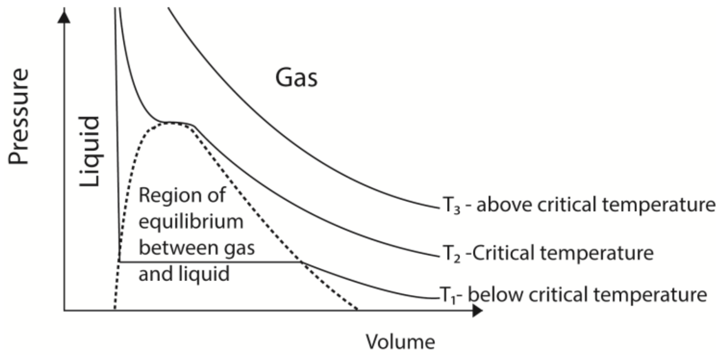
$\therefore \overline{c^2} = 3\overline{u^2}$ => $\overline{u^2} = \frac{1}{3}\overline{c^2}$

$$\therefore P = \frac{1}{3}\rho\overline{c^2}$$

(ii) State the assumptions made in deriving this expression (02marks)

- Intermolecular forces of attraction are negligible
- The volume of the gas molecules are negligible compared to that of the container
- Molecules make perfectly elastic collision
- The duration of collision is negligible compared to the time between collisions

(b) Sketch the pressure versus volume curve for a real gas for temperatures 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.

(c) For 1 mole of a real gas, the equation of state is $\left(P + \frac{a}{V^2}\right)(V - b) = RT$

Explain the significance of the terms $\frac{a}{V^2}$ and b. (02marks)

$\frac{a}{V^2}$ - corrects deficit in pressure due to intermolecular attractions of gas molecules

b – accounts for the finite volume of molecules themselves.

(d) A balloon of volume $5.5 \times 10^{-2}m^3$ is filled with helium to a pressure of $1.10 \times 10^5Nm^{-2}$ at a temperature of $20^0C$. Calculate the

(i) the number of helium atoms in the balloon (03marks)

From PV =nRT

$$n = \frac{1.10 \; x \; 10^5 \; x \; 5.5 \; x \; 10^{-2}}{8.31 \; x \; 293} = 2.48 \text{ moles}$$

Number of atoms = 2.48 x 6.02 x $10^{23}$ = 1.49 x $10^{24}$.

(ii) net force acting on the square meter of material of the balloon if the atmospheric temperature is 1.01 x $10^5$Nm$^{-2}$ (04marks)

F = PA

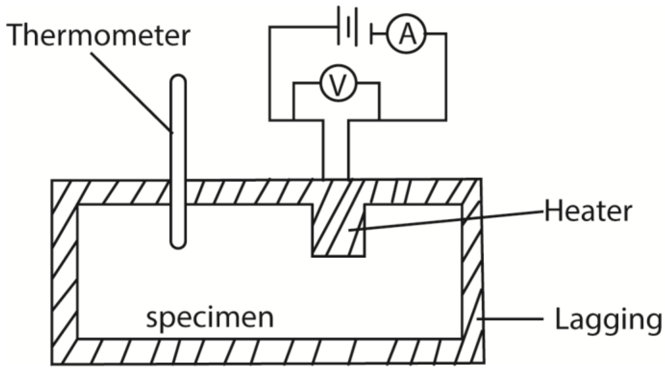
Net force = internal force in the bulb – external force on the bulb

= (1.10 x $10^5$ – 1.01 x $10^5$) x 1.0 = 9.0 x $10^3$N

7. (a) (i) Define thermal conductivity of a material (01mark)

Thermal conductivity is the rate of heat flow through a material per unit cross sectional area per unit temperature gradient.

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



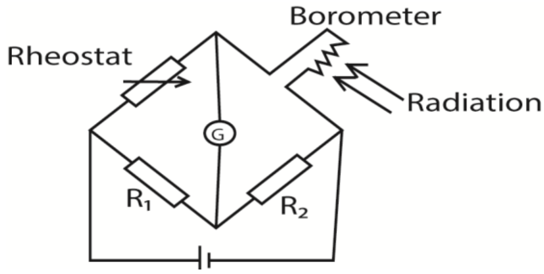

- Two holes are drilled into the specimen solid of copper of mass m.
- A thermometer is inserted in one of the holes and an electric heater into the other hole. The holes are then filled with a good conducting fluid, e.g. oil to ensure thermal contact.
- The apparatus is insulated and initial temperature $\theta_0$ 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 $\theta_1$ recorded and time t taken noted.
- The specific heat capacity, c, of the conducting solid is calculated from

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

(b) (i) What is a black body? (01 marks)

A black body is one which absorbs all the radiation of every wavelength falling on it, reflects and transmits none.

(ii) Describe how infrared radiation can be detected using a bolometer. (03marks)




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.

(iii) Give one characteristic property of infrared radiation. (01mark)
Causes sensation of warmth (increases body temperature.

(c) (i) A spherical black body of radius 2.0cm at -73$^0$C is suspended in an evacuated enclosure whose walls are maintained at 27$^0$C. If the rate of exchange of thermal energy is equal to 1.85Js$^{-1}$, find the value of Stefan's constant, (05marks)

$T_1$ = 27 + 273 = 300K

$T_2$ = -73 + 273 = 200K

P = Aσ$(T_1^4 - T_2^4)$

1.85 = 4π$(0.02)^2$σ$(300^4 - 200^4)$

σ = 5.66 x $10^{-8}$Wm$^{-1}$K$^{-4}$

(ii) Calculate the wavelength at which the radiation emitted by the enclosure ha maximum intensity (03mark)

$\lambda_{max}T$ = 2.9 x $10^{-3}$

$\lambda_{max} = \frac{2.9\ x\ 10^{-3}}{300}$ = 9.7x $10^{-6}$m

**SECTION C**

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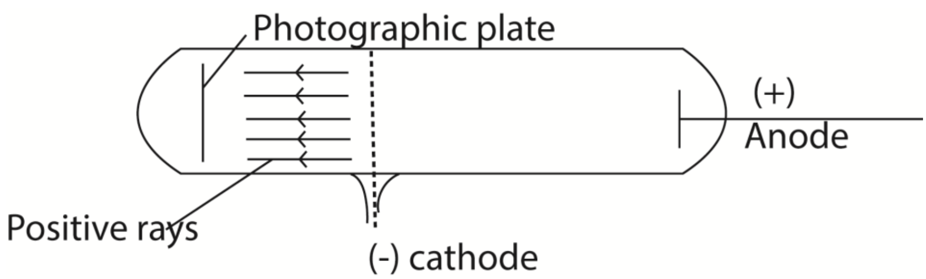
8. (a) Explain briefly how positive rays are produced (03marks)




- Positive rays are produced when a stream of electrons is passed through a vapor (gas) in discharge tube.
- The electrons dislodge electrons from the atoms producing positively charged ions.

- The positive ions are accelerated towards perforated cathode.
- The ions pass through the slits and are further accelerated.
- These ions constitute a stream of positive rays.

(b) An electron of charge, e, and mass, m, is emitted from a hot cathode and then accelerated by an electric field towards the anode. If the potential difference between the cathode and the anode is V, show that the speed of the electron, u, is given by

u = $\sqrt{\left(\frac{2eV}{m}\right)}$ (03marks)

Gain in K.E = work done on an electron by the accelerating p.d, V

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

$\therefore u = \sqrt{\frac{2eV}{m}}$

(c) An electron starts from rest and moves in an electric field intensity of 2.4 x $10^3$ $Vm^{-1}$.

Find the

(i) force on the electron (02 marks)

Force, F, on electron

F = eE = 1.6 x $10^{-19}$ x 2.4 x $10^3$ = 3.84 x $10^{-16}$N

(ii) acceleration of the electron. (02marks)

From F =ma

a = $\frac{F}{a} = \frac{3.84 \; x \; 10^{-16}}{9.11 \; x \; 10^{-31}}$ = 4.22 x $10^{14}$ $ms^{-1}$

(iii) velocity acquired in moving through a p.d of 90V (02marks)

From $u = \sqrt{\frac{2eV}{m}} = \sqrt{\frac{2 \; x \; 1.6 \; x \; 10^{-19} x \; 90}{9.11 \; x \; 10^{-31}}}$ = 5.62 x $10^6$ $ms^{-1}$

(d) A beam of electrons each of mass, m, and charge, e, is directed horizontally with speed, u, into an electric field between two horizontal metal plates separated by a distance, d.

(i) If the p.d between the plates is V, show that the deflection y of the beam is given by

y = $\frac{1}{2m}\left(\frac{eV}{du^2}\right)x^2$

where, x, is the horizontal distance travelled. (06marks)

Horizontal motion, x =ut

In the same time, t, vertical displacement

y = $\frac{1}{2}at^2$

from F =ma = eE

$\therefore a = \frac{eE}{m}$

$y = \frac{eE}{2m}t^2 = \frac{eE}{2m}\left(\frac{x}{u}\right)^2 = \frac{eEx^2}{2mu^2}$

$But\ E = \frac{V}{d}$

$y = \frac{eEx^2}{2mu^2} = \frac{1}{2m}\left(\frac{eV}{du^2}\right)x^2$

(ii) Explain the path of the electron beam as it emerges out of the electric field. (02marks)

The electron beam continues in a straight path with constant velocity since the electric force on it is zero.

9. (a) The table below shows the energy levels of a hydrogen atom.

| Principal quantum number, n | Energy, eV |
|---|---|
| 6 | -0.38 |
| 5 | -0.54 |
| 4 | -0.85 |
| 3 | -1.51 |
| 2 | -3.39 |
| 1 | -13.60 |

(i) Why are the energies for the different levels negative? (01mark)
Work is done in order to remove an electron to infinity.

(ii) Calculate the wavelength of the line arising from a transition from the third to the second level. (03marks)

$$E_3 - E_2 = hf = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{E_3 - E_2} = \frac{6.6\ x\ 10^{-34}\ x\ 3.0\ x\ 10^{8}}{(-1.51+3.39)\ x\ 1.6\ x\ 10^{-19}} = 6.58 \times 10^{-7}\text{m}$$

(iii) Calculate the ionization energy in joules of hydrogen atom. (02marks)
Ionization energy = $13.6 \times 1.6 \times 10^{-19} = 2.18 \times 10^{-18}$J

(b) Explain the physical processes in an X-ray tube that account for

(i) cut off wavelength (03marks)

Electrons from the cathode strike the target and lose all their kinetic energy in single encounter with the target atoms. This results in the production of the most energetic X-rays photon of maximum frequency and corresponding minimum wavelength ($\lambda_{min}$) called the cut off wavelength.

(ii) characteristic lines (04marks)

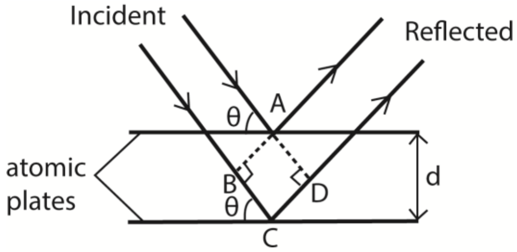
At high tube voltages, the bombarding electron penetrate deep into the atom and knock out the electron from inner shell. The knocked out electron can either be ejected completely out of the atom or it occupies any of the higher shell. This puts an atom in an excited state and the atom therefore becomes unstable. Electron transition from higher shell to a vacancy left in the lower shell results in emission of an X-ray photon of energy equal to the difference between the energy levels.

(c) Calculate the maximum frequency of radiation emitted by an X-ray tube using an accelerating voltage of 33.0kV (03marks)

$$f_{max} = \frac{eV}{h} = \frac{1.6 \ x\ 10^{-19} \ x\ 33 \ x\ 10^{3}}{6.6 \ x\ 10^{-34}} = 8.0 \ x\ 10^{18} Hz$$

(d) Derive Bragg's law of X-ray diffraction in crystals. (04marks)

- A parallel beam of monochromatic X-rays incident on a crystal is reflected from successive atomic planes and super-imposed, forming an interference pattern.




For constructive interference to occur, the path difference is equal to the whole number of wavelength

Thus BC + CD = nλ

⇨ dsinθ + dsinθ = nλ

or 2dsinθ = nλ where n = 1, 2, 3, 4 …

10. (a) A beam of α-particles is directed normally to a thin metal foil

Explain why

(i) Most of the α-particles passed straight through the foil (02marks)

The atoms of the foil contain concentrated mass in a very tiny nuclei surrounded by empty space containing electrons

(ii) Few α-particles are deflected through angles more than $90^0$. (02marks)

The nucleus a very small space of an atom. Therefore very few α-particles are incident close to it that are strongly repelled.

(b) Calculate the least distance of approach of a 3.5MeV α-particles to the nucleus of a gold atom. (Atomic number of gold= 79) (04marks)

Initial K.E = eV = P.E at the closest distance of approach; Z = 79

$$eV = \frac{2e \ x\ Ze}{4\pi\varepsilon_0 d}$$

$$= \frac{2e^2 Z}{4\pi\varepsilon_0 d}$$

$$3.5 \ x\ 10^6 \ x\ 1.6 \ x\ 10^{-19} = \frac{2(1.6 \ x\ 10^{-19})^2 \ x\ 79}{4\pi\varepsilon_0 \ x\ d}$$

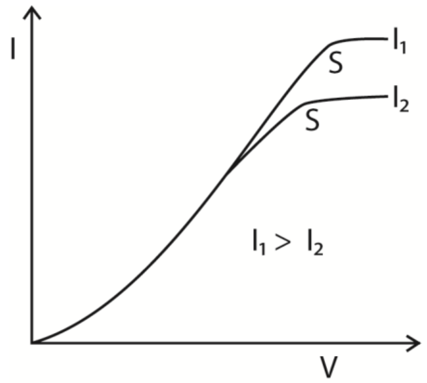
d = $\frac{2 \, x \, 1.6 \, x \, 10^{-19} \, x \;\; 79 \, x \, 9 \, x \, 10^{9}}{3.5 \, x \, 10^{6}}$

= $6.5 \times 10^{-14}$m

(c) (i) Define space charge as applied to thermionic diodes. (01mark)

Space charge is cloud of negative charge around the cathode at low anode potential difference.

(ii) Draw anode current-diode voltage curves of a thermionic diode for two different filament currents and explain their main features. (06marks)




The current increases with the positive anode potential as far as the point S. Beyond this point the current does not increase, because the anode is collecting all the electrons emitted by the filament ; the current is said to be saturated.

(d) (i)What is a decay constant?

Decay constant is the fractional number of disintegrations per second.

(ii) A sample from fresh wood of a certain species of tree has activity of 16.0 counts per minute per gram. However, the activity of 5g of dead wood of the same species of tree is 10 counts per minute. Calculate the age of the deadwood. (Assume half-life of 5730years) (04marks)

From $N = N_0e^{-\lambda t}$

$\lambda = \frac{0.693}{5730}$ = $1.21 \times 10^{-4}$ per year

A = $\frac{10}{5} = 2.0 min^{-1} g^{-1}$

$2 = 16e^{-1.21 \, x \, 10^{-4} t}$

$t = 1.719 \, x \, 10^{4} years$

**Compiled by Dr. Bbosa Science**