UACE Physics paper 1 2001 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

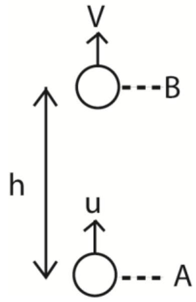
Acceleration due to gravity, g	$9.81ms^{-2}$
Electron charge, e	$1.6 x10^{-19}C$
Electron mass	$9.11 x 10^{-31}kg$
Mass of the earth	$5.97 x 10^{24}kg$
Plank's constant, h	$6.6 x 10^{-34}Js$
Stefan's-Boltzmann's constant, σ	$5.67 x 10^{-8}Wm^{-2}K^{-1}$
Radius of the earth	6.4 x 106m
Radius of the sun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

SECTION A

1. (a) (i) State the principle of conservation of mechanical energy. (01mark)

The total mechanical energy (K.E + P.E) of a body in an isolated system is constant.

(ii) Show that a stone thrown vertically upwards obeys the principle in (a)(i) above throughout its upward motion. (04marks)



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

(b)(i) A wind turbine made of a blade of radius, r, is driven by wind of speed, V. If σ is the density of air, derive an expression for minimum power, P, which can be developed by the turbine in terms of σ, r and V. (03marks)

K.E = $\frac{1}{2}mv^2$

Volume of air striking blade per second = $\pi r^2 v$

Mass of air striking the blade per second = $\pi r^2 v^3 \sigma$

∴Power available = K.E of air per second

$= \frac{1}{2}\pi r^2 v^3 \sigma$

(ii) Explain why the power attained is less than the maximum value in (b)(i) above. (02marks)

- Velocity of air is not reduced to zero as assumed in the calculation which means that not all the K.E of the air per second is passed on to the blade
- Some power is wasted as heat due to friction forces in the parts

(c) State the conditions under which the following will be conserved in collision between two bodies

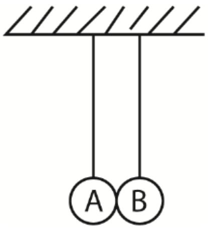
(i) linear momentum (10mark)

- no external force on interactingbodies

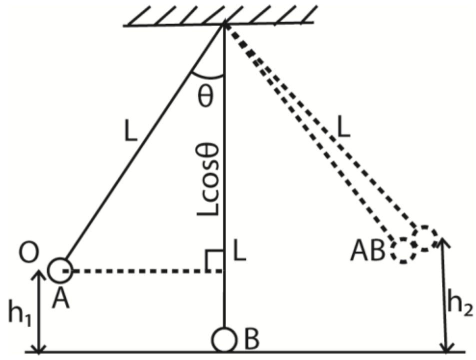
(ii) kinetic energy (01mark)

- The interaction must be perfectly elastic or must move separately after collision

(d) Two pendulum bobs A and B of equal length L, and masses 3M and M respectively. The pendula are hung with bobs in contact as shown below



The bob A is displaced such that the string makes an angle θ with the vertical and released. If A makes a perfectly inelastic collision with B, find the height to which B rises. (08marks)



Let h_1 be the height of A above the ground when the string is inclined at an angle θ to the vertical

$h_1 = L - L\cos\theta$

K.E of A before collision = Initial P.E of A at O

Initial P.E at O = $3Mgh_1 = 3MgL(1-\cos\theta)$ …………. (i)

If u_1 is the velocity of A before collision

$\frac{1}{2}(3M)u_1^2 = 3MgL(1-\cos\theta)$

$$u_1 = \sqrt{2gL(1-cos\theta)}$$

Momentum is conserved after collision, if v is the velocity after collision

$3M\sqrt{2gL(1-cos\theta)} = (3M + M)v$

$v = \frac{3}{4}\sqrt{2gL(1-cos\theta)}$

From conservation of energy, kinetic energy before collision = maximum potential energy gained.

$\frac{1}{2}x\ (3M+M)\left(\frac{3}{4}\sqrt{2gL(1-cos\theta)}\right)^2 = (3M+M)gh_2$

$\frac{1}{2}\ x\ \frac{9}{16}(2gL(1-cos\theta) = gh_2$

$h_2 = \frac{9}{16}gL(1-cos\theta)$

2. (a) Define the following terms
   (i) Stress (01mark)
   Stress is the force acting per unit cross sectional area
   Strain is the extension per unit original length.
   (ii) Strain (01mark)

   (b) The velocity, V, of sound travelling along a rod made of a material of Young's Modulus, Y, and density, ρ is given by V = $\sqrt{\frac{Y}{\rho}}$.

   Show that the formula is dimensionally consistent. (03marks)

   [V] = LT^{-1}

   [Y] = $\frac{[F][L]}{[A][e]} = \frac{MLT^{-2}L}{L^2.L}$ = MLT^{-2}

   [ρ] = ML^{-3}

   [V] = $\sqrt{\frac{[Y]}{[\rho]}} = \sqrt{\frac{MLT^{-2}}{ML^{-2}}}$ = LT^{-1}

   Hence the formula is dimensionally consistent.

   (c) State the measurement necessary in the determination of Young's Modulus of a metal wire. (02marks)

   - Original length of the sample wire
   - Diameter, d, of the wire to find A = $\frac{\pi d^2}{4}$
   - Extension, e, of the wire
   - load

   (d) Explain why the following precautions are taken during an experiment to determine Young's Modulus of a metal wire.

   (i) two long, thin wires of the same material are suspended from a common support. (02marks)

   Long and thin to enable measurable extension

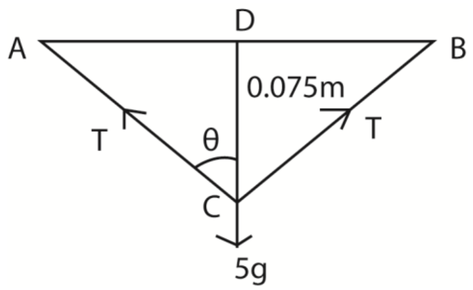
   Same material and suspended from common support to cater for thermal expansion and other focters

   (ii) the readings of the vernier are also taken when the loads are gradually removed in steps. (01marks)

   To ensure that elastic limit is not exceeded, and to obtain average values for extentions.

(e) The ends of a uniform wire of length 2.00m are fixed to points A and B which are 2.00m apart in the same horizontal line. When a 5kg mass is attached to the mid-point C of the wire, the equilibrium position of C is 7.5cm below the line AB. Given that Young's Modulus for the material of the wire is 2.0x 10^{11}Pa, find

(i) the strain in the wire (03marks)



AC = CB = $\sqrt{(0.075)^2 + 1^2}$ = 1.003m

ACB= 2 x 1.003 = 2.006m

Extension = 2.006 – 2.000 = 0.006m

Strain = $\frac{e}{L} = \frac{0.006}{2} = 3\ x\ 10^{-3}$

(ii) the stress in the wire, (02marks)

From E = $\frac{Stress}{Strain}$

Stress = 2 x 10^{11} x 3 x 10^{-3} = 6 x 10^{8}Nm^{-2}

(iii) The energy stored in the wire (04marks)

Resolving vertically;

Tcosθ + Tcosθ = mg

2Tcosθ = mg but θ = $tan^{-1}\left(\frac{1}{0.075}\right)$ = 85.7^0

∴ T = $\frac{Mg}{2\cos\theta} = \frac{5\ x\ 9.81}{2\cos 85.7^0}$ = 327.1N

Energy stored = $\frac{1}{2}Te = \frac{1}{2}\ x\ 327.1\ x\ 6\ x\ 10^{-3}$ = 0.9813J

(iv) State any assumptions made. (01mark)
Elastic limit is not exceeded.

3. (a) Define surface tension and derive its dimensions (03marks)

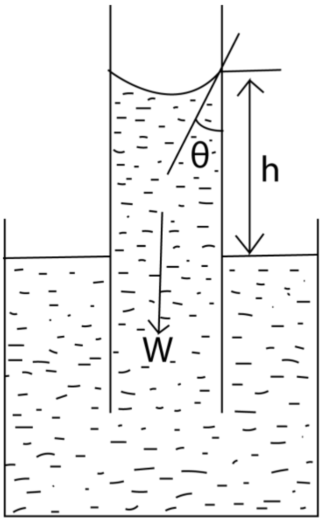
Surface tension is the force per unit length acting perpendicularly to one side if an imaginary line.

γ = $\frac{Force}{length} = \frac{[Ma]}{[L]} = \frac{MLT^{-2}}{L} = MT^{-2}$

(b) Explain using the molecular theory the occurrence of surface tension. (04 marks)
Molecules at the liquid surface have greater molecular separation than the equilibrium separation. These molecules experience greater attraction from their neighbours. This puts

them in a state of tension. Thus the liquid surface behaves like a stretched elastic skin, a phenomenon called surface tension

(c) Derive an experiment to measure surface tension of a liquid by the capillary tube method. (06marks)



A capillary tube of radius, r, is vertically placed in a liquid. The liquid rises until the vertical component of the upward forces due to surface tension is equal to the weight of the liquid column.

$F\gamma\cos\theta = W$

$\gamma = \frac{F}{L}$

$F = \gamma L$

$L = 2\pi r$

But $W = mg$ and $m = V\rho$ (where ρ is the density of the liquid in kg/m^3)

$W = v\rho g = 2\pi r^2 h\rho g$

$F\gamma\cos\theta = 2\pi r^2 h\rho g$

$\gamma.2\pi r\cos\theta = 2\pi r^2 h\rho g$

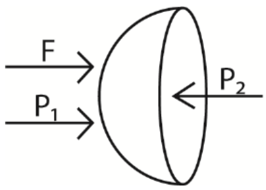
$\gamma = \frac{hr\rho g}{2\cos\theta}$

γ – coefficient of surface tension

θ – angle of contact

ρ – density of the liquid

(d) (i) Show that the excess pressure in a soap bubble is given by $P = \frac{4\gamma}{r}$, (03marks)



A soap bubble has two liquid surfaces in contact with air, one inside the bubble and the other outside the bubble.

The force, F, on one half of the bubble due to surfaces is thus = $\gamma \times 2\pi r \times 2 = 4\pi r\gamma$

For equilibrium of A, it follows that.

$$4\pi r\gamma + \pi r^2 \times P_1 = \pi r^2 \times P_2$$

Where P_2, and P_1 are pressure inside and outside the bubble respectively
Simplifying

$$P_2 - P_1 = \frac{4\gamma}{r}$$

Therefore, excess pressure, $P = \frac{4\gamma}{r}$

(ii) Calculate the total pressure within a bubble of air of radius 0.1mm in water if the bubble is formed 10cm below the water surface and surface tension of water is $7.27 \times 10^{-2} Nm^{-1}$. [Atmospheric pressure = 1.01×10^5Pa] (05marks)

Excess pressure = $\frac{2\gamma}{r} = \frac{2 \times 7.27 \times 10^{-3}}{0.1 \times 10^{-2}} = 1454Pa$

Total pressure within the bubble = atmospheric pressure + hρg + excess pressure

$= 1.01 \times 10^5 + (0.1 \times 10^3 \times 9.81) + 1454$

$= 1.034 \times 10^5$Pa

4. (a) (i) Define coefficient of viscosity and determine its dimensions. (04marks)

Coefficient of viscosity is the fractional force acting on an area of $1m^2$ of a fluid when it is in a region of unit velocity gradient.

$$\eta = \frac{Force}{velocity\ gradient} = \frac{F}{A(V_2 - V_1)/L}$$

$$[\eta] = \frac{[F]}{[A][(V_2 - V_1)/L]} = \frac{MLT^{-2}}{L^2 x\,(\frac{LT^{-1}}{L})} = ML^{-1}T^{-1}$$

(ii) The resistive force on a steel ball bearing of radius, r, falling with speed, V, in a liquid of viscosity, η is given by F = KηrV, where K is a constant. Show that K is dimensionless. (04marks)

$$K = \frac{F}{\eta r V}$$

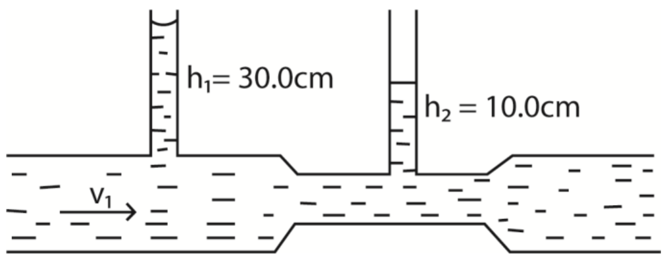
$$[K] = \frac{[F]}{[\eta][r][V]} = \frac{MLT^{-2}}{(ML^{-1}T^{-1})(L)(LT^{-1})} = 1$$

∴ K is dimensionless

(b) Write down Bernoulli's equation for fluid flow, defining all symbols used (03marks)

$P + \frac{1}{2}\rho v^2 + h\rho g$ = constant, where P = pressure, ρ= density of fluid, v = velocity of fluid, h= height above a reference level and g = acceleration due to gravity.

(c) A venturi meter consists of a horizontal tube with a constriction which replaces part of the piping system as shown below



If the cross-sectional area of the main pipe is $5.81 \times 10^{-3}m^2$ and that of the constriction is $2.58 \times 10^{-3}m^2$, find the velocity v_1 of the liquid in the main pipe. (5marks)

From P + $\frac{1}{2}\rho v^2 + h\rho g$ = constant

$P_1 + \frac{1}{2}\rho v_1^2 + h_1\rho g = P_2 + \frac{1}{2}\rho v_2^2 + h_2\rho g$ but $P_1 = P_2$

$g(h_1 - h_2) = \frac{1}{2}(v_2^2 - v_1^2)$

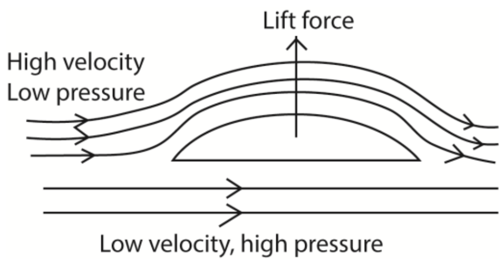
Also $A_1v_1 = A_1v_2$ from continuity equation

$\frac{v_1}{v_2} = \frac{A_1}{A_2}$ => $v_2 = \frac{A_1v_1}{A_2}$

$\therefore\ g(h_1 - h_2) = \frac{1}{2}((\frac{A_1}{A_2})^2 - 1)\ v_1^2$

$0.2\ x\ 9.81 = \frac{1}{2}\left[\left(\frac{5.81}{2.58}\right)^2 - 1\right] v_1^2;\ v_1 = 0.98ms^{-1}$

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



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

SECTION B

5. (a) Define thermal conductivity of a substance and state its units. (02marks)
Thermal conductivity is the rate of heat flow through a unit cross section area at per unit temperature gradient.
(b) Flux of solar energy incident on the earth's surface is $1.36x\ 10^3Wm^{-2}$.
Calculate
(i) The temperature of the surface of the sun (04marks)
$\frac{4\pi r_s^2\sigma T_s^4}{4\pi R^2} = 1.36\ x\ 10^3$
$T_s = \sqrt[4]{\frac{1.36\ x\ 10^3\ x\ (1.5\ x\ 10^{11})^2}{(6.96\ x\ 10^8)^2\ x\ 5.67\ x\ 10^{-8}}}$ = 5777K

(ii) The total power emitted by the sun (03marks)
Power emitted by the sun = Power radiated by the sun
= $A\sigma T_s^4$
= $4\pi r_s^2\sigma T_s^4$
= $4\pi(6.96\ x\ 10^8)^2\ x\ 5.67\ x\ 10^{-8} x\ 5777^4$
= $3.85\ x\ 10^{26}W$
(iii) The rate of loss of mass by the sun (03marks)
From $E = mc^2$
$\frac{dm}{dt} = \frac{P}{c^2} = \frac{3.85\ x\ 10^{26}}{(3\ x\ 10^8)^2}$ = $4.3\ x\ 10^9kgs^{-1}$

(c)(i) Explain how heat is conducted through a glass rod. (03marks)

Atoms or molecules at the heated end vibrate more vigorously about their fixed positions. They collide and pass on heat to the neighboring atoms which in turn vibrate vigorously; collide and pass on heat to their neighboring atoms. In this way heat is transferred from the hot end to the cold end.

(ii) Why is a metal a better conductor of heat than glass? (02marks)

In addition to conduction of heat as in glass metal have free electrons that acquired high kinetic energy when heat, move ant transfer heat collide with atoms in the cold

(iii) Explain briefly why it is necessary to use a thin specimen of large cross-section area in determining thermal conductivity of a poor conductor of heat. (03marks)
To ensure steep temperature gradient.

6. (a) (i)Explain what happens when a quantity of heat is applied to a fixed mass of a gas (02marks)
Heat supplied increase internal energy of the gas and used to overcome external pressure during the expansion.

(ii) Derive the relationship between the principal molar heat capacities C_p and C_v for an deal gas. (05marks)

From dQ = dU + dW……………. (i)
But dQ = C_pdT, dU = C_vdT and dW= PdV = RdT
Substituting in (i)

C_pdT = C_vdT + RdT
∴$C_p - C_v$ = R

(b) (i) What is adiabatic process? (01mark)
An adiabatic process is one in which no heat is added or removed from the system.

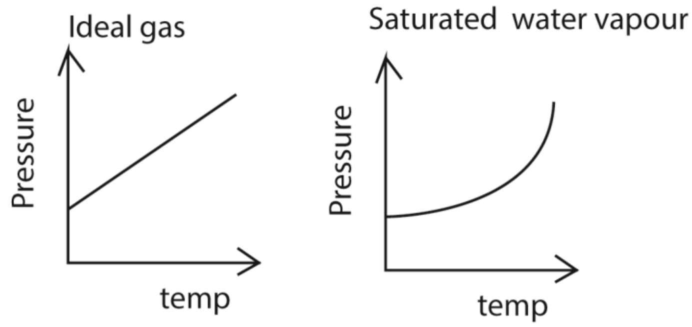
(ii) A bicycle pump contains air at 290K. The piston of the pump is slowly pushed in until the volume of the air enclosed is one fifth of the total volume of the pump. The outlet is sealed off and the piston suddenly pulled out to full extension. If no air escapes, find its temperature immediately after pulling the piston. $\left(Take\ {}^{C_p}/_{C_v} = 1.4\right)$ (03marks)

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

$T_2 = 290\left(\frac{5V}{V}\right)^{0.4}$ = 152K

(c) (i) Distinguish between unsaturated and saturated vapors. (02marks)
Unsaturated vapour is a vapour that is not in dynamic equilibrium with its own liquid while saturated vapour is a vapour that is in dynamic equilibrium with its own liquid.

(ii) Draw graphs to show the relationship between pressure and temperature for ideal gas and for saturated water vapour originally at 0^0C. (03marks)



(d) In an experiment, the pressure of a fixed mass of air at constant temperature is 10.4kPa. When the volume is halved, keeping the temperature constant, the pressure becomes 19.0kPa. Discuss the applicability of the above results in verifying Boyle's law. (04marks)

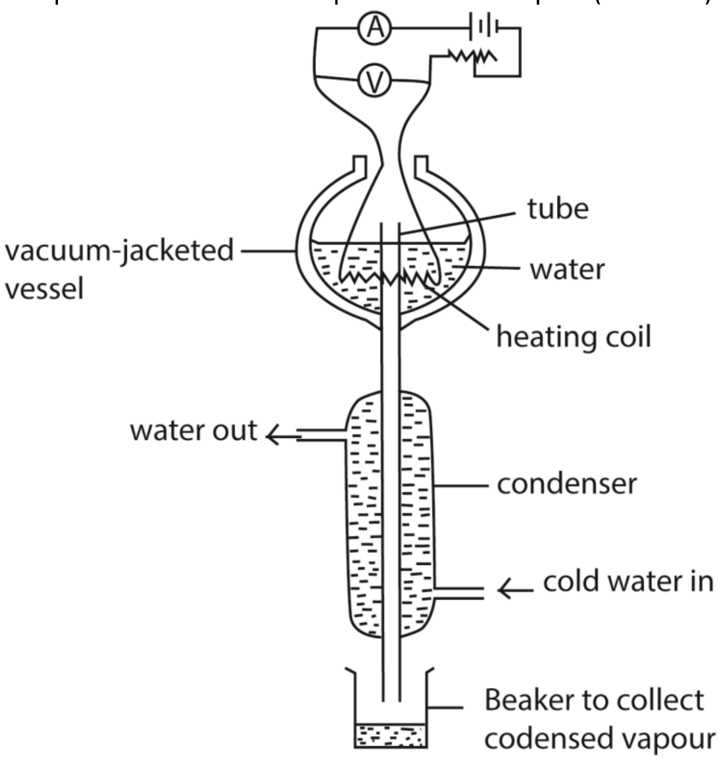
From PV = constant

Halving the volume ta constant temperature doubles pressure. Since pressure was not doubled, Boyles's law is not verified.

7. (a) Explain why temperature remains constant during change of phase. (04marks)

The energy supplied goes into increasing the amplitude of oscillation of atoms which become so large that the regular arrangement of these atoms collapses. Until the process is complete, the temperature remain constant, hence no increase in temperature.

(b) Describe with the aid of labelled diagram, an electrical method for determination of specific latent heat of vaporization of a liquid. (07marks)

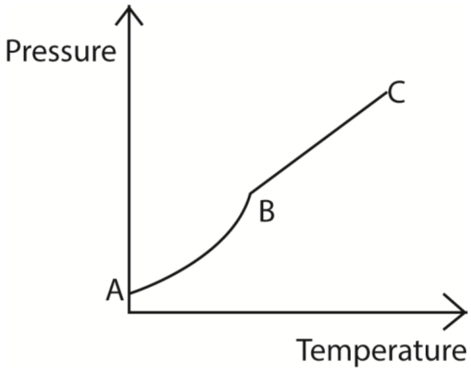


- Put the liquid whose specific latent heat of vaporization is required in a vacuum jacketed vessel as shown above.
- The liquid is heated to boiling point.
- The current, I, and voltage, V are recorded.

- The mass of condensed water, m, condensed in time, t, is determined.
- Then IV = $\frac{m}{t}L + h$, where h is the rate of heat loss to the surroundings
- To eliminate, h, the experiment is repeated for different values of I' and V' and the mass of the condensed water, m' condensed in tie t is determined.
- Again I'V' = $\frac{m'}{t}L + h$

  Latent heat of vaporization, L =$\frac{(I'V'-IV)t}{(m'-m)}$

(c) Water vapour and liquid water are confined in an air tight vessel. The temperature of the water is raised until all the water has evaporated.
Draw a sketch graph to show how the pressure of water vapour changes with temperature and account for its main features. (06marks)



- Water vapor is saturated up to B; i.e. between A and B, increase in temperature increases the kinetic energy of the liquid molecules. The fastest molecules leave the liquid hence the liquid evaporates.
- The density of the vapour above the liquid increases implying that saturated vapour pressure increases.
- Beyond B, the unsaturated vapour obeys gas laws and hence the graph is linear.

(d) Calculate the work done against the atmosphere when 1kg of water turns into vapour at atmospheric pressure of 1.01×10^5Pa.
[Density of water vapour =0.598kgm^{-3}](03marks)
Work done =Pdv = P(V_2 –V_1) where V_2 = volume of the vapor, V_1 = volume of water
Volume = $\frac{mass}{density}$

$\therefore Work\ done = 1.01\ x\ 10^5 \left(\frac{1}{0.598} - \frac{1}{1000}\right) = 1.69\ x\ 10^5 J$

SECTION C

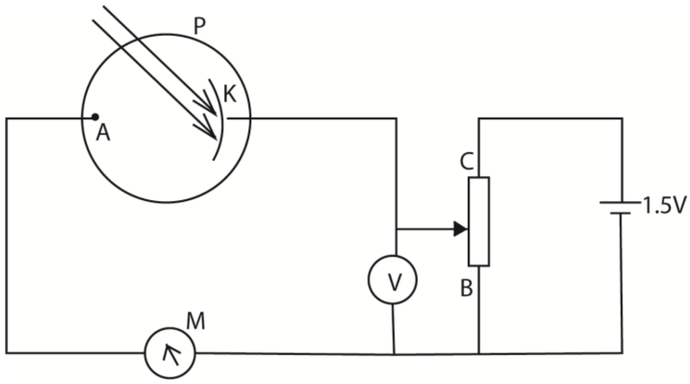
8. (a) (i) Write down the Einstein photo-electric equation (01mark)
hf = hf$_0$ + ½ mv$^2_{max}$ where h = Plank's constant, f = frequency of incident radiation, f_0 = threshold frequency and v_{max} is the maximum velocity of a photoelectron

(ii) Explain how the equation in (a)(i) above accounts for the emission of electrons from metal surfaces illuminated by radiation. (04marks)

Radiation consists of discrete packets of energy called photons, each of energy, hf, where f is the frequency. A free electrons absorb the whole amount of energy of a single photon or none.

If the energy is sufficient, part of it, hf_0, goes into overcoming nuclear attraction and the rest become kinetic energy of photoelectron. Thus the electron can escape from the metal.

(b)



P is a vacuum photocell with anode, A, and cathode, K, made from the same metal of work function 2.0eV. The cathode is illuminated by monochromatic light of constant intensity and wavelength 4.4 x 10^{-7}m

(i) Describe and explain how the current shown by the micro ammeter, M will vary as the slider of potential divider is moved from B to C. (03marks)
As the slider moves towards C, the cathode becomes more positive. This reduces the number of photoelectrons, photoelectric current decreases.

(ii) What will the reading of the high-resistance voltmeter, V, be when photo-electric emission just ceases? (03marks)

$V = \frac{1}{e}\left(\frac{hc}{\lambda} - w_0\right) = \frac{1}{1.6 \times 10^{-19}}\left(\frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{4.4 \times 10^{-7}} - 2 \times 1.6 \times 10^{-19}\right)$ = 0.8125V

(c) With the slider set mid-way between B and C, describe and explain how the reading of M would change if

(i) the intensity of the light was increased, (03marks)

Increasing intensity increases the number of photons reaching the cathode per unit time. This in turn increases the number of electron emitted per second. At this point, the p.d across the photo cell is $\frac{1.5}{2} = 0.75V$. this is below the stopping potential (0.825V) reading. Therefore M also increases.

(ii) the wavelength of the light was changed to 5.5 x 10^{-7}m

$$w_0 = \frac{hc}{\lambda_o}$$

$$\lambda_0 = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{2 \times 1.6 \times 10^{-19}}$$ = 6.1875 x 10^{-7}m

Since the new frequency is greater than the previous one, but greater than threshold, electrons will be emitted but with lower kinetic energy. The number of electrons emitted per second remain the same if the intensity remains constant. Hence reading of M remains the same.

9. (a) What is meant by the following

(i) an alpha particle, (01mark)

An alpha particle is helium nucleus

(ii) radioactivity (01mark)

Radioactivity is spontaneous disintegration of the nucleus with emission of radiation.

(b) Show that when an alpha particle collides head –on with an atom of atomic number Z, the closest distance of approach to the nucleus b_o, is given by

$$b_o = \frac{Ze^2}{\pi\varepsilon_0 mv^2}$$

where e is the electronic charge, ε0 is the permittivity of free space, m, mass of the alpha particle and v is the initial velocity of the particle. (06marks)

Initial K.E of alpha particle = ½ mv^2

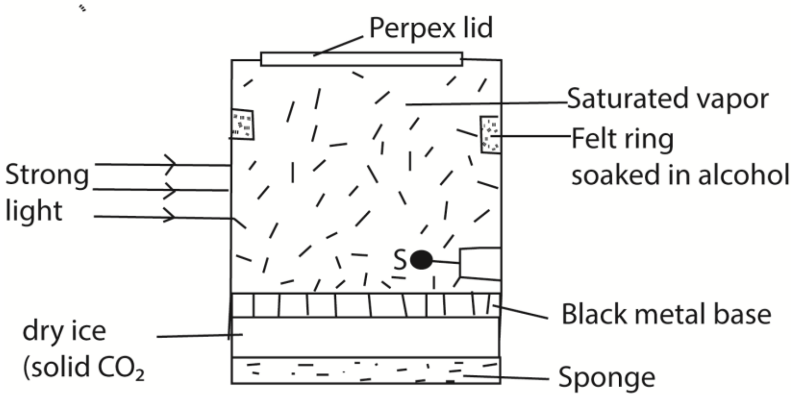
Electrostatic P.E of alpha particle and the nucleus at closet distance of approach = $\frac{Ze(2e)}{4\pi\varepsilon_0 b_0}$

At closest distance of approach, the α-particle is instantaneously at rest and its initial kinetic energy = electrostatic potential energy

Therefore $\frac{1}{2}mv^2 = \frac{Ze(2e)}{4\pi\varepsilon_0 b_0}$

$$b_0 = \frac{Ze^2}{\pi\varepsilon_0 mv^2}$$

(c) Describe the structure and action of a cloud chamber. (06marks)



- The base of the chamber is maintained at low temperature, about -80^{0}c by the solid carbon dioxide while the top of the chamber is at room temperature, and so there is a temperature gradient between the top and the bottom of the chamber.

- The air at the top of the chamber is saturated with alcohol vapor from the felt ring. This vapor continuously diffuse downwards into the cooler regions so that the air at the chamber is super saturated with alcohol vapor.
- Radiations from the radioactive source S cause the ionization of the vapor.
- The ionizations from the radioactive source S cause condensation of the vapor on the ions formed, hence the path of the ionizing radiations are traced by series of small droplets of condensation.
- The thickness and length of the path indicate the extent to which ionization has taken place.
- Alpha particles produce short, thick, continuous straight tracks
- Beta particles which are less massive produce longer, thin but straggly paths owing to collisions with gas molecules
- Gamma radiations are uncharged and for ionization to take place, it must collide with an atom and eject an electron which then ionizes the vapor.

(d) State four uses of radioactive isotopes (02marks)

- Detecting leakage in underground pipes
- Measuring rate of flow of liquids
- Tracing fertilizers using phosphorus-32
- Treatment of cancer

(e) one kilogram of wood from a ship wreck has activity of 1.2×10^2 counts per second due to ^{14}C, whereas the same amount of wood had an activity of 2.0×10^2counts per second. Find the age of the ship wreck. [Half-life of 14C = 5.7×10^3years] (04 marks)

$\lambda = \frac{In\ 2}{t_{\frac{1}{2}}} = \frac{0.693}{5.7\ x\ 10^3} = 1.22 \times 10^{-4}\text{year}^{-1}$

Using $A = A_0e^{-\lambda t}$

In $\left(\frac{2\ x\ 10^2}{1.2\ x\ 10^2}\right) = 1.22\ x\ 10^{-4}t$

t = 4187years

10. (a) What is meant by emission line spectra?

When a gas is heated to high temperatures, electronic transition occur from low to high energy levels. As electrons return to lower energy levels radiation of wavelength λ are emitted such that $\frac{hc}{\lambda}$ = energy difference between the initial and final levels is given off. The radiation consists of a series of lines when viewed through grating.

E_∞ …………………………………………………………	0eV
E_4…………………………………………………………	-0.81eV
E_3…………………………………………………………	-2.77eV
E_2…………………………………………………………	-4.87eV
E_1…………………………………………………………	-27.47eV

(ii) The figure above shows some energy levels of neon. Determine the wavelength of the radiation emitted in an electron transition from E_4 to E_3. In what region of the electromagnetic spectrum does the radiation lie? (04marks)

$\frac{hc}{\lambda} = E_4 - E_3$

λ = $\frac{6.6\ x\ 10^{-34}\ x\ 3\ x\ 10^{8}}{(2.77-0.81)\ x\ 1.6\ x\ 10^{-19}}$ = 6.31×10^{-7}m

(b) Outline the principles of generation of continuous line spectra of X-rays in X-ray tube. (05marks)

Electrons make multiple collisions with the target atoms. During the collision, X-rays of different wavelength are produced. This gives a continuous X-ray spectrum.

When energetic electrons strike a target atom, an electron from innermost energy levels is displaced to higher energy levels leaving a vacancy and making an atom unstable. When the electron returns to the lower energy level, X-rays characteristic to target atoms are given off leading to X-ray line spectra

(c) State Bragg's law of X-ray diffraction. (01mark)

For two neighboring crystal planes separated by a distance, d, for diffraction, 2dsinθ = nλ; where λ = wavelength of incident radiation, θ = glancing angle, and n = order of diffraction.

(d) A beam of X-rays of wavelength 1.0×10^{-10}m is incident on a set of cubic planes in a sodium chloride crystals. The first order diffraction m is obtained for a grazing angle of 10.2^0.

Find

(i) The spacing between consecutive planes (03marks)
From 2dsinθ = nλ
d = $\frac{1\ x\ 1\ x\ 10^{-10}}{2sin10.2}$ = 2.82×10^{-10}m = 2.82×10^{-8}cm

(ii) The density of the sodium chloride (04marks)
Molecular mass of NaCl = 58.5g
1mole contain 6.02×10^{23}molecules
6.02×10^{23} molecules weigh 58.5g
1molecule weighs = $\frac{58.5}{6.02\ x\ 10^{23}} g$
Volume occupied by 1molecule (2atoms- Na and Cl) = $\frac{mass}{density}$

$= \frac{58.5}{6.02\ x\ 10^{23}\ x\ density\ of\ NaCl}$

Volume associated with each atom = $\frac{1}{2}\ x\ \frac{58.5}{6.02\ x\ 10^{23}\ x\ density\ of\ NaCl}$ for cubic lattice

$d^3 = \frac{1}{2}\ x\ \frac{58.5}{6.02\ x\ 10^{23}\ x\ density\ of\ NaCl}$

density of NaCl = $\frac{58.5}{6.02\ x\ 10^{23}\ x\ (2.82\ x\ 10^{-8})^3}$ = 2.165gcm^{-3}