P510/1
PHYSICS
Paper 1
July 2017
Duration: 2 ½ hours

UGANDA ADVANCED CERTIFICATE OF EDUCATION
INTERNAL MOCK UACE 2017
PHSYICS
PAPER 1
2 h 30 min

INSTRUCTIONS TO CANDIDATES
Answer 5 questions including at least 1 but not more than 2 from each of sections A, B and C.
These values of physical quantities may be useful to you.

Acceleration due to gravity, *g*	=	9.81 m s^{-2}
Specific heat capacity of water	=	4200 J kg^{-1} K^{-1}
Specific heat capacity of copper	=	400 J kg^{-1} K^{-1}
Density of water	=	1000 kg m^{-3}
Speed of sound in air	=	340 m s^{-1}
Electron charge, *e*	=	1.6×10^{-19} C
Plank's constant, *h*	=	6.6×10^{-34} J s
Mass of an electron	=	9.11×10^{-31} kg
Gas constant, *R*	=	8.31 J mol^{-1} K^{-1} Radius of the earth
= 6.4×10^{6} m		
Speed of light *c*	=	3.0×10^{8} m s^{-1}
Avogadro number	=	6.02×10^{23}
Universal gravitational constant, *G*	=	6.67×10^{-11} N m^{-2} kg^{-2}
Radius of the earth	=	6.4×10^{6} m
Mass of earth	=	5.97×10^{24} kg

SECTION A

1. a) (i) State Kepler's laws of planetary motion (3 marks)
(ii) A satellite is an orbit just above the surface of the planet whose density is $\boldsymbol{\rho}$. If the periodic time for the orbit is $\boldsymbol{T}$, show that

$$\rho T^2 = \frac{3\pi}{G}$$

where $\boldsymbol{G}$ is the universal gravitational constant. (4 marks)

b) A body weighs 63 N on the earth's surface. How much will it weigh at a height equal to half the radius of the earth's surface? (4 marks)

c) (i) Define frequency and angular velocity as used in circular motion (2 marks)
(ii) Explain why it is necessary for a bicycle rider moving round a circular path to lean towards the centre of the path (4 marks)
(iii) Derive the expression for the angle of inclination to the horizontal necessary for a rider moving in a circular track of radius, $\boldsymbol{r}$without skidding at a velocity $\boldsymbol{V}$, in terms of $\boldsymbol{g}$, $\boldsymbol{r}$ and $\boldsymbol{V}$. (3 marks)

2.a) (i) Derive the dimension for surface tension. (2 marks)

(ii) Explain the origin of surface tension using the molecular theory. (3 marks)

(iii) Describe an experiment to measure surface tension of a liquid by capillary tube method.(5 marks)

b) Calculate the pressure inside a spherical air bubble of diameter 0.5 cm blown at a depth of 10 cm below the surface of the liquid of density 1.26×10^3 kg m^{-3} and surface tension of 6.4×10^{-2} N m^{-1}. Hint (height of mercury barometer = 76 cm and density of mercury = 13.6×10^3 kg m^{-3}) (4 marks)

c) (i) state Bernoulli's principle (1 marks)

(ii) A venturi flow meter consists of a horizontal tube with a constriction which replaces part of the piping system. If the cross section areas of the main pipe and the constriction are A_1 and A_2, pressures are P_1 and P_2, and the heights of the liquids in the upper tubes are $h_1$and $h_2$respectively. Given that v_1 and v_2 are velocities of the liquids in the main pipe and the constriction. Show that the expression below is true for liquids of the same density.

$$(\boldsymbol{h_1} - \boldsymbol{h_2}) = \frac{1}{2g}\left(\left(\frac{A_1}{A_2}\right)^2 - 1\right)v_1^2$$ (5 marks)

3. a) (i) State the laws of solid friction. (3 marks)

(ii) Describe an experiment to determine the coefficient of dynamic friction between two wooden surfaces in contact. (4 marks)

(iii) A bullet travelling at 100 m s^{-1} penetrates a depth 2t in cm, of a fixed block of wood. Find the velocity with which it would emerge, if fired through a fixed board of thickness t in cm, assuming the resistance is uniform and has the same value in both cases. (4 marks)

b) (i) Distinguish between *velocity of projection* and *horizontal velocity*. (2 marks)

(ii) Show that the maximum height H attained by a particle that is projected forward in air at an angle of θ to the horizontal with speed u is given by $H=\frac{u^2}{2g}\sin^2\theta$, where g is acceleration due to gravity. (3 marks)

(iii) If a particle is projected inside a horizontal tunnel which is 2.5 m high with a velocity of 14 m s^{-1}, find the greatest possible range. (4 marks)

4. (a) What is meant by simple harmonic motion? (1 mark)

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

i. If the piston oscillates with simple harmonic motion, show that its frequency, f, is given by $f = \frac{A}{2\pi}\sqrt{\frac{P}{mV}}$ (6 marks)

ii. Show that the expression for f in b(i) is dimensionally correct. (3 marks)

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

i. Amplitude of oscillation. (3 marks)

ii. Frequency of the particle. (3 marks)

(d) Give two examples of oscillatory motion which approximate to simple harmonic motion and state the assumptions made in each case. (4 marks)

SECTION B

5.(a) Define **thermal conductivity**. (01 mark)

(b) (i) Explain the mechanism of thermal conduction in non-metallic solids. (03 marks)

(ii) Why are metals better thermal conductors than non-metallic solids? (02 marks)

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

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

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

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

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

6.(a) (i) State Boyle's law. (01 mark)

(ii) Describe an experiment that can be used to verify Boyle's law. (06 marks)

(b) Explain the following observations using kinetic theory.

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

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

(c) (i) What is meant by a reversible process? (01 mark)

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

(d) A mass of an ideal gas of volume 200 cm^3 at 144 K expands adiabatically when its temperature is raised to 137 K. calculate its new volume.(Take $\gamma = 1.40$) (03 marks)

7. (a) (i) What is meant by cooling correction? (1 mark)

(ii) Explain how the cooling correction may be estimated in the determination of the heat capacity of poor conductors of heat by the method of mixtures. (5 marks)

(b) (i) Define the term specific heat capacity of a substance. (1 mark)

(ii) An electrical heater rated 500 W is immersed in a liquid of mass 2.0 kg contained in a large thermos flask of heat capacity 840 J K^{-1} at 28 ^{0}C. Electrical power is supplied to the heater for 10 minutes. If the specific heat capacity of the liquid 2.5×10^3 J kg^{-1} K^{-1}, its specific latent heat of vaporization is 8.54×10^3 J kg^{-1} and its boiling point is 78 ^{0}C, estimate the amount of liquid which boils off, stating any assumptions made. (7marks)

(c) (i) With reference to an electrical thermometer, describe the steps involved in setting up a kelvin scale of temperature. (3 marks)

(ii) The resistance of the element of a platinum resistance thermometer is 4.00 Ω at the ice point and 5.46 Ω at the steam point. What temperature on the platinum resistance scale would correspond to a resistance of 9.84 Ω? (3 marks)

SECTION C

8. (a) (i) With the aid of a labelled diagram, describe how an X – rays are produced. (05 mrks)

(ii) How do X – rays differ from beta particles? (02 marks)

(iii) Distinguish between X – ray production and the photo electric effect.(02 marks)

(b) A beam of cathode rays is directed midway between two parallel metal plates of length 4.0 cm and separation 1.0 cm. The beam is deflected through 10.0 cm on a fluorescent screen placed 20.0 cm beyond the nearest edge of the plates when a potential difference of 200 V is applied across the plates.

If this deflection is annulled by a magnetic field of flux density 1.14×10^{-3} T applied normally to the electric field between the plates, find the charge to mass ratio of cathode rays. (06 marks)

(c) With the aid of a labelled diagram, describe and give the theory of a mass spectrometer for measuring the charge to mass ratio of positive ions. (05 marks)

9.(a) (i) What is meant by the term Binding energy of a nucleus? (01 mark)

(ii) Calculate the binding energy per nucleon of an alpha particle, expressing your result in MeV.

Mass of a proton = 1.0080 u
Mass of a neutron = 1.0087 u
Mass of an $\alpha -$particle = 4.0026 u
1 u = 931 MeV (04 marks)

(iii) Sketch a graph of binding energy per nucleon against mass number and use it to explain liberation of energy by nuclear fusion and nuclear fission. (06 marks)

(b) Derive an expression relating the half life of a radioactive material, $T_{½}$ and the decay constant, λ. (03 marks)

(c) When ${}^{238}_{92}U$ decays, the end product is ${}^{206}_{82}Pb$. The half life is 1.4×10^{17} s.

Suppose a rock sample contains ${}^{206}_{82}Pb$ and ${}^{238}_{92}U$ in the ratio 1 : 5 by weight, calculate

(i) the number of ${}^{206}_{82}Pb$ atoms in 5.0 g of rock sample. (03 marks)

(ii) the age of the rock. (03 marks)

Assume decay law $N = N_0 e^{-\lambda t}$

10.(a) State the lawsof photoelectric effect. (04 marks)

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

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

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

(ii) If 16% of the photons emit photoelectrons, find the resulting photocurrent. (03 marks)

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

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

END

SOLUTIONS

SECTION A

4.

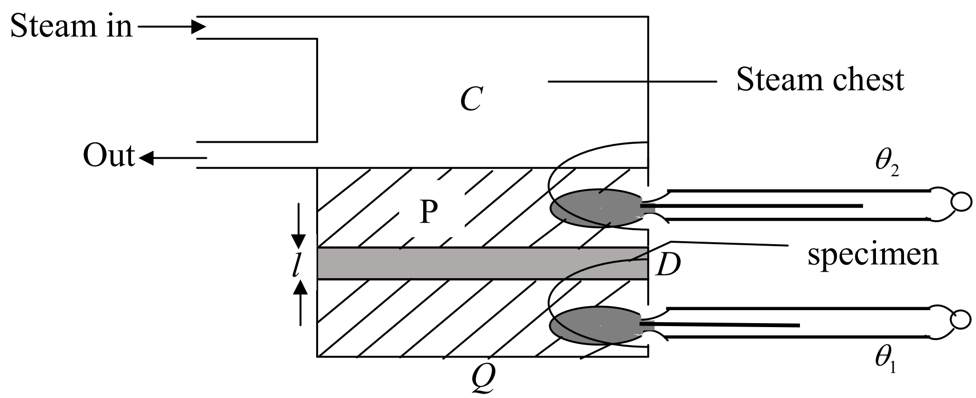
SCCTION B

5.(a) Thermal conductivity is the rate of flow of heat per second normal to $1m^2$ of a material when the temperature gradient is $1\ K\ m^{-1}$.

(b) (i) in solids the atoms are closely packed and have strong intermolecular forces as they vibrate within a fixed lattice. When one end is heated, the atoms vibrate with bigger amplitude, collide with neighboring atoms and lose some of their vibratory energy to them. These in turn also vibrate more vigorously, collide with others and lose energy to them. In this way, heat is propagated throughout the solid.

(ii) In metals, there are free electrons which gain kinetic energy when heated and move faster over longer distances and then pass on some of their energy by colliding with other electrons and atoms.

(c)

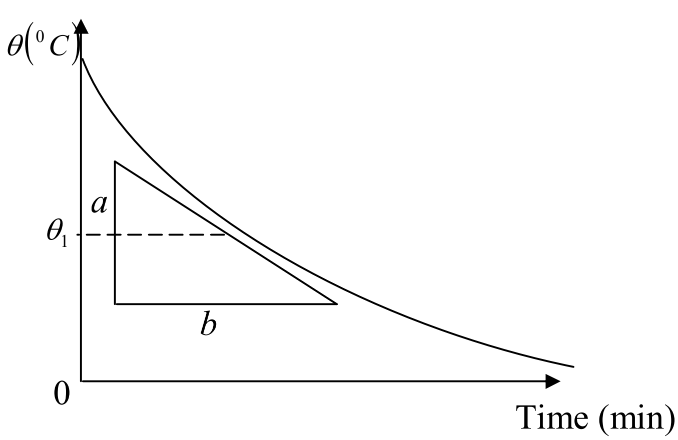


The specimen is made into a thin disc of thickness l and placed between brass slabs P and Q each containing a thermometer. Steam is passed through the chest and the system left to run until steady state is attained. Temperatures θ_1 and θ_2 are read and recorded.

Rate of heat flow through P, $\frac{H}{t} = \frac{kA(\theta_2 - \theta_1)}{l}$ where A is cross sectional area of specimen and k is thermal conductivity. The specimen is removed and Q heated directly by P until its temperature rises by about 10 ºC above θ_1.

P is removed and the specimen placed on top of Q. The temperature of Q is recorded as it cools at one minute intervals until its temperature is 10 ºC below θ_1.

The cooling curve of Q is plotted.



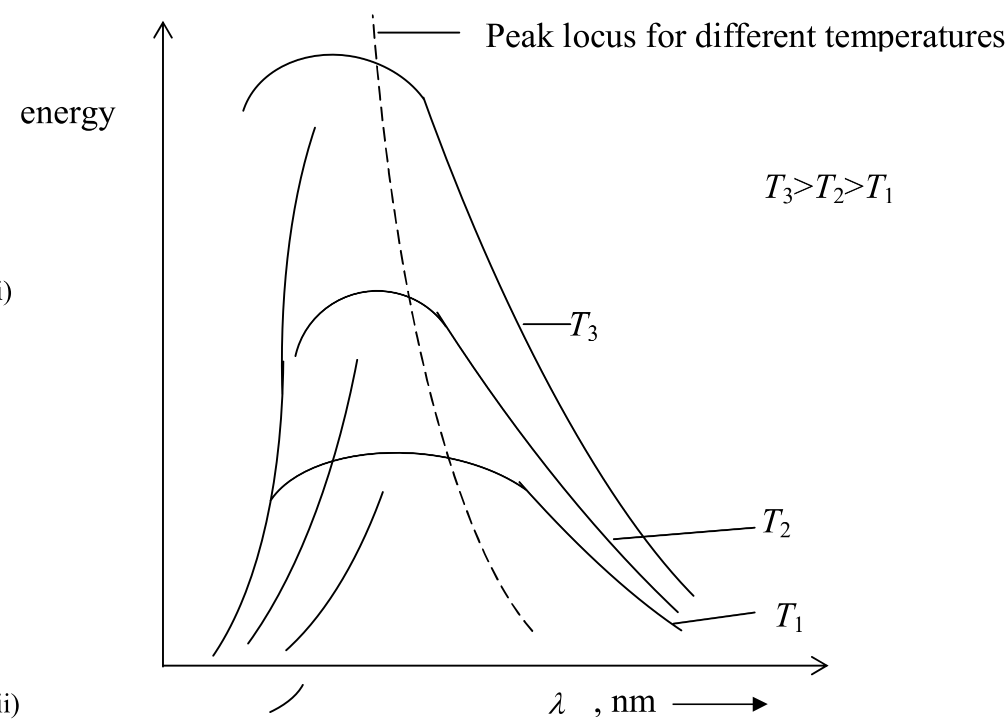
The gradient S, of the curve at θ_1 is obtained; $S = \dfrac{a}{b}$

The rate of loss of heat by slab Q $=$ mcS where m = mass of Q and c is its specific heat capacity, (given).

$\therefore \dfrac{kA(\theta_2 - \theta_1)}{l} = mcS$, Hence, $k = \dfrac{mcSl}{A(\theta_2 - \theta_1)}$. Substitution is made and a value for k calculated.

(d) (i) A black body is the one that absorbs all radiation incident all radiation incident on it, transmits and reflects none.

(ii)



(iii)

- As temperature increases, the energy emitted incr but energy for shorter wavelengths increases more rapidly than that for longer wavelength.
- λ_{max} decreases as temperature increases.
- At each temperature, there is a maximum energy for a particular wavelength.

(e) Power supplied, $P = \sigma A\left(T_2^4 - T_1^4\right)$

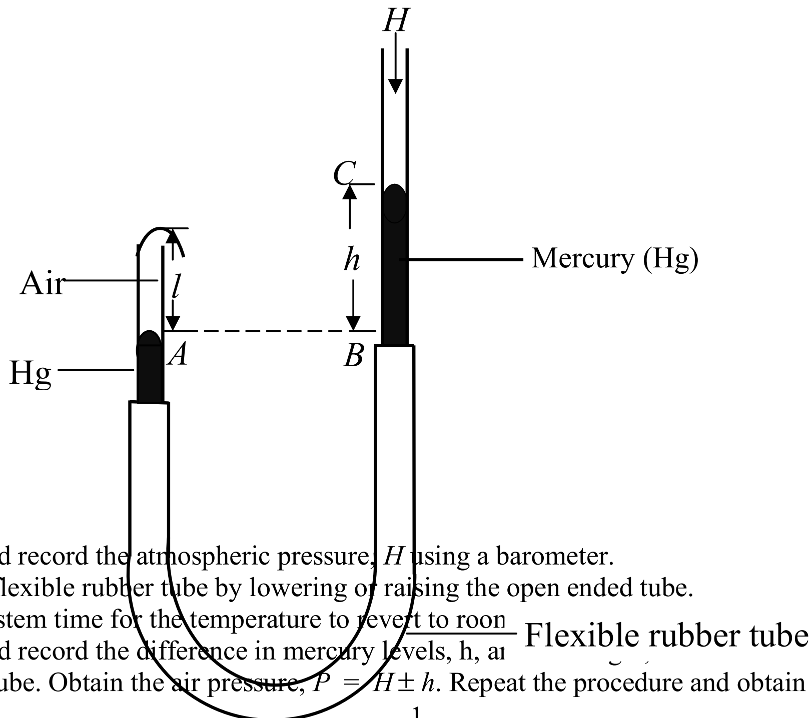
$P = \sigma 4\pi r^2\left(T_2^4 - T_1^4\right)$

$P = 5.67\times10^{-8}\times4\times3.14\times(2\times10^{-2})^2(400^4 - 373^4)$

$P = 1.78$ W

6.(a) (i) Boyle's law: The pressure of a fixed mass of gas at constant temperature is inversely proportional to the volume of the gas.

(ii)



Measure and record the atmospheric pressure, H using a barometer.
Adjust the flexible rubber tube by lowering or raising the open ended tube.
Give the system time for the temperature to revert to room [illegible]
Measure and record the difference in mercury levels, h, a[illegible] trapped in the closed tube. Obtain the air pressure, $P = H \pm h$. Repeat the procedure and obtain a series of values of P and l($\propto$ to volume). Plot a graph of $\frac{1}{l}$ against P. A straight line through the origin verifies the law.

(b) (i) A gas contains molecules with negligible intermolecular forces and are free to move in all directions. As they move, they collide with each other and with the walls of the container. The movements make them to fill the available space and the collisions with the walls constitute the pressure exerted by the gas on the walls.

(ii) When temperature of the gas increases, the molecules move faster and they collide more frequently with the container walls. This implies greater pressure of the gas. In addition, pressure increases as a result of higher rate of change of momentum at each collision.

(c) (i) A reversible process is the one that can take place in the reverse direction through the same values of pressure, volume and temperature in small changes or steps.

(ii) isothermal process requires that the gas is in a thin walled container which is highly conducting and enclosed in a constant temperature reservoir and the process occurs slowly.
Adiabatic process requires that the gas is in a thick walled vessel with poorly conducting walls and the process occurs rapidly so that heat does not leave or enter the system.

(d) $T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$

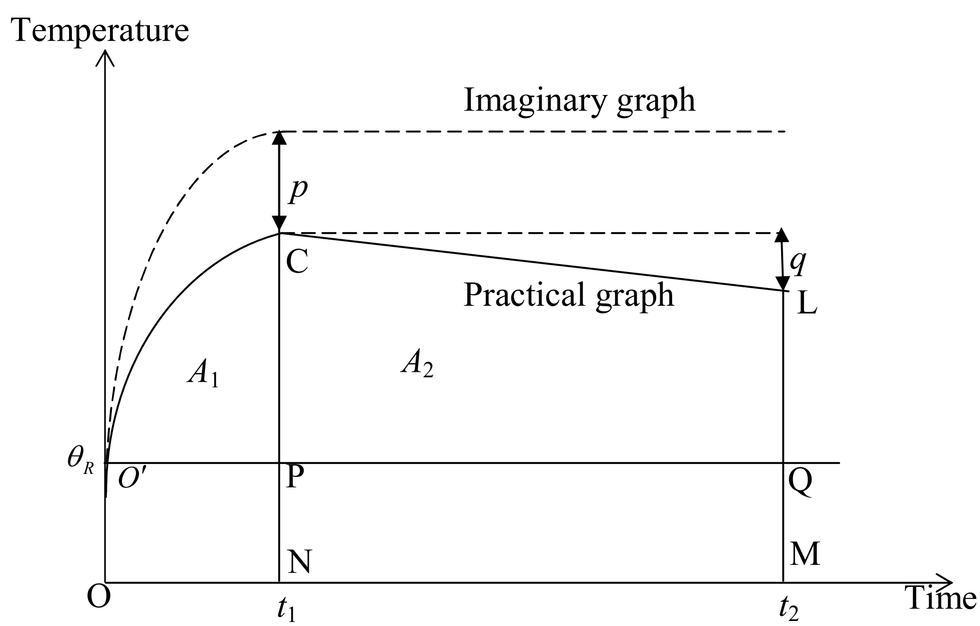
$144 \times 200^{1.4-1} = 137 \times V_2^{\gamma-1}$

$V_2^{0.4} = \frac{144}{137}(200)^{0.4}$

$V_2 = 226\ 5\ \text{cm}^3$

7. (a) (i) A cooling correction is the temperature difference between the maximum observed temperature and the would- be maximum temperature without heat loss.

(ii) The poor conductor (e.g. glass or rubber) is heated to a high temperature and then quickly transferred to the calorimeter with water. The temperature of the calorimeter with contents is taken at half-minute intervals starting just before the hot solid is added and ending when the temperature has just fallen by about 1 K from the observed maximum. A graph of temperature against time is plotted and has the shape below.



Draw a line CN through the top of the curve parallel to the temperature axis. Draw a line LM further along the curve such that NM $\geq$ 2 ON. Note the value of q.

Draw a line O'PQ through θ_R, parallel to the time axis. By counting the squares on the graph paper estimate the areas A_1 and A_2.

The cooling correction p is obtained by substitution for A_1, A_2 and q in the formula $p = \frac{A_1}{A_2} q$

(b) (i) specific heat capacity is the quantity of heat required to raise the temperature of a unit mass of a substance by one degree (1^0C or 1 K).

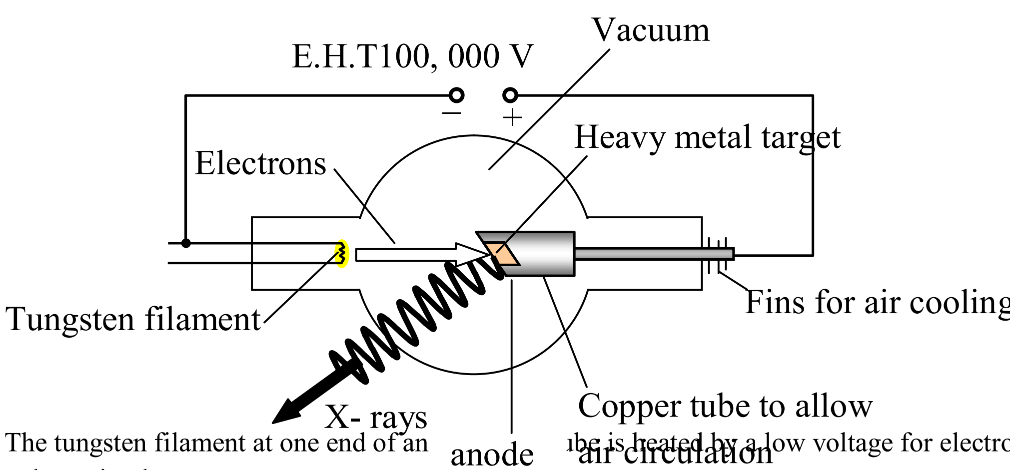
(ii)

Heat supplied by heater = Heat absorbed by flask + Heat absorbed by liquid

$50 \times 10 \times 60 \quad = \quad 840\,(78 - 28) + 2.0 \times 2.5 \times 10^3\,(78 - 28) + m \times 8.54 \times 10^3$
$3.0 \times 10^5 \quad = \quad 4.2 \times 10^4 + 2.5 \times 10^5 + 8.54 \times 10^3 m$
$8000 \quad = \quad 8.54 \times 10^3 m$ Hence $m =$ 0.9368 kg This is mass of liquid which boils off.
Assumptions:
All the heat supplied by the heater goes into raising the temperature of the liquid and flask.
The temperature of the flask does not change during vaporisation of the liquid.
(c) (i) The electrical resistance of a pure metal is determined at the triple point. Let it be R_{tr}. The resistance is next determined at any absolute temperature, T. Let it be R_T. Then $T = \frac{R_T}{R_{tr}} \times 273.16$

(ii) $\frac{\theta}{100} = \frac{9.84 - 4.00}{5.46 - 4.00} \Rightarrow \theta = \frac{5.84}{1.46} \times 100 =$ 400 ^{0}C

SECTION C
8.(a) (i)
Production of X-rays



- The tungsten filament at one end of an ... ube is heated by a low voltage for electrons to be emitted.
- The emitted electrons are accelerated to a very high velocity by the anode which is at a very high positive potential with respect to the cathode, forming cathode rays with a lot of kinetic energy.
- On striking the metal target, a small percentage of the kinetic energy of the electrons is converted to X-rays and most of the energy is converted mainly to heat. The target gets heated up to a very high temperature.
- The air circulating in the copper tube together with the copper fins facilitate the cooling.
- The tube is highly evacuated in order to reduce collisions with gas molecules which they would ionise and so lose energy in the process.
- When the accelerating anode potential is so great, Hard X-rays are produced, and when it is low, soft X-rays are produced. The greater the accelerating voltage, the higher the frequency of the X-rays.
- Hard X-Rays have high frequency, short wavelength and high penetrating ability *while* soft X-rays have low frequency, long wavelength and low penetrating ability.

(ii)

- X-rays is a flow of energy as a wave of high frequency while beta particles are material having mass.
- X-rays are neutral while beta particles carry a negative charge.
- X-rays cannot be deflected by both electric and magnetic fields while beta particles can be deflected by the electric and magnetic fields.

(iii) X-rays are produced when fast moving electrons in an evacuated tube are stopped by a heavy metal target with a release of a lot of heat, *while* photoelectric effect is the emission of electrons by a clean metal plate when exposed to light of high enough frequency.

(b) $l = 4.0$ cm 4.0×10^{-2} m, $d = 1.0$ cm $= 1.0\times10^{-2}$ m, $D = 10.0$ cm $= 10.0\times10^{-2}$ m, $L = 20.0$ cm $= 20.0\times10^{-2}$ m, P.d between plates, $V = 200$ V, $B = 1.14\times10^{-3}$ T.

$\frac{e}{m} = ?$

$$r = \frac{HK.OL}{OG} = \frac{l\times L}{D}$$ where r is the radius of the path taken by electrons in the magnetic field.

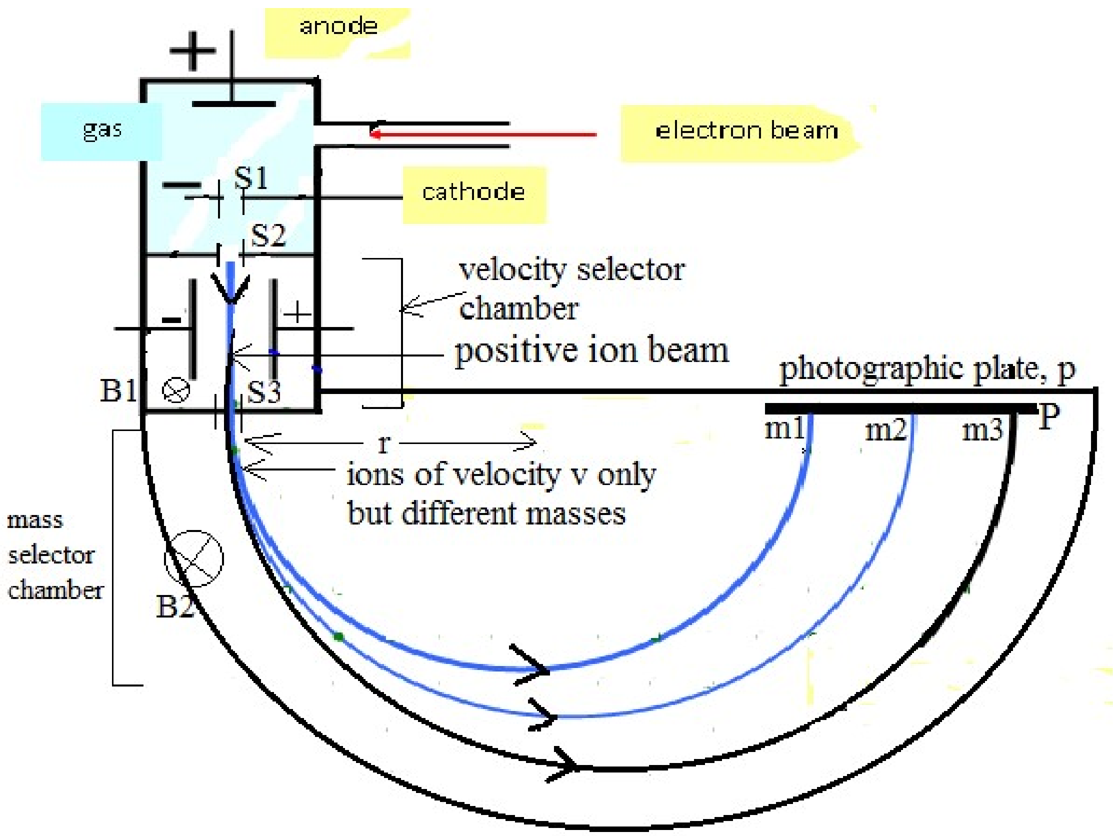
$$\frac{e}{m} = \frac{E}{B^2 r}.$$

$$\frac{e}{m} = \frac{V\times D}{d\times B^2 l\times L}$$

$$\frac{e}{m} = \frac{200\times0.1}{0.01\times\left(1.14\times10^{-3}\right)^2\times0.04\times0.2} = \frac{20}{1.04\times10^{-10}}$$

$$\frac{e}{m} = 19.2\times10^{10} : 1$$

(c)



The positive ions are produced in the discharge tube and get accelerated to pass through slits S_1 and S_2. They then enter the velocity selector chamber to pass through the magnetic and electric fields which are mutually at right angles(cross fields) and are of ***known magnitudes***. Ions of velocity v, such that $B_1qv = Eq$, only, are the ones which are able to pass through slit S_3, hence velocity selector.

$$v = \frac{E}{B_1} \quad \text{.......................................} \quad (i)$$

The ions of velocity v enter the mass selector chamber to undergo deflection by magnetic field B_2, *whose magnitude is known*.

$$B_2qv = \frac{mv^2}{r}$$

$$\frac{q}{m} = \frac{v}{rB_2} \qquad \text{But, } v = \frac{E}{B_1}$$

$$\therefore \frac{q}{m} = \frac{E}{rB_2B_1} \quad \text{.......................................} \quad (ii)$$

Since the ions entering the mass selector chamber have different velocities, they are brought to various focal points as indicated by m_1, m_2, and m_3.
The radius r for a particular selected mass is measured on the photograph on the plate and recorded.

Substitution for r, E, B_1 and B_2 in equation (ii) is made and a value for $\frac{q}{m}$ calculated.

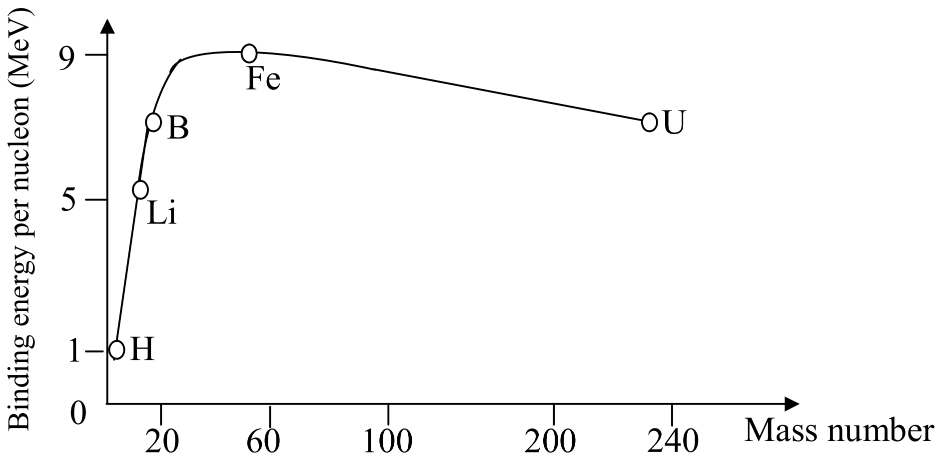
9.(a) (i) Binding energy of the nucleus is the energy needed to take all the nucleons apart so that they are completely separated.

(ii) An $\alpha -$particle has two protons and 2 neutrons.

Mass of nucleons = 2(1.0080 + 1.0087) = 4.0334 u

Binding energy = (4.0334 – 4.0026) ×931
B.E. = 0.0308 ×931 = 28.6748 MeV

B.E. per nucleon $= \frac{28.6748}{4} = 7.17$ MeV



Nuclear fusion occurs when light nuclei combine to form a heavier one. There is an increase in binding energy per nucleon. The mass of resulting nucleus is less than total mass of the light nuclei, the mass deficiency accounts for the energy released.
Nuclear fission occurs when a heavy nucleus splits into lighter nuclei of higher binding energy per nucleon (more stable). The total mass of lighter nuclei is less than mass of the heavy nucleus before break up. The mass deficiency accounts for the energy released.

(b) $N = N_0 e^{-\lambda t}$

At $t = T_{½}$, $N = \frac{N_0}{2}$

$\Rightarrow \frac{N_0}{2} = N_0 e^{-\lambda T_{\frac{1}{2}}}$

$\Rightarrow ln2 = \lambda \; T_{½}$

$\therefore \; T_{½} = \frac{0.693}{\lambda}$

(c) (i) Let x grams of ${}^{206}_{82}Pb$ be in sample.

$\therefore$ $(1 - x)$ grams is the mass of ${}^{238}_{92}U$.

$\therefore \frac{x}{1-x} = \frac{1}{5} \Rightarrow 6x = 1$

$\therefore x = 5 \times 0.167$ g of ${}^{206}_{82}Pb$.

The number of ${}^{206}_{82}Pb$ atoms $= \frac{0.167 \times 6.02 \times 10^{23} \times 5}{206} = 2.435 \times 10^{21}$ atoms

(ii) Number of ${}^{238}_{92}U$ atoms in sample $= \frac{0.833 \times 6.02 \times 10^{23}}{238}$

Number of atoms $= 1.05 \times 10^{22}$ atoms

Original number of ${}^{238}_{92}U$ atoms $= 2.1 \times 10^{21} + 4.87 \times 10^{20} = 2.587 \times 10^{21}$

From $N = N_0 e^{-\lambda t}$

$$2.1\times10^{21} = 2.587\times10^{21}\times e^{-\frac{0.693t}{1.4\times10^{17}}}$$

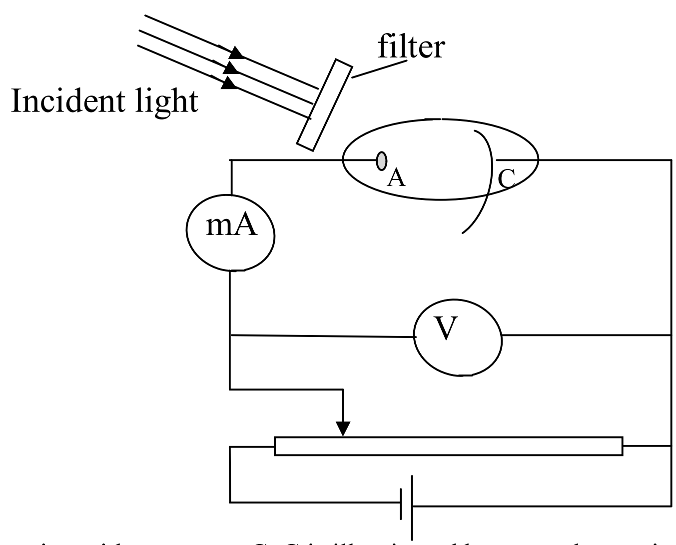
$$\Rightarrow \frac{0.693t}{1.4\times10^{17}} = \ln\left(\frac{2.587}{2.1}\right)$$

$t = 4.21\times10^{16}$ s

10.(a)

- The number of photoelectrons emitted per second (photocurrent) is proportional to the intensity of the incident radiation.
- The kinetic energy of photoelectrons ranges from zero to a maximum which increases with increasing frequency but independent of intensity of incident radiation.
- For every metal there is a threshold frequency below which no emission occurs irrespective of the intensity.
- There is no time lag between irradiation and emission. (04 marks)

(b)



A is made negative with respect to C. C is illuminated by monochromatic light and the photoelectrons emitted experience a retarding potential. The P.d, V is adjusted until the milliammeter just reads zero. The voltmeter reading is noted and this is the stopping potential.

(c) (i)

Power = number of photons per second ×energy per photon

$$P = \frac{nhc}{\lambda} \Rightarrow n = \frac{p\lambda}{hc} = \frac{100\times10^{-3}\times4.0\times10^{-7}}{6.6\times10^{-34}\times3.0\times10^{8}} = 2.02\times10^{17}$$

(ii) 65% of n $= \frac{65}{100}\times2.02\times10^{17}$ electrons

$I = ne = 0.65\times2.02\times10^{17}\times1.6\times10^{-19}$

$I = 2.1\times10^{-2}$ A

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

$$\therefore \text{ k.e.} = \frac{hc}{\lambda} - 2.2\times1.6\times10^{-19} = \frac{6.6\times10^{-34}3.0\times10^{8} - 3.52\times10^{-19}}{4\times10^{-7}}$$

k.e. = 1.43×10^{-19} J

(d)

A continuous spectrum is formed when electrons make multiple collisions with the target atoms in which case they are decelerated.

A line spectrum is formed as a result of electron transition from higher to lower energy levels.