## UACE Physics paper 1 2000 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 | $9.11 \times 10^{-31}kg$ |
| Mass of the earth | $5.97 \times 10^{24}kg$ |
| Plank's constant, h | $6.6 \times 10^{-34}Js$ |
| Stefan's-Boltzmann's constant, σ | $5.67 \times 10^{-8}Wm^{-2}K^{-1}$ |
| Radius of the earth | 6.4 x 106m |
| Radius of the sun | $7 \times 10^{8}m$ |
| Radius of the earth's orbit about the sun | $1.5 \times 10^{11}m$ |
| Speed of light in the vacuum, c | $3.0 \times 108ms^{-1}$ |
| 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 | $6.67 \times 10^{-11}Nm^{2}Kg^{-2}$ |
| Avogadro's number, $N_A$ | $6.02 \times 10^{23}mol^{-1}$ |
| Surface tension of water | $7.0 \times 10^{-2}Nm^{-1}$ |
| Density of water | $1000kgm^{-3}$ |
| Gas constant, R | $8.31Jmol^{-1}K^{-1}$ |
| Charge to mass ratio, e/m | $1.8 \times 10^{11}Ckg^{-1}$ |
| The constant, $\frac{1}{4\pi\varepsilon_0}$ | $9.0 \times 10^{9}F^{-1}m$ |
| Faraday's constant, F | $9.65 \times 10^{4}Cmol^{-1}$ |

**SECTION A**

1. (a) (i) State Newton's laws of motion (03marks)

- A body continues in its state of rest or uniform motion in a straight line unless acted upon by an external force
- The rate of change of momentum of a body is directly proportional to applied force and takes place in the direction of the force
- For every action, there is an equal and opposite reaction

(ii) Define impulse and derive its relation to linear momentum of the body on which it acts. (03marks)

Impulse is the product of force and the time for which it acts.

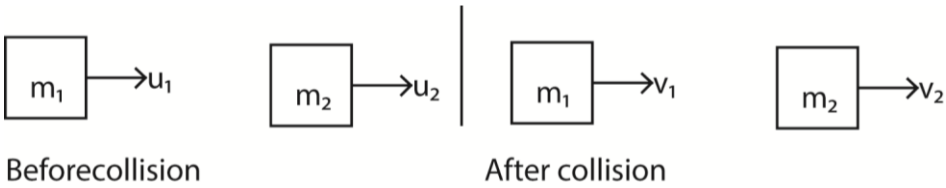
F = ma

F = $m\left(\frac{v-u}{t}\right)$

Ft = mv – mu

Hence impulse = change in momentum

(b) A body of mass $m_1$ and velocity, $u_1$ collides head on with a body of mass, $m_2$ having velocity, $u_2$ in the same direction as $u_1$. Use Newton's laws to show that the quantity $m_1u_1 + m_2u_2$ is conserved. (5marks)




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

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

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

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

Equation (i) + equation (ii)

0 = $M_1v_1 - m_1u_1 + m_2v_2 - m_2u_2$

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

(c) A ball of mass 0.5kg is allowed to drop from rest, from a point a distance of 5.0m above a horizontal concrete flow. When the ball first hits the floor, it rebounds to a height of 3.0m.

(i) What is the speed of the ball just after the first collision with the floor? (3marks)

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

$v^2 = 0 + 2 \times 9.81 \times 5$

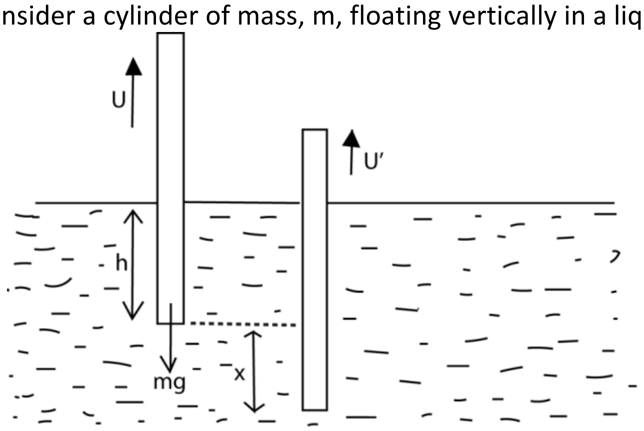
$v = 9.9ms^{-1}$

After collision, using $v^2 = u^2 + 2as$
$0 = u^2 - 2 \times 9.81 \times 3$
u = 7.672ms-1

(ii) If the collision lasted 0.01s, find the average force which the floor exerts on the ball. (02marks)
Impulse = change in momentum.
$F = m\left(\frac{v-u}{t}\right) = \frac{0.5(7.672-9.9)}{0.01} = 878.9N$

2. (a) (i) state Archimedes' Principle. (01mark
Archimedes' Principle states that when a body is wholly or partially immersed in a fluid, it experiences an upthrust equal to the weight of fluid displaced.
(ii) What is simple harmonic motion? (02marks)
Simple harmonic motion is a periodic motion of a body in which the acceleration due to of the body is directly proportional to the displacement from a fixed point and directed to that fixed point.
(b) A uniform cylindrical rod of length 0.08m, cross sectional area 0.02m$^2$ and density 900kgm$^{-3}$ floats vertically in a liquid of density 1000kgm$^{-3}$. The rod is displaced through a distance of 0.005m and released.
(i) Show that the rod performs simple harmonic motion. (05marks)

Consider a cylinder of mass, m, floating vertically in a liquid of density, ρ, to a depth, h




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

Resultant force = mg - (h + x) Aρg

But, m = Ahρ
ALρa = Ahρg – Ahρg – Aρgx
$a = \frac{-A\rho g x}{Ah\rho} = \frac{-gx}{h}$
But $a = -\omega^2 x$
Hence it performs simple harmonic motion with $\omega^2 = \frac{g}{h}$
(ii) Find the frequency of the resultant oscillation. (04marks)

From ω = 2πf

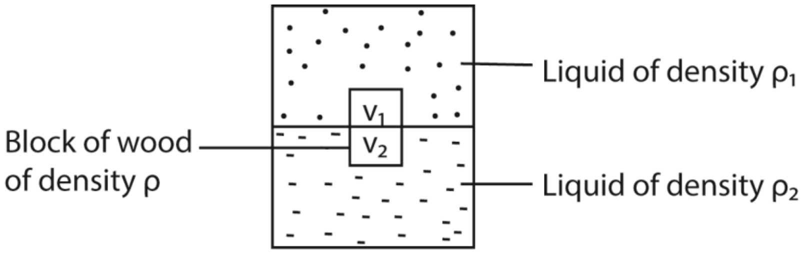
$4\pi^2 f^2 = \frac{g}{h}$

f = $\frac{1}{2\pi}\sqrt{\frac{g}{h}} = \frac{1}{2\pi}\sqrt{\frac{9.81}{0.08}}$ = 1.76

(iii) Find the velocity of the rod when it is a distance of 0.004m above the equilibrium position. (03marks)

v = $\omega\sqrt{a^2 - x^2}$ = 2πf$\sqrt{a^2 - x^2}$ = 2π x 1.76$\sqrt{0.005^2 - 0.003^2}$ = 0.04ms$^{-1}$

(c)




A block of wood of density ρ floats at the interface between immiscible liquids of densities $\rho_1$ and $\rho_2$ as shown in the figure above.

(i) Show that the ratio of volumes $v_1$ to $v_2$ of the block in the two liquids is given by $\frac{v_1}{v_2} = \frac{\rho_2 - \rho}{\rho - \rho_1}$ (04marks)

Total upthrust = weight of a liquid displaced

= weight of floating solid

⇨ $V_1\rho_1 g + V_2\rho_2 g = (V_1 + V_2)\rho g$

$V_1(\rho_1 - \rho) = V_1(\rho - \rho_2)$

$\frac{V_1}{V_2} = \frac{\rho - \rho_2}{\rho_1 - \rho}$

(ii) What happens when this block of wood is replaced with a denser one? (01mark)

The block sinks deeper

3. (a) Distinguish between scalar and vector quantities. Give two examples each. (03marks)

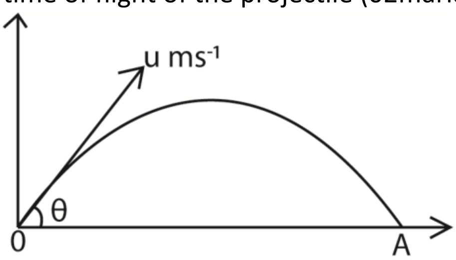
A scalar quantity has magnitude but no direction, e.g. volume. Mass, speed, densty, temperature

A vector quantity has magnitude and direction, e.g. acceleration, velocity, and displacement, momentum, mpulse

(b) (i) Define the time of flight and range as applied to projectile motion. (02 marks)

Time of flight is the time taken by a projectile to move from the point of projection to where it lands

(ii) A projectile is fired in air with a speed u ms$^{-1}$ at an angle θ to the horizontal. Find the time of flight of the projectile (02marks)




At point A, the vertical distance covered above the point of projection is zero

From s = ut + $\frac{1}{2}at^2$

0 = usinθ x t - $\frac{1}{2}gt^2$

$t = \frac{2usin\theta}{g}$

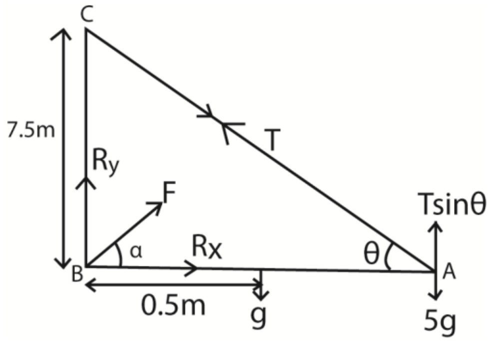
therefore the time of flight of projectile is $\frac{2usin\theta}{g}$.

(c) State the conditions for equilibrium of a rigid body under action of coplanar forces. (02marks)

- The algebraic sum of all the forces acting in one direction is equal to the algebraic sum of all the forces acting in the opposite direction.
  Or
- The algebraic sum of all moments of forces at any given point is equal to zero.

(d) A mass of 5.0kg is suspended from the end A of a uniform beam of mass 1kg and length 1.0m. The end B of the beam is hinged in a wall. The beam is kept horizontal by a rope attached to A and a point C, in the wall at a height 0.75m above B.

(i) Draw a sketch diagram to show the forces acting on the beam. (02marks)




(ii) Calculate the tension in the rope. (04marks)

Moments At B: T x 1sin$\theta$ = 1.0 x 0.5 + 5g x 1

But tanθ = $36.9^0$

$T = \frac{5.5\ x\ 9.8}{\sin 36.9} = 89.9N$

(iii) What is the force exerted by the hinge on the beam? (05marks)

Rx = 0.8T = 0.8 x 89.9 = 71.9N

Ry = 6 x 9.81 – 0.6 x 89.9 = 4.9N

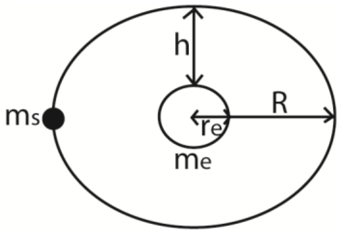
Resultant, R = $\sqrt{R_x^2 + R_y^2} = \sqrt{71.9^2 + 4.9^2}$ = 72.1N

Direction: tan α = $\frac{R_y}{R_x} = \frac{4.9}{71.9}$; α = $3.89^0$

4. (a) State Kepler's laws of gravitation (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

(b) (i) Show that the period of a satellite in a circular orbit of radius r about the earth is given by $T = \left(\frac{4\pi^2}{GM_S}\right)^{\frac{1}{2}} r^{\frac{3}{2}}$ where G is the universal constant and Ms is the mass of the earth. (05marks)




Centripetal force required to maintain circular motion is provided by the gravitational force of attraction between the earth and satellite.

From Newton's of gravitation

F = $\frac{Gm_s m_e}{R^2}$

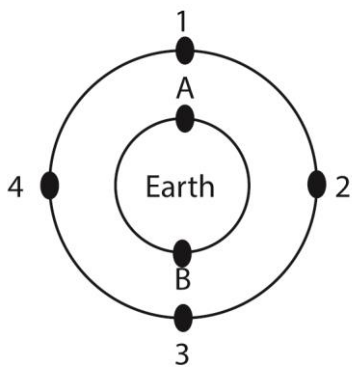
$\therefore m_s\omega^2 R$ = $\frac{Gm_s m_e}{R^2}$

ω² = $\frac{Gm_e}{R^3}$ but ω = $\frac{2\pi}{T}$

⇨ $\left(\frac{2\pi}{T}\right)^2 = \frac{Gm_e}{R^3}$

$T = \left(\frac{4\pi^2}{GM_s}\right)^{\frac{1}{2}} r^{\frac{3}{2}}$

(ii) Explain briefly how world-wide radio or television communication can be achieved with the help of satellites. (04marks)




- A set of satellites is launched in parking orbit as shown in the diagram above.
- A radio signal from A is transmitted to a geosynchronous satellite 1
- The signals are retransmitted from satellite 1 to geosynchronous satellite 2, then to 3 and finally to B.

(c) A satellite of mass 100kg is in a circular orbit at height of 3.39 x $10^7$m above the earth' surface.

(i) Find the mechanical energy of the satellite (04marks)

Mechanical energy, M.E. = $\frac{-Gm_e m}{2r}$; r = (3.59 x $10^7$ + 6.4 x $10^6$) = 4.23 x $10^7$m

M.E = $\frac{-6.67 \times 10^{-11} \times 5.97 \times 10^{24} \times 100}{2 \times 4.23 \times 10^7}$ = -4.71 x $10^8$J

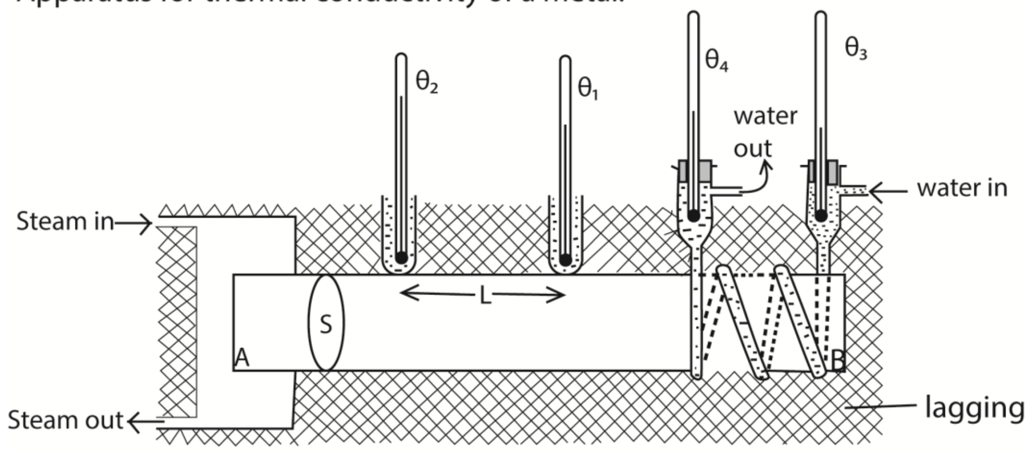
(ii) Explain what would happen if the mechanical energy was decreased. (04marks)

From M.E. = $\frac{-Gm_em}{2r}$, when mechanical energy decreases, r, also decreases. Therefore the satellite drops into an orbit of smaller radius. If mechanical energy continued to decrease, the satellite would enter the earth's atmosphere and would eventually burn out due to frictional resistance. Velocity and kinetic energy increase.

**SECTION B**

5. (a)(i) Describe Searle's method of determining the thermal conductivity of a good conductor of heat. (07marks)

Apparatus for thermal conductivity of a metal.



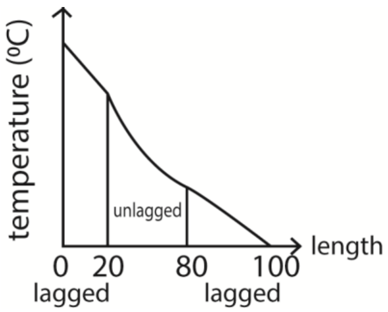

- Specimen bar AB of mean diameter, d, is heated by steam at end A and cooled by water at end B as shown above
- The lagging ensure a constant rate of heat flow
- The setup is left to run for some time until steady temperatures $\theta_1$, $\theta_2$, $\theta_3$ and $\theta_4$ are obtained.
- The rate water flow m $kgs^{-1}$ is measured using a cylinder and stop clock.
- Cross section area A = $\frac{\pi d^2}{4}$
- The rate of heat flow is given by
  $\frac{Q}{t} = kA\left(\frac{\theta_2 - \theta_1}{L}\right) = mc_w(\theta_4 - \theta_3)$
  where k = thermal conductivity of the metal and $c_w$ is specific heat capacity of water

(ii) Why is the method in (a)(i) best suited for a good conductor of heat? (02marks)

- Rate of heat flow through the conductor is measurable
- There is a steep temperature gradient.

(b) The two ends of a metal bar of length 1.0m are perfectly lagged up to 20cm from either end. The ends of the bar maintained at $100^0C$ and $0^0C$ respectively.

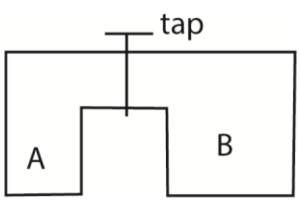
(i) Sketch a graph of temperature versus distance of a bar. (02marks)




(ii)Explain the features of the graph in (b)(i)(03marks)

- In lagged portions there is constant heat flow because there I no heat loss to the surroundings
- In unlagged portion heat flow is not uniform due to heat loss to the environment.

6. (a) (i) State Boyles law. (01mark)
The pressure of a fixed mass of a gas is inversely proportional to volume.
(ii) What is meant by partial pressure of a gas? (01 mark)
Partial pressure is the pressure that would be exerted by a gas if it alone occupied the volume of the mixture.
(iii)




Two cylinders A and B of volumes V and 3V respectively are separately filled with a gas. The cylinders are connected as shown above with the tap closed. The pressures of A and B are P and 4P respectively. When the tap is opened the common pressure becomes 60Pa. Assuming isothermal conditions find the value of P. (04marks)

Solution

From PV = nRT

Moles $n_1$ of the gas in A before mixing= $\frac{PV}{RT}$

Moles $n_2$ of the gas in B before mixing = $\frac{4P\ x\ 3V}{RT} = \frac{12PV}{RT}$

Moles $n_3$ of the gas when tap is opened = $\frac{60\ x\ 4V}{RT}$

But moles of the gas before mixing = mole of the gas after mixing

⇨ $n_1 + n_2 = n_3$

$\frac{PV}{RT} + \frac{12PV}{RT} = \frac{60\ x\ 4V}{RT}$

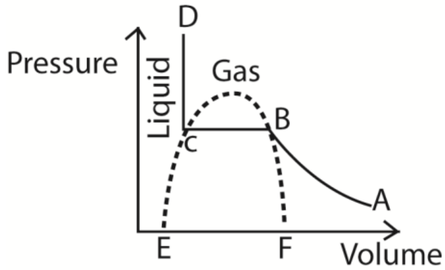
$13P = 240$

P = 18.46Pa

(b) (i) State three differences between ideal and real gases. (03marks)

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

(ii)Sketch a pressure versus volume curve for a real gas undergoing compression below its critical temperature. (01mark)




(iii)Explain the main features of the curve in (b)(ii) above (03marks)

- AB represents unsaturated vapour that approximately obey Boyle's law.
- BC represents saturated vapour, the gas turns into a liquid at constant pressure.
- CD is a liquid, small decrease in volume leads to a big increase in pressure because liquids are incompressible

(c) Two similar cylinders P and Q contain different gases at the same pressure. When gas is released from P the pressure remains constant for some time before it starts dropping. When gas is released from Q the pressure continuously drops. Explain the observation above. (05marks)

- The gas in P is in form of a saturated vapour; that is, in dynamic equilibrium with a liquid. As the gas is released, more liquid turns into a gas to restore pressure until the gas becomes unsaturated and the pressure begins to drop as the moles of the gas decrease
- The gas in Q is unsaturated, and thus pressure reduces as the moles of the gas reduces up on release.

(d) Using the expression for the kinetic pressure of an ideal gas, deduce the ideal gas equation of $\frac{1}{2}m\overline{c^2} = \frac{3}{2}K_BT$ (02marks)

Given $\frac{1}{2}m\overline{c^2} = \frac{3}{2}K_BT$

From P = $\frac{1}{3}\rho\overline{c^2}$ = $\frac{1}{3}x\ \frac{M}{V}\overline{c^2}$

PV = $\frac{1}{3}M\overline{c^2} = \left(\frac{1}{2}M\overline{c^2}\right)x\ \frac{2}{3}$ = $\frac{3}{2}K_BT\ x\ \frac{2}{3}$ = $K_BT$ = Constant

$\therefore PV = constant$

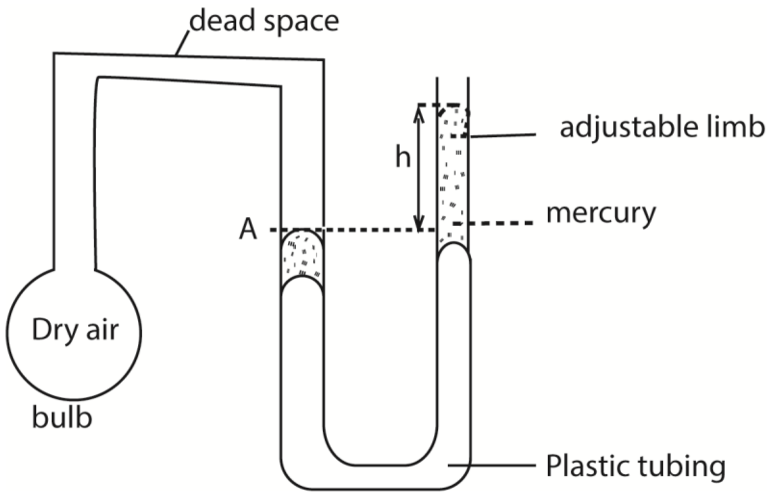
7. (a)(i) State the desirable properties of a material must have to be used as thermometric substance, (02marks)

- Should change considerably for a small change in temperature
- Should vary linearly and continuously with temperature.

(ii) Explain why scales of temperature based on different thermometric properties may not agree.(01marks)

Because different thermometric properties respond differently to temperature

(b) (i) Draw a labelled diagram to show a simple constant volume gas thermometer. (03marks)




(ii) Describe how a simple constant volume gas thermometer cab be used to establish a Celsius scale of temperature. (05marks)

- Place the bulb inside whose temperature is to be measured.
- Allow some time for the gas to acquire the temperature of the enclosure. The gas in the bulb may expand and forces mercury up the adjustable tube.
- Adjust the adjustable limb to bring back mercury to constant volume at A and record the height of mercury, $h_\theta$.
- The Celsius scale is given by $\theta = \left(\frac{h_\theta - h_0}{h_{100} - h_0}\right) x\ 100^0C$ where $h_{100}$ and $h_0$ are the heights at steam and ice points

(iii) State the advantages and disadvantages of mercury in glass thermometer and constant-volume gas thermometer. (03marks)

Advantages of mercury in glass

- Give direct reading
- Cheap
- Portable

Disadvantage of mercury in glass

- Have limited temperature range
- Not very accurate

Advantages of constant volume gas thermometer

- Very sensitive to temperature change

- Has wide range
- Very accurate

Disadvantage of constant volume gas thermometer

- It is bulky
- Cannot measure temperature at a point
- Slow to respond to rapidly changing temperature
- Does not give direct readings

(c) The resistance of the element of platinum resistance thermometer is 4.00Ω at ice point and 5.46Ω at steam point. What is the temperature on the platinum resistance scale would correspond to a resistance of 9.84Ω. (03marks)

θ = $\frac{R_\theta - R_0}{R_{100} - R_0} \ x\ 100^0 C = \frac{9.84-\ 4.0}{5.46-4.00}\ x\ 100$ =400⁰C

(d) The mean kinetic energy of one mole of helium gas at room temperature is 3.74 x $10^3$J. Calculate room temperature.

$\frac{1}{2}m\overline{c^2} = \frac{3}{2}K_B T$

Mean kinetic energy = $\frac{3}{2}K_B T$

3.74 x $10^3$ = = $\frac{3}{2}\ x\ 8.31\ x\ T$

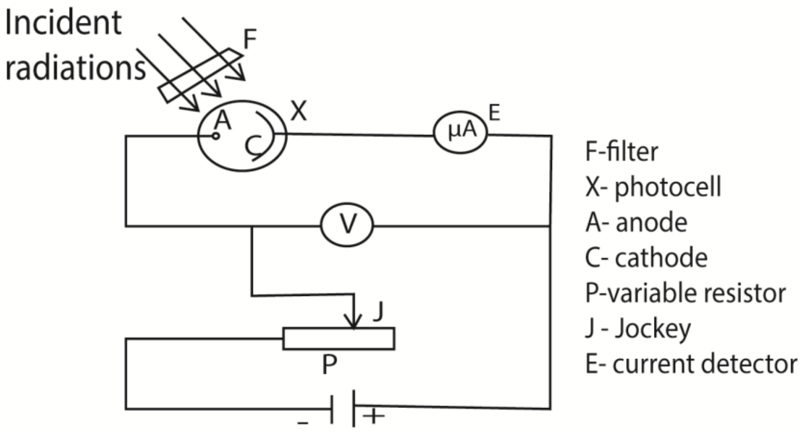
T = 300.04K

**SECTION C**

8. (a) State the laws of pho electric 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

(b) (i) Describe an experiment Plank's constant. (05marks)




- A radiation of known frequency, f, is made incident on the photocathode
- Emitted electrons travel to the anode and cause a current to flow, detected at E.
- The p.d V is adjusted until the reading of E is zero (i.e. no current flows).
- The value of this p.d is the stopping potential (Vs) and is recorded from the voltmeter V.
- The procedure is repeated with light of different frequencies, f.
- A graph of stopping potential (Vs) against frequency (f) is plotted
- A straight line graph is obtained which verifies Einstein's equation; $V_s = \frac{h}{e}f - \frac{h}{e}f_0$
- The slope of the graph is $\frac{h}{e}$ from which Plank's constant, h, can be obtained.

(ii) Violet light wavelength 0.4μm is incident on a metal surface of threshold wavelength 0.65μm. Find the maximum speed of emitted electrons

From hf = $hf_0$ + ½ $mv^2$

$v = \sqrt{\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda_0\lambda}\right)} = \sqrt{\frac{2x\ 6.6\ x\ 10^{-34}\ x\ 3\ x\ 10^{8}}{9.11\ x\ 10^{31}}\left(\frac{0.65-0.4}{0.4\ x\ 0.65}\right) x\ 10^{-6}}$ = 6.48 x $10^6$ms$^{-1}$

(i) Explain why light whose frequency is less than the threshold frequency cannot cause photoemission. (02marks)
According to the quantum theory, radiation is absorbed or emitted in discrete packets of energy called quanta with energy hf. Therefore light of frequency less than threshold would not be absorbed.

(c) (i) What are X-rays? (01marks)

X-ray are electromagnetic radiation of very short wavelength produced when fast moving electrons are stopped by metal target.

(ii) Explain how the intensity and penetrating power of X-rays produced by an X-ray tune can be varied. (04marks)

Intensity is the power transmitted per unit area. It is controlled by the filament current which determines the number of electrons striking the anode per second. The greater the filament current, the greater the number of electrons striking the anode per second and the greater the intensity.

Penetrating power is controlled by p.d between the filament and the anode which determines the kinetic energy with which electrons strike the anode.

9. (a)(i) Define the terms half-life and decay constant as applied to radioactivity. (02marks)

**Half-life** is the time taken for the number of active nuclie in a source at a given time to fall to half its value.

**Decay constant** is the number of nuclei decaying per unit time.

(ii) State relationship between half-life and decay constant. (01mark)

Half-life, $t_{½} = \frac{In\ 2}{decay\ constant,\ \lambda}$

(b) The radioisotope $^{60}Co$ decays by emission of a β-particle and γ-rays. Its half-life is 5.3years.

(i) find the activity of a source containing 0.10g of $^{60}Co$. (04marks)

60g of cobalt contains $6.02 \times 10^{23}$ atoms

0.1g of cobalt contain $\frac{6.02\ x\ 10^{23}\ x\ 0.1}{60}$ = $1 \times 10^{21}$atoms

From activity = λN = $\frac{In\ 2N}{decay\ constant,\ \lambda}$ = $\frac{0.693\ x\ 1\ x\ 10^{21}}{5.3\ x\ 365\ x\ 24\ x\ 60\ x\ 60}$ = $4.15 \times 10^{12} s^{-1}$

(ii) In which ways do γ-rays differ from β-particles (03marks)

| Beta particle | Gamma rays |
|---|---|
| Negatively charges | No charge |
| Deflected by electric and magnetic field | Not affected by magnetic and electric field |

(c) (i) What is meant by mass defect in nuclear physics? (01mark)

Mass defect is the difference in the mass of the constituents of a nucleus and mass of the nucleus

(ii) Calculate the mass defect for $^{59}_{26}Fe$, given the following information

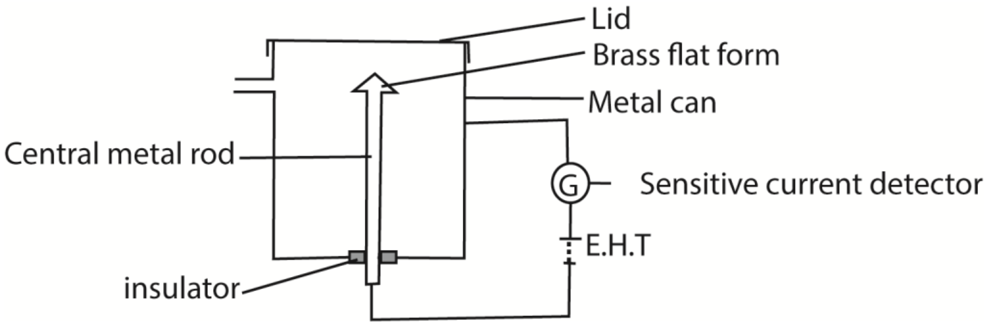
Mass of $^{59}_{26}Fe$ nucleus = 58.93488u

Mass of a proton = 1.00728u

Mass of neutron = 1.00867u (04marks)

Mass defect = (26 x 1.0072 + 33 x 1.00867) – 58.93488 = 0.53733U

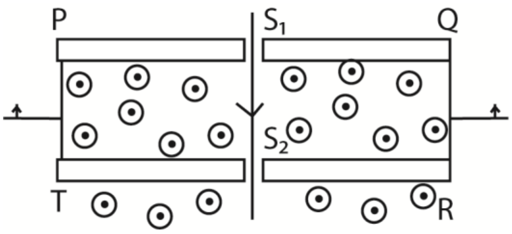
(d) Describe the structure and action of ionization chamber. (05marks)




- A radiation source on the brass flat form causes ionization of air in the chamber producing electrons and positive ions.
- The electrons move to the metal can and positive ions drift to the central metal rod.
- Movement of the ions to the electrodes causes discharge and current pulse flows in external circuit.
- The current sensitive detector detects current.
- The magnitude of current detected shows the extent to which ionization takes place.

10. (a) What is meant by specific charge of an ion? (01mark)
It is the ratio of the charge to the mass of an ion.

(b)



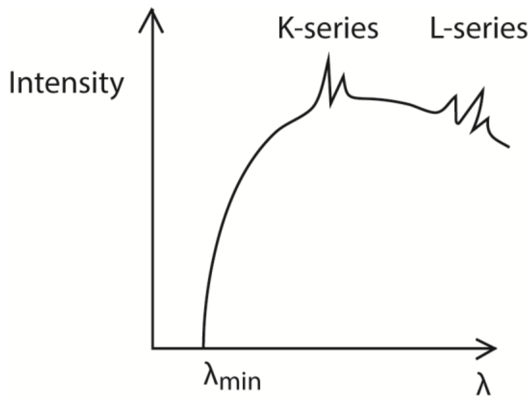

Positive ions of the same charge are directed through slit $S_1$ into a region PQRT as shown in the figure above. There is a uniform electric field of intensity 300NC$^{-1}$ between the plate PT and QR. A uniform magnetic field of flux density 0.6T is directed perpendicularly out of the paper as shown above.

(i) Calculate the velocity of the ions which go through slit $S_2$. (03marks)
Since the ions follow a straight line it implies that electrostatic force = magnetic force
qE = Bqv
$v = \frac{E}{B} = \frac{300}{0.6} = 500ms^{-1}$

(ii) Describe the motion of ions in the region TR. (3marks)
The path of ions in magnetic field is circular and the path is perpendicular to magnetic field due to the magnetic force producing a centripetal force.

(c) When fast moving electrons strike a metal target in X-ray tube, two type of X-ray spectra are produced

(i) Draw a sketch graph of intensity against wavelength of the X-rays (02marks)




(ii) Account for the occurrence of the two types of spectra (05marks)

The spectrum consists of two major components, i.e. the continuous (background) spectrum and the very sharp line spectrum superimposed onto the background spectrum.

The continuous spectrum is produced when electrons make multiple collisions with the target atoms in which they are decelerated. At each deceleration, X-rays of differing wavelength are produced.

The shortest Wavelength X-rays are produced when electrons lose all their energy as X-ray photon in a single encounter with the target atoms. The wavelength of the X-rays at this point is known as the cut off wavelength. At cut off wavelength, energy in an X-ray photon equals kinetic energy of the electron; i.e. hf = eV or $\frac{hc}{\lambda_{max}} = eV$ where V = p.d

**The line spectrum**

At high tube voltages, the bombarding electrons penetrate deep into the target atoms and knock out electrons from inner shell. The knocked out electrons occupy vacant spaces in higher unfilled shells putting the atom in excited state and making them unstable.

Transition of an electron from higher to lower energy levels results in an emission of X-ray photon of energy equal to energy difference between the energy levels.

If the transition ends in the K-shell, it produces K-series and if the transition ends in L-shell. It produces L-series.

(d) Outline the experimental evidences for the quantum theory of matter. (06marks)

The quantum theory of matter states that energy of a radiation exists in discrete packets of magnitude hf where h is Plank's constant and f is the frequency. Some evidences are

- Photoelectric effect: to liberate an electron from a metal surface, a quantum (or packet) of energy called work function which is characteristic of the metal has to be supplied.
- Optical spectra: a line in optical emission spectrum indicates presence of a particular frequency, f, of light considered to arise from loss of energy which occurs in an

excited atom when electron jumps directly or in steps from a higher energy level $E_2$ to lower energy level (s), $E_1$. The frequency of a photon= hf = $E_1 - E_2$.

- X-ray line spectra: electron transition from one shell to another leads to liberation of energy in packets which are characteristic of the target atom

**Compiled by Dr. Bbosa Science**