P510/1
PHYSICS
PAPER 1
SEPT.2022
2 ½ HOURS

RESOURCE MOCK EXAMINATIONS

Uganda Advanced Certificate of Education

PHYSICS

PAPER P510/1

2 Hours 30 Minutes

INSTRUCTIONS TO CANDIDATES:

- Answer FIVE questions, including at least one, but not more than two questions from each of the sections **A, B** and ***C***.
- Non-programmable scientific electronic calculators may be used.
- **Assume where necessary:**

Acceleration due to gravity, g	=	$9.81\ ms^{-2}$
Electronic charge , e	=	1.6×10^{-19} C
Mass of the earth	=	5.97×10^{24} Kg
Plank's constant , h ,	=	6.6×10^{-34} Js
Stefan's Boltzman's constant , σ	=	$5.67 \times 10^{-8}\ wm^{-2} K^4$
Radius of the earth	=	6.4×10^6m
Radius of the sun	=	7×10^8m
Universal gravitational constant, G	=	$6.67 \times 10^{-11}\ Nm^2 Kg^{-2}$
Avogadro's number, N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Surface tension of water	=	$7.0 \times 10^{-2}\ Nm^{-1}$
Gas constant, R	=	$8.31\ Jmol^{-1}\ K^{-1}$
The constant $\frac{1}{4\pi\varepsilon_o}$	=	$9.0 \times 10^9\ F^{-1}$ m

SECTION A

1. (a) (i) State one difference between scalar and vector physical quantities. (01 mark)

(ii) Give any one example of each; scalar and vector quantities. (01 marks)

(b) (i) A senior six student is to design a wind turbine to help in the generation of electricity in her home town. She knows that the maximum power; P it can produce depends on length; l of its blades, speed; v of wind and average density; σ of air. Use dimensional analysis to derive the relationship between P, l, v, σ and a dimensionless constant; k. (04 marks)

(ii) Basing on the factors mentioned in b(i) above, explain why the actual power generated will be less than the maximum calculated. (01 mark)

(c) (i) State the principle of conservation of energy. (01 mark)

(ii) Prove that the mechanical energy is conserved for a body falling from rest in a vacuum. (04 marks)

(d) A child of weight 330N is at point X at the top of a slide. The slide is at the edge of a swimming pool, as shown in Fig. 1.1

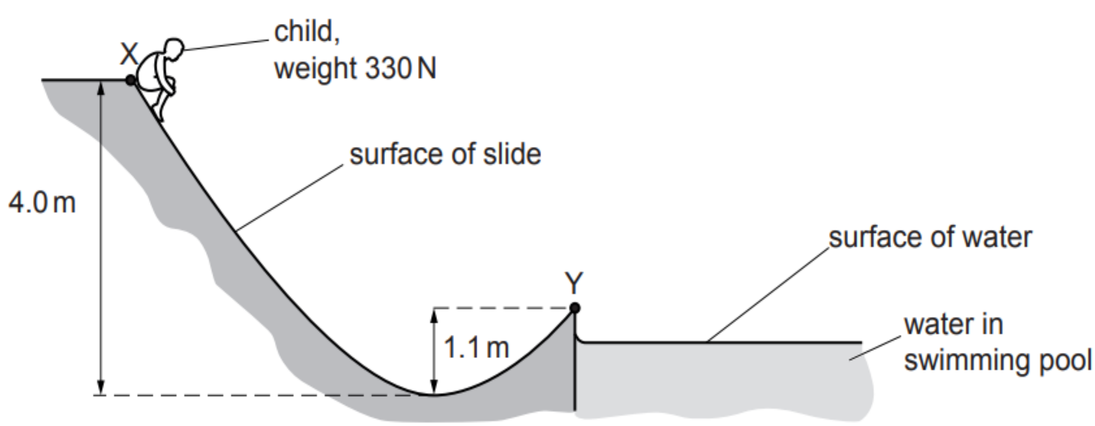


Fig 1.1

The child moves from rest to the lowest point of the slide that is a vertical distance of 4.0m below X. The child continues moving towards point Y which is at the end of the slide and a vertical distance of 1.1m above the lowest point. The kinetic energy of the child at Y is 540J.

(i) Using the principle of conservation of energy, determine the distance moved by the child from X to Y given that an average frictional force of 52N acts on the child when moving from X to Y. (04 marks)

(ii) The child leaves the slide at point Y with a velocity that is at an angle of projection of 41° to the horizontal. Assume that air resistance is negligible. Calculate the speed of the child at highest point of its motion after projection at Y. (04 marks)

2. (a) Define the following terms with reference to materials:

(i) Elastic materials

(ii) Plastic deformation. (02 marks)

(b) For an experiment to determine Young's modulus of elasticity;

(i) List down some of the measurements to be made. (03 marks)

(ii) Explain why two wires of the same material are used. (01 mark)

(iii) Explain why two long and thin wires are used. (02 mark)

(c) (i) State the principle of moments. (01 mark)

(iii) State the conditions for a body to in equilibrium under the action of coplanar forces. (02 marks)

(d) Fig. 2.1 shows a type of balance that is used for measuring mass.

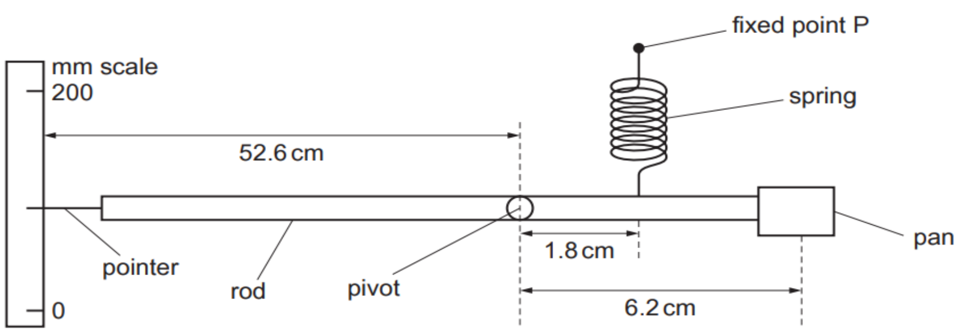


Fig 2.1

A rigid rod is pivoted about a point 6.2cm from the centre of a pan which is attached to one end. The object being measured is placed on the centre of this pan. A spring, attached to the rod 1.8cm from the pivot, is attached at its other end to a fixed-point P. The spring obeys Hooke's law over the full range of operation of the balance. A pointer, on the other side of the pivot, is set against a millimeter scale which is a distance 52.6cm from the pivot. When the system is in equilibrium with no mass on the pan, the rod is horizontal and the pointer indicates a reading on the scale of 86mm. An object of mass 0.472kg is now placed on the pan. As a result, the pointer moves to indicate a reading of 123mm on the scale when the system is again in equilibrium.

(i) State Hooke's law. (01 mark)

(ii) Show that the increase in the length of the spring is approximately 1.3mm. (02marks)

(iii) Calculate the increase in the tension in the spring due to the 0.472kg mass and hence the spring constant. (04 marks)

(iv) Determine the increase in elastic potential energy stored in the stretched. (02 marks)

3. (a) The defining equation of simple harmonic motion is $a = -\omega^2 x$.

(i) State the significance of the minus (–) sign in the equation. (01 mark)

(ii) State any more two characteristics of simple harmonic motion. (01 mark)

(b) A trolley rests on a bench. Two identical stretched springs are attached to the trolley as shown in Fig. 3.1. The other end of each spring is attached to a fixed support.

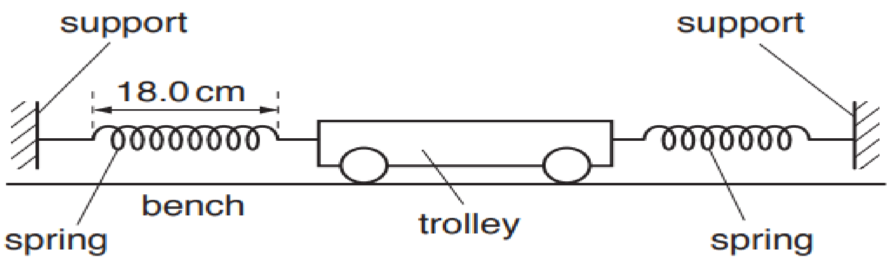


Fig 3.1

The unstretched length of each spring is 12.0cm. The spring constant; k of each spring is 5.0Nm^{-1}. When the trolley is in equilibrium the length of each spring is 18.0cm. The trolley is displaced a distance; x = 1.8cm to one side and then released. Assume that resistive forces on the trolley are negligible.

(i) Show that the trolley executes simple harmonic motion. (04 marks)

(ii) Calculate for its periodic time given that its mass is 250g. (03 marks)

(iii) Using a sketch graph, illustrate the variation of its mechanical energy with displacement. (01 mark)

(iv) Illustrate on a sketch graph the effect on the trolley if the bench was not perfectly smooth and state one application of such effect. (02 mark)

(c) (i) State Kepler's third law of planetary motion. (01 mark)

(ii) Use Newton's law of gravitation to verify Kepler's third law. (03 marks)

(d) (i) State any two characteristics of geosynchronous satellites. (02 marks)

(ii) Explain what would happen if the mechanical energy of a satellite was decreased. (03marks)

4. (a) Define the terms below in relation to fluid mechanics

(i) Viscosity

(ii) Viscous drag. (02 marks)

(b) Explain the effect of increase in temperature on viscosity in liquids and in gases. (04 marks)

(c) (i) State Bernoulli's principle. (01 marks)

(ii) Jesca stands by the roadside to wait for her uber taxi. A trailer truck passes by her and as a result, she experiences a force. Explain the origin of that force and state its direction. (02 marks)

(iii) A house is to be designed to withstand hurricane-force winds. The maximum wind velocity is $88ms^{-1}$. The surface area of the roof is $450m^2$. If the density of air is $1.029kgm^{-3}$, how much force must the roof supports be able to withstand? (04 marks)

(d) (i) Define surface tension in terms of free surface energy. (01 mark)

(ii) Explain the origin of surface tension. (02 marks)

(iii) Calculate the work done in breaking up a drop of water of radius 5mm into tiny droplets of water each of radius 0.1cm assuming isothermal conditions, given that surface tension of water is $7x10^{-2}Nm^{-1}$. (04 marks)

<u>SECTION B.</u>

5. (a) (i) Define the term thermometric property. (01 mark)

(ii) State any four characteristics of a good thermometric property. (02marks)

(iii) The resistance R of platinum wire at temperature θ°C as measured by mercury-in-glass thermometer is given by; $R_\theta=R_0(1+b\theta+a\theta^2)$ where b $=3.8x10^{-3}K^{-1}$ and $a=-5.6x10^{-7}K^{-2}$. Calculate the temperature of platinum thermometer corresponding to 200°C on glass scale. (04 marks)

(iv) State any reason as to why the two thermometers do not give the same temperature. (01 mark)

(b) (i) State any three ways in which heat losses are minimized in calorimetry experiments. (02 marks)

(ii) Describe an experiment to determine the specific latent heat of vaporization water by method of mixtures. (06 marks)

(c) (i) Explain why the specific latent heat of vaporization is greater than that of fusion. (03 marks)

6. (a) (i) What is meant by the terms coefficient of thermal conduction and temperature gradient. (02 mark)

(ii) Describe an experiment to determine the coefficient of thermal conduction of a plastic material. (06 marks)

(iii) A cooking saucepan made of iron has a base area of $0.05m^2$ and thickness of 2.5mm. It has a thin layer of soot of average thickness 0.5mm on its bottom surface. Water in the saucepan is heated until it boils at 100°C. $10gs^{-1}$ of water boils away and the side of the soot nearest to the heat source is at 150°C. Find the thermal conductivity of soot. (K for iron = 66 $Wm^{-1}K^{-1}$, Specific latent heat of vaporization = $2200kJkg^{-1}$) (04 marks)

(b) (i) State Stephan's law of black body radiation. (01 mark)

(ii) What is meant by the term intensity of radiations. (01 mark)

(iii) Sketch a graph to show how relative intensity of radiations varies with wavelength for two different temperatures. (02 marks)

(c) A metal sphere with a blackbody surface and radius 30mm is cooled to -73°C and' is placed inside an enclosure at a temperature of 27°C. Assuming that the density of metal is $800kgm^{-3}$ and that its specific heat capacity is $400kJkg^{-1}K^{-1}$, calculate the initial rate of temperature rise of the sphere. (04 marks)

7 (a) (i) State Charles' law. (01 marks)

(ii) Show that the ideal gas equation is consistent with Charles' law (03 marks)

(iii) Describe an experiment to verify Charles' law. (05 marks)

(b)(i) State the assumptions made in the derivation of the ideal gas equation that do **NOT** apply for real gases. (02 marks)

(ii) For the Vander Waal's gas equation; $(P+ a/v^2) + (V-b)$ = constant, account for the terms ' a/v^2 ' and 'b' (04 marks)

(c) (i) What is meant by the term saturated vapour pressure. (s.v.p) (01 mark)

(ii) Explain the effect of volume change on the s.v.p (03 marks)

(iii) Represent the effect for b(ii) on a sketch graph for a saturated vapour. (01 mark)

SECTION C.

8. (a) (i) Distinguish between cathode and positive rays. (02 marks)

(ii) An electron gun operating at 3×10^3V is used to project electrons into a space between two oppositely charged parallel plates of length 10cm and 5cm apart. Calculate the vertical deflection of an electron as it emerges from the region between the charged plates when the potential difference is 1×10^3V. (05 marks)

(iii) Explain the motion of electrons between the plates in a(ii) above. (02 marks)

(b) (i) State any two uses of a cathode ray oscilloscope (C.R.O). (02 marks)

(ii) A C.R.O has its Y-sensitivity set to $6Vcm^{-1}$. A sinusoidal input voltage is suitably applied to give a steady p.d. The time base switched on so that the electron beam takes 0.01s to traverse the screen. If the trace seen has a peak-to-peak height of 4cm and contains two complete cycles, determine the root mean square value of the input voltage and the frequency of the signal. (05 marks)

(c) Explain the meaning of the terms below as used in a vacuum diode.

(i) Space charge limitation. (03 marks)

(ii) Saturation. (01 mark)

9. (a) (i) What is meant by a photon. (01 mark)

(ii) State the laws of photo electric emission. (04 marks)

(iii) Explain why the wave theory of light fails to account for photoelectric effect. (06 marks)

(b) A 100mW beam of light of wave length 4×10^{-7}m falls on a metal surface of a photocell.

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

(ii) If 65% of the photons emit photoelectrons, find the resulting photocurrent. (02 marks)

(iii) Calculate the kinetic energy of each photon if the work function of the metal is 2.2eV (02 marks)

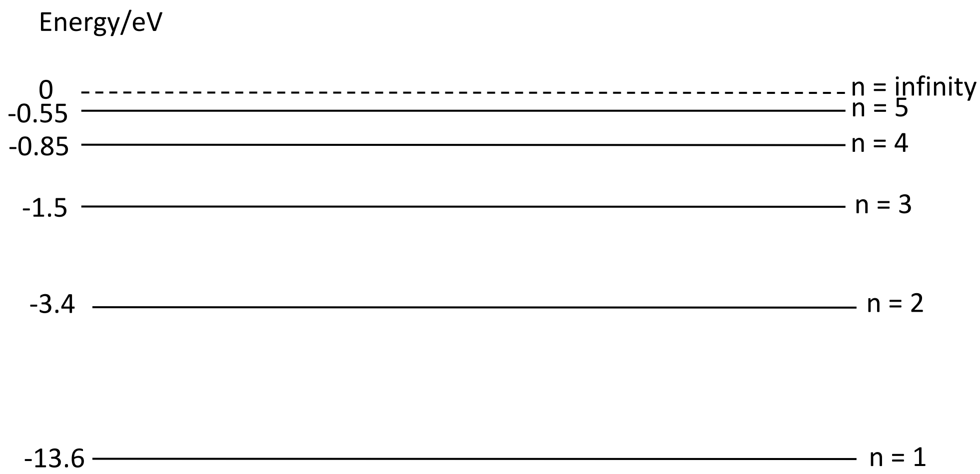
(c) A beam of X-rays of wave length 8.42×10^{-11}m is incident on a sodium chloride crystal of inter planar separation of 28.2nm. Calculate the first order diffraction angle. (02 marks)

10. (a) Define the terms (i) Nucleon number.

(ii) Radio-isotope. (02 marks)

(b) State Bohr's postulates about models of an atom. (03 marks)

(c) The diagram below shows some energy levels of the hydrogen atom.



(i) Redraw the diagram above to indicate the emission of the visible spectrum, infrared rays, and the ultra violet light. (03 marks)

(ii) Calculate the speed of an electron which would just ionize the hydrogen atom. (02 marks)

(d) (i) Define the terms unified atomic mass and binding energy per nucleon as used in nuclear physics. (02 marks)

(ii) Calculate the binding energy per nucleon of iron (Fe) whose atomic mass is 56 and atomic number is 26 given that the mass of one proton is 1.007825U, mass of one neutron is 1.008665U. (1U = 931MeV) (03 marks)

(e) (i) What is meant by the terms radioactive decay and decay constant. (02 marks)

(ii) Show that the half-life of a radioactive isotope is given by $t_{\frac{1}{2}} = 0.693/\lambda$ where λ is the decay constant. (03 marks)

END.

UNMASE UACE PHYSICS P510/1 MARK SCHEME.

	COMMENT(S).
1. a(i) Scalar quantities have no direction ✓ while vector quantities have direction ✓. (01mk)	Emphasis is on direction.
(ii) Scalar quantities – Mass, distance, time, pressure, energy, speed, --- (0½) Vector quantities – Velocity, acceleration, displacement, Momentum, forces--- (0½)	Any one in each (0½)
b(i) $P \propto l^x v^y \delta^z$ ✓ $\Rightarrow P = k l^x v^y \delta^z$	Expressing the relationship.
$[P] = [k].[l]^x.[v]^y.[\delta]^z$. $ML^2T^{-3} = 1 \cdot L^x \cdot (LT^{-1})^y \cdot (ML^{-3})^z$ ✓ $= L^{x+y-3z} \cdot T^{-y} \cdot M^z$.	Getting dimensions of quantities.
Equating powers: (04mks) M; $1 = z \Rightarrow z = 1$. T; $-3 = -y \Rightarrow y = 3$. ✓ L; $2 = x + y - 3z \Rightarrow x = 2 - 3 + 3(1)$ $x = 2$.	Evaluating for x, y and z
$\therefore P = k l^2 v^3 \delta$ ✓	Correct equation obtained.
ii) It is assumed that all the wind energy is converted into electrical energy which is not the case since the velocity; v of air molecules is NOT ✓ reduced to zero. hence the actual power is less than the calculated.	(01mk) Emphasis is on velocity of air molecules not being reduced to zero.

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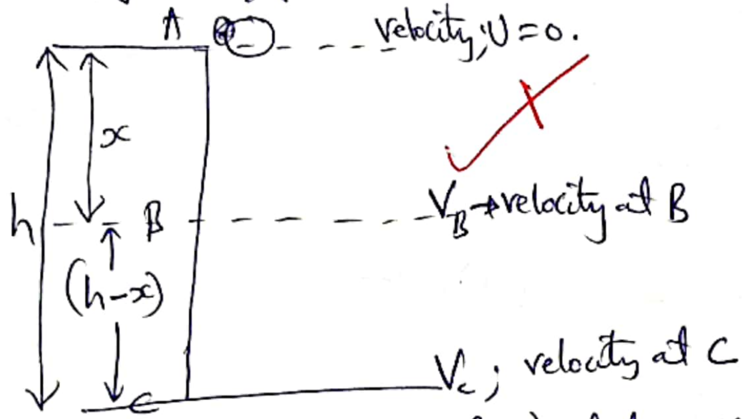
c (i) Total energy in a closed system is always a constant

OR

Energy can neither be created nor lost but changes from one form to another.

(01 mk).

(ii) Consider a body of mass; M falling from rest through a height; h.



Total mechanical energy (M.E) at A $= mgh + 0$
$= mgh.$

M.E at B $= mg(h-x) + \frac{1}{2}mv_B^2$; $V=\sqrt{2gh}$.

$= mgh - mgx + \frac{1}{2}m\left[\sqrt{2gx}\right]^2$

$= mgh.$

(04 mks)

M.E at C

$= 0 + \frac{1}{2}mv_c^2 = \frac{1}{2}m\left(\sqrt{2gh}\right)^2$

$= mgh.$

Since M.E at A = M.E at B = M.E at C, then M.E is conserved.

Expression for M.E MUST be in terms of that due to potential energy.

Deny otherwise.

1 d)(i) Total energy at X = Total energy at Y

$$Mgh_x = \frac{1}{2}Mv_y^2 + mgh_y + \text{Workdone against friction}$$

(04mks)

$$(330 \times 4) = (540) + (330 \times 1.1) + (52 \times d)$$

- Correct substitution

- Answer.

$$d = 8.02m.$$

ii) let U be velocity at Y.

$mg = 330$

$m = \frac{330}{9.81} =$

$= 33.64kg.$

$$\frac{1}{2}mU^2 = 540$$

$$\frac{1}{2} \times 33.64 U^2 = 540$$

$$\therefore U = 5.67ms^{-1}$$

Using $V = \sqrt{V_x^2 + V_y^2}$. $V = u + at$.

At maximum height;

$$V_x = (5.67 \cos 41) + (0 \times t).$$

(04mks)

$$V_x = 4.28ms^{-1}.$$

$$V_y = 0$$

$\therefore$ velocity at maximum height $= \sqrt{(4.28)^2 + 0^2}$

$$= 4.28ms^{-1}$$

Total = 20marks.

2 a(i) Elastic materials - Materials that regain their original shape and size when the stretching [or compressing] is removed. (01mk).

(ii) Plastic deformation - Is the permanent distortion/change in shape (or size) of a body when a streching/compressing/bending/torsion forces are removed. (01mk). Allow condition where materials fail to regain original shape/size where forces are removed.

b(i) - Diameter of the wire for calculation of the cross-sectional are.
- New and original length for calculation of extension.
- Mass [weight]. (03mks).

(ii) Identical wires - To minimise (or eliminate) errors due to changes yielding of support (or due to bending of the support and due to temperature change. (01mk)

(ii) • Long wires as to obtain a measurable extension [or strain]. ~~when~~
• Thin so that there is no need of bigger weights. (02mk).

c (i) At equillibrium, the sum of clockwise moments and sum of anticlockwise moments are equal at the same point. (01mk). Accept. At equillibrium, resultant moment at a point is zero.

(ii) - Resultant moment at a point is zero.
- Resultant forces on the body is zero. (02mks).

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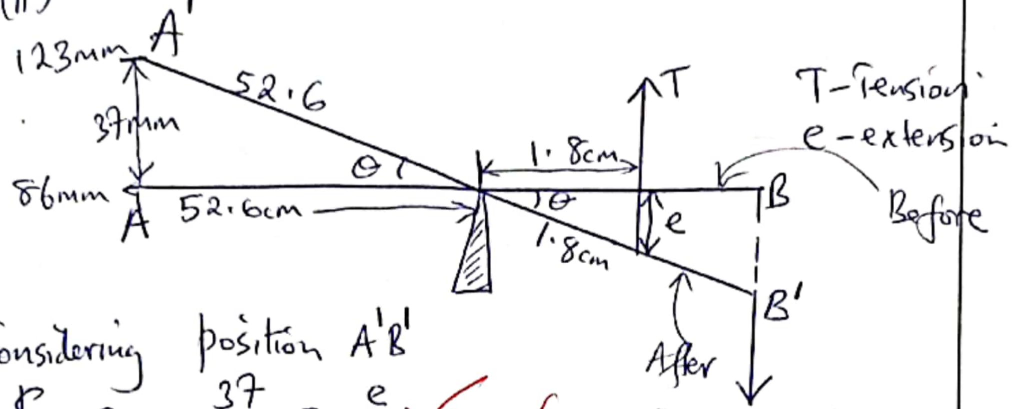
d) (i) Extension of a material is directly to the applied force provided the elastic/proportional limit is not exceeded. (01mk). Condition must be stated.

(ii)



Considering position A'B'

$\tan\theta = \frac{37}{526} = \frac{e}{18}$ (02mks)

$\Rightarrow e = 1.3mm$.

(iii) $T \times 1.8\cos\theta = 0.472 \times 9.81 \times 6.2\cos\theta$

$T = 15.95N$

From $F = ke$

$k = \frac{15.95}{1.3\times10^{-3}} = 12,268\,Nm^{-1}$ (04mks)

(iv) Elastic potential energy $= \frac{1}{2}Fe$ (02mks)

$= \frac{1}{2} \times 15.95 \times (1.3\times10^{-3})$

$= 0.01\,J$

OR

$p.e = \frac{1}{2}ke^2$.

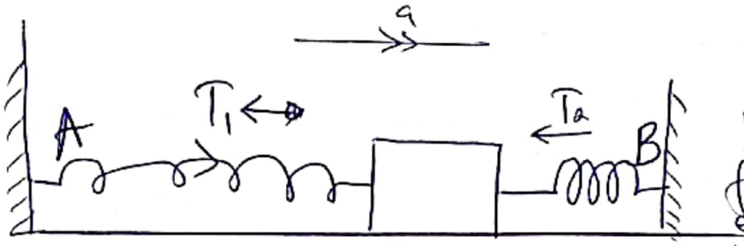
Total = 20 mks

3 a(i) Negative sign means acceleration and displacement are in opposite directions. (01mk)

(ii) - Motion is periodic.
- Mechanical energy is conserved.
- Acceleration is directly proportional to the displacement.

Any 2. (02mks)

b)

(i) 

x - Displacement from the equilibrium position.

Tension; $T_1 = kx$

Compression $T_2 = kx$

Restoring force; $F = ma = -(kx + kx)$

$\Rightarrow a = -\left(\frac{2k}{m}\right)x$ ———— ⊛

Equation ⊛ is in the form $a = -\omega^2 x$ hence the body executes simple harmonic motion.

(04mks).

(ii) $T = \sqrt{\frac{4\pi^2 m}{2k}} = \sqrt{\frac{4\times(3.142)^2 \times 0.25}{2\times 5}}$

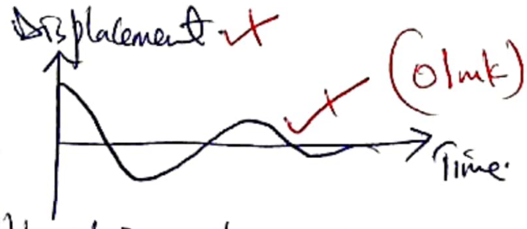
$= 0.993$ seconds.

(02mks)

(iii) 

M.E - Mechanical energy,
A - Amplitude.

(01mk).

(iv) 

(01mk).

On the graph, the amplitude reduces, axes must be labelled.

Application: Shock absorbers in vehicles. (01mk)

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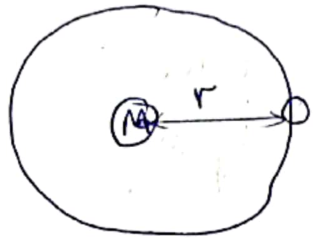
c) (i) Square of period of revolution of planets round the sun is directly proportional to the cubes of the mean (distance) radius of the circular path. (01mk).

(ii) 

Consider a body of mass m orbiting another of mass M. as shown.

Centripetal force $F_1 = m\omega^2 r$ ——(i)

Gravitational force $F_2 = \frac{GMm}{r^2}$ ——(ii)

(03mks).

(i) = (ii)

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

$$\Rightarrow T^2 = \frac{4\pi^2}{GM} r^3$$

$$\therefore T^2 \propto r^3.$$

d(i) • Their period of rotation about the earth is the SAME as that of the earth's spinning/rotation.

• Both satellites and earth rotate [spin] in the same direction. (02mks).

(ii) • Kinetic energy also ~~reduces~~ increases and from K.e = ½mv², ~~it~~ implies that ~~its~~ velocity increases

• Increase in speed/velocity increases the friction between the satellite and air molecules as it enters the earth's atmosphere hence may lead to burning of the satellite. (03mks).

20marks

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4. a(i) Frictional force between adjascent layers of a fluid moving at different velocities. (01mk)

(ii) Frictional force between a solid and a fluid moving relative to one another. (01mk).

b) In liquids;
Increase in temperature weakens/reduces the viscosity in liquids.
This is due to the weakening of intermolecular forces of attraction between molecules of neighbouring layers as temperature increases hence increase in molecular separation and hence speed. (02 mks).

In gases;
Increase in temperature increases the viscosity.
Gas molecules undergo random motion due to negligible intermolecular forces. As temperature increases, the average speed of molecules increases [hence the K.E] or momentum change increases. which in turn increases the viscosity [The side where one faster molecule comes from, its momentum reduces] (02mks).

C (i) For an Incompressible, non viscous fluid undergoing steady/lamina/streamline flow, the sum of pressure, kinetic energy per unit volume, kinetic energy per unit volume at a point is a constant.

The 3 conditions must be stated as well.

(01mk).

(ii) As the trailer by passes, the air molecules between her and the trailer, are made to move faster hence reducing the pressure.

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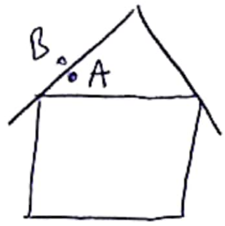
Since the air behind her is at its normal greater atmospheric pressure, the pressure difference creates a resultant force on Jesca towards the middle of the road, hence she feels being "sucked" in. (02mks).

(iii)



A – Air inside [still air]

B – Air outside [moving air].

A and B are almost at the same level.

Using Bernolli's equation;

$$P_A + \tfrac{1}{2}\rho_A V_A^2 + \cancel{\rho_A g h_A} = P_B + \tfrac{1}{2}\rho_B V_B^2 + \cancel{\rho_B g h}$$

$$P_A - P_B = \tfrac{1}{2}\rho\left[V_B^2 - V_A^2\right]$$

$$= \tfrac{1}{2} \times 1.029 \times \left[88^2 - 0^2\right]$$

$$= 3984.3\ Pa.$$

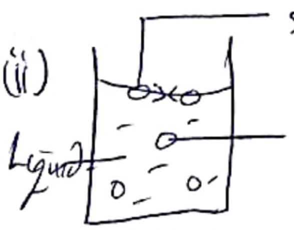
But from $\Delta P = \frac{\Delta F}{A}$ $\Rightarrow F = 3984.3 \times 450$ (04mks)

$= 1792929\ N$

$\simeq 1.8 \times 10^6\ N.$

d(i) Is the work done in creating a unit are of surface of a liquid under isothermal conditions.

(ii)



Molecules attract each other.

Bulk molecules experient No net resultant force on them.

Surface molecules experience a net downward force on them and make the surface to be under tension. (02mks).

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4 d(iii)

Volume of big drop = Total volume of small drops

$$\frac{4\pi}{3}[5\times10^{-3}]^3 = n\times\frac{4\pi}{3}[0.1\times10^{-2}]^3$$

$$\Rightarrow n = 125 \text{ drops}$$

Work done $= \gamma A$

For Big drop; $W.D = 7\times10^{-2}\times4\pi(5\times10^{-3})^2$
$= 2.2\times10^{-5}J$

(04 mks)

Total workdone for small drop, $= 125\times7\times10^{-2}\times4\pi(0.1\times10^{-2})^2$
$= 1.1\times10^{-4}J$

$\Delta W.D = \underline{\underline{8.8\times10^{-5}J}}$

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5 a(i) Physical property that varies linearly and continuously with temperature change. (01mk).

(ii) - Have a wide range of temperatures i.e can measure

- Must vary linearly and continuously with temperature change.
- Must be sensitive to slight temperature changes.
- Must be accurately measurable by simple apparatus

Any four (02mks).

iii) $R_\theta = R_0[1 + b\theta + a\theta^2]$

$R_0 = R_0$ —— (i)

$R_{100} = R_0[1 + 100b + 10{,}000a]$ —— (ii)

$R_{200} = R_0[1 + 200b + 40000a]$ —— (iii)

$$\theta = \frac{\cancel{R_0}[\cancel{1} + 200b + 40000a - \cancel{1}]}{\cancel{R_0}[\cancel{1} + 100a + 10{,}000a - \cancel{1}]} \times 100°C$$ (04mks)

$$= \frac{(200 \times 3.8 \times 10^{-3}) - (40{,}000 \times -5.6 \times 10^{-7})}{(100 \times 3.8 \times 10^{-3}) - (100{,}000 \times -5.6 \times 10^{-7})} \times 100°C$$

$= 202.9°C$

iv) - Different thermometers are designed to measure temperatures of different bodies.

- They use different thermometric properties which vary differently with temperature changes.

(02mks)

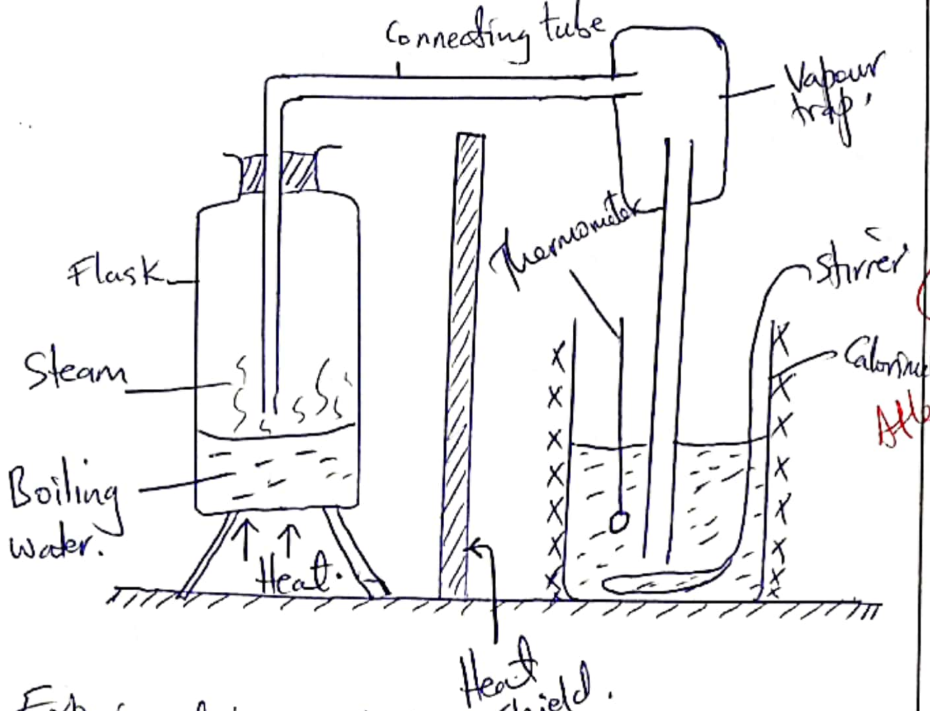
b) (i) - By lagging.

- Covering [minimise convection].
- Making/Painting surfaces white/silvery.
- Carrying out experiments at steady state.

(02mks) Any 3 - (2m) less than 3 (1m

13/

180



(02mks) Any 4 parts correctly labelled.

Experiment is set up as shown ~~below~~ above with a calorimeter of known specific heat capacity C_c and mass M_c. Water of known mass M_w and specific heat capacity C_w is also poured into the calorimeter and the initial temperature θ_1 recorded.

Before the connecting tube is put in position, water in the flask is heated until it boils and then tube replaced. (02mks)

After some some time, new temperature θ_2 is noted.

Mass of condensed steam M_s is obtained by subtracting total mass of the calorimeter before and after connecting the tube.

Assuming no heat losses to the surrounding, the specific latent heat of water, L_v is obtained from

$$L_v = \frac{(M_wC_w + M_cC_c)(\theta_2-\theta_1) - M_sC_w(100-\theta_2)}{M_s}$$

100°C is the Boiling pt of water.

c (i). • During fusion, molecules are still some how close to each other and so less heat is used to weaken the bonds hence change of state.

• During vapourisation however molecules are far apart and so heat supplied breaks the bonds in addition to doing work against atmospheric pressure.

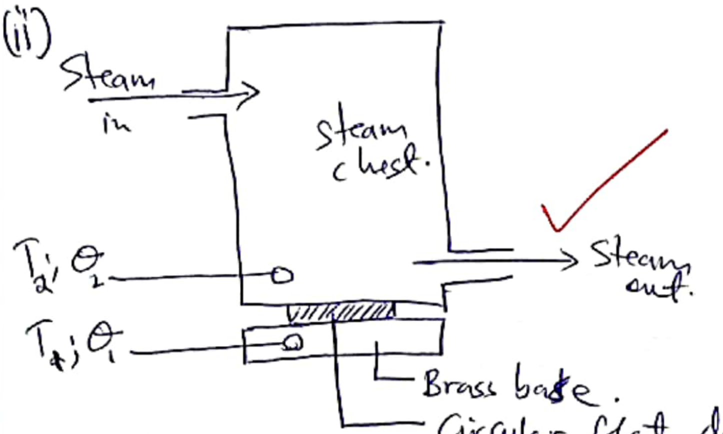
(03mks)

20mks

6 a(i) Thermoconductivity — Rate of heat transfer through a material per unit cross-sectional area per unit temperature gradient when heat flows normal to the cross-sectional area. (01mk)

Temperature gradient — Temperature fall per unit length of a conductor. (01mk).

(ii)



T_1, T_2 – Thermometers.

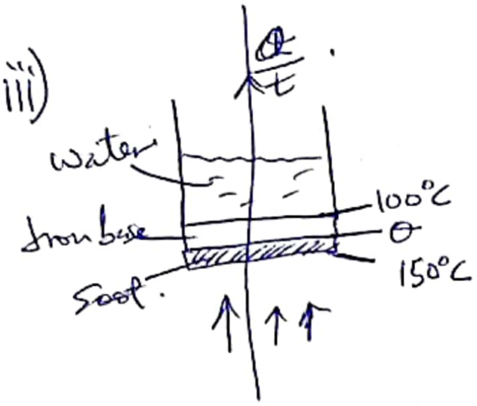
- The experimental setup is as shown above with a brass base of known specific heat capacity, c and mass, M and a plastic disc of thickness, L known.
- Experiment is left to run until thermometers T_1 and T_2 give constant readings θ_1 and θ_2 respectively.
- Disc is then removed and the steam chest heats the brass directly until temper θ_2 is about 10°C above θ_1
- Steam chest is removed, disc replaced and the temperature fall is recorded at regular time intervals.
- At temperature θ_1, the slope, $s = \frac{\Delta\theta}{\Delta t}$ of a graph of temperature against time is determined.
- Thermo conductivity, k is then obtained from (06mks).

16/

$$K = \frac{mcL \times \text{slope}}{A(\theta_2 - \theta_1)}$$

where A is the cross-sectional area of the disc.

iii)



For Iron and water

$$\frac{dQ}{dt} = 66 \times 0.05\left(\frac{\theta - 100}{2.5\times10^{-3}}\right) = \frac{10\times10^{-3}}{1} \times 2200\times10^{3}$$

$$\Rightarrow \theta = 116.7°C$$

For Soot and Iron

$$\frac{dQ}{dt} = K \times A\left(\frac{150 - 116.7}{0.5\times10^{-3}}\right) = 66\,A\frac{(116.7 - 100)}{2.5\times10^{-3}}$$

$$K = 6.62\,Wm^{-1}K^{-1}$$

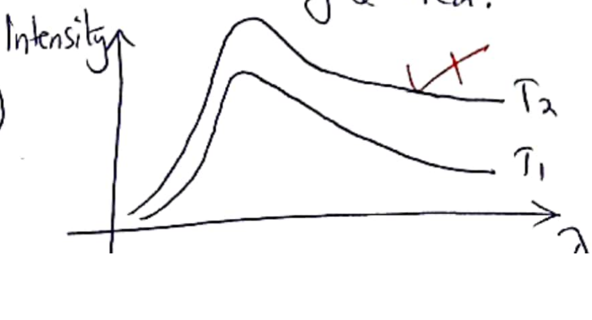
(04mks).

b(i) Stephan's law; Power of radiations emitted from a black body per unit area is directly proportional to the fourth power of the absolute temperature.

Instead of power, accept energy per unit time.

(ii) Intensity – Power incident normally per unit surface area.

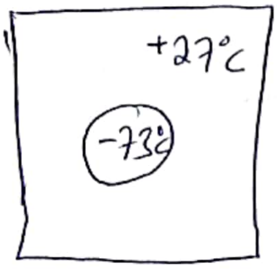
(iii)



$T_2 > T_1$.

(01mk).

6 (c)



$$\frac{dQ}{dt} = mc\frac{\Delta\theta}{\Delta t} = \sigma A(T_s^4 - T_0^4)$$

$$800 \times \frac{4}{3}\pi(30\times10^{-3})^3 \times 400\frac{\Delta\theta}{\Delta t} = 5.67\times10^{-8} \times 4\pi(30\times10^{-3})^2 \times [300^4 - 200^4]$$

(04mks).

$$\Rightarrow \frac{\Delta\theta}{\Delta t} = 0.115\,Ks^{-1}$$

20mks

15/.

7 a(i) States that the volume of a fixed mass of a gas is directly proportional to it's absolute temperature at constant pressure. (01mk)

(ii) $P = \frac{1}{3}\rho \overline{c^2}$

$P = \frac{1}{3}\frac{NM}{V}\overline{c^2}$

$PV = \frac{2N}{3}\left(\frac{1}{2}m\overline{c^2}\right)$ but $\frac{1}{2}m\overline{c^2} = \frac{3}{2}k_BT$

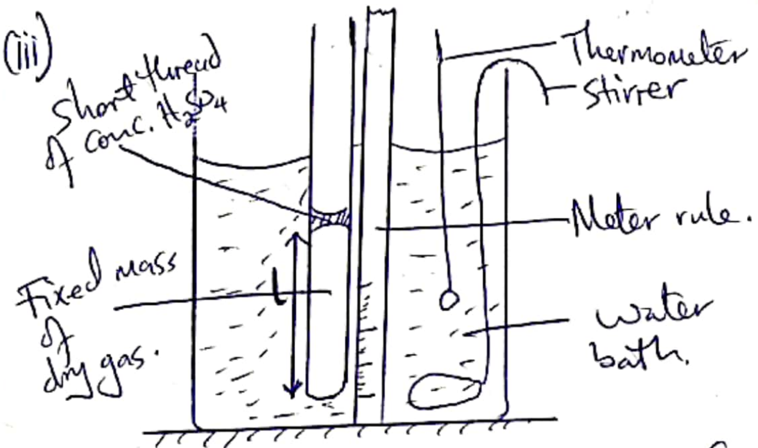
Accept K.e $\propto$ T.

$\Rightarrow PV = Nk_BT$

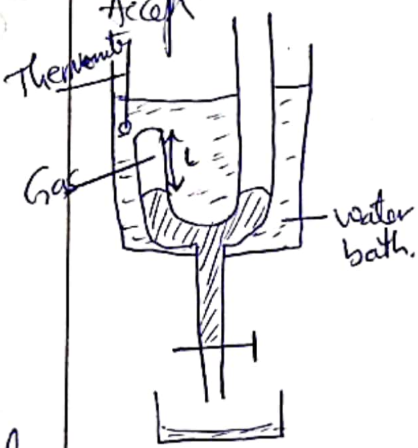
$V = \left(\frac{Nk_B}{P}\right)T$

$\therefore V \propto T$ hence charle's law.

(iii)



Accept



- Set up is as shown above with a fixed mass of a gas enclosed in a capillary tube placed in a water bath.
- Capillary tube is of a uniform cross-sectional area A and gas is of length L; volume V=AL, $V \propto L$.
- Temperature; θ is measured using a thermometer.
- Steam is passed through the water bath and at constant temperature, length; L is measured and recorded. Repeat for other temperatures.
- A graph of volume [or length] against temperature is plotted and a straight line graph with a positive gradient is obtained. This verifies charle's law.

/19

7 b(i) - Intermolecular force are negligible.
- Volume of gas is negligible compared to volume of container. (02 mks).

(ii) $\frac{a}{V^2}$;
Due to attractive forces in real ~~gas~~ gases, molecules approaching the wall of the container experience an attractive force from the bulk molecules which in turn reduce their momentum hence reduction in pressure onto the walls/molecules. (02 mks)
Therefore an extra pressure $\frac{a}{V^2}$ must be added onto the observed pressure. hence the expression $(P + \frac{a}{V^2})$.

b;
Due to repulsive forces, molecules approaching each other experience a repulsive force which increases as the separation reduces. Therefore there is a volume (total volume of b) in which molecules can not occupy. (02 mks)
Therefore the volume of free movement of gas molecules is not; V but rather $(V - b)$.

c (i) Pressure exerted by a vapour which is in thermodynamic equillibrium with its own liquid. (01 mk)
Emphasis - thermodynamic equillibrium

(ii) No effect observed
When volume increases, the rate of evaporation increases but rate of condensation reduces only for a short while and the equillibrium is retained.
When the volume reduces, rate of evaporation remains constant but that of condensation increases for a short while until equillibrium is re-instated. (03 mks).

(iii) 

(01 mk).

Axes — 0½
Relation — 0½

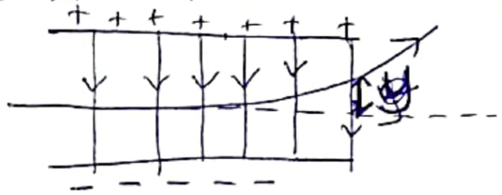
21

8 (a)(i)

Cathode rays	Positive rays.
- Negatively charged	- Positively charged.
- Very light	- Massive compared to cathode rays.
- Travel at the same speed.	- Have a range of velocities.
- Have a higher penetrating power.	- Have a low penetrating power.
- Produce X-rays when they bombard matter	- Not

Any two. (02mks)

(ii)



let the vertical deflection be y

As the electron enters the plates, it's

Work done = Kinetic energy

$eV = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2eV}{m}}$

$= \sqrt{\left(\frac{2 \times 1.6\times10^{-19} \times 3\times10^{3}}{9.11\times10^{-31}}\right)}$

$= 3.25\times10^{7} m/s$

At the point of exit;

vertical displacement, $y = \frac{1}{2}at^2$

$F = ma = Eq$

$= \frac{V}{d}q.$

$\Rightarrow a = \frac{1\times10^{3} \times 1.6\times10^{-19}}{5\times10^{-2} \times 9.11\times10^{-31}}$

$= 3.51\times10^{15} ms^{-2}.$

Also speed $= \frac{distance}{time}$

$\Rightarrow t = \frac{10\times10^{-2}}{3.27\times10^{7}}$

$= 3.08\times10^{-9}s$

$\therefore y = \frac{1}{2} \times 3.51\times10^{15} \times (3.08\times10^{-9})^2$

$= 1.66\times10^{-2} m.$

(05mks)

(iii) As the ~~plates~~ electron moves between the plates, they describe a parabolic path.

At any time, t its horizontal component of velocity is a constant because it experiences no net force in this direction.

The vertical component of velocity however changes due to a net vertical force; $F = \vec{E}e$.

(02mks).

/22

b(i) - Measuring voltage of both a.c and d.c
- Measuring the phase difference. (02mks).
- Displaying wave forms.

Any 2 (02mks)

(ii) From $V_{rms} = \frac{V_o}{\sqrt{2}}$

For $6Vcm^{-1}$; ⇒ Peak-to peak voltage $= 6 \times 4$
$= \underline{24V}$

$\Rightarrow 2V_o = 24 \quad \Rightarrow V_o = 12V$

(03mks)

$\therefore V_{rms} = \frac{12}{\sqrt{12}} = \underline{8.49V}$

For 2 cycles; $t = 0.01s$
$\Rightarrow T = \frac{0.01}{2} = 0.005s$

$\therefore f = \frac{1}{T} = \frac{1}{0.005} = \underline{200Hz}$ (02mks)

OR $f = \frac{n}{t} = \frac{2}{0.01}$
$= 200Hz.$

(c) (i) When the anode potential is not high enough to attract all the emitted electrons from the cathode, an electron cloud that is nearly stationary is formed around the cathode. This is called a space charge and it exerts a repulsive force to more electrons emitted from the cathode.

If the emitted electrons are finally prevented from reaching the anode, the anode current reduces and hence the term anode current being space charge limited.

(03mks)

(ii) Occurs when the anode potential has a high value such that all electrons emitted by the cathode reach the anode.

(01mk)

20 marks

9 a(i) A photon is a packet of energy of electromagnetic radions. (01mk).

(ii) - Number of photo electrons emitted per second is proportional to the intensity of the incident radiations.

- The photoelectrons are emitted with a range of kinetic energies ranging ~~with~~ from zero to a maximum that increases as the frequency of the radiation increases but it is independent of intensity of the incident radiation.

- There is negligible time lag between irradiation and emission of electrons from the metal surface. (04mks)

- For any given metal surface, there is a threshold frequency of radiations below which no emission occurs.

iii) Instantaneous electron emission;

According to the wave (classical) theory, the radiation ~~of~~ energy is spread over a wave front and since the energy that is incident on one electron is so small, there would be a time lag during which the electron continues to absorb/accumulate enough energy so as to escape but this is not the case as there's no time lag. (02mks)

Existance of threshold frequency;

As per the wave theory, there would be a continuous absorption of energy by the electron so that any frequency [or λ] of incident radiation would cause emission no matter how intense it. However, it's observed that the threshold frequency exists and this is a failure. (02mks)

Variation of maximum kinetic energy of emitted electrons with frequency.

The wave theory suggests that increasing the intensity of the incident radiation would increase the energy per unit area hence more energy absorbed and consequently an increase in the maximum kinetic energy. (02mks).

However, the maximum kinetic energy is observed to depend on frequency of incident radiation but not its intensity.

b(i) Energy of a photon; $E_o = hf = h\frac{c}{\lambda}$

$$= \frac{6.6\times10^{-34} \times 3\times10^{8}}{4\times10^{-7}}$$

$$= 4.95\times10^{-19}\,J.$$

$\Rightarrow$ Total photons energy per second = Power of the incident radiation.

$$n \times 4.95\times10^{-19} = 100\times10^{-3}$$

$$n = 2\times10^{17} \text{ photons.}$$

(03mks)

Accept. $E = Ve$, $V = \frac{E}{e}$

$P = IVt = \frac{n.e}{t}.\frac{E}{e}.t$

$P = nh\frac{c}{\lambda}$

$n = \frac{P\lambda}{hc}$

$=$

$= 2\times10^{17}.$

(ii) $I = \frac{Q}{t} = \left(\frac{n}{t}\right).e$

If 65% is used then

$$I = \frac{65}{100} \times 2.0\times10^{17} \times 1.6\times10^{-19}$$

$$= 0.02A.$$

(02mks)

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

$\therefore k.e = hf - hf_o.$

$$= 4.95\times10^{-19} - 2.2\times10^{-19}$$

$$= 1.43\times10^{-19}\,J$$

(02mks)

c(c) Using $2d\sin\theta = n\lambda$

$$2\times2.82\times10^{-10}\sin\theta = 1\times 8.42\times10^{-11}$$

$\Rightarrow \theta = 8.6°.$ (02mks)

25/. 20mks

25

10a a (i) Total number of protons and neutrons in the nucleus of an atom.

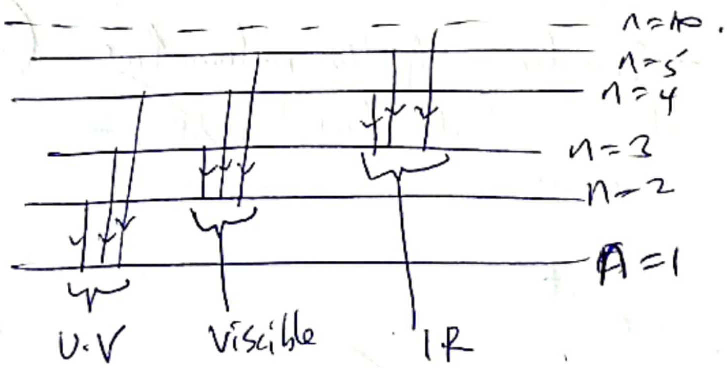
(ii) Radio-Isotope — Atoms of the same radioactive element with same number of protons but different number of neutrons. (02mks)

b (i) Electrons revolve round the nucleus ONLY in certain allowed orbits and while in these orbits, they do not emit radiations.

An electron can jump from one orbit of a higher energy level to one with a lower one hence emitting radiations.

The angular momentum of electrons are whole number multiples of $\frac{h}{2\pi}$ where h is plank's constant. (03mks)

c (i)



(ii) $\frac{1}{2}M_eU^2 = 0 - E_1$

$\frac{1}{2} \times 9.11 \times 10^{-31} U^2 = 0 - -13.6 \times 1.6 \times 10^{-19}$

$U = 2.186 \times 10^6 ms^{-1}$. (02mks)

d (i) Unified atomic mass — Is the $\frac{1}{12}$th of the mass of a Carbon-12 Isotope.

(ii) Binding energy per nucleon — Total energy needed to split up the nucleus into its component (individual) protons and neutrons per the mass number of the atom. (02mks)

(ii) $^{56}_{26}Fe \longrightarrow 26\,^1_1p + 30\,^1_0n + \text{energy}$.

Mass for ^{56}Fe = 56.0U

" $26\,^1_1p$ = $26 \times 1.0078250U = 26.20345U$?

" $30\,^1_0n$ = $30 \times 1.0086650U = 30.25995U$] Total on the right.

Binding energy = $(26.20345U + 30.25995U) - 56U$

= 0.4634U

= 0.4634×931 = 431.4254MeV. (03mks).

$\therefore$ B.E per nucleon = $\frac{431.4254}{56}$

= 7.704025MeV

(e) (i) Radioactive decay – Spontaneous disintegration of an Unstable nucleus so as to attain stability by emission of alpha and beta particles plus gamma rays.

Decay constant – Fraction of the radioactive atoms which disintegrate per second. (02mks).

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

when $t = t_{1/2}$, $N = \frac{N_0}{2}$

$\Rightarrow \frac{N_0}{2} = N_0 e^{-\lambda t_{1/2}}$.

$\ln\left(\frac{1}{2}\right) = \ln e^{-\lambda t_{1/2}}$ (03mks)

$-0.693 = -\lambda t_{1/2}$

$\therefore t_{1/2} = \frac{0.693}{\lambda}$.

Total 20mks

≡ END ≡