P510/1
PHYSICS
Paper 1
August 2023
2½ hours

UGANDA ADVANCED CERTIFICATE OF EDUCATION
END OF TERM II EXAMINATIONS 2023
SENIOR FIVE
PHYSICS
PAPER 1

Time: 2 ½hours

Instruction

- Answer five questions, including at least one but not more than two from each of the sections A, B and C

Assume where necessary

- Acceleration due to gravity (g) = $9.8ms^{-2}$
- Electron charge (e) = $1.6x10^{-19}c$
- Electron mass (m) = $9.11x10^{-31}kg$
- Plank`s constant (h) = $6.6x10^{-34}Js$
- Gass constant (R) = $8.31Jmol^{-1}k^{-1}$

SECTION A

1. (a)(i) Define linear momentum and state its units (02 marks)

   (ii) State the law of conservation of linear momentum. (01 mark)

   (b) A horse pipe has a cross section area of $50cm^2$ and ejects water horizontally t a speed of $0.3ms^{-1}$. If the water is incident on a vertical wall and its horizontal velocity becomes zero, find the force the water exerts on the wall. (04 marks)

   (c) For uniformly decelerated motion, sketch

   (i) a displacement time graph (1 ½ marks)

   (ii) a velocity time graph (1 ½ marks)

   (d) A projectile is fi~~x~~ed in air with a speed U at an angle $\propto$ to the horizontal. Show that the path of the projectile is parabolic. (04 marks)

   (e) A bullet of mass 20g travelling at $100ms^{-1}$ embeds in the centre of the block of wood of mass 1kg suspended by a light vertical inelastic string of length 1.0m

   (i) State the factor upon which the angle of swing θ , depends. (01 mark)

   (ii) Calculate the maximum angle of inclination of the string to the vertical. (05 marks)

2. (a) What is meant by relative velocity? (01 mark)

   (b) A ship is heading due North at a speed of $30kmhr^{-1}$. Water in the lake is moving in the north-East direction at an average speed of $5kmhr^{-1}$. Calculate the;

   (i) Velocity of the ship. (04 marks)

   (ii) Distance off course the ship will be after. 40 minutes (02 marks)

   (c) (i) Explain why a passenger in a car jerks forward when the brakes are suddenly applied. (03 marks)

   (ii). Use Newton's second law to define a Newton. (04 marks)

(d) Three forces of 8.0N, 12.5N and 2.0N act on a body of mass 0.7kg as shown in the figure 1 below.

8.0N 12.5N

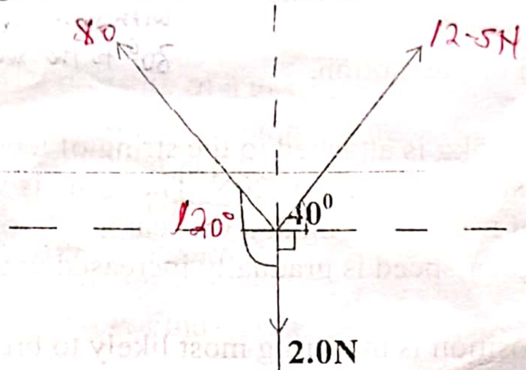


Fig: 1

Calculate the acceleration of the body. (06 marks)

3. (a) State the laws of solid friction. (04 marks)

(b) (i) Describe an experiment to determine the coefficient of static friction. (04 marks)

(ii). A block of mass 5.0kg resting on the floor is given a horizontal velocity of $5.0ms^{-1}$ and comes to rest in a distance of 7.0m. Find the coefficient of kinetic friction between the block and thefloor. (04 marks)

(c) Two pendula of equal length (l) have bobs A and B of masses 3M and M respectively. The pendula are hung with the bobs in contact as shown in figure 2.

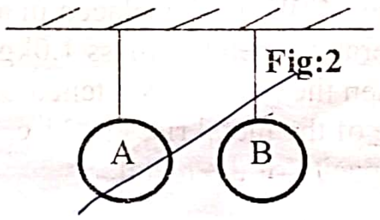
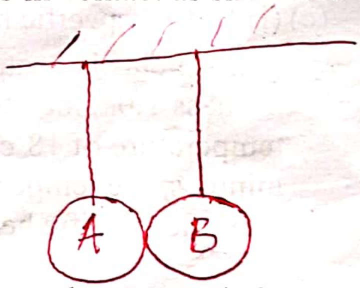


Fig:2



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

4. (a) Define the following s applied to circular motion.

(i) Angular velocity (01 mark)

(ii) Centripetal acceleration (01 mark)

(iii) Centripetal force. (01 mark)

(b) An object moves in a circular path of radius (r) with a uniform speed (v). Derive an expression for its acceleration. (04 marks)

(c) A pendulum bob of mass 0.2kg is attached to one end of an inelastic string of length 1.2m. The bob moves in a horizontal circle with string inclined at 30° to the vertical. Calculate;

(i) the tension in the string (02 marks)

(ii) the period of the motion. (04 marks)

(d) A stone of mass 0.5kg is attached to the string of length 0.5m which breaks if the tension in it exceeds 20N. The stone is whirled in a vertical circle, the axis of rotation being at a vertical height of 1.0M above the ground. The angular speed is gradually increased until the string breaks.

(i) In what position is the string most likely to break? (01 mark)

(ii) At what angular speed will the string break? (03 marks)

(iii) Find the position where the stone hits the ground when the string breaks. (03 marks)

SECTION B

5. (a) Define a thermometric property and state any four commonly used thermometric properties. (03 marks)

(b) With the aid of a labeled diagram, describe how an optical pyrometer is used to measure the temperature of a hit body. (06 marks)

(c) (i) Define specific heat capacity. (01 mark)

(ii). An elastic heater rated 48W, 12V is placed in a well lagged metal of mass 1.0kg at a temperature metal of mass 1.0kg at a temperature of 18^0c. When the power is switched on for 5 minutes, the temperature of the metal rises to 34^0c.
Find the specific heat capacity of the metal. (04 marks)

(d) State Newton's law of cooling and use it to show that $\frac{d\theta}{dt} = {}^{-}k(\theta - \theta_R)$ where $\frac{d\theta}{dt}$ is the rate of fall of temperature and Θ_R is the temperature of the surrounding. (03 marks)

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

6. (a)(i) Distinguish between an adiabatic and an isothermal change of a gas. (02 marks)

(ii). Define molar heat capacity of a gas at constant pressure Cp. (01 mark)

(iii) Explain why the molar heat capacity at constant volume Cv differs from the molar heat capacity at constant pressure Cp. (02 marks)

(iv) Derive n expression for the difference between Cp and Cv for (n) moles of a gas. (04 marks)

(b)(i) Define partial pressure of a gas. (01 mark)

(ii). State Dalton's law of partial pressure. (01 mark)

(iii) A sealed container at a temperature of 27^0c contains air and saturated vapor. The total pressure inside the vessel is $1.0x10^5pa$. If saturated vapour pressure of water at27^0c is $2.1x10^3pa$ and the total pressure inside the container is $1.184x10^5pa$ when the temperature is raised to 80^0c. Find the saturation vapour pressure of water at 80^0c. (04 marks)

(c). One mole of an ideal gas is initially at a pressure of $1.0x10^5pa$ and temperature 25^0c. It undergoes a reversible adiabatic expansion to twice its volume, followed by a reversible isothermal compression to its original volume. Calculate the final ~~comparative~~ temperature and pressure of the gas $(Take\gamma = 1.4)$ (05 marks)

7. (a) Differentiate between conduction and convection (02 marks)

(b) Describe an experiment to determine the thermal conductivity of glass. (07 marks)

(c) (i) Define a black body. (01 mark)

(ii). State Stefan's law of black body radiation

(d) Describe an experiment to show how infrared radiation may be detected using a bolometer. (05 marks)

(e) The Earth receives energy from the sun at the rate of $1400Wm^{-2}$. If the ratio of the radius of the earth to sun's radius is 216. Calculate the surface temperature of the sun. (04 marks)

SECTION C

8. (a) Define the term;

(i) Decay constant (01 mark)

(ii) Half-life (01 mark)

(b)(i) Derive an expression for the relationship between half-life and decay constant. (Assume decay law$N = Noe^{-\lambda t}$) (03 marks)

(ii). A radioactive isotopes isotope ${}^{99}_{43}X$ decay by emission of a gamma ray. The half-life of the isotope is 360 minutes. What is the activity of 1mg of the isotope? (06 marks) (c). With the aid of a labeled diagram, describe the structure and action of a cloud chamber. (05 marks)

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

9. (a) What is meant by the following
   (i) Work function (01 mark)
   (ii) Threshold frequency (01 mark)
   (iii) Threshold wave length (01 mark)

(b) State the laws of photoelectric emission. (04 marks)

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

(d)(i) Define unified atomic mass unit and binding energy per nucleon. (02marks)

(e) 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)

10.(a)(i) State and explain the observations made in Rutherford`s alpha particle experiment with a thin gold foil. (06 marks)

(ii). Explain why the above experiment carried out in a dark room and why it has to be evacuated. (02 marks)

(b)(i) Show that when an alpha particles collides head on with an atom of atomic number z, the closest distance of approach to the nucleus, χ_0 is given by; $\chi_0 = \frac{Ze^2}{\pi\varepsilon_o mv^2}$ where all symbols carry usual meaning. (04 marks)

(ii). In a head on collision between an alpha particles and a gold nucleus, the minimum distance of approach is $5x10^{-14}$m.
Calculate the energy of the alpha particles ($in\ Mev$)
(Atomic number of gold = 79) (03 marks)

(c) (i) Define a Bohr atom. (01 mark)

(ii). The diagram below shows some of the energy levels of mercury atom in ev.

$0ev$	$n=\infty$
$^{-}2.71ev$	$n=6$
$^{-}3.74ev$	$n=5$
$^{-}4.98ev$	$n=4$
$^{-}5.55ev$	$n=3$
$^{-}5.77ev$	$n=2$
$^{-}10.44ev$	$n=1$

Calculate the speed of the electrons which can ionize the atom. (04 marks)

END

Seluumu Ronald,
Physics Department Lukwanga S.S

9:35
15

MARKING GUIDE

P510/1 PHYSICS PAPER ONE

E-O-T II

SENIOR FIVE

Question one

1 a (i) - Linear momentum is the product of mass and Velocity of body moving in a straight line.

- Its S.I unit is $kgms^{-1}$ 02

ii) For a system of colliding objects, their total linear momentum remains constant provided no external forces act on the system. 1

b) Force exerted = Rate of change in momentum

$= \frac{m}{t}(u-v)$ But $v = 0$

$F = \frac{mu}{t}$

But mass per second, $\frac{m}{t}$ = density x Volume per second 04

$\frac{m}{t} = \rho(Au)$

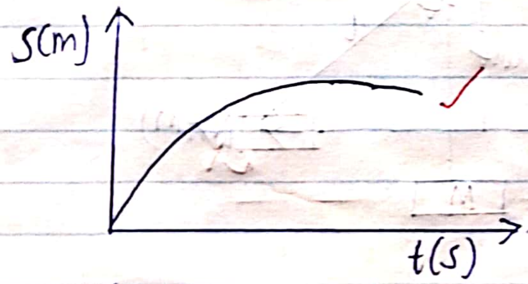
$\therefore F = \rho A u^2$

$= 1000 \times (50 \times 10^{-4}) \times (0.3^2)$

$F = 0.45N$

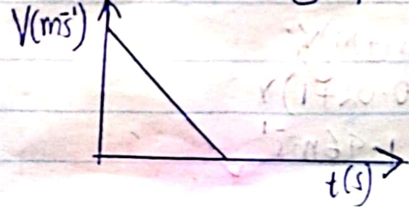
1.c

(i) Displacement time graph.



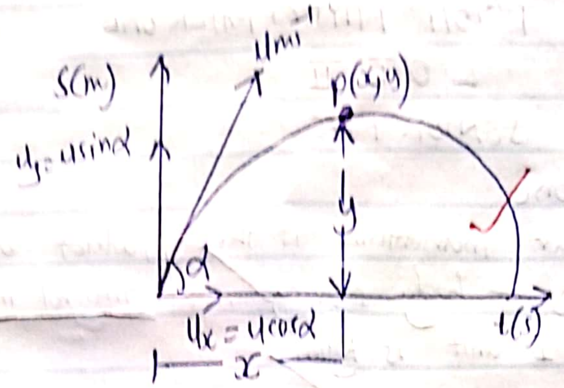
1

ii) a Velocity time graph



1

1 d)



$\therefore$ Horizontal distance $x = u_x t$

$$x = (u\cos\alpha)t$$

$$\therefore t = \frac{x}{u\cos\alpha} \quad \text{--- (1)}$$

Using $s = ut + \frac{1}{2}at^2$ and Considering Vertical motion;

$$y = (u\sin\alpha)\left(\frac{x}{u\cos\alpha}\right) - \frac{1}{2}g\left(\frac{x}{u\cos\alpha}\right)^2$$

$$y = x\tan\alpha - \frac{gx^2}{2u^2\cos^2\alpha}$$

$$y = x\tan\alpha - \left(\frac{g(1+\tan^2\alpha)}{2u^2}\right)x^2$$

4

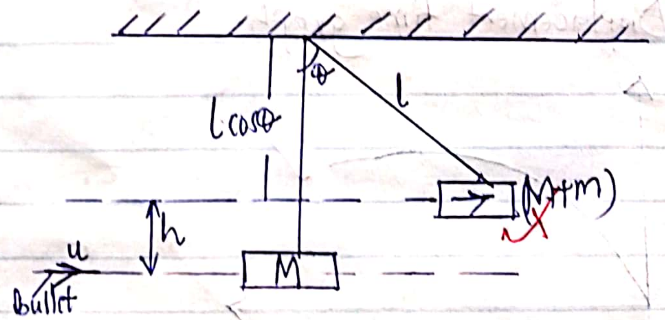
---

e) (i) θ depends on; - length of the string.
- Final velocity attained by bodies

Any 1 correct

1

ii)



From the Conservation of linear momentum;

$$mu = (m+M)v$$

$$0.02 \times 100 = (0.02+1)v$$

$$v = 1.96\,ms^{-1}$$

From the Conservation of energy;

K.E just after collision = P.E of the system

$$\frac{1}{2}(m+M)v^2 = (m+M)gh$$

But $h = l - l\cos\theta = l(1-\cos\theta)$

$$\frac{v^2}{2} = gl(1-\cos\theta)$$

$$1-\cos\theta = \frac{v^2}{gl}$$

$$\cos\theta = 1 - \frac{v^2}{gl}$$

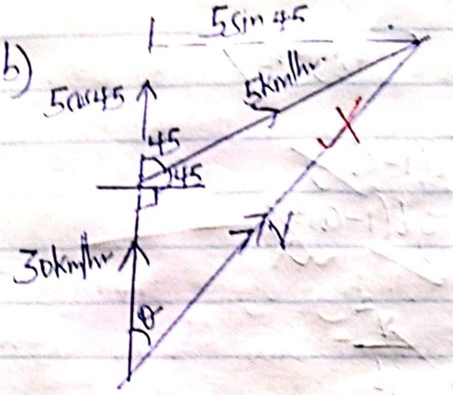
$$\theta = \cos^{-1}\left(1 - \frac{1.96^2}{9.81 \times 1}\right)$$

$$\theta = 78.7^\circ$$

5

Question 2

i) Relative velocity is the velocity with which a body moves as observed from another body. 1



By cosine rule;

$$V^2 = 30^2 + 5^2 - 2(5)(30)\cos(90+45)$$

$$V^2 = 925 - 300\cos 135$$

$$V = \sqrt{925 - 300\cos 135}$$

$$V = 33.72 \text{ km/hr}$$

Alternatively;

By Pythagoras theorem;

$$V^2 = (30 + 5\cos 45)^2 + (5\sin 45)^2$$

$$V^2 = 1137.132$$

$$V = 33.72 \text{ km/hr}$$

Direction; $\frac{5}{\sin\theta} = \frac{33.72}{\sin 135}$ (By Sine rule)

$$\theta = 6.0°$$

$\frac{\quad}{4}$

ii) Distance $d = V_x t$

$$= (5\sin 45) \times \frac{40}{60}$$

$$= 2.36 \text{ km}$$

$\frac{\quad}{2}$

C(i) Before the brakes are applied, both the passenger and car are moving with the same velocity. When brakes are applied, the force is exerted on the car and not the passenger. The passenger thus tends to continue moving in the straight line because of inertia. 3

ii) Consider a body of fixed mass, m acted upon by a constant force F and its velocity changes from u to v in time t.

Change in momentum $= (mv - mu)$

By Newton's second law $F \propto \frac{mv - mu}{t}$

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

$F = kma$ since $a = \frac{v-u}{t}$

for $F = 1N$, $m = 1kg$ and $a = 1ms^{-2}$ $\Rightarrow k = 1$

$\therefore F = ma$

A newton is therefore a force which gives a mass of 1kg an acceleration of $1ms^{-2}$. 4

d)

Force (N)	Resolving Force	
	horizontally	Vertically
8.0	$-8\cos 30 = -4\sqrt{3}$	$8\sin 30 = 4$
2.0	0	-2
12.5	$12.5\cos 40$	$12.5\sin 40$
Sum	2.647	10.035

Resultant Force $F = 2.647i + 10.035j$

$|F|^2 = 2.647^2 + 10.035^2$

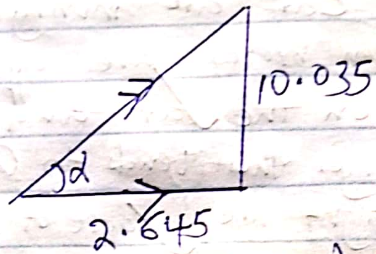
$|F| = 10.38N$

But $|F| = ma$

$10.38 = 0.7a$

$a = 14.829ms^{-2}$ 05

Direction of acceleration:



$$\theta = \tan^{-1}\left(\frac{10.035}{2.645}\right)$$

$$\theta = 75.2^{\circ}$$

01

Question 3

a) Laws of Solid friction;

- Frictional force acts parallel to the two surfaces in contact and in a direction so as to oppose their relative motion.

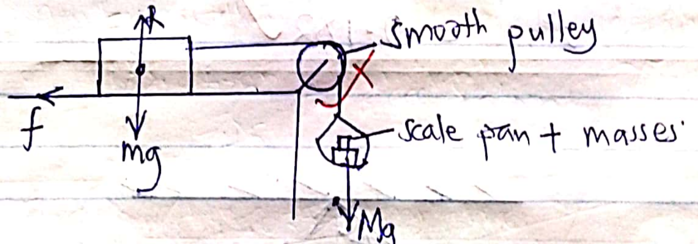
- The frictional force is independent of the area of contact ~~prate~~ of the given surfaces provided the normal reaction is constant but depends on the nature of the surfaces in contact.

- For given pair of surfaces in contact and are at rest, the limiting frictional force is directly proportional to the normal reaction ie $f \alpha R \Rightarrow F = \mu_s R$.

- For two surfaces in contact and are in motion, the sliding frictional force is directly proportional to the normal reaction and is independent of the relative velocity of the surfaces.

4

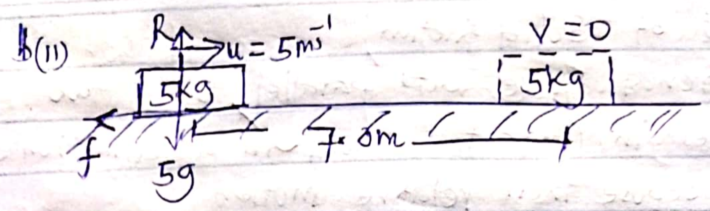
b(i) <u>Determination of Coefficient of static friction μ_s</u>



A wooden block of known mass m is connected to a scale pan by a string passing over a smooth pulley as shown above.
Masses are added to the scale pan until the block just slides. The total mass M of the scale pan and masses added is noted.
The coefficient of static friction μ_s is determined from $\mu_s = \frac{M}{m}$

4

b(ii)



Resultant Force, $F = 0 - f$

$ma = -\mu R$

But $m = 5kg$ and $R = 5g$

$5a = -5g\mu$

$a = -g\mu$ ——— (1)

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

$0 = 5^2 + (2\times7)a$

$0 = 25 + 14a$

$a = -\frac{25}{14}$

$a = -1.786ms^{-2}$

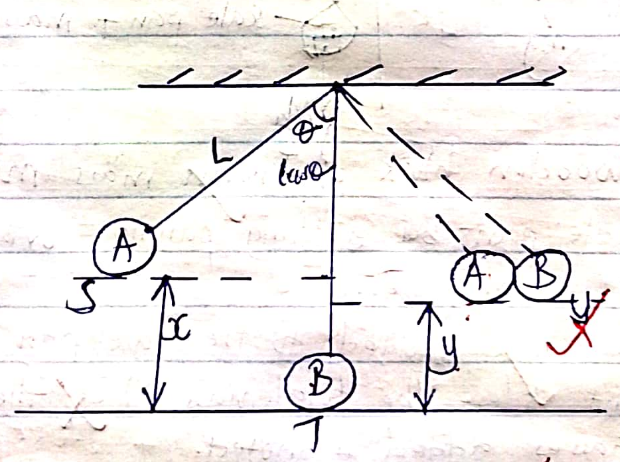
From (1)

$\mu = \frac{-1.786}{-9.81}$

$\mu = 0.182$

4

c)



At S, $x = l - l\cos\theta = L(1-\cos\theta)$

$p.e = K.E$ (By energy Conservation)

$(3m)gx = \frac{3}{2}mv^2$

where v is the Velocity with which A is released.

$$3mgx = \frac{1}{2}3mv^2$$

$$gx = \frac{v^2}{2}$$

$$gl(1-\cos\theta) = \frac{v^2}{2}$$

$$v^2 = 2gL(1-\cos\theta)$$

$$v = \sqrt{2gL(1-\cos\theta)} \quad \text{—— (i)}$$

At T momentum is conserved when A makes an inelastic collision with B.

$(3m)v + m \times 0 = (3m+m)V_c$ where V_c is the common velocity of A and B.

$$3v = 4V_c$$

$$V_c = \frac{3v}{4}$$

$$V_c = \frac{3}{4}\sqrt{2gL(1-\cos\theta)} \quad \text{—— (ii)}$$

At U, mechanical energy is conserved;

$$\frac{1}{2}(3m+m)V_c^2 = (3m+m)gy$$

$$\frac{V_c^2}{2} = gy$$

$$y = \frac{V_c^2}{2g}$$

$$y = \frac{1}{2g}\left(\frac{3}{4}\sqrt{2gL(1-\cos\theta)}\right)^2$$

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

$$y = \frac{9L}{16}(1-\cos\theta)$$

B rises $\frac{9L}{16}(1-\cos\theta)$

8

Question 4

a (i) Angular velocity is the rate of change of angular displacement of a body moving in a circular path.

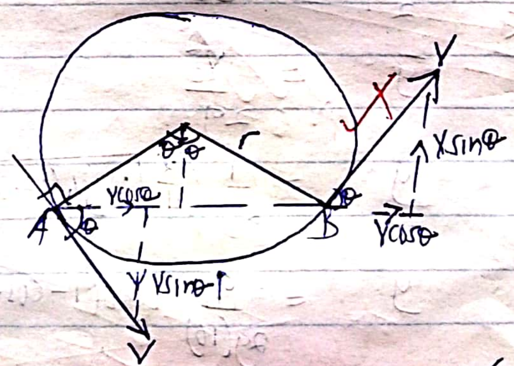
or

- Angular velocity is the rate of change of angle swept at the centre of a circle during circular motion.

ii) - Centripetal acceleration is the rate of change of velocity of an object moving round a circle and it's directed towards the centre of the circular path.

iii) Centripetal Force is the force which keeps an object round a circle and acts towards the centre.

B Let an object describe an angle 2θ at the centre of a circle of radius r in a time t with uniform velocity v from A to B.



$$V_A = \begin{pmatrix} V\cos\theta \\ -V\sin\theta \end{pmatrix} \text{ and } V_B = \begin{pmatrix} V\cos\theta \\ V\sin\theta \end{pmatrix}$$

From defn, acceleration, $a = \frac{V_B - V_A}{t}$

$$a = \left[\begin{pmatrix} v\cos\theta \\ v\sin\theta \end{pmatrix} - \begin{pmatrix} v\cos\theta \\ -v\sin\theta \end{pmatrix}\right] \times \frac{1}{t}$$

$$a = \begin{pmatrix} 0 \\ \frac{2v\sin\theta}{t} \end{pmatrix}$$

$a_x = 0$, no acceleration in horizontal direction

So $a = a_y = \frac{2v\sin\theta}{t} \uparrow$

$a = \frac{2v\sin\theta}{t}$,

Since θ is too small, $\sin\theta \simeq \theta$

$$a = \frac{2v\theta}{t} \quad \text{--- (1)}$$

From figure, if s is the distance covered from A to B and that angle 2θ is small;

$$s = r \times 2\theta$$

$$\Rightarrow 2\theta = \frac{s}{r} \quad \text{--- (2)}$$

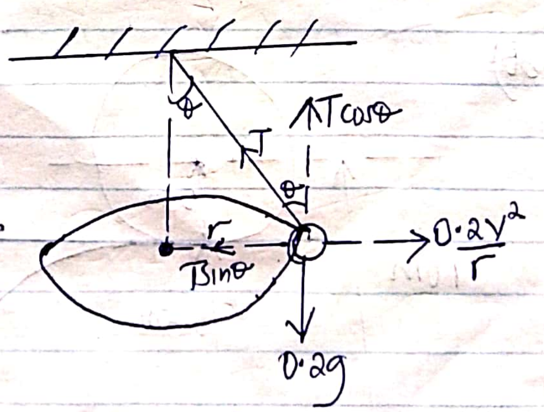
Putting (2) in eqn (1) gives;

$$a = \frac{2v}{t}\left(\frac{s}{2r}\right) = \frac{v}{r}\left(\frac{s}{t}\right) \quad \text{But } s/t = v$$

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

4

c)



$\theta = 30°$

Resolving Vertically; $T\cos 30 = 0.2g$

$$T = \frac{0.2 \times 9.81}{\cos 30°}$$

$$T = 2.266N$$

2

Resolving horizontally;

$$T\sin\theta = \frac{0.2v^2}{r}$$

$$v^2 = \frac{r\,T\sin 30}{0.2}$$

but $r = 1\sin 30$

$$v^2 = \frac{1.2\sin 30 \times 2.266\sin 30}{0.2}$$

$$v^2 = 3.399$$

$$v = 1.844ms^{-1}$$

4

Also $v = \omega r$

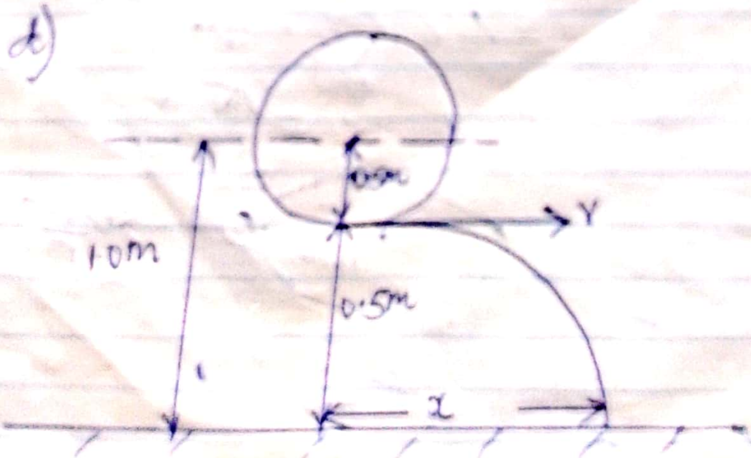
$$\omega = \frac{v}{1\sin 30}$$

$$\frac{2\pi}{T} = \frac{v}{1\sin 30}$$

$$T = \frac{2\pi(1.2\sin 30)}{1.844}$$

$$T = 2.044s$$

d)



(i) Breaking point is at the bottom of the circle.

1

ii) $T_{max} = \frac{mv^2}{r} + mg$

$20 = \frac{0.5v^2}{0.5} + 0.5 \times 9.81$

$20 = v^2 + 4.905$

$v = \sqrt{20 - 4.905}$

$v = 3.885 ms^{-1}$

From angular speed, $w = \frac{v}{r}$

$w = \frac{3.885}{0.5}$

$w = 7.77 \, rads^{-1}$

3

iii). Using $s = ut + \frac{1}{2}at^2$ and considering vertical motion,

$0.5 = 0 \times t + \frac{9.81t^2}{2}$

$t = \left(\frac{0.5 \times 2}{9.81}\right)^{1/2}$

$t = 0.3193 s$

From horizontal motion,

$x = ut$

$x = 3.885 \times 0.3193$

$x = 1.24 m$

3

Question 5

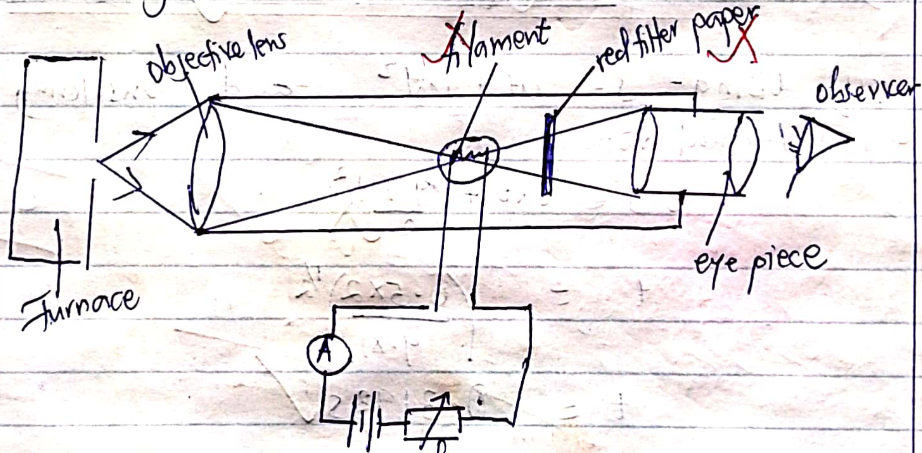
a Thermometric property is a physical measurable property which varies linearly and continuously with temperature ~~and~~ is constant ~~at~~ constant temperature. 1

Examples of thermometric properties include;
- Length of liquid column.
- Electrical resistance of wire.
- EMF of a thermocouple
- Wavelength of electromagnetic radiation emitted by a hot body
- Pressure of a fixed mass of gas.

any four correct 2

5b) Optical pyrometer:

It consists of a refracting telescope having a tungsten filament lamp at the focus of its objective as shown below.



A hot source is focused using an objective lens such that its image lies in same plane as the filament.

When the image of the hot body is brighter than the filament, the filament will appear dark on a bright background. This implies the hot body is hotter than the filament.

When the filament appears brighter on a dark background, then the filament is hotter than the hot body.

Current through the filament is adjusted until the filament light can not be distinguished from that of hot body. At this point they have the same temperature. 06

The ammeter A, calibrated to read temperature in °C will give the temperature of the body.

C (i) Specific heat capacity is the quantity of heat required to raise the temperature of 1kg mass of a substance by 1K. 1

(ii) Assuming no heat loss to the surrounding

Electrical energy supplied by the heater = heat energy gained by metal

$$Pt = mc\Delta\theta$$

$$48 \times (5 \times 60) = 1.0c(34-18)$$ 4

$$48 \times 300 = 16c$$

$$c = \frac{48 \times 300}{16}$$

$$c = 900\,J\,kg^{-1}K^{-1}$$

d) Newton's law of cooling states that the rate of heat loss of a body is directly proportional to its excess temperature over that of the surroundings under conditions of forced convection of air.

$$\frac{dQ}{dt} \propto (\theta - \theta_R) \text{ — ①}$$ 03

But $Q = mc\Delta\theta$

$$\frac{dQ}{dt} = -mc\frac{d\theta}{dt} \text{ — ②}$$

$$-mc\frac{d\theta}{dt} \propto \theta - \theta_R$$

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

e) Evaporation occurs when the most energetic molecules at the liquid surface escape. The molecules that remain are those with low kinetic energy. Since mean kinetic energy of of the molecules is directly proportional to absolute temperature the liquid cools. 3

Question 6

a (I) – Adiabatic change is a thermodynamic process which takes ~~place at~~ when there is no heat exchange between the gas ~~and~~ its surroundings.

– An isothermal change is a thermodynamic process which takes place at constant temperature.

1

1

II) Molar heat capacity at constant pressure C_p is the amount of heat required to raise the temperature of 1 mole of a gas by 1K at constant pressure.

1

III) With C_v, the amount of heat supplied is only used to raise the internal energy of the gas. Whereas with C_p the amount of heat energy supplied is used to both raise the internal energy of the gas ~~and~~ enable the gas do external work during expansion against atmospheric pressure.

2

IV) Suppose n moles of an ideal gas ~~are~~ heated at constant volume so that the temperature changes by ΔT.

$$\Delta Q_v = nC_v\Delta T$$

From 1st law of thermodynamics;

$$\Delta Q = \Delta U + \Delta W$$

$$nC_v\Delta T = \Delta U \quad \text{—— (1)} \quad (\text{Since } \Delta W = P\Delta V \text{ and } \Delta V = 0 \Rightarrow \Delta W = 0)$$

Now suppose n moles of the same gas are heated at constant pressure so that temperature changes by same amount ΔT

4

$$\Delta Q_v = nC_p\Delta T$$

$$\Delta Q = \Delta U + \Delta W$$

$$nC_p\Delta T = nC_v\Delta T + P\Delta V \quad \text{—— (2)}$$

From ideal gas eqn; $PV = nRT$ —— (*)

$$P(V+\Delta V) = nR(T+\Delta T)$$

$PV + P\Delta V = nRT + nR\Delta T$ —— xx

Eqn ** — Eqn * gives;

$P\Delta V = nR\Delta T$ —— (3)

putting Eqn 3 in Eqn 2 yields;

$nC_p\Delta T = nC_v\Delta T + nR\Delta T$

$C_p = C_v + R$

$C_p - C_v = R$

b(i) Partial pressure is the pressure the constituent of the mixture would have if it's to occupy the container alone

ii) Dalton's law of partial pressure states that the total pressure of a mixture of gases that do not react chemically is equal to the sum of the partial pressures of the constituent gasses.

iii) $T_1 = 300K$ $T_2 = 353K$

$P_{T_1} = 1.0 \times 10^5 Pa$ $P_{T_2} = 1.184 \times 10^5 Pa$

$P_{s_1} = 2.1 \times 10^3 Pa$ $P_{s_2} = ??$

$P_{a_1} = ??$ $P_{a_2} = ??$

By Dalton's law of partial pressures;

$P_T = P_s + P_a$

$P_{a_1} = P_{T_1} - P_{s_1}$

$P_{a_1} = 1.0 \times 10^5 - 2.1 \times 10^3$

$P_{a_1} = 9.79 \times 10^4 Pa$

CamScanner

$P_{a_2} = P_{T_2} - P_s$

$P_{s_2} = 1.184 \times 10^5 - P_{a_2}$ ⟵ ①

By pressure law; $\frac{P_{a_1}}{T_1} = \frac{P_{a_2}}{T_2}$

$P_{a_2} = \frac{9.79 \times 10^4 \times 353}{300}$

$P_{a_2} = 1.152 \times 10^5\ Pa$

4

From Eqn ①

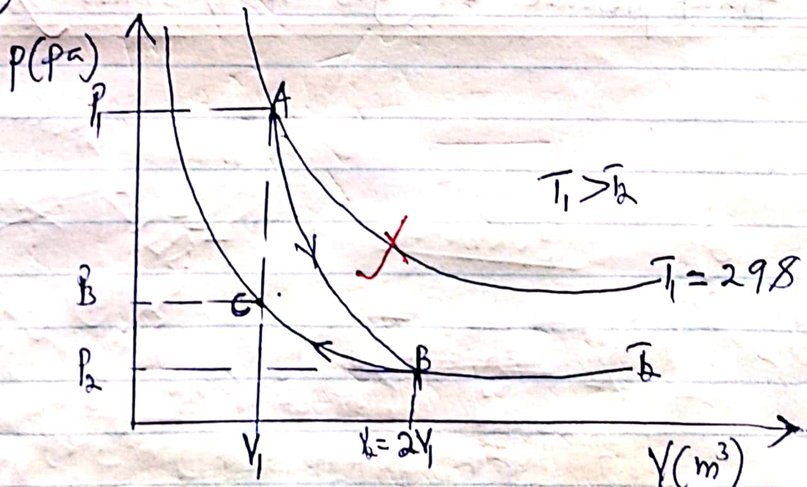
$P_{s_2} = 1.184 \times 10^5 - 1.152 \times 10^5$

$P_{s_2} = 3.2 \times 10^3\ Pa$

SVP at $80°C$ is $3.2 \times 10^3\ Pa$

---

6 c)



Considering an adiabatic expansion AB

$TV^{\gamma-1} = \text{constant}$

$T_1 V_1^{\gamma-1} = T_2 (2V_1)^{\gamma-1}$

$T_2 = T_1 \left(\frac{1}{2}\right)^{\gamma-1}$

$T_2 = 298 (0.5)^{0.4}$

$T_2 = 225.84°C$ hence final temperature.

Also, $PV^{\gamma} = \text{constant}$

$$P_1 V_1^{\gamma} = P_2 (2V_1)^{\gamma}$$

$$P_2 = P_1 \left(\frac{1}{2}\right)^{\gamma}$$

$$P_2 = 1.0 \times 10^5 (0.5)^{1.4}$$

$$P_2 = 3.789 \times 10^4 \text{ Pa}$$

05

Considering an isothermal compression BC

$$PV = \text{Constant}$$

$$P_2 (2V_1) = P_3 (V_1)$$

$$2P_2 = P_3$$

$$P_3 = 2 \times 3.789 \times 10^4$$

$$P_3 = 7.58 \times 10^4 \text{ Pa}$$

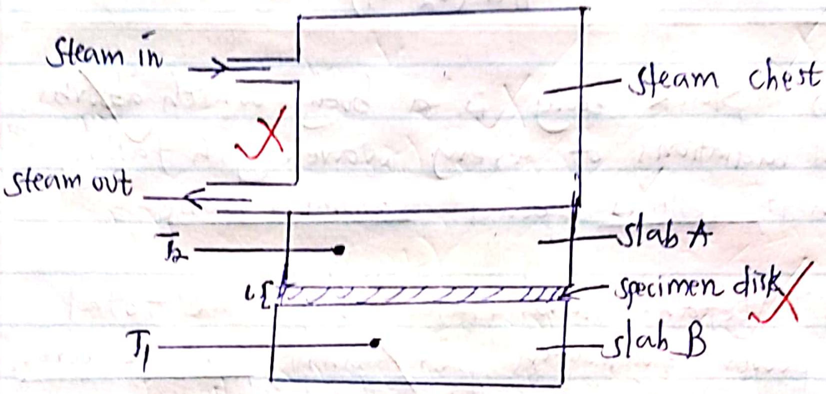
final pressure of gas = 7.58×10^4 Pa

Question 7

a) _ Conduction is the transfer of heat energy from hot end to cold end without the movement of a substance as a whole. 1

\- Convection is the transfer of heat energy from the hot end to the cold end that involves the actual movement of a medium. 1

b) Determination of thermal conductivity of glass.



\- A sample in the form of a disc of small thickness l and diameter d is used.
\- The thin disc is sandwiched between two metal slabs A and B each carrying a thermometer.
\- Steam is passed through the steam chest until the thermometers record steady temperatures θ_2 and θ_1 which are recorded.

$$\frac{dQ}{dt} = \frac{\pi d^2 K(\theta_2 - \theta_1)}{4l} \quad \text{--- --- ---(1)}$$

\- The sample is withdrawn and slab B is heated directly when in contact with A until its temperature is about 10°C above θ_1. 07
\- The steam chest is removed and the disc is placed on top of slab B
\- The temperature of slab B is recorded at suitable time intervals.
\- A cooling curve is plotted and the slope s of the graph at θ_1 is determined.

$$\frac{dQ}{dt} = mcs \quad \text{---} \quad (2)$$

where m is the mass of slab B and c is its specific heat capacity.

- Thermal conductivity K of glass is got from;

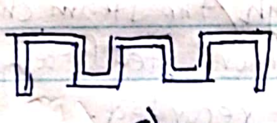
$$mcs = \frac{K\pi d^2(\theta_2 - \theta_1)}{4l}$$

$$K = \frac{4mcls}{\pi d^2(\theta_2 - \theta_1)}$$

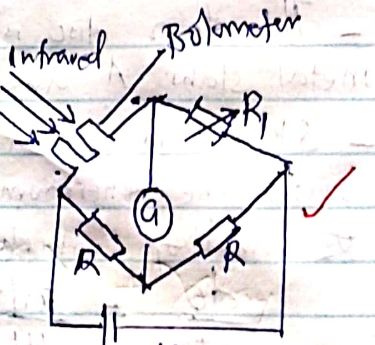
C(i) Black body is a body which absorbs all radiations of every wavelength falling on it, reflects and transmits none. 1

ii) Stefan's law states that the total power radiated per unit surface area of the black body is directly proportional to the fourth power of its absolute temperature. 1

d) Bolometer



a)

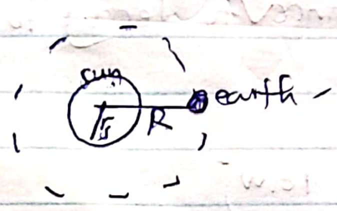


b)

A bolometer consists of a blackened strip of platinum foil arranged in a zig zag pattern as shown in (a) above. The strip is then connected to a wheatstone bridge as shown in (b) above. When infrared radiation falls on the bolometer, heat is generated/gained by the platinum strip and this increases temperature and hence resistance of the strip. 5

The increase in resistance is seen by the deflection of the galvanometer G. This shows the presence of infra-red radiation and

e)



Power radiated by the sun $= A_s \sigma T_s^4$

$$P_s = 4\pi r_s^2 \sigma T_s^4$$

$$\text{Solar Constant} = \frac{4\pi r_s^2 \sigma T_s^4}{4\pi R^2}$$

$$\text{Solar constant} = \sigma T_s^4 \left(\frac{r_s}{R}\right)^2$$

$$1400 = 5.7\times10^{-8}\left(\frac{1}{216}\right)^2 T_s^4$$

$$T_s = \left(\frac{1400 \times 216^2}{5.7\times10^{-8}}\right)^{1/4}$$

$$T_s = 5818\,K$$

4

Question 8

a. i) Decay constant is the fractional number of atoms that decay per second. 1

ii) Half life is the time taken by a radioactive substance to decay to half its original value. 1

b (i) From decay law;

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

at $t = T_{1/2}$, $N = \frac{N_0}{2}$

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

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

$$\ln 2^{-1} = \ln e^{-\lambda T_{1/2}}$$

$$-\ln 2 = -\lambda T_{1/2}$$

3

$$T_{1/2} = \frac{\ln 2}{\lambda}$$

$$T_{1/2} = \frac{0.693}{\lambda}$$

---

iii) $${}^{99}_{43}X \longrightarrow {}^{99}_{43}Y + \gamma\text{-ray}$$

$T_{1/2} = 360$ minutes

From $$\lambda = \frac{0.693}{T_{1/2}}$$

$$\lambda = \frac{0.693}{360}$$

$$\lambda = 0.001925 \text{ min}^{-1}$$

99g of $^{99}_{43}X$ contain 6.02×10^{23} atoms

1g of $^{99}_{43}X$ contains $\frac{6.02\times10^{23}}{99}$ atoms

1mg of isotope contains $\left(\frac{6.02\times10^{23}}{99}\times 1\times10^{-3}\right)$ atoms

$= 6.081\times10^{18}$ atoms 06

Also Activity $A = \lambda N$

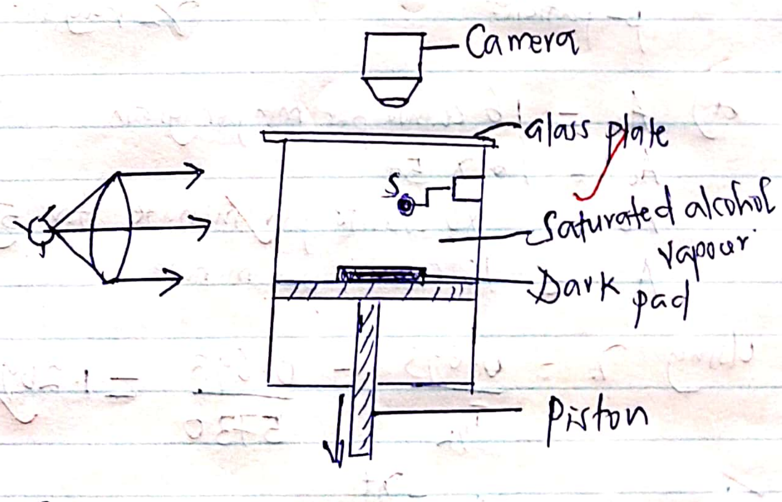
$A = 0.001925 \times 6.081\times10^{18}$

$A = 1.1706\times10^{16}$ minute^{-1}

c) Cloud chamber

Here an expansion cloud chamber or diffusion type can be used by a learner

Expansion Cloud chamber

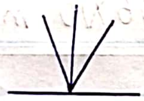


S - Source of radiation

Mode of operation

A small quantity of acrohol is poured on the dark pad attached on the piston. Acrohol evaporates and the vapour fills the chamber.

- The piston is moved down quickly making the vapour inside undergo an adiabatic expansion. The air cools down as a result.
- Dust nuclei in the chamber are carried away by drops falling on them making the air inside dust free and supersaturated.
- Ionizing radiations from S ionizes the air to form ions which act as centres of condensation.
- The chamber is illuminated by light and a photograph taken using a camera shows trails that represent the paths of ionizing particles. 05
- If the particles are alpha, the paths are short thick straight trails.



- For Beta particles the paths are long straggy lines ~~and for~~ gamma rays the paths are short cloudy trails

β-paticles

γ-rays.

d) $A_0 = 16$ counts per min per gram.

$A_0 = 16 \times 5g$

$A_0 = 80$ counts per minute for 5g

$A = 10$ counts per minute.

Using $\lambda = \frac{0.693}{T_{1/2}} = \frac{0.693}{5730} = 1.209 \times 10^{-4}$ year

From $A = A_0 e^{-\lambda t}$

$10 = 80 e^{-(1.209 \times 10^{-4})t}$ 4

$\ln(10/80) = -1.209 \times 10^{-4} t$

$t = 17199.68$ years

Age of dead wood is 17199.68 years

Question 9

a (i) Work function is the minimum amount of energy required to remove an electron from the bulk of the metal interior to its surface against the attractive forces of the positive ions.

ii) Threshold frequency is the minimum frequency of incident radiation on a metal surface below which no photoelectric emission occurs regardless of the intensity of the incident radiation.

iii) Threshold wavelength, is the maximum wavelength of incident radiation on metal surface above which no photoelectric emission occurs regardless of the intensity of the incident radiation.

b) Laws of photoelectric emission:

- For a given metal, there is minimum frequency of incident radiation below which no photoelectric emission occurs irrespective of the intensity of the incident radiation.
- Number of electrons emitted per second is is directly proportional to the intensity of the incident radiation.
- The photoelectrons ~~are~~ emitted with variable kinetic energy which ranges from zero to a maximum with frequency of incident radiation but independent of the intensity of incident radiation.
- There is no time lag between irradiation and emission of photoelectrons provided the incident radiation has high enough energy.

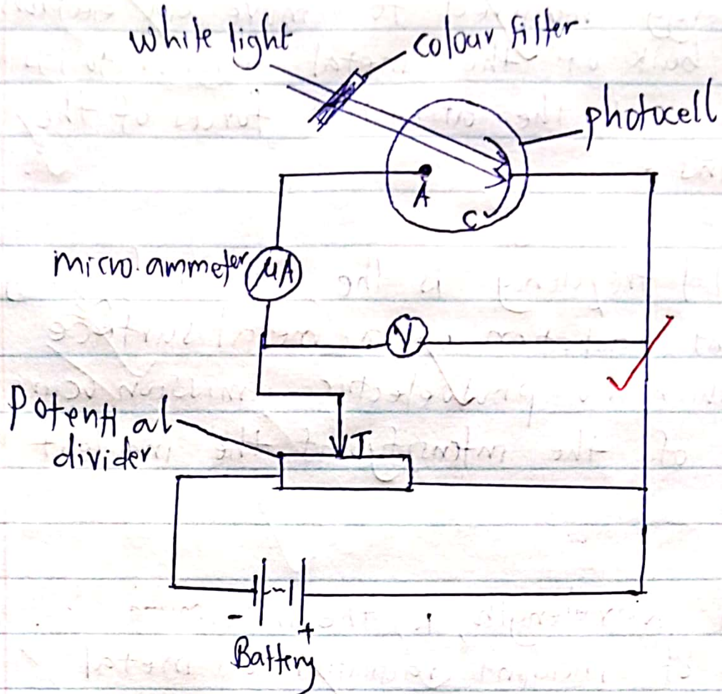
1

1

1

4

c) Determination of stopping potential



Procedure

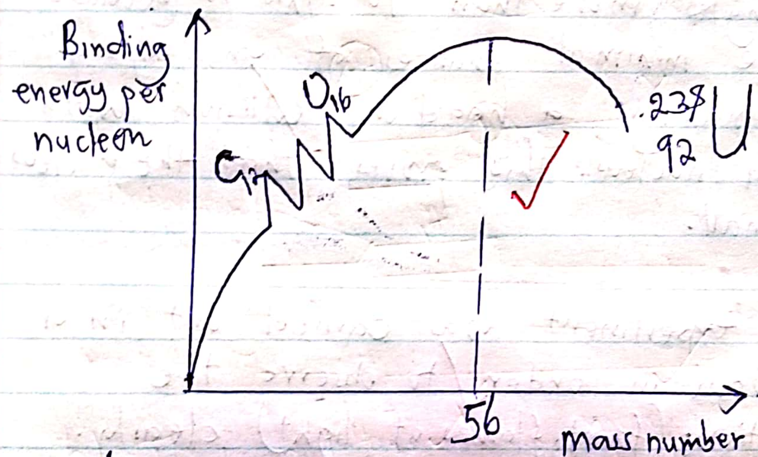
- The anode is made more negative relative to the cathode.
- White light is made to shine through a filter to obtain monochromatic beam of radiation which is directed to thermal cathode C whose stopping potential is required.
- If the frequency of incident radiation is greater than the threshold frequency of the metal, photoelectrons are emitted and are attracted by the anode, hence a current flows.
- The pd across the photocell is adjusted by moving the jockey J along the potential divider until the reading of the microammeter is zero.
- The corresponding reading on the voltmeter is read and is taken as the stopping potential of the metal surface.

05

d (i) Unified atomic mass unit is a twelfth $(\frac{1}{12})^{th}$ of the mass of one atom of Carbon-12 isotope.

- Binding energy per nucleon is the ratio of binding energy ~~per nucleon~~ to mass number.

e A graph of binding energy per nucleon against mass number



Elements with mass number around 56 are more stable due to high binding energy per nucleon.

During nuclear fussion, two lighter nuclei combine two form a heavier nucleus of higher binding energy per nucleon. The mass of the heavier nucleus is less than the total mass of the lighter nuclei. The mass difference accounts for the energy released during nuclear fussion.

During nuclear fission a heavy unstable nucleus splits to form two lighter nuclei of higher binding energy per nucleon. The mass of the lighter nuclei is less than the mass of the heavier nucleus. The mass difference accounts for the energy released during nuclear fission.

06

Question 10

a (i) Most of the alpha particles ~~particle~~ passed undeflected. This is because most of the space in an atom is empty.

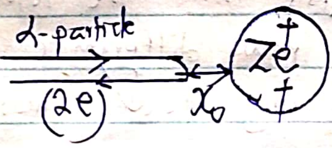
- Few alpha particles were deflected through small angles less than 90°. This is due to the repulsion force on the alpha particles due to the positive charge of the gold nucleus 6

- Very few alpha particles were deflected through large angles more than 90°. This is because there are minimal chances of an alpha particle making ~~a~~ head on collision with the gold nucleus. This proves that the nucleus is very small.

ii) - The experiment was carried out in a dark room in order to observe the scintillations (faint flashes of light) clearly. 1

- It was evacuated so as to prevent an alpha particle from colliding with the air molecules which would lower their kinetic energy. 1

b (i)



At closest approach x_0;

K.E of incoming α-particle = electrostatic potential energy

$$\frac{1}{2}mv^2 = \frac{(2e)(Ze)}{4\pi\varepsilon_0 x_0}$$

$$\frac{1}{2}mv^2 = \frac{Ze^2}{2\pi\varepsilon_0 x_0}$$

$$mv^2 = \frac{Ze^2}{\pi\varepsilon_0 x_0}$$

$$x_0 = \frac{Ze^2}{\pi\varepsilon_0 mv^2}$$

4

ii) $x_0 = 5\times10^{-14}$ m, $Z = 79$

$$x_0 = \frac{Ze^2}{\pi\varepsilon_0 mv^2}$$

$$\frac{1}{2}mv^2 = \frac{Ze^2}{2\pi\varepsilon_0 x_0}$$

$$K.E = \frac{79\times(1.6\times10^{-19})^2}{2\pi\times(8.85\times10^{-12})\times5\times10^{-14}}$$

$$K.E = 7.274\times10^{-13}\ J$$

3

But $1eV = 1.6\times10^{-19} J$

$1MeV = 1.6\times10^{-13} J$

$1J = 6.25\times10^{12}$ MeV

$$K.E = 7.274\times10^{-13}\times6.25\times10^{12} MeV$$

Kinetic energy $= 4.55$ MeV

C i)

A Bohr atom is an atom with a small centrally located positive nucleus around which electrons revolve only in certain allowed orbits and while in these orbits, they do not emit radiations

1

C(11)

Ionisation energy $E_{ion} = E_\infty - E_1$.

$$E_{ion} = 0 - -10.44\, eV$$

$$= 10.44 \times 1.6 \times 10^{-19}\, J$$

$$E_{ion} = 1.6704 \times 10^{-18}\, J$$

$$\frac{1}{2} m v^2 = 1.6704 \times 10^{-18}$$

$$v^2 = \frac{2 \times 1.6704 \times 10^{-18}}{9.11 \times 10^{-31}}$$

$$V = \sqrt{\frac{2 \times 1.6 \times 10^{-19}}{9.11 \times 10^{-31}}}$$

$$=$$

$$V = 1.91 \times 10^{6}\, m s^{-1}$$

4

END

By Ronald Seluuma (0781302667/0754888673)
Physics & mathematics department Lukwanga SS