P510/1
PHYSICS
Paper 1
2½ hours

WAKISSHA

Uganda Advanced Certificate of Education

PHYSICS

Paper 1

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

- *Answer five questions, including **at least one,** but not more than two from each of the Sections A, B and C.*
- *Any additional question(s) answered will **not** be marked.*
- *Non programmable silent scientific calculators may be used.*

Assume where necessary:

Acceleration due to gravity	g	=	$9.81\ ms^{-2}$
Electron charge	e	=	$1.6 \times 10^{-19}\ C$
Electron mass		=	$9.11 \times 10^{-31}\ kg$
Mass of earth		=	$5.97 \times 10^{24} kg$
Planck's constant,	h	=	$6.6 \times 10^{-34} Js$
Stefan's – Boltzmann's constant,	σ	=	$5.67 \times 10^{-8}\ Wm^{-2}K^{-4}$
Radius of the earth		=	$6.4 \times 10^{6} m$
Radius of the sun		=	$7.0 \times 10^{8} m$
Radius of earth's orbit about the sun		=	$1.5 \times 10^{11} m$
Speed of light in a vacuum		=	$3.0 \times 10^{8} m$
Specific heat capacity of water		=	$4{,}200 Jkg^{-1}K^{-1}$
Specific latent heat of fusion of ice		=	$3.34 \times 10^{5}\ Jkg^{-1}$
Universal gravitational constant,	G	=	$6.67 \times 10^{-11} Nm^{2}kg^{-2}$
Avogadro's number	N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Density of mercury		=	$13.6 \times 10^{3} kgm^{-3}$
Charge to mass ratio,	e/m	=	$1.8 \times 10^{11}\ Ckg^{-1}$
The constant $1/4\pi\varepsilon_0$		=	$9.0 \times 10^{9}\ F^{-1}m$
Density of water		=	$1000 kgm^{-3}$
Gas constant	R	=	$8.31 Jmol^{-1}K^{-1}$

SECTION A

) (i) Define the terms **displacement** and **uniform velocity**. (2 marks)

(ii) Sketch **displacement – time** and **speed – time** graphs for a body thrown vertically upwards. (2 marks)

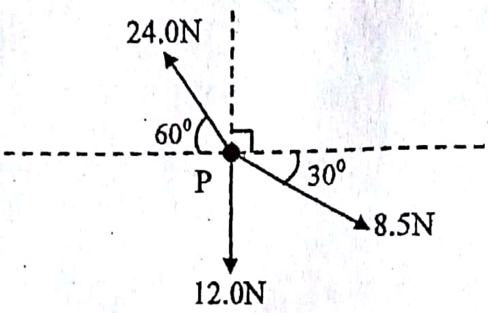

Fig. 1

Three forces of 24.0N, 12.0N and 8.5N act on a body P of mass 0.5kg as shown in fig. 1. Find the acceleration produced on P. (4 marks)

c) (i) What is meant by saying that a body is moving with velocity v relative to another? (1 mark)

(ii) A car is travelling in a direction due East at $30kmh^{-1}$ while a bus is travelling at 40 kmh^{-1} due North. Find the velocity of the bus relative to the car. (3 marks)

(iii) If the bus in (c) (ii) above is 15km due East of the car at 11.00 a.m, find the shortest distance between them and the time when this occurs. (5 marks)

d) (i) What is meant by **torque** of a couple? (1 mark)

(ii) State the conditions for a body to be in equilibrium. (2 marks)

a) (i) What is meant by the term **centripetal acceleration?** (1 mark)

(ii) Derive an expression for the centripetal force acting on a body of mass ***m*** moving in a circular path of radius ***r***. (4 marks)

(iii) Explain why a body moving in a circular path with uniform speed has an acceleration. (3 marks)

(b) (i) State **Newton's law** of gravitation. (1 mark)

(ii) Describe, with the aid of a labeled diagram, an experiment to determine the universal gravitational constant, G. (6 marks)

(c) (i) What is meant by **gravitational potential?** (1 mark)

(ii) Calculate the period of a satellite which is 100km above the surface of the earth. (4 marks)

(1 mark)

(a) (i) What is meant by hydrostatic pressure?

(ii) Derive the expression for the pressure at a point which is at a depth h below the surface of a liquid of density ρ. (3 marks)

(b) (i) State **Archimedes' principle.** (1 mark)

(ii) Using Archimedes' principle and the principle of moments, describe an experiment to determine relative density of a liquid. (5 marks)

(c) An empty cylindrical metal can of radius 4.5cm is made to float vertically in water. If 5 litres of engine oil of density 800 kgm^{-3} is poured into the can, find the extra depth to which the can will sink. (5 marks)

(d) (i) State **Bernoulli's principle.** (1 mark)

(ii) A cylinder of large cross sectional area, containing water, stands on a horizontal bench. The water surface is at a height h above the bench. Water emerges horizontally from a hole in the side of the cylinder, at a height x above the bench. Use Bernoulli's principle to derive expressions for the speed at which the water emerges from the hole. (4 marks)

4. (a) What is meant by the following terms as applied to materials:

(i) **Tensile stress** (1 mark)

(ii) **Yield point** (1 mark)

(b) Derive an expression for the energy stored in a unit volume of a stretched metal wire in terms of stress and strain. (4 marks)

(c) A rubber cord of a catapult has an unscratched length of 10 cm and cross sectional area 2.0mm^2. The catapult is loaded with a small mass of 20g and is stretched to 15cm.

(i) Calculate the velocity at which the mass is fired on releasing the cord. Take Young's modulus for rubber to be 1.0 x 10 x^8 pa. (4 marks)

(ii) State **any assumptions** made in the calculation in (c) above. (1 mark)

(d) (i) Distinguish between **elastic deformation** and **plastic deformation.** (2 marks)

(ii) On the same axes, draw the stress – strain curves for rubber and glass, and compare their elastic properties. (4 marks)

(e) Outline the measurements to be made in the determination of Young's modulus for the material of steel. (3 marks)

SECTION B

5. (a) (i) State the **assumptions** made in the derivation of the kinetic theory expression for the pressure of an ideal gas. (2 marks)

(ii) Which of the assumptions made above have to be modified for real gases? (1 mark)

Turn Over

(iii) The equation of state of one mole of a real gas is given by the expression: $(P + a/V^2)(V - b) = RT$.
Account for the terms a/V^2 and b. (3 marks)

(b) Calculate the root-mean-square speed of molecules of an ideal gas at 147^0C given that the density of the gas at a pressure of $1.01 \times 10^5 Nm^{-2}$ at a temperature of 0^0C is $1.5kgm^{-3}$. (5 marks)

(c) (i) Explain why the pressure of a fixed mass of gas in a closed container of fixed volume increases when temperature of the container is raised. (2 marks)

(ii) Explain, with the aid of a volume – temperature sketch graph, what happens to a gas cooled at constant pressure from room temperature to zero kelvin. (4 marks)

(d) An ideal gas of volume $400cm^3$ at -129^0C expands adiabatically to a temperature of -136^0C. Calculate its new volume. (Take $\gamma = 1.40$). (3 marks)

6. (a) (i) State the desirable properties a material must have in order to be used as a thermometric property. (2 marks)

(ii) Explain why a constant – volume gas thermometer is used to calibrate other thermometers. (2 marks)

(b) Describe, with the aid of a labeled diagram, how an optical pyrometer can be used to measure high temperatures. (6 marks)

(c) (i) What is meant by **latent heat of fusion?** (1 mark)

(ii) Explain why specific latent heat of vaporization of a substance is much higher than specific latent heat of fusion of same substance. (3 marks)

(d) 50g of ice at 0^0C is added to 200g of water initially at 70^0C in a vacuum flask. When all the ice has melted, the temperature of the flask and its contents dropped to 40^0C. On adding a further 80g of ice, the temperature of the flask and its contents became 10^0C when all the ice melted.
Calculate the specific latent heat of fusion of ice, and the heat capacity of the flask neglecting the heat loss to the surrounding. (marks)

7. (a) (i) Define **thermal conductivity.** (1 mark)

(ii) Explain the mechanism of heat transfer in metals. (3 marks)

(b) A window having two glass panes each of thickness 10mm are separated by an air gap of thickness 5.0mm. The outer faces of the panes are maintained at 20^0C and 5^0C respectively.

(i) Calculate the temperatures of the inner surfaces of the panes. (6 marks)

(ii) Compare the rate of heat loss through the layer of air with that through a single glass layer. (3 marks)
Take thermal conductivity of air and glass to be respectively 0.02 $Wm^{-1}k^{-1}$ and $0.6Wm^{-1} K^{-1}$

(c) (i) State **Stefan's law of blackbody radiation.** (1 mark)

(ii) The average distance of a certain planet from the sun is about 40 times that of the Earth from the sun. If the sun radiates as a blackbody at 6000K, calculate the surface temperature of the planet. (6 marks)

SECTION C

8. (a) (i) What is meant by **photoelectric emission?** (1 mark)

(ii) Explain, using **quantum theory**, the experimental observations on the photoelectric effect. (5 marks)

(iii) When light of wavelength 455 nm falls on certain metal surface, electrons of maximum kinetic energy 0.75 eV are emitted. Find threshold frequency for the metal. (4 marks)

(b) Explain, using suitable sketch graphs, how X-ray spectra in an X-ray tube are formed. (6 marks)

(c) The current in a water – cooled X-ray tube operating at 60kV is 30 mA. If 99% of the energy supplied to the tube is converted into heat at the target and is removed by water flowing at a rate of $0.060kgs^{-1}$, calculate the increase in temperature of the cooling water. (4 marks)

9. (a) What is meant by the following terms as applied to radioactivity:

(i) **Half-life.** (1 mark)

(ii) **Decay constant.** (1 mark)

(iii) **Radioisotopes.** (1 mark)

(b) Given the radioactive law $N = N_0e^{-\lambda t}$, obtain the relation between λ and half-life $t_{1/2}$. (2 marks)

(c) Describe briefly how the age of a fossil can be estimated using **uranium dating.** (4 marks)

(d) A certain radioisotope X having mass number 90 and atomic number 38 decays by emission of beta particles. If the half-life of the radioisotope X is 30 days, determine the activity of 2g of the isotope. (5 marks)

(e) (i) Sketch the count rate – voltage characteristics of the Geiger – Muller tube and explain its main features. (4 marks)

(ii) Identify, giving reasons, the suitable range in (e) (i) of the operation of the tube. (2 marks)

Turn Over

10. (a) (i) State **Rutherford's model of the atom.** (2 marks)

(ii) Explain **two** main failures of Rutherford's model of the atom. (3 marks)

(b) (i) What is meant by a **line spectrum?** (2 marks)

(ii) Explain how line spectra account for the existence of discrete energy levels in atoms. (4 marks)

(c) The energy levels in a mercury atom are – 10.4eV, -5.5eV, -3.7eV and -1.6eV.

(i) What is an **energy level?** (1 mark)

(ii) Why are the energies for the different levels negative? (1 mark)

(iii) Find the ionization energy of mercury in joules. (2 marks)

(d) (i) Define **space charge** as applied to thermionic diodes. (1 mark)

(ii) Draw a node current – anode voltage characteristics of a thermionic diode for two different filament currents and explain their main features. (4 marks)

END

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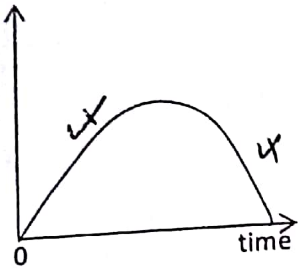
MARKING GUIDE
Uganda Advanced Certificate of Education
PHYSICS P510/1

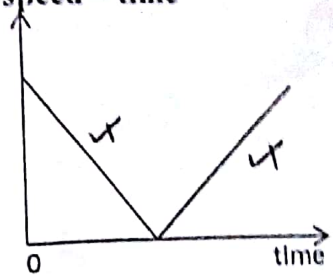
SECTION A

1. (a) (i) Displacement is the distance moved in a specified direction.
Uniform vol. is the constant rate of change of displacement with time. (02 marks)

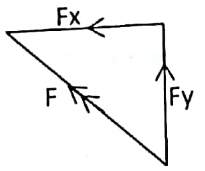
(ii) Displacement – time



speed – time



(b)
Component of the resultant force in the x - direction. $F_x = 24\cos 60^0 - 8.5\cos 30^0 = 4.64$ N (←) component of the resultant force in the y direction
$F_y = 24\sin 60^0 - (8.5\sin 30^0 + 12) = 4.53N(\uparrow)$



Resultant force $F = \sqrt{4.64^2 + 4.53^2}$

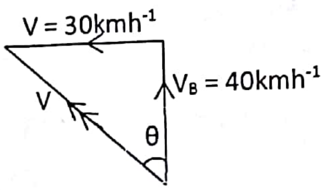
$= 6.48N$

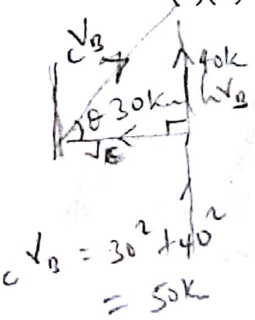
$\therefore a = {}^{F}/_{m} = {}^{6.48}/_{0.5} = 12.96ms^{-2}$

(4 marks)

(c) (i) If a body is moving with a vel V relative to another means that it has a vel. V as seen by an observer from (on) the other body. (01mark)

(c)(ii)





$_{B}V_{C} = \sqrt{40^2 + 30^2}$

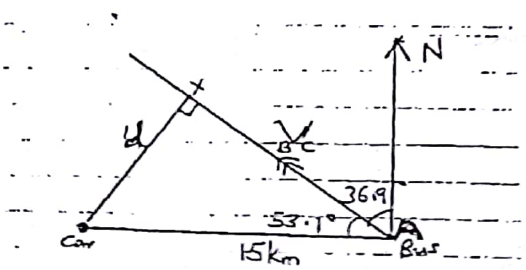
$= 50kmh^{-1}$

In a direction:

$\theta = tan^{-1}\left(\frac{30}{40}\right) = 36.9^0$

In the direction **N36.9⁰W** (3 marks)

(c) (iii)



Shortest distance $d = 15\sin 53.1^0 = 11.99km$
$= 12km$

Time taken = $\frac{\textit{Distance along relative path}}{\textit{relative speed}}$

$= \frac{AX}{|BC|} = \frac{15\cos 53.1}{50}$

$= 0.18$ hours

$= 10.8$mins

$\therefore$ *time at which distance is shortest* $= 11{:}00 + 10.8$
$\approx 11{:}10$ *am*

or

11:11am (5 marks)

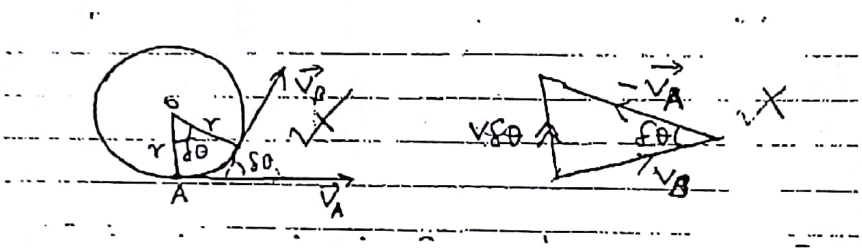
(d) (i) **Torque** of a couple is the product of one the forces that make a couple and the perpendicular distance between lines of action of the couple. (01 mark)

(ii) - The resultant force acting on the body is zero.
- The algebraic sum of moments about a point is zero. (2marks)

Total = 20 marks

2. (a)(i) **Centripetal acceleration** is the rate of change of vel. of a body moving in a circular path and is directed towards the centre of the path. (1mark)

(ii)



Suppose the body travels from A to B in time St. acceleration

$a = \frac{\Delta vel}{time\ take} = \frac{|\vec{V}_B - \vec{V}_A|}{St}$

But $|\vec{V}_B - \vec{V}_A| = \frac{v\delta\theta}{\delta t}$

$\therefore a = \frac{v\delta\theta}{\delta t} = Vw = rw^2$

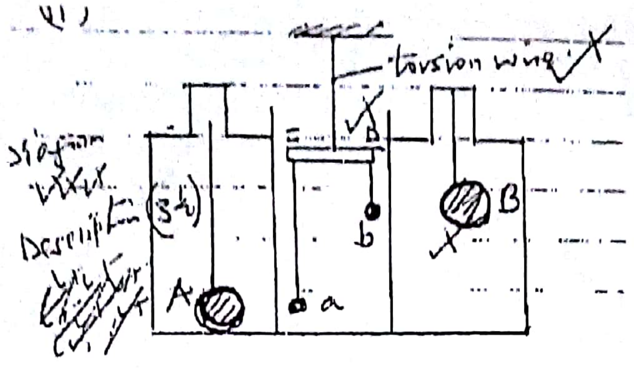
$\therefore$ *Centripetal force* $F = ma = mr\,w^2$

(4marks)

(iii) - When a body moves in a circular path with uniform speed; its velocity will be constant changing since its direction is changing.
- The change in direction is due to a force (centripetal) that keeps acting on the body thereby producing an acceleration on the body towards the centre of motion. (3marks)

(b) (i) Newton's law of gravitation states that every particle in the universe attracts any other particles with a force directly proportional to the produce of their masses and inversely proportional to the square of the distance between them. (1mark)

(ii) - Two identical gold balls **a** and **b** are suspended by a long and short final quartz strings; respectively from the ends of a highly polished bar CD.



- Two large identical lead spheres A and B are brought into positions near **a** and **b** respectively.
- The deflection θ of the bar CD is measured by a lamp and scale method.
- The distance **d** between A and **a** or **B** and **b** is measured and recorded.
- The mass **m** and **M** of **a** and **A** respectively are noted.
- The gravitational constant G obtained from G = $\frac{c\theta\, d^2}{mMCD}$

Where **c** = torsional constant of the quartz or torsion wire and CD is the length of the polished bar CD. (6marks)

(c) (i) Gravitational potential at a point is the work done to more a body of mass 1kg from infinity to that point in the gravitation field. (1mark)

(ii) from: T = $\sqrt{\frac{4\pi^2 r^3}{r_e^2 g}}$

Where r = re + h =$6.4\ x\ 10^6 + 1 - 0\ x\ 10^5 = 6.5\ x\ 10^6 m$

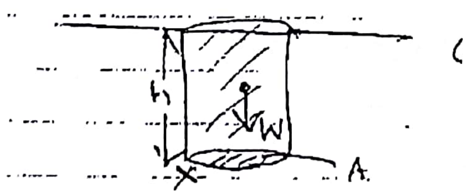
$\therefore T = \sqrt{\frac{4x3.14^2 x(6.5x10^6)^3}{(6.4x10^6)^2 x9.81}}$

= **5.192 x 10^{3}s** (4marks)

Total marks 20

3. (a) (i) **Hydrostatic pressure** – Is the pressure exerted by a fluid at equilibrium at a given point with in the fluid, due to its weight (or force of gravity) (1 mark)

(ii)



Consider a cylindrical region of cross-sectional area A and height h in a fluid of density p.

- Volume of liquid in the column above x = hA

→Weight of liquid in the column, W = hA ρ_ℓ

= force acting vertically downwards on A

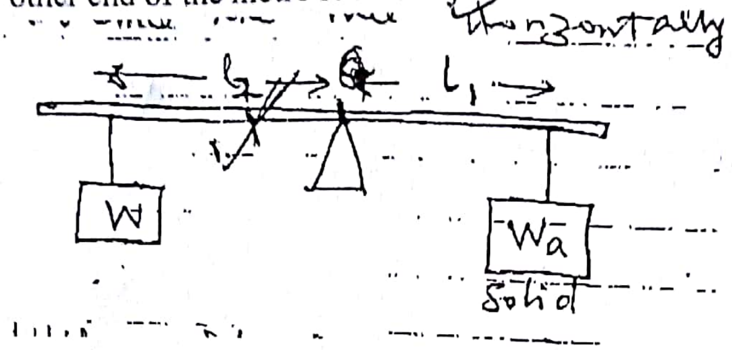
Thus Pressure P at A = $\frac{Weight}{area} = \frac{hA\rho g}{A}$

= hϑg (3 marks)

(b) (i) **Archimedes' principle** state that when a body is wholly or partially immersed in a fluid, it experiences an upthiust equal to the which is equal to the weight of the fluid displaced. (1mark)

(ii) - A metre rule is balanced horizontally on a knife edge and the position of its Centre of gravity G is located and marked unit.

- A solid is hung at a distance L from G (pilot) and the position of a weight W at the other end of the metre rule is adjusted so as to balance the rule horizontally.



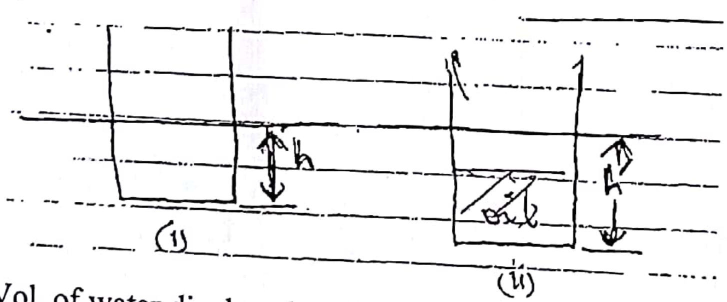
From the principle of moments.

$W_a = W\frac{l_2}{l_1}$ (1mark)

- While maintain the position of the solid and submerging it completely the specimen liquid; W is adjusted so as to balance the rule horizontally.
- The distance L_3 of W from G is noted; and apparent weight of the solid, W_1, is determined from $W_1 = W\frac{l_3}{l_1}$.
- The above procedure is repeated with the solid completely immersed in water and the corresponding distance of W from G (L_4) is noted; and apparent weight W_4 of the solid is determined from $W = W\frac{l_4}{l_1}$ (iii)
- From definition of rel. density of a liquid; R.D of the liquid $= \frac{W_a - W_1}{W_a - W_w} = \frac{l_2 - l_3}{l_2 - l_4}$

(5marks)

(c)



In (i) Vol. of water displaced = Ah = $\pi r^2 h$

$\therefore$ *weight of water displ.* $= \pi r^2 h \int_w g = wt\ of com.$

In (ii) Vol. of water displaced = Ah' = $\pi r^2 h'$

$\therefore$ *new weight of water displ.* $= \pi r^2 h \int_w g$

But new weight of water displ. = wt of com + wt of oil.

$= \pi r^2 h' \int_w g = \pi r^2 h \int_w g + V_o \int_o g$

Or $\pi r^2 h \int_w g(h' - h) = V_o \int_o g$

$= h' - h = \frac{V_o \int_o g}{\pi r^2 h \int_w g} = \frac{V_o \int_o}{\pi r^2 h \int_w}$

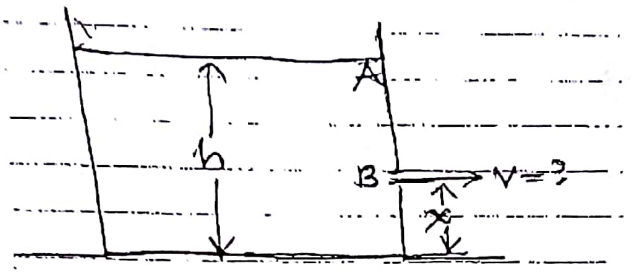
$= \frac{5x10^{-3}x800}{3.14\ x\ (4.5x10^{-2})^2 x1000}$

$\underline{= 0.629m}$

(5marks)

3.(d) (i)**Bernoulli's principle** states that a long a stream line in an incompressible non riscons fluid, the sum of the pressure at any point, the K, e per unit volume and the p.e. per unit volume is constant. (1 mark)

(ii)



Assuming the top of the bench is the reference height

= At A = Pressure = p_o *(atmosphere)*

k.e/vol $= \frac{1}{2}pV^2 = 0$

D.e/vol $= \int hg$ Since v = 0 (4marks)

At B = Pressure = P_0

k.e/vol $= \frac{1}{2}\int V^2$ (where V = vol. at B)

D.e/vol $= \int xg$

∴ *Using* ***Bernoulli's principle***:

$$P_0 + 0 + \int hg = P_0 + \frac{1}{2}\int v^2 + \int xg$$

$$\therefore \frac{1}{2}\int V^2 = \int g\,(h - x)$$

$$=V^2 = \frac{2\int g(h\_x)}{\int} = 2g(h - x)$$

$$\therefore V = \sqrt{2g(h - x)}$$

Total marks 20

4. (a)

(i) **Tensile stress** is the ratio of the tensile a tensile force to the cross sectional area of a material.

(1mark)

(ii) **Yield point** is the point beyond which a material gets permanently deformed or no extension is recovered at all when the deforming force is removed.

(1mark)

(b) Consider a wire of original length L stretched by an amount e on applying a force F. work done to stretch the wire W = average force x extension

i.e $W = \left(\frac{0+F}{2}\right) x\ e = \frac{1}{2}Fe$

= Stored energy in the wire.

= Energy stored per unit vol $= \frac{W}{Al}, A = X -$

sectioning area

$\therefore$ *Energy stored for unit vol* $= \frac{1}{2}\frac{Fe}{Al}$

= ½ x stress x strain.

(4marks)

(c)

$l_0 = 10\ cm;\ \lambda = 15cm = e = \lambda - l_0 = 15 - 10 = 5cm.$

$E = 5x10^{-2}$ m;

$A = 2.0 \times 10^{-6}m^2$, m – 0.02kg

(4marks)

(c) (i)Energy stored in the cord $= \frac{1}{2}Fe$

$= \frac{1}{2}\frac{EAe^2}{l}$

$= \frac{1}{2}x\frac{1.0x\ 10^8x2x10^{-6}x\ (5\ x\ 10^{-2})^2}{0.10}$

= 2.5 J

(1mark)

But Energy stored = K.e of the small mass

i.e $\frac{1}{2}mV^2 = 2.5$

$\frac{1}{2}x\ 0.02xV^2 = 2.5$

= V = 15.81ms^{-1}

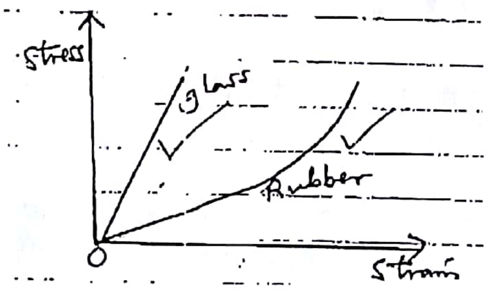
(c) (ii) Assumption: All the energy becomes k.e of the and none is lost as heat in the mass cord.

or Elastic limit of the cord is not exceeded when the cord is stretched.

(01 mark)

(d) (i) (2marks)

Elastic deformation	**Plastic deformation**
• Change in shape of a material (at how stress) and material is able to recover its original shape when the force is removed, (temporary change in shape). • Heat is not given out.	- Change in shape of a material without fracture under the action of a force and material is not able to recover its original shape when the force is removed. (Permanent change in shape) (02 marks) - Heat is given out.



• **Rubber** - has coiled molecules and thus stretches more than glass.
- Doesn't undergo plastic deformation.
- **Glass** – has a small elastic region; no plastic region and fractures easily; it's brittle and any concentration of stress at any crack makes it break.

(04 marks)

(e) - Original length of the test wire.
- Its diameter at three different points and its average determined.
- Extension produced in the test wire.

Total marks = 20

SECTION B

5. (a)(i) - The mols of an ideal gas behave like peyeethy elastic spheres and therefore make perfectly elastic collisions.

- The intermolecular forces between the mols are negligible (except during collisions).
- The vol. of the mols themselves is negligible compared to the vol. of the (gas) or container.
- The duration of a collision is negligible compared to (with) the time between collisions. (2 marks)

(ii) - Intermolecular forces are negligible. (1mark)

- The vol. of the mob. Are negligible compared to the vol. of the gas (or container).

(iii) - The mob. that strike the wall of the vessel are retarded by the unbalanced force due to the mols behind them, so the observed pressure **p** is less than what it should have been without these forces. Hence $^a/_{v2}$ accounts for the pressure defect.

- The vol. of the mols may not be negligible in relation to the vol. of the container when they approach each other very closely; thus in effect cause a reduction in the vol. in which they can move freely i.e free vol. = (v-b), where **b** is a factor called co-volume.

(03 marks)

(b) $T_1 = 147^0C = 420k, \rho = 1.5kgm^{-3}, \sqrt{C^2{}_1} = ?$

$T_0 = 0^0C = 273k, \quad P_0 = 1.01x10^5, Nm^{-2}$

From $P_0 = \frac{1}{3}\rho\ \overline{C_0^2} = \sqrt{\overline{C_0^2}} = \sqrt{\frac{3p_0}{\ }}$

$\therefore \sqrt{\overline{C_0^2}} = \sqrt{\frac{3 \ x\ 1.01 \ x\ 10^5}{1.5}} = 1.42x10^3 ms^{-1}$

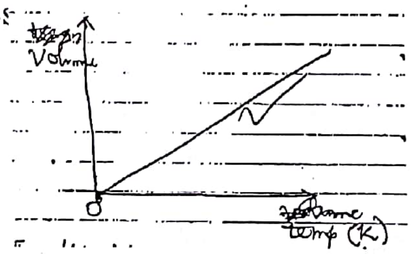
But $\sqrt{\overline{C^2}}\ \alpha \sqrt{T} = \frac{\sqrt{\overline{C_1^2}}}{\sqrt{\overline{C^2}}} = \frac{\sqrt{T_1}}{\sqrt{T_0}}$

$\sqrt{\overline{C_1^2}} = \sqrt{420}\quad \sqrt{\overline{C_1^2}} = \mathbf{1.76 \ x\ 10^3}$

(c)(i) When the temperature of container is increased, the average vel. of the mols increases. So the number of collisions made with the walls of the container per second in creases.

- Consequently the momentum change per second of the mols increases as they bomb and the walls.
- This leads to an increase in the force exerted on the walls, and hence pressure of the gas increases. (2marks)

(ii)



- When a gas is cooled at constant pressure, its volume reduces and become more and more dense.
- The kinetic energy of its molecules keep reducing until it turns into a vapour.

- When the temperature reaches zero, the gas will have zero volume, and molecular motion ceases.

(d) $V_1 = 400cm^3$,
$V_2 = ?$

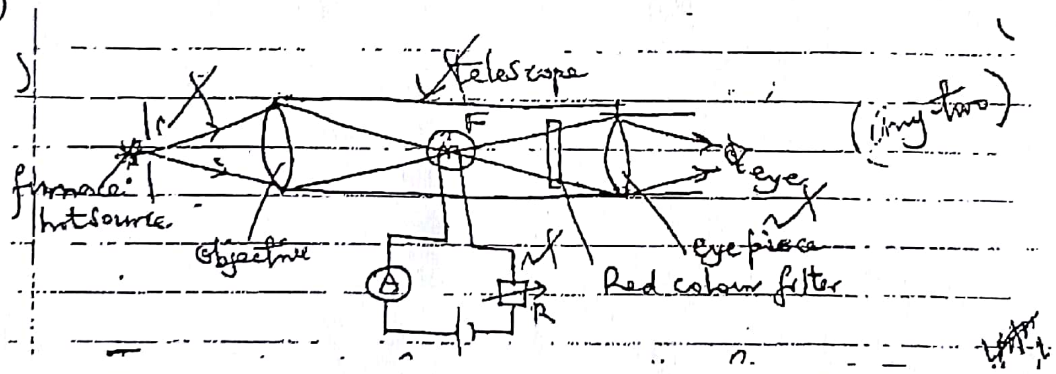
$T_1 = -129^0C = 144k$,
$T_2 = -136^0 C = 137k$, $\gamma = 1.40$
From $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$
$144 \times (400)^{1.40} = 137 \times (V_2)^{1-40}$
$144 \times 144^{0.04} = 137 \times V_2^{0.40}$
$V_2^{0.04} = \frac{144x400^{0.40}}{137}$
$\therefore V_2 = 453.1cm^3$ (3marks)

Total marks 20

6. (a)
(i) - The value of the property chosen must be measurable and must change appreciably for small temperature - changes.
- The value must change linearly or uniformly with temperature. (2marks)

(ii) - It is very accurate since the pressure of the gas varies nearly linearly with temperature. (gas is anideal gas).
- It measures a wide range of temperature. (2marks)

(b)



- The eyepiece is focused upon the filament E of the lamp.
- The telescope is then directed to be furnace and light from it is focused by the objective so its image lies in the plane of the filament.
- While viewing through the eye piece, the rheostat R is adjusted until the bright pass of filament F merges with that of the furnace (or the filament just disappears') (6 marks)
- The temperature of the furnace is their read off directly from ammeter A previously calibrated in degrees Celsius or Kelvin.

(c) (i) **Latent heat of fusion** is the heat required to change the state of any given mass of a solid into liquid at constant temperature. (1mark)

(iii) During fusion, the latent heat is used to weaken the bonds between mols (or atoms) of the solid and thus the regular structure of the solid is broken down, characterizing a liquid state.

(iv) During vaporization, the latest heat of vap. Is not only used to separate the mols, i.e breaking the molecular bonds, but is also used by the vapour to expand and do work against a temperature pressure. Thus s. l. h. f > s. l. h. vap. (3 marks)

(d) In the first part,

Ht used to melt Ice at 0°C + Ht used to warm melted Ice from 0°c to 40°c = Ht given out by water and flask from 70°c to 40°c

$$i.e\ 0.05l + 0.05 \times 4200 \times (40^0 0) = 0.2 \times 4200 \times (70-40) + C(70-40)$$

where C= ht capacity of flask

$\therefore 0.05l + 8400 = 25200 + 30c$ or $0.05l - 30c = 16800$ (i)

In the second case;

new mass of water in the flask = 0.2 + 0.05 = 0.25kg.

∴Ht used to melt (80g) Ice at 0°C + Ht used to water melted Ice from 0°c to10°c = Ht given on by water and flask from 40°c to 10°c

$$i.e\ 0.08l + 0.08 \times 4200 \times (10-0) = 0.25 \times 4200 \times (40-10) + C(40-10)$$

$0.08l + 3360 = 31500 + 30c$

Or $0.08l - 30c = 28140$ (ii)

From (i) and (ii), **$l = 3.78 \times 10^5\ Jkg^{-1}$**

06

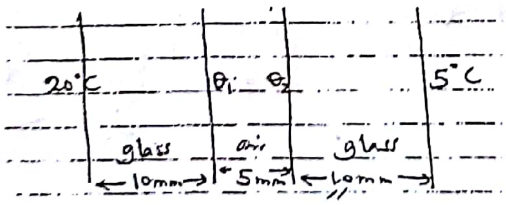
Total marks 20

7. (a) (i) **Thermal conductivity** is the rate of heat flow through a conductor per unit area of cross – section per unit temperature gradient. (1 mark)

(ii) In metals, there are free elections that move randomly with in the latrine of the metal. (3 marks)

- When one end of the material is heated, the electron there gain thermal energy, thereby increasing their vels and thus their k. e. as they drift from the heated end.
- They collide with atoms on their way towards the colder end, giving up some of their k. e. to these atoms.
- The vibrational energy of the atoms increases. This energy is passed on, leading to propagation of heat along the metal. (3 marks)

(b)



$Ka = 0.02Wm^{-1}k$

$Kg = 0.6Wm^{-1}k$

(i) $$Q/_A = \frac{kgA(20-\theta_1)}{xg} = \frac{kaA(\theta_1-\theta_2)}{xa} = \frac{kgA(\theta_2-5)}{xg}$$

$$Thus: \frac{0.6A(20-\theta_1)}{0.01} = \frac{0.02A(\theta_1-\theta_2)}{0.005}$$

From which $16\theta_1 - \theta_2 = 300$ (i)

Also, $\frac{0.6A(20-\theta_1)}{0.01} = \frac{0.6A(\theta_2-5)}{0.01}$

From which $\theta_1 + \theta_2 = 25$ (ii)

Solving (ii) and (ii) gives $\theta_1 = 19.12^0C$

$\theta_2 = 5.88^0C$ (6marks)

(ii) Rate of heat loss through the buyer of air $Q/_t$.

(c) (i) **Stefan's law of blackbody radiation** states that the power radiated per unit area of surface of a blackbody is directly proportional to those fourth power of the absolute temperature. (1 mark)

(ii) R = 40Re , where Re = distance of earth from sun.

➢ Power that falls on the planet, Pp

$$Pp = \frac{4\pi r_s^2 \sigma T_s^4}{4\pi R^2} x\ \pi rp^2 = \frac{r_s^2 \sigma T_s^4}{(40R_e)^2} x\ \pi rp^2$$

Where r_p = radius of the planet

At thermal equilibrium

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

➢ $4\pi r_p^2 \sigma T_p^4 = \frac{r_s^2 \sigma T_s^4}{(40R_e)^2} x\ \pi r_p^2$

➢ $T_p^4 = \frac{r_s^2 \sigma T_s^4}{(40R_e)^2} x \frac{1}{4}$

$$\therefore T_p = \left(\frac{5.67\ x\ 10^{-8} x (6000)^4 x r_s}{4\ x\ (40\ R_e)^2}\right)^{1/4} K$$

(6 marks)

NB: R_e = distance of Earth from sun not given.

r_s = radius of the sun not given.

20 marks

SECTION C

8. (a) (i) **Photoelectric emission** the ejection of electrons from the surface of a metal when irradiated by an electromagnetic radiation of high – enough frequency.

(1mark)

Observations.

- Photoelectric effect starts at the instant the metal surface is irradiated.
- Photo current (no. of electrons emitted per second) is proportional to the intensity of the radiation.
- The max k. e. of the photoelectrons is proportional to the intensity of the radiation.
- For a given metal surface, there exists a minimum frequency below which no photoelectric emission occurs regardless of the intensity of the radiation.

Explanation.

- According to quantum theory, radiation is emitted and absorbed in discrete amounts (quanta).
- So each quantum of light (photon) interacts with only ore electron in the metal surface, giving all its energy or none of it to the electron.
- The no of electrons emitted per second is proportional to the no. of incident photons falling on the surface per unit time (i.e intensity of the radiation).
- When the photoelectron energy high frequency is greater than the energy needed to overcome the attraction of the nucleus, an electron is emitted from the surface but if high frequency is less, then no photoemission loccurs. The difference between these energies become the k. e. of the emitted electrons;
  - ➢ As frequency increases, k. e. also increases.

(5 marks)

(8)(a)(iii) λ = 455nm = 455 x 10^{-9}m

$k.e_{max} = 0.75eV = 0.75 \, x \, 1.6 \, x \, 10^{-19}$J

From hf = $\frac{hc}{\lambda}$ = $w_o + ke_{max}$

wo = $\frac{hc}{\lambda} - ke_{max}$

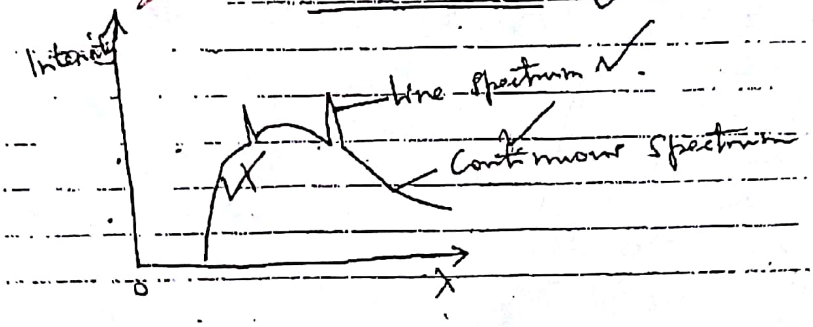
= $\frac{6.6 \, x \, 10^{-34} x \, 3.0 \, x \, 10^{8}}{455 \, x \, 10^{-19}}$ – 0.75 x 1.6 x 10^{-19}

wo = 4.23 x 10^{-19} = hf_0

f_0 = 4.23 x 10^{-19} / 6.6 x 10^{-34}

= 6.41 x 10^{14} Hz (4 marks)

8(b)



Continuous spectrum

- Is due to multiple collisions between the electrons and target atoms; Different electrons lose different amounts of energy, then x-ray photons with frequencies lower than maximum frequency are produced, covering a range of wavelengths.

Line spectrum.

- This is formed when highly energetic electrons bombard the target and are able to penetrate deep in the atoms and dislodge electrons from the innermost shell. The atom gets excited. The sub-segment electron transition from higher to lower energy levels causes a high energy x – ray photon to be emitted, which is the line spectrum.

(6 marks)

8 (c) I = 30mA = 30 x 10^{-3}A

V = 60kV = 60 x 10^{3}V

At the target; ht per second generated

$= \frac{99}{100} \, x \, IV = MC\theta$

$= \frac{99}{100} \, x \, 30 \, x \, 10^{-3} x 60 x 10^{3} = 0.060 \, x \, 4200 x \theta$

$\theta = 7.07^{0}C$ (4 marks)

20marks

9. (a) What is meant by the following terms as applied to radioactivity:

(i) **Half-life** Is the time taken for half the no of radioactive atoms of a substance to decay. (1 mark)

(ii) **Decay constant** Is the fractional n. of radioactive atoms that decay per second. (1 mark)

(iii) **Radioisotopes** are radioactive atoms of the same element that have the same atomic no. but different mass nos. (1 mark)

(b) Given the radioactive law N = $N_0 e^{-\lambda t}$

Let at time t = 0, N = No

and at time t = $t_{\frac{1}{2}}$, N = $\frac{N_0}{2}$

At one half-life; $N_{\frac{0}{2}} = N_0 e^{-\lambda t_{\frac{1}{2}}}$

$= \frac{1}{2} = e^{-\lambda t_{\frac{1}{2}}}$ or $2 = e^{-\lambda t_{\frac{1}{2}}}$

$= \ln 2 = \; ^{-}\lambda t_{\frac{1}{2}}$ or $t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$ or $\frac{t}{2} = \frac{0.693}{\lambda}$ (2 marks)

(c) Every a tom of **Uranium** that decays turns into a lead atom.

- When a mineral grain is formed, say, in the fossil, below its trapping temperature, it sets the uranium – lead clock to zero.
- The lead atoms created are trapped in the crystal and buildup in concentration with time.

The lead – Uranium proportion is determined in terms of mass and from the formula.

$$M_u = (M_u + M_{pb})e^{\lambda t}$$

t *can be obtained if half life of uranium is known.* (4 marks)

(d) 90 g of X contains 6.02×10^{23} atoms

$\therefore 2g$ *of* x *contains* $\frac{6.02 \times 10^{23}}{90} x \; 2 = 1.34 \times 10^{22}$ *atoms* (5 marks)

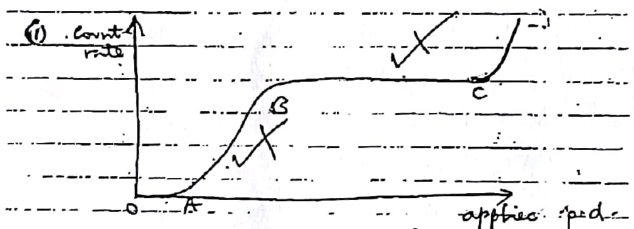
$\therefore N = 1.34 \times 10^{22}$ *atoms*

But $A = AN$, *where* $\lambda \; \frac{0.693}{20 \times 24 \times 60 \times 60} = 4.01 \times 10^{-7} S^{-1}$

$\therefore A = 4.01 \times 10^{-7} \times 1.34 \times 10^{22} = \underline{5.37 \times 10^{16} S^{-1}}$ (5 marks)

(4 marks)

(e) (i)



- Along OA, the applied voltage is less than the time hold voltage, and there is insufficient gas amplification (i.e there is recombination of in - pairs) and so no detectable pulses are produced.
- Along AB – the proportional region, the magnitude of any particular pulse depends on the strength of the initial ionization and the count-rate increases with p.d.
- A long BC – plateau region, all the ion pairs reach their respective destinations, and the pulses have the same amplitude regardless of the strength of the initial ionization – every particle produced ionization is detected.
- Beyond C (region CD), the quenching process becomes less and less effective and eventually, a continuous / discharge occurs.

(ii) The suitable region for operating the tube is region BC because every particle that produces ionization is detected. (2 marks)

(20 Total marks)

10. (a) (i) **Rutherford's model of the atom** of the atom states that;

- The positive charge of an atom and nearly all the mass are concentrated in a small volume at the centre.
- Electrons are in motion in spheres round the nucleus; and the volume of the atom are accounted; for by this electron cloud.

(2 marks)

(ii) Rutherford's failures were that;

- His model could not explain the stability of the atom and cannot explain why electrons move in circular orbits and how they emit energy.
- An orbiting electron is constantly changing its direction and therefore has acceleration due to electrostatic attraction force. In classical physics; changes that undergo acceleration emit electromagnetic radiation continuously and they would lose energy. In the process, the electrons would spiral towards the nucleus and atom could collapse or cease to exist within a short time; yet te atom ia a stable structure – Thus model can't explain stabilities of the atom.
- Since electrons, continuously accelerating around the nucleus, continuous emission spectra should be emitted by the atom; however experimental observation reveals that it is atomic emission line spectra which occur. (3 marks)

(b) (i) **Line spectrum** are discontinuous lines produced by electronic transition within the atoms as the electrons in them fall back to the lower energy levels. (2 marks)

(ii) The atoms of a particular element emit radiation (line spectrum) with definite frequencies or wavelengths. When an atom is in an excited state, an electron may fall into a vacancy in the lower energy levels. This is accompanied by an emission of electromagnetic rad whose frequency is got from $E = hf$, where E is the difference in the energy of the levels involved.

- So since the frequencies are definite for a particular element, then it implies that the energy levels are discrete.

(4 marks)

(c) (i) An energy levels is a specific or discrete amount of energy an electron can have when occupying a specific orbital. (1 mark)

(ii) Energy levels are negative because the electrons are bound to the nucleus so work has to be done to move them to infinity when energy is zero.

(iii) Ionisation energy $= 0 - -10.4$

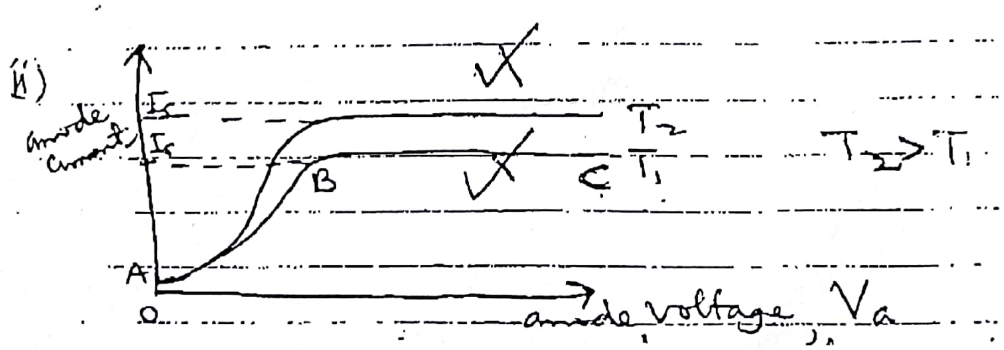
$= 10.4\text{eV}$, (2 marks)

$= 10.4 \times 1.6 \times 10^{-19}$

$= \underline{1.66 \times 10^{-18}\text{J}}$

(d) (i) **Space charge** Is the large number of electrons that gather close to the cathrode as an almost stationary cloud of negative charge due to buck of sufficient energy to enable them reach the anode. (1 mark)

(ii)



- At $V_a = 0$, some electrons are too energetic and may cause little current to flow. As va increases, the electron density of the space charge decreases and more electrons reach the a mode, so cure along AB increases.

- AB, all the electrons reach the anode (space charge no longer exists) and current will be max. (4 marks)
- A long BC, the current depends on the temperature of the filament. At higher temperature; more electrons are remitted, causing an increase in the saturation current. (4 marks)

Total marks = 20

END