WAKISSHA JOINT MOCK EXAMINATIONS
MARKING GUIDE
Uganda Advanced Certificate of Education
UACE August
PHYSICS P510/1

SECTION A

1. (a) (i) Linear momentum is the product of mass and velocity of a body. **(01 mark)**

(ii) The total momentum of any two or more bodies interacting is constant provided there are external forces acting. **(01 mark)**

(iii) Consider two bodies each mass m_1 and M_2 moving in the same direction at velocities V_1 and V_2 ($u_1 > u_2$). Suppose the two bodies collide and after each moves with velocity. V_1 and V_2 respectively in the same direction.
(In accordance with Newton's first law of motion)'

The force exerted by M_1 on M_2 = , F_{12} $\dfrac{m_2(v_2 - u_2)}{t}$ and force exerted by m_2 or

m_1, $F_{21} = \dfrac{m_1(v_1 - u_1)}{t}$ where t = time of impact

(In accordance with Newton's 2nd law of motion).
But $F_{12} = -F_{21}$(Newton's 3rd law)

$$\Rightarrow \frac{m_1(v_1 - u_1)}{t} = \frac{-m_2(v_2 - u_2)}{t}$$

$$\Rightarrow m_1v_1 - m_1v_2 + m_2u_2$$

Rearranging gives $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ which is the law of conservation of linear momentum.

(04 marks

(b) (i) Bending his knees when landing on the ground **increases the time during** which his body comes to rest.
The **rate of change of momentum of his body reduces;** and the force with which his legs hit the ground reduces; leading to a **reduced pain** on his legs.

(02 marks

(ii) $W = mg = 490.5 \Rightarrow \dfrac{490.5}{9.81} = 50kg$

From $\dfrac{1}{2}mv^2 = mgh \Rightarrow v = \sqrt{2gh}$

$$\sqrt{2 \times 9.81 \times 2.5}$$
$$= 7.0$$

$$\text{Force F} = \frac{m(v-u)}{t} = \frac{50(7.0-0)}{0.5}$$
$$= 700 \text{ N}$$

(04 mar

(c) (i)

Perfectly elastic collision	perfectly inelastic collision
• Kinetic energy is conserved.	• Kinetic energy is not conserved ie. Some is lost.
• Bodes move at different velocities(or separate)	• Bodies move with a common velocity (or stick together after collision.
• Examples collision between Molecules of an ideal gas.	• Collision between two vehicles that stick together after impact.

(03 marks)

(ii) For perfectly inelastic collision:

$m_1u_1+m_2u_2 = (m_1+m_2)V$

where V= common velocity.

$$\Rightarrow v = \frac{m_1u_1 + m_2u_2}{m_1 + m_2} \qquad \text{(i)}$$

Loss in k.e = Total k.e Before coil - Total k.e after coil.

$$= \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \frac{1}{2}(m_1 + m_2)V^2$$

$$= \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \frac{1}{2}(m_1 + m_2)\left(\frac{m_1u_1 + m_2u_2}{m_{1+m_2}}\right)^2$$

$$= \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \frac{1}{2}\left(\frac{m_1^2u_1^2 + 2m_1m_2u_1u_2 + m_2^2u_2^2}{m_1 + m_2}\right)$$

$$= \frac{1}{2}m_1m_2\left(\frac{u_1^2 - 2u_1u_2 + u_2^2}{m_1 + m_2}\right)$$

$$= \frac{m_1m_2(u_1 - u_2)^2}{2(m_1 + m_2)}$$

(04 mar

(iii) - Launch of rockets (rockets propulsion)
- Jet engine operation.
- Recoil of a gun. ***Any 2@ ½***
- Motion of motor boats.

(01 ma

TOTAL MARKS =

2. (a) (i) Centripetal acceleration is the rate of change of velocity of a body moving in a circular path and is directed towards the Centre of the path.

(01 ma

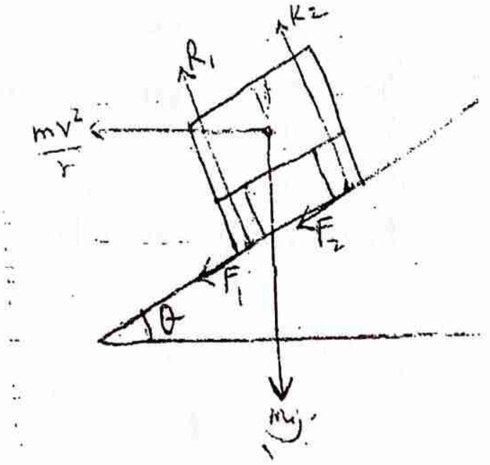
(ii) Angular velocity is the rate of change of angular displacement of a body moving in a circular path.

(01 mark)

(b) (i) Banking a track help to increase the forces that provide the **centripetal force,** ie. The horizontal components of the normal reaction and friction; thereby **increasing** the **speed at** which a car moves around the bend without skidding or toppling.

(0 1 mark)

(ii)



$F_1 = \mu R_1$, $F_2 = \mu R_2$

$$\left(R_1\sin\theta + R_2\sin\theta\right) + \left(F_1\cos\theta + F_2\cos\theta\right) = \frac{mv^2}{r}$$

$$\Rightarrow \left(R_1 + R_2\right)\left(\sin\theta + \mu\cos\theta\right) = \frac{mv^2}{r} \quad \text{—————— (i)}$$

Also; $\left(R_1\cos\theta + R_2\cos\theta - (F_1\sin\theta + F_2\sin\theta\right) = mg$

$$\Rightarrow \left(R_1 + R_2\right)\left(\cos - \mu\sin\theta\right) = mg \quad \text{—————— (ii)}$$

Dividing (i) by (ii) gives

$$\frac{\sin\theta + \mu\cos\theta}{\cos\theta - \mu\sin\theta} = \frac{v^2}{rg}$$

Dividing this by $\cos\theta =$

$$\frac{\tan\theta + \mu}{1 - \mu\tan\theta} = \frac{v^2}{rg}$$

From which;

$$\theta = \tan^{-1}\left(\frac{v^2 - \mu rg}{v^2\mu + rg}\right)$$

(04 marks)

(iii) r=65m, $\theta = \tan^{-1}\left(5/12\right) = 22.6^0$, V=?

For no tendarney to slip, these will be no friction.

$$\therefore v = \sqrt{rg\tan\theta}$$

$$= \sqrt{65 \times 9.81 \times \tan 22.6}$$

$$= 16.29\text{ms}^{-1}$$

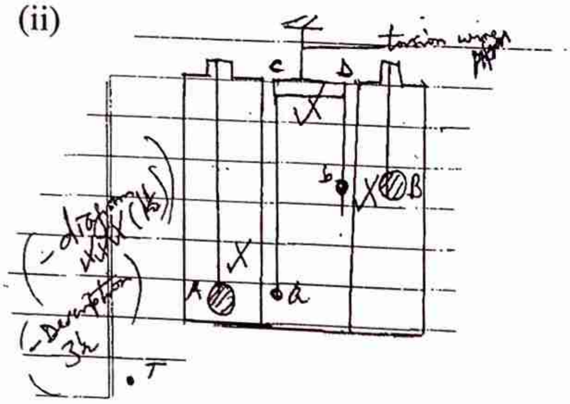
(03 mark

(c) (i)

- Planets describe elliptical orbit about the sun as one focus.
- The imaginary line joining a planet to the sun sweeps out equal areas in equal time intervals.
- The squares of the period of revolutions of planets about the sum is directly proportional to the cubes of their mean distances from the sun.

(03 mark

(ii)



Two **identical gold balls** a and b are suspended by a long and short fine quarts strings respectively from the end of a highly polished bar CD.

- Two **large lead spheres** A and B are brought into position near a and b as show
- The deflection θ of the bar CD is measured and noted by a lamp and seale method.
- The distance **d** between A and a or B and b is noted.
- The mass **m and M** of a and A respectively is also measured and recorded.
- The gravitational constant G is the obtained from; $G = \dfrac{c\theta d^2}{MmCD}$

where C= obtained constant of the wire.

(05 mark

(c) (iii) m = 10 kg, h=30m.

Difference in the weight

$$= GMm\left(\frac{1}{re^2} - \frac{1}{(re+h)^2}\right)$$

$$= 6.67\times10^{-11}\times Me\times10\left(\frac{1}{\left(6.4\times10^6\right)^2} - \frac{1}{\left(6.4\times10^6+10\right)^2}\right)$$

$$= 9.11\times10^{-4}\,N$$

(02 mark

TOTAL MARKS = 2

3. (a) (i) Surface tension is the tangential force per meter that its perpendicularly to one si of an **imaginary** line drawn on a liquid surface.

(01 mark

(ii) - Some lycopodium powder or light dust in sprinkled on the surface of clean water standing in a flat metal dish.
- One side of the dish is then gently heated with a candle or bursen flame.

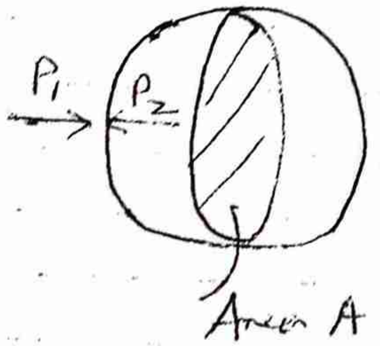
- It will be noted that the particles of the powder will be swept away from the heated portion, implying that the surface tension force can no longer hold the particles of the powder in their previous positions.

(03 marks)

(iii) The other factor is **presence of impurities** in the liquid; which **reduces** surface tension force of the liquid.

(02marks)

(b) (i)



A soap bubble in air has two liquid surface in contact with air.

This surface tensional forces = $2\times 2\pi r\gamma = 4\pi r\gamma$

For the bubble to be in equilibrium:

force due to external pressure P_1 + force due to surface tension. = force due to internal Press P_2

ie. $P_1 . A + 4\pi r\gamma = P_2 . A$

where A = area of cross – section of the bubble

$= \pi r^2$

$$\Rightarrow p_1 .\pi r^2 + 4\pi r\gamma = p_2 .\pi r^2$$

$$\text{or } (p_2 - p_1)\pi r^2 = 4\pi r\gamma$$

$$\Rightarrow \text{pressure diff } (P_2 - P_1) = \frac{4\gamma}{r}$$

(04 marks)

(ii) $r_1 = 1.5$cm, $r_2 = 30$cm, excess pressure =?

Pressure difference, $P = \frac{4\gamma}{r}$

Where $r = \sqrt{r_1^2 + r_2^2}$

$$\therefore p \frac{4}{\sqrt{r_1^2 + r_2^2}} = \frac{4\times 2.0\times 10^{-2}}{\sqrt{(0.015)^2 + (0.03)^2}}$$

$$= 2.38 \text{ Nm}^{-2}$$

(03marks)

(c) (i) Coefficient of viscosity is the tangential force acting on an area of $1m^2$ of fluid which resists the motion of one layer over another when the velocity gradient is $1s^{-1}$ (or tangential force per unit area of surface between two fluid layers in contact per unit velocity. Gradiant) **(01 marl**

(ii) - In liquids, viscosity is due to the **existence of intermolecular** forces of attraction. When temperature is increased, the molecules **move further apart with increased** k.e

- Thus the **internal Force area weakened;** leading to a decrease in viscosity of the liquid.

(03 marks)

(d) $A_1 = 15cm^2 = 15\times10^{-4}m^2, V_1 = 0.5ms^{-1}$

$A_2 = 3.0cm^2 = 3.0\times10^{-4}m^2, V_2e$

from $A_1V_1 = A_2V_2$

$\Rightarrow 15\times10^{-4}\times0.5 = 3.0\times10^{-4}\times V_2$

$$V_2 = 2.5ms^{-1}$$

Pressure difference, $P = \frac{1}{2}\rho\left(v_2^2 - v_1^2\right)$

Where ρ = density of the liquid.

$\therefore P = \frac{1}{2}\rho\left(2.5^2 - 0.5^2\right)$

$= 3\rho Nm^{-2}$

(03 marks)

TOTAL 20 MARKS

4. (a) (i) Elasticity is the property of a material to regain its original shape (size or length) if the deforming force has been removed. **(01 mark)**

(ii) Force constant is the ratio of force to extension of an elastic material. Or the amount of force that causes a unit extension of a material. **(01 mark)**

(b) Original length =l, x-sectional area =A, force constant =k new length = l+x, stretching force =F.

(i) Young's modulus,$E = \frac{\text{stress}}{\text{strain}} = \frac{F/A}{x/l}$

$$\therefore E = \frac{Fl}{Ax}$$

from which $F = \frac{EAx}{l}$

But $F = kx$

$\Rightarrow F = \frac{EAx}{l} = kx$

$\therefore k = EA/l$

(03 marks)

(ii) Energy stored in the wire = work done to stretch material ie.
W= average force × extension.
$= F/2 \times x = \frac{1}{2}Fx$
Since F =kx.

$\Rightarrow W = \frac{1}{2}kx^2$

$$\text{But } K = \frac{EA}{l}$$

$$\therefore w = \frac{1}{2}\frac{EA}{l}.x^2$$

Also ; energy stored per unit vol = $^{w}/_{Al} = \frac{1}{2}\,^{EAx2}/_{Al}{}^2$
$= \frac{1}{2}E(^x/_l)^2$

(03 marks)

(c) $lc = 1.0m$, dc = 0.5mm = 0.5×10^{-3}m

$ls = 0.5m, ds = 0.8m = 0.8 \times 10^{-3} m$
$M = 12kg;\ W = 12 \times 9.81 = 117.72N$

(i) From extension $x = \frac{Fl}{EA}$

$$\text{For copper, } xc = \frac{Flc}{EcAc} = \frac{12\times9.81\times1.0\times4}{Ec\times3.14\times\left(0.5\times10^{-3}\right)^2}$$

$$= x_c = \frac{6.0\times10^8}{E_c}$$

$$\text{For steel, } X_s = \frac{Fl_s}{E_sA_s} = \frac{12\times9.81\times0.5\times4}{Es\times3.14\times\left(0.8\times10^{-3}\right)^2}$$

$$= \frac{2.93\times10^7}{Es}$$

$$x_s = \frac{1.17\times10^8}{E_s} = \frac{1.17\times10^8}{E_s}$$

$\therefore$ Total extension, $x = xc + xs$

$$= \frac{1.49\times10^8}{Ec} + \frac{2.93\times10^7}{Es}$$

$$= \frac{6.0\times10^8}{E_c} + \frac{1.117\times10^8}{E_s}$$

$$= 10^8\left(\frac{6.0}{Ec} + \frac{1.17}{Es}\right)$$

(04 mark

(ii) Energy stored in the compound wire

$$W = \frac{1}{2}Fx_1 + \frac{1}{2}Fx_2 = \frac{1}{2}Fx$$

$$= \frac{1}{2} \times 12 \times 9.81 \times 10^{8} \left(\frac{6.0}{Ec} + \frac{1.17}{Es} \right)$$

$$= 5.89 \times 10^{9} \left(\frac{6.0}{Ec} + \frac{1.17}{E_s} \right) J$$

(03 mar[ks])

(d) (i) Bernorth's principle states that in an **incompressible non-viscons** fluid undergoing a steamline flow, the sum of the pressure at any point, the k.e per unit vol. and the p.e per unit vol. is constant.

(01 ma[rk])

(ii)

- A strong wind above the roof causes a faster flow of air above it than below, where the air is almost stationary.
- By Benouill's principle the presence under neath is greater than that abov[e] the roof.
- The **pressure difference** this produces an **upward resultant** force on the roof which consequently **lift it** and is blown off.

(04 mar[ks])

TOTAL MARKS 2[0]

SECTION B

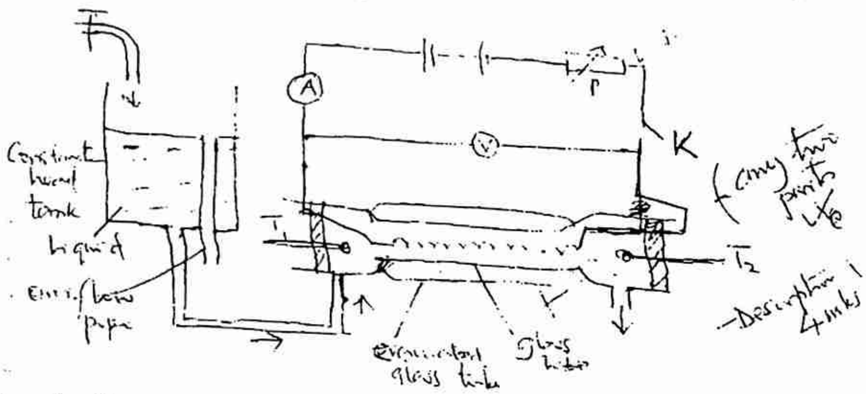
5. (a) (i) Heat capacity is the heat required the raise the temperature of any mass of substance by 1K

(01 mar[k])

(ii) Cooling correction is the temperature that is added to observed max temperature to cater for heat losses to the surroundings.

(01 mar[k])

(b) (i)



Any 2 parts @ ½ = 01

- A **steady flow of the liquid** is set at a constant rate.
- K is closed and liquid is heated as it flows through the tube until the thermometer readings indicated by **T_1 and T_2 are constant;** and their readings **θ_1 and θ_2 are noted.**
- The ammeter and voltmeter readings **I_1 and V_1** respectively are noted.
- The liquid is collected in a measured time and its mass per second M_1 collected is determined.
- The experiment is repeated by adjusting the flow rate of the liquid to a new value; P is adjusted until the therm readings indicated by T_1 and T_2 are the same as before i.e. θ_1 and θ_2.
- The new ammeter and voltmeter readings **I_2 and V_2** and the mass per second m[2] of the liquid collected in the same time are noted.

The s.h.c of the liquid is then obtained from; $C = \frac{I_2V_2 - I_1V_1}{(m_2 - m_1)(\theta_2 - \theta_1)}$

-

(05 marks)

(ii) This is to maintain the same rate of heat loss to the surrounding in the two parts of the experiment. **(01 marks)**

(iii) Heat capacity of the apparatus is not required.

- Cooling correction is not required.
- Heat losses to the surroudings can be accounted for by repeating the experiment.
- Heat losses are minimized by use of a vacuum.
- Readings can be recorded at leisure.

(03 marks)

(c) $\theta = 2.0^0 C$, $m_1 = 20gs^{-1} = 0.02kgs^{-1}$, $P_1 = 40W$

$m_2 = 75gs^{-1} = 0.075kgs^{-1}$, $P_2 = 80W$

from $= mc\theta + h$,

$40 = 0.02\ C \times 2.0 + h$

$\Rightarrow 40 = 0.04C + h$ ______ (i)

Also $80 = 0.075\ C \times 2.0 + h$

$\Rightarrow 80 = 0.150\ C + h$ ______ (ii)

Solving (i) and (ii) gives: $h = 25.45W$

$\therefore$ heat lost in 5 minutes $= 25.45 \times 5 \times 60$

$= 7635\ J$

or $= 7.635 \times 10^3 J$

(05 marks)

(d) (i) Latent heat of fusion of ice is the heat required to change the state any given mass of ice into water at its melting point.

(01 mark)

(ii) When the cold ice comes into contact with one's hand heat is lost from the hand to the ice, causing a thin layer of water to form on ice due to melting.
This thin layer of water together with the sweat in the hand **will freeze** into the tiny indentations in the surface of the hand.
The oxygen and hydrogen atoms in the water molecules in the ice will **form strong bonds** with the hydrogen and oxygen atoms respectively in the sweat.
This strong bond **will give the "sticking"** feeling in the hand.

(03 marks

TOTAL 20 MARKS

6. (a) (i) Isothermal change is the expansion or contraction of a gas that takes place at constant **temperature.** While Achiabatic change is the expansion or contraction of a gas that takes place at **constant heat.** **(01 mark**

(ii) - The expansion or contraction of the gas must take place **rapidly** to give little time fo heat to escape or enter the system.
- The walls of the container of the gas must be **thick walled** and of **poor conducting** materials.
- Frictionless

(iii) - Transmission of sound waves through air. (02 mar
- Rapid expansion of air during a tyre burst.
- Inflating tyre.

(b) $P_1 = 2.0\times10^6$ Pa, $V_1=3.0l = 3.0\times10^{-3}m^3$, $T_1=50^0C = 323k$ (02 mar
$P_2 = 1.0\times10^7$ Pa.

(i) From $n = \frac{P_1V_1}{RT_1} = \frac{2.0\times10^6 \times 3.0\times10^{-3}}{8.31\times323}$

$= 2.24$ moles

(ii) $T_2 = ?$ from $P_1V_1 = P_2V_2$ (03 mar
1.4

$$V_2 = \frac{P_1}{P_2}.V_1 = \frac{2.0\times10^6}{1.0\times10^7}\times\left(3.0\times10^{-3}\right)^{1.4}$$

$$V_2^{1.4} = \frac{P_1}{P_2}.V_1^{1.4} = V_2 = \left(\frac{2.0\times10^6}{1.0\times10^7}\times\left(3.0\times10^{-3}\right)^{1.4}\right)^{\frac{1}{1.4}}$$

From $V_2 = 9.5\times10^{-4}m^3$

Also $T_1V_1 = T_2V_2^{6-1}$

$$\Rightarrow T_2 = \left(\frac{v_1}{v_2}\right)^{6-1}\times T_1$$

$$= \left(\frac{3.0\times10^{-3}}{9.5\times10^{-4}}\right)^{1.40-1}\times323$$

$= 511.63K$

(c) (i) Molar heat capacity at constant pressure is defined as the heat required to raise the temperature of one mole of a gas by 1K when its pressure is constant. (04 mar

(ii) If 1 mole of a gas is heated through ΔT at constant vol; $\Delta Q = CV\Delta T$. (01 ma
Where CV = Molar heat capacity at constant vol.
Since $\Delta V = 0 \Rightarrow \Delta w = 0$
from $\Delta Q = \Delta u + \Delta w$
$\Rightarrow \Delta Q = \Delta u = Cv\Delta T$
If the same gas of 1 mole is heated through ΔT at constant pressure;

$$\Delta Q = Cp\Delta T$$

Where Cp = molar ht capacity at constant pressure.
$\Rightarrow \Delta Q = Cp\Delta T = \Delta u + \Delta w$
$\therefore Cp\Delta T = Cv\Delta T + P\Delta V$
But for 1 mole; $PV = RT$ ______ (i)
And $P(V+\Delta V) = R(T+\Delta T)$ ______ (ii) for constant pressure.
from (i) and (ii): $P\Delta V = R\Delta T$

$\therefore$ In(*)$C_p\Delta T = C_v\Delta T + R\Delta T$

from which $C_p = C_v + R$ or $C_p - C_v = R$

(05 marks)

(d)

- When a gas is composed in a vessel, its molecules **bounce off the wall with increased speed.**
- The frequency of collisions between the molecules also increases and this increases the mean k.e of the molecules.
- Since mean k.e of the moles is portional to **absolute temperature,** $\Rightarrow$ temp. **of the gas increases.**

(02 marks)

TOTAL = 20 MARKS

7. (a) (i) A black body is a body which absorbs all the radiations of every wave length falling on it and transmits none.

(01 mark)

(ii) Stefan's law- the energy radiated per second per unit surface area of a black body is directly proportional to the fourth power absolute temperature of the body.

(or $\frac{P}{A}$ α T^4- with P and T defined)

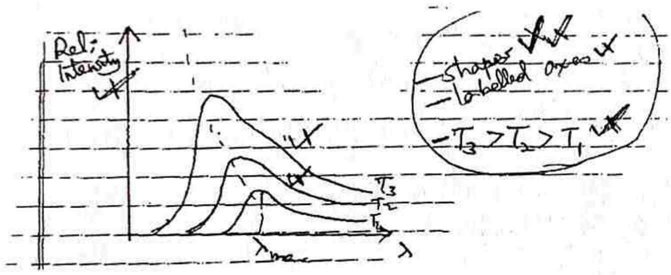
(01 mark)

Wien's displacement law the wave length at which intensity of energy emitted by a black body is inversely prop to its absolute temperature.

(01 mark)

(or λ_{max} α $\frac{1}{T}$ with λ_{max} and T defined

(b)



(02 marks

- As the temperature of the body increases, the intensities of every wave length increases, the **intensities of the shorter wave lengths increase more rapidly.**
- At each temp; there is max. intensity which occurs at a particular wave **length** λ_{max} which decreases with increasing temp.

(03 marks

7. (c) $T = 3500^0C = 3773K$, $A = 0.42cm^2 = 0.42\times10^{-4}m^2$

(i) $P = 0.29\sigma AT^4$

$= 0.29\times 5.67\times10^{-8}\times0.42\times10^{-4}\times(3773)^4$

$= 140w$

(03 marks

(ii) $\lambda_{max}T = 2.90\times10^{-3}$

But $\lambda_{max} = {}^{c}/_{f}$

$$\Rightarrow \frac{c}{f}.T = 2.90\times10^{-3}$$

$$\therefore f = \frac{CT}{2.90\times10^{-3}} = \frac{3.0\times10^{8}\times3773}{2.90\times10^{-3}}$$

$= 3.9\times10^{14}$Hz

(d) (i) **(03 mar**

- Atoms in a solid are closely packed together.
- When one end of the solid is heated, the **atoms there absorb the heat energy** a begin to **vibrate with increased amplitudes about their fixed positions.**
- Since they are coupled by **interatomic bonds** to the neighboring atoms, they pa on their vibrational energy to them; which in turn **pass on the energy to their neighbors,** causing heat **energy to be transmitted to the colder** end.

(ii) **(03 mark**

- Metals have **free electrons** in their lattice that move **with high** or increased **velocities once they gain heat energy** from the heated end unlike in insulator
- Also, owning to the fact they **are lighter,** they carry the heat energy which the pass on to the positive nucleus of atoms **due to collisions** in the metal lattice. This makes heat transfer faster unlike **in insulators** where heat transfer is due atomic vibrations only.

(03 mark

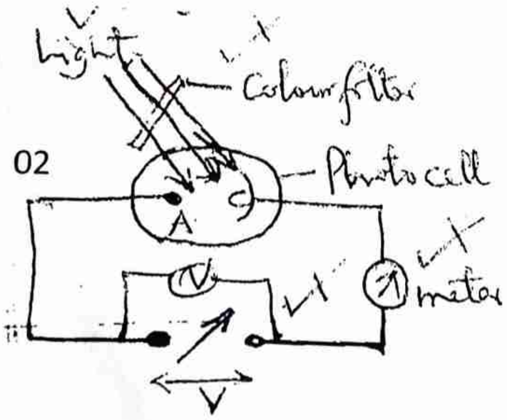
TOTAL 20 MARK

SECTION C

8. (a) (i) Photoelectric emission – is the ejection of electrons from a metal surface when irradiated by an electromagnetic radn (light) of high enough frequency. **(01 mar**

(ii) Stopping potential – Is the minimum negative potential (voltage) applied to the anode to stop the most energetic electron from reaching it. (or to reducing the photo current zero). **(01 mark**

(b)



- An evaluated photo cell that has a photo emissive cathode C of large surface area and an anode A is used.
- Circuit is connected across a variable potential.

- A is made negative in potential relative to C.
- The p.d V is **increased negatively** until the **photo current registered by the meter is zero.**
- The p.d Vs is then noted from the voltmeter V and is the stopping potential.

(05 marks)

(c) $\lambda = 145\text{nm} = 145\times10^{-9}\text{m}$, $w_o = 2\text{eV}$

(i) $\frac{1}{2} m V_{max}^2 = \frac{hc}{\lambda} - w_o$

$$\Rightarrow \frac{1}{2} \times 9.11 \times 10^{-31} \times V_{max}^2 = \frac{6.6 \times 10^{-34} \times 3.0 \times 10^{8}}{145 \times 10^{-9}} - 2 \times 1.6 \times 10^{-19}$$

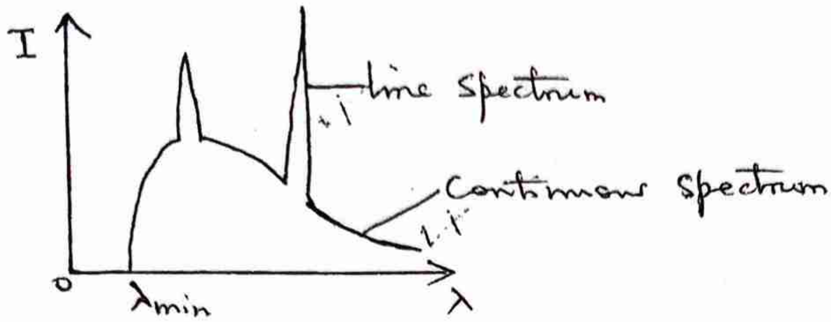
$\therefore V_{max} = 1.52 \times 10^6\ ms^{-1}$ **(03 marks)**

(ii) $hf_o = w_o \Rightarrow f_o = \frac{w_o}{h} = \frac{2 \times 106 \times 10^{-19}}{6.6 \times 10^{-34}} = 4.85 \times 10^{14} Hz$ **(02 marks)**

(d) (i) X-rays are electromagnetic radiations of very high frequency and short wave length emitted or produced when fast moving electrons are stopped by matter.

(01 mark)

(ii)



- Continuous spectrum is produced when multiple collision occur between the energetic electrons and the target atoms.
- At each collision, X-rays photons of different wave lengths are emitted since each electron gives up a different amount of its k.e.
- Line spectrum is produced when a highly energetic **electron penetrates deeper** into an atom of the target metal and **knocks out an electron from the inner** most shell. The **electron transition to the vacancies** left results and leads to emission of X-rays of definite wave length seen as line spectrum.
- When an electron gives up all its k.e in a single collision, a highly energetic X-ray photon of max. frequency and min wave length λ_{min} is emitted.

(04 marks

(iii) $f_{max} = \frac{eVa}{h} = \frac{1.6 \times 10^{-19} \times 40 \times 10^{3}}{6.6 \times 10^{-3.4}} = 9.69 \times 10^{18} H\cancel{z}$

(03 marks

Total 20 mark

9. (a) (i) Background radiation – is the natural ionizing radiation present in the environment, emitted from a variety of source to which all humans are exposed to.

(01 marks

(ii) Main sources.
- Cosmic radiation.
- Terrestrial radiation.
- Inhalation/ingestion radiation.

(02 mark

(iii) Examples of background radiation:
- Cosmic rays from the sun.
- Gaseous radon. **(any 2 @ 1 = 02)**

(01 mar

(b) (i) The law of radioactive decay states that for a particular time, the rate of radioactive disintegration is directly proportional to the number of nuclei of the element present at that time.

(or $\frac{dN}{dt} \propto N$ – with symbols defined)

(ii) To show that $\lambda T_{\frac{1}{2}} = \ln 2$. (01 mark)

from $N = N_o e^{-\lambda t}$

when $t = T_{½}$, $N_o = \frac{N_o}{2}$

$$\Rightarrow \frac{N_o}{2} = N_o e^{-\lambda T\frac{1}{2}}$$

$$\Rightarrow \frac{1}{2} = e^{-\lambda T\frac{1}{2}} \text{ or } 2 = e^{\lambda T\frac{1}{2}}$$

Taking $\log_e$ of both sides;

$$\ln e^{\lambda T\frac{1}{2}} = \ln 2$$

$$\Rightarrow \lambda T\frac{1}{2} = \ln 2$$

9. (b) (iii) $T\frac{1}{2} = 28$yrs, $t = 15$ yrs (02 marks)

$$\lambda = \frac{0.693}{T_{\frac{1}{2}}} = \frac{0.693}{28} = 0.0248\,yr^{-1}$$

Original no. of atoms, $N_o = \frac{N_A}{M}.m_o = \left(\frac{N_A}{M} \times 5 \times 10^{-6}\right)$

where N_A = Avogadro no.
M = molar mass of strontium.

from $N = N_o e^{-\lambda t}$, $N = \left(\frac{N_A}{M} \times 5.0 \times 10^{-6}\right) e^{-(0.0248 \times 15)}$

$$= \left(3.45 \times 10^{-6}\frac{N_A}{M}\right) atoms$$

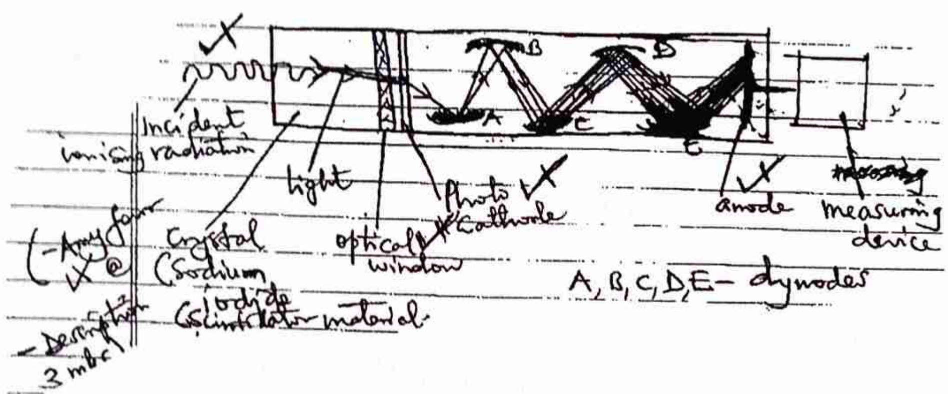
∴ mass remaining in the N atoms.

$$= \left(3.45\times10^{-6}\frac{N_A}{M}\right)\times\frac{M}{N_A} \qquad N = \frac{6.02\times10^{33}\times3.4\times10^{-6}}{M}$$

$= 3.45\times10^{-6}$ g or 3.45ng.

(04 marks)

(c) (i)



(02)

- Ionizing radiation enters into the crystal of sodium iodide and causes a photon of visible light to be produced.
- Electrons are then released when this light strikes the photocathrode.
- These electrons are then accelerated towards the first dynode A by a p.d, high enough to release electrons from A.
- These electrons are attracted towards the second dynode B, and more electrons are released.
- Each dynode impact release more electrons producing a current amplifying effect at each dynode stage.
- At the find dynode, sufficient electrons are available to produce pulse of current which can be analyzed by the measuring device.

(05 marks)

(ii) Two advantages of the scihtillator counter over the GM tube;
- Its counting rate is very fast;
- It can also be used to detect x-rays. **(any 02)**
- It is more sensitive compared to the GM tube.
- It can detect lower levels of radiation.

(02 marks)

(d) Industrial use
- In tracers to monitor fluid flow
- Detection of leaks. **(any 01)**
- Ganging engine wear and corrosion
- Monitoring thickness of metal sheets during manufacture.

Medical use
- In therapy to treat cancer. **(any 01)**
- In diagrosis of tumours and other maligrat growths in the body.

(02 marks)

Total 20 marks

10. (a) (i) Mass defect is the difference between the mass of nucleus and total mass of the constituent nucleons of an atom. **(01 mark)**

(ii) E = me²
where E = binding energy in joules.
m = mass defect in kg
e = speed of light in vacuum. **(01 mark)**

(b) (i) Nuclear fusion – is the combining of two lighter nuclei to form a heavier stable nucleus accompanied by release of energy. **While**

- Nuclear fusion is the splitting of a heavy unstable nuclear into two or more lighter nuclei accompanied by emission of energy.

(02 marks)

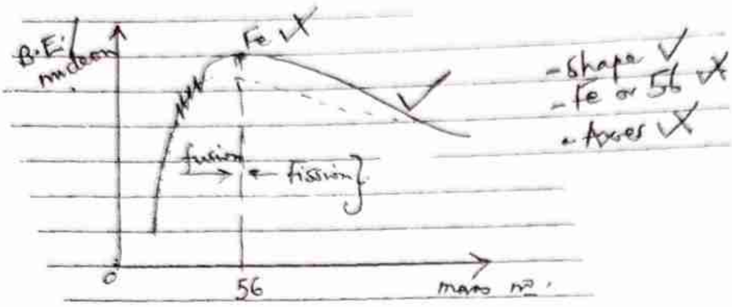
(ii) High temperature.

- This gives the nuclei of atoms enough **kinetic energy to destroy** and overcome the **electrostatic force** of repulsion between their nuclei so as to fuse. **(02 marks)**

High pressure.

- This helps to squeeze the nuclei together into a smaller space thereby increasing the density of the atoms and increasing their chances to fuse. **(02 marks)**

(iii)



(02 marks)

10. (c) Mass of 5 protons = 5×1.0080U = 5.0400U
Mass of 5 neutrons = 5×1.5087U = 7.5435U
Total mass of nucleons = 12.5835U
∴mass defect = 12.5835U-10.0129U
= 2.5706U
= 2.5706×1066×10^{-27}kg.
= 4.27×10^{-27}kg.

From $E = mc^2 = 4.27\times10^{-27} \times(3.0 \times10^{8})^2$

$= 3.843\times10^{-10}$J

B.E pernucleon = $\frac{3.843\times10^{-10}}{10}$ J

$= 3.843\times10^{-11}$J

(05 marks)

(d) (i) Bohr's postulates;

- In an atom, electrons revolve round the nucleus in discrete circular orbits **without emission** of energy.
- Electrons revolve around the nucleus only in an integral multiple of $\frac{h}{2\pi}$.
- When electron makes a transition from one orbit to another of lower energy, a photon is emitted equal to the energy difference between the two states.

(02Marks)

(ii)

- When an atom is involved in a violent collision, an electron may **gain energy** and move from its normal orbit to **one of a higher energy** level.
- This makes the atom excited **but soon the electron returns to its** original orbit.
- This electron transition is accomplished by **emission of energy** in form of light.
- The wave length of the emitted **light is dependent** on the two orbits involved.
- Light of a number of different λ_s may be produced corresponding to the electronic transition and this constitute the line spectrum.

(03 marks)

TOTAL 20 MARKS

END