LUBOWA

WAKISSHA JOINT MOCK EXAMINATIONS
MARKING GUIDE
Uganda Advanced Certificate of Education
UACE August 2023
PHYSICS P510/1

SECTION A

1. (a) (i) Dimensions of a physical quantity is the way the physical quantity is expressed in terms of fundamental quantities of mass, length and time. **(01)**

(ii) - It is used to check the validity or consistency of an equation.
- Used to derive equation and units of physical quantities. **(01)**

(iii) $S = \dfrac{v^2 - u^2}{2a} \Rightarrow [S] = \dfrac{[v^2 - u^2]}{[2a]}$

But $[S] = L$

$[v^2 - u^2] = (LT^{-1})^2 = L^2T^{-2}$

$[2a] = LT^{-2}$

$\therefore [R.H.S.] = \dfrac{L^2T^{-2}}{LT^{-2}} = L$ **(03)**

Since $\therefore [L.H.S.] = [R.H.S.]$,
therefore the expression is dimensionally consistent.

(b) (i) – In a perfectly elastic Collision, total k.e. is conserved while in perfectly in elastic coll. total k.e. is not conserved. **(02)**
- In perfectly elastic coll, bodies move at different vels (or separate) after coll. While in a perfectly inelastic coll, bodies more at constant vel. (or stick together) after coll.

(ii) From principle of conserve. of lin. Mom.

$m_1u_1 = m_1v_1 + m_2v_2$ ________(i)

Where, $u_1 =$ Initial vel. of m_1

$v_1 =$ Initial vel. of m_1

$v_2 =$ Initial vel. of m_2

Also: $E_0 = \frac{1}{2}m_1u_1^2$ and final ke of $m_1 = \frac{1}{2}m_1v_1^2$

$\therefore \Delta E = \frac{1}{2}m_1u_1^2 - \frac{1}{2}m_1v_1^2$ __________(ii)

$\therefore \dfrac{\Delta E}{E_0} = \dfrac{\frac{1}{2}m_1u_1^2 - \frac{1}{2}m_1v_1^2}{\frac{1}{2}m_1u_1^2} = \dfrac{u_1^2 - v_1^2}{u_1^2}$ __________(iii)

From equation (i): $u_1 = v_1 + xv_2$ where $x = \dfrac{m_2}{m_1}$

$\Rightarrow v_2 = \dfrac{u_1 - v_1}{x}$, also $x = \dfrac{u_1 - v_1}{v_2}$

Again from the principle of conserve of k.e

$$\frac{1}{2}m_1u_1^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

$$\therefore u_1^2 = v_1^2 + Xv_2^2$$

$$\Rightarrow u_1^2 = v_1^2 + \left(\frac{u_1 - v_1}{v_2}\right)v_2^2 = \cancel{u_1v_2 - v_1v_2 - v_1v_2}$$

$$\therefore u_1^2 - v_1^2 = v_2(u_1 - v_1)$$

$$\Rightarrow (u_1 + v_1)(u_1 - v_1) = v_2(u_1 - v_1)$$

From which $v_2 = u_1 + v_1 = \dfrac{u_1 + v_1}{x}$

$$\therefore xu_1 + xv_1 = u_1 + v_1$$

$$u_1(x-1) = -(1+x)v_1$$

$$\frac{v_1}{u_1} = -(x-1)\Big/1+x$$

$$\therefore \frac{v_1}{u_1} = \frac{1-x}{1+x}$$

Thus $\dfrac{\Delta E}{E_0} = \dfrac{v_1^2 - u_1^2}{u_1^2} = \dfrac{v_1^2}{u_1^2} - 1$

From (iii) $= \left(\dfrac{1-x}{1+x}\right)^2 - 1$

$$= \frac{(1-x)^2 - (1+x)^2}{(1+x)^2}$$

$1-2x+x^2 - 1-2x-x^2$

$-4x.$

$$= \frac{-4x}{(1+x)^2}$$ **(05)**

(c) (i)
- Solid surfaces have molecular projections.
- When in contact, the actual area of contact is very small, and high pressures develop at the points of contact, pushing the molecules at points of contact, into close proximity, resulting into cold welds; which have to be broken for relative motion to take place, hence existence of frictional force. **(03)**

(ii) m = 1 ton = $10^3 kg$; u=72kmh^{-1} = 20ms^{-1}

From $a = \dfrac{v^2 - u^2}{2S} = \dfrac{0 - 20^2}{2\times 90} = -2.22ms^{-1}$

From F = $\mu mg = ma \Rightarrow \mu = \dfrac{-a}{g}$

$\therefore \mu = \dfrac{-(-2.22)}{9.81} = 0.226$ **(05)**

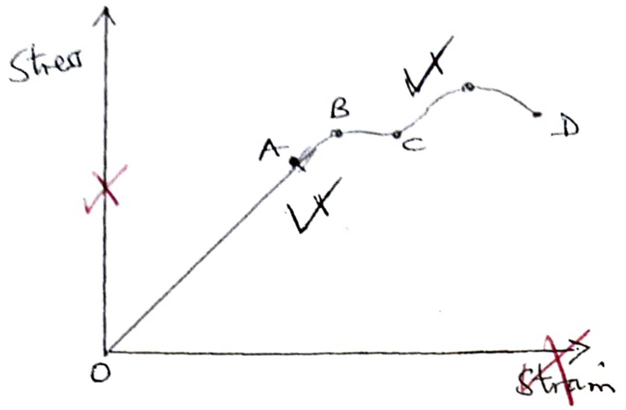
K.E → Heat + sound.

20

2. (a) (i) Tensile stress – Is tensional force acting per unit cross – sectional area of a material. **(01)**

(ii) Tensile strain is the ratio of extension produced to the original length of a material, **(01)**

(b) (i)



• Shape ✓
• Explanation ✓✓

- OA – region in which stress is proportional to strain and the wire regains its original length when stress is removed,
- AB – the material is elastic but does not obey Hooke's law.
- Beyond B – the wire undergoes plastic deformation – i.e. it does not regain its length when the stress is removed.
- Beyond C - material surfers permanent deformation and none of the extension is recovered at all; and as stress is increased, greater increase is produced in the strain and wire thins until it breaks at D.

(04)

(b) (ii) – During elastic deformation from A to B, the energy used in stretch the wire

is stored in the wire as elastic (molecular) p.e. due to molecular separation. This energy is recovered when the stretching force is removed.

- During plastic deformation, there is further increase in molecular separation which causes an increase in elastic p.e and heat is dissipated. The heat dissipated is not recoverable when the stress is removed. **(04)**

(iii) Work done = Average stretching force X extension.

i.e $W = \frac{(O+F)}{2} \times e = \frac{F}{2} e$

$F = ke$

$\therefore W = \frac{ke}{2} \times e = \frac{1}{2} ke^2$

(c) A = 1mm^2 = 1.0 x 10^{-6} = m^2, $\Delta\theta = 40^0 - 20^0 = 20^0 c$

(i) $\propto = \frac{e}{lo\Delta\theta} \Rightarrow strain \frac{e}{lo} = \propto \Delta\theta$

$\therefore \frac{e}{lo} = 1.1 \times 10^{15} \times 20 = 2.2 \times 10^{-4}$ **(02)**

(ii) $F = EA\left(\frac{e}{lo}\right) = 2.0 \times 10^{11} \times 1.0 \times 10^{-6} \times 2.2 \times 10^{-4}$

$\underline{= 44N}$ **(03)**

(d) Work hardening is the process of strengthening a material due to repeated deformation or bending without it breaking. **(02)**

20 marks

3. (a) (i) Is the rate of change in angular displacement. velocity (01)

(ii) On unbanked track, the centripetal force is provided for by only the frictional force, while on a banked track the centripetal force is provided for by both the component of normal reaction acting horizontally and the horizontal component of the frictional force. Thus a car travels faster on a banked track than on the flat track of the same radius. (03)

(b) (i)

- All planets describe elliptical orbits about the sun as one focus.
- The imaginary line joining a planet to the sun sweeps out equal areas in equal times.
- The squares of the periods of revolution of the planets around the sun is directly proportional to the cubes of the mean distance of the planets from the sun. (03)

(ii)

$F = \frac{GM_cM_s}{R^2}$ $Fc = M_sW^2R$

$\frac{GMcMs}{R^2} = M_s\frac{4\pi^2}{T^2}R$

$R = \sqrt[3]{\frac{GM_cT_s}{4\pi^2}}$ $GM_C = r_e^2 g$

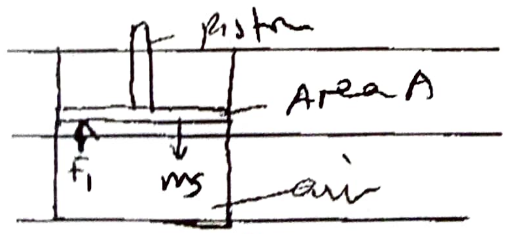
$= \sqrt[3]{\frac{9.81\times(6.4\times10^6)^2\times(24\times3600)^2}{4\pi^2}}$

$= 42.35 \times 10^6$m

h = $42.35\times10^6 - 6.4 \times 10^6$

$= 35.92 \times 10^6$m (04)

(c) (i) Simple harmonic motion is the periodic to and fro motion of a body whose acceleration is directly proportional to its displacement from a fixed point and is always directed towards the fixed point. (01)



mg = F_1=PA

When the piston is given a slight down ward displacement, X the restoring force.

$F = P_2A - mg$

$F = ma$

From newton's law

$ma = -(P_2A - mg)$

$ma = -(P_2A - P_1A)$

but $P_1V_1 = P_2V_2$

$Pv = P_2(V - Ax)$ $P_2 = \frac{Pv}{V - Ax}$

$$ma = -\left(\frac{PVA}{V - Ax} - PA\right)$$

$$ma = -PA\left(\frac{V}{V - Ax} - 1\right) \text{but } V - Ax \approx v$$

$$= -PA\left(\frac{V - V + Ax}{V - Ax}\right)$$

$a = \frac{PA^2}{Vm}x$ hence Shm

since $a \propto x$

$$\frac{4\pi^2}{T^2} = \frac{PA^2}{vm}$$

$T = \sqrt{\frac{4\pi^2 mV}{PA^2}}$ or $T = \sqrt{\frac{4\pi^2 V}{Ag}}$ **(05)**

(c) (ii) $F = ma = mw^2 A$

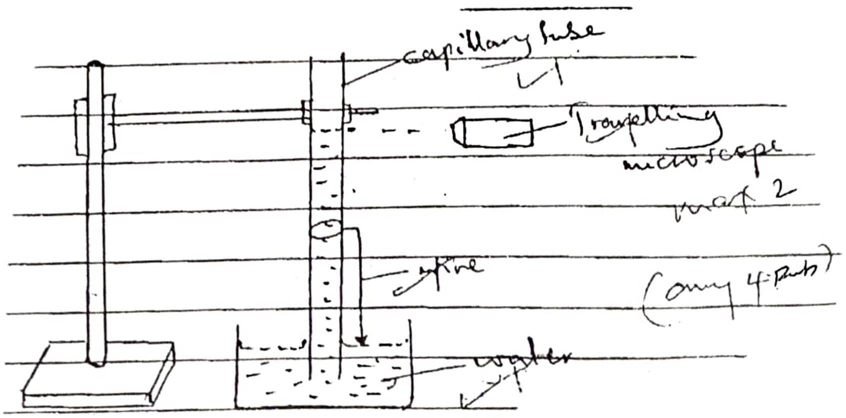
$= m4\pi^2 f^2 A$

$= 0.5x4\pi^2 \times \left(\frac{240}{60}\right)^2 \times 0.045 = 14.212N$ **(03)**

4. (a) (i) Surface energy is the work done in creating a unit area of a new surface under isothermal conditions. **(01)**

(ii) Increase in temperatures of a liquid, the liquid molecules gain kinetic energy and the molecules move faster, weakening the intermolecular forces thus reducing surface tension of the liquid. **(03)**

(b)



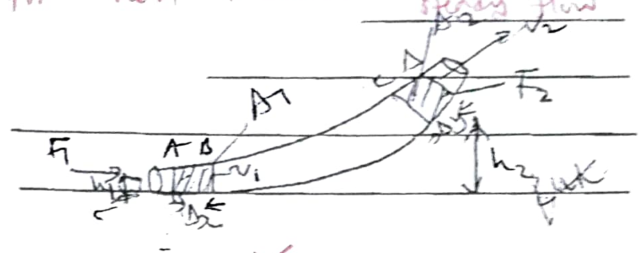
- A capillary tube is dipped in liquid and a wire is bent at right angles and tied along the capillary tube with rubber band.
- The wire is made to just touch the surface of liquid.
- A travelling microscope is focused on the liquid meniscus in the capillary tube and reading is noted h,
- The beaker is removed and the microscope is focused to the tip of the wire and reading h_2 is noted.
- The height of the liquid rise $h = |h_2 - h_1|$.
- The diameter of the capillary tube is measured to determine the radius r.
- The angle of contact θ is calculated from $\cos\theta = \frac{r\rho gh}{2\delta}$

  Where ρ – density of the liquid

  δ = Coefficient of surface tension.

(c) (i) for non viscous incompressible fluid under steady flow $P + \frac{1}{2}\rho v^2 + \rho g h =$ a constant. ·Define terms

(ii)



$W = F_1\,\Delta x - F_2\,\Delta y$

Gain in Kinetic energy $= \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$

Gain is potential energy = $mgh_2 - mgh_1$

Work done = $\frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2 + mgh_2 - mgh_1$

$\therefore F_1\Delta x - F_2\Delta y = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2 + mgh_2 - m_sh_1$

$P_1A_1V_1\Delta t - P_2A_2V_2\Delta t = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2 + mgh_2 - mgh_1$ (03)

But $A_1\Delta x = A_2\Delta y = \frac{m}{\rho}$, $v_2\Delta t = \frac{\Delta y}{\Delta t}.\Delta t.$

$v_1\Delta t = \frac{\Delta x}{\Delta t}.\Delta t.$

$P_1\frac{m}{\rho} - P_2\frac{m}{\rho} = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2 + mgh_2 - mgh_1$

$P_1 - P_2 = \frac{1}{2}\rho v_2^2 - \frac{1}{2}\rho v_1^2 + \rho gh_2 - \rho gh_1$

$P_1 + \frac{1}{2}\rho v_1^2 + \rho gh_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho gh_2$

(d) $P_2 - P_1 = \frac{1}{2}\times1.29(120^2 - 110^2)$

$= \frac{1}{2}\times1.29(120^2 - 110^2)$

$F = (P_2 - P_1)A$

$F = \frac{1}{2}\times1.29(120^2 - 110^2)\times20$ (03)

$= 2.97\times10^4\,N$

(ii) The speed of air between the train and the person is high which reduces the pressure in front than at in back of the person. The pressure difference make him be pushed Awards on train.

(03)

SECTION B

(a) (i) Thermometric property is a physical property of a substance which varies linearly and continuously with temperature and is constant at constant temperature.

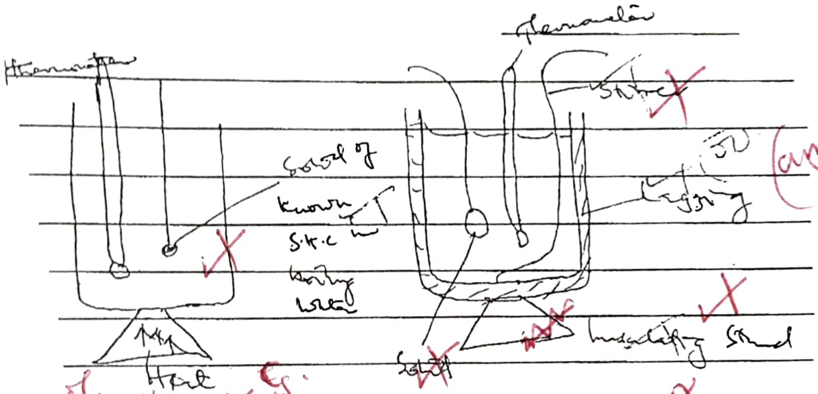
(ii) Specific heat capacity is the amount of heat required to raise the temperature of 1 kg mass of a substance by 1K or 1^0C.

not required

(b) (i) Liquid –in-glass thermometer, it is easy to use, quick and great precision is not required.

(ii) Thermocouple; the smallness of the thermocouple enables the temperature of specific points of the cylinder head to be measured.

(c) (i)



(any four)

- The solid of mass M_s and SHC C_s in boiling water at a temperature θ_1 is transferred to liquid of mass M_c whose SHC C_l is to be determined in a colorimeter of mass M_c and SHC C_c both at temperature θ_2, recorded from the thermometer.
- The mixture is stirred uniformly until the final steady temperature θ_3 is obtained. and
- Assuming there is no heat gained by the striver and thermometer and no heat is lost to the surrounding.
- Heat lost by solid = Heat grained by calometer + heat gained by liquid.

$$Ms\ Cs(\theta_1-\theta_3)=m_cC_l(\theta_3-\theta_2)+m_cc_c(\theta_3-\theta_2)$$

$$c_l=\frac{m_sc_s(\theta_1-\theta_3)-m_cc_c(\theta_3-\theta_2)}{m_l(\theta_3-\theta_2)}$$

(04)

(ii) I = 2.5A

R = 20Ω

$M_w = 600g = 0.6kg$

$\theta_1 = 0^0C$

$\theta_2 = 10^0C$

t = 6 minutes = 6 x 60

= 360 seconds

Mw = 300g = 0.3kg

M_i = 300g = 0.3kg

Heat supplied = Heat absorbed by water + Heat absorbed by flask electrical energy $= m_w c_w(\theta_2-\theta_1)+c_f(\theta_2-\theta_1)$

$I^2Rt = m_w c_w(\theta_2-\theta_1)+c_f(\theta_2-\theta_1)$

$(2.5)^2\ 20\times360 = 0.6\times4200(10-0)+c_f\times10$ **(05)**

$C_f = 1980 Jk^{-1}$

05

$I^2Rt = milf + m_w c_w(\theta_2-\theta_1)+C_f(\theta_2-\theta_1)$

$I^2\times20\times360 = 0.3\times3.26\times10^5+0.6\times750\times10+1980\times10$

I = 17.375A. $\quad I = 4.491$ A.

(d) The rate of heat flow depends on surface area to volume ratio. Small pieces of wood / charcoal have a bigger surface area to volume ratio than larger surfaces making them absorb heat at a higher rate than larger pieces. **(03)**

6. (a) (i) Is the amount of heat required to change the temperature of one mole of a gas by one kelvin when heated at constant pressure. **(01)**

(ii) Cp is greater than Cv because at constant pressure, the heat energy supplied is partly taken to increase the internal energy and also do external work. However at constant volume, all the heat energy supplied is used to raise the internal energy since no external work is done. **(02)**

(b) Consider one mole of a gas heated at constant volume so that its temperature changes by ΔT.

$\Delta w = \int p.dv$

At constant volume $dv = 0$

$\Rightarrow \Delta W = 0$

From first law of thermodynamics.

$\Delta Q = \Delta u + \Delta W$

$\Delta Q = \Delta u \ldots\ldots\ldots(i)$

From definition of Cv

$\Delta Q = C_v \Delta T \ldots\ldots\ldots(i)$

Equating eqn(i) and (ii) gives

$\Delta u = C_v \Delta T \ldots\ldots\ldots(iii)$

04

Consider one mole of an ideal gas heated at constant pressure.

$\Delta w = \int_{v_1}^{v_2} p.dv$

From definition of C.p

$\Delta Q = Cp\Delta T$

From first law of thermodynamics

$\Delta Q = \Delta V + \Delta W$

$C_p\Delta T = C_v\Delta T + P(V_2 - V_1)\ldots\ldots\ldots\ldots\ldots *$

Using the ideal gas equation.

Pv = RT

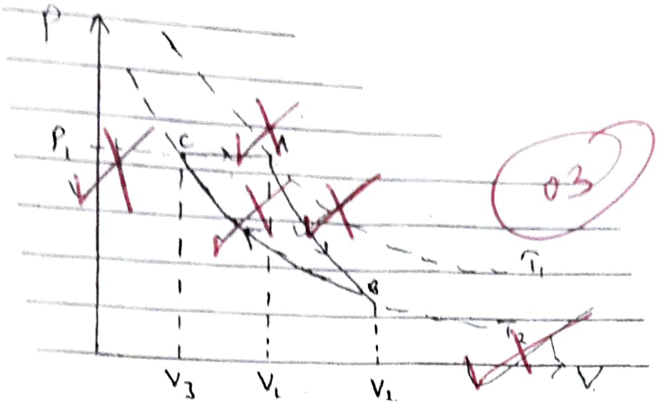
$P(V_2-V_1) = R\Delta T \ldots\ldots\ldots\ldots\ldots **$

Put eqn ** into eqn *

$C_P\Delta T = C_v\Delta T + R\Delta T$

$\therefore C_p - C_v = R$

(c) (04)



(02)

$\gamma = 1.40$ $P_1 = 80$cmHg

$T_1 = 110 + 273$ $P_2 = 30$cmHg

$V_1 = 4m^3$ $V_1 = ?$ $V_3 = ?$

Considering the a adiabatic expansion

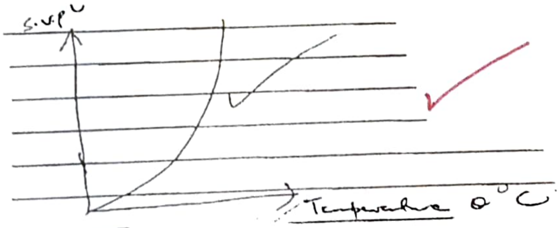
$Pv^0 =$ a constant

$P_1v_1^\gamma = P_1v_2^\gamma$

$$\left(\frac{V_2}{V_1}\right)^\gamma = \frac{P_1}{P_2} = \frac{80}{30}$$

$$\left(\frac{V_2}{V_1}\right)^{1.40} = 2.67$$

- The pressure above the water is set to any ~~decimal~~ suitable value (below and above) atmospheric pressure using a vacuum pump.
- The tap is closed and the liquid is heated until it boils.
- The temperature θ_1 of the vapour is ~~determined~~ measure using a thermometer and noted.
- The difference, h, in memory levels is noted from the manometer.
- The pressure P of the vapour, P = H + h.
- The procedure is repeated for different pressure, P and corresponding temperature θ noted.
- A graph of P against θ is plotted.



The graph shows that s.v.p increase with temperature but not linearly. (06)

$v_2 = 2.64^{0.714} \times 4$

$v_2 = 8.6cm^3$ (02)

(iii) Considering the adiabatic expension.

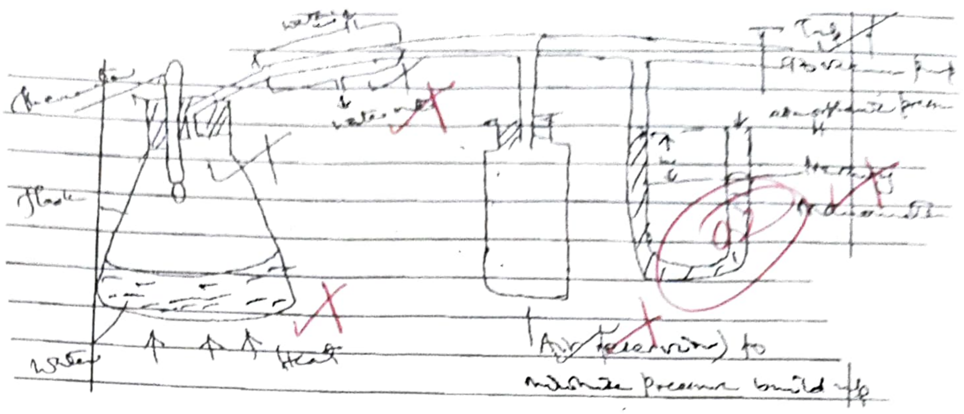
$TV^{\gamma-1} = k$

$T_2V_2^{\gamma-1} = T_1V_1^{\gamma-1}$

$$T_2 = 383\left(\frac{4}{8.60}\right)^{0.4}$$ (02)

$T_2 = 289.4k$

(d) (i) Saturated vapour pressure in the pressure exert by a vapour which is in dynamic equilibrium with the liquid. (01)

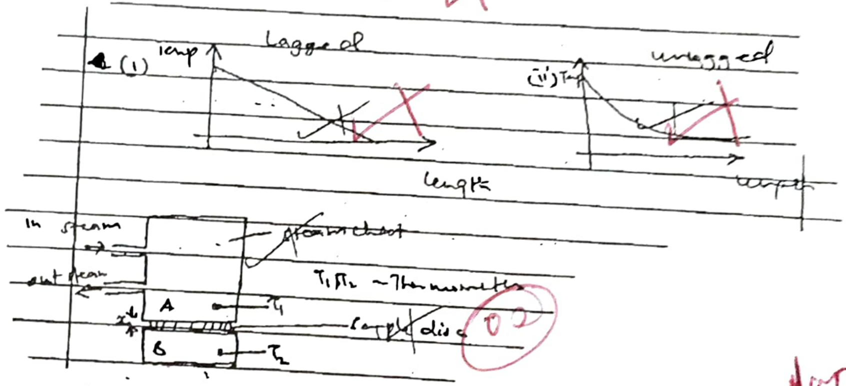


7. (a) (i) Is the rate of heat flow at right angles to the opposite face of $1m^2$ of material when the temperature gradient is $1\ km^{-1}$. **(01)**

(ii) When one end of glass is heated molecules gain heat an start vibrating with increasing amplitude, making them colluding with their immediate neighbours and in turn also start to vibrate them heat energy is passed on in that way to the end. **(03)**

(b) (i) Heat flow is uniform, rate of heat flow is the same and the temperate gradient is the same. **(02)**

(ii) Heat flow is not uniform, and heat energy is lost in the sides making the temperate gradient not uniform. **(02)**



A sample is cut into a disc of small thickness **x** and diameter **d.**

- The thin disc is sand witched between two metal slabs A and B each carrying thermometer.
- Steam is passed through the steam chest until the thermometer record steady temperature θ_2 and θ_1 which are recorded.

$$\frac{\theta}{t}=\frac{KA(\theta_2-\theta_1)}{x}\text{............}(i)$$

- The sample is withdrawn and block B is heated directly when in contact with A until its temperature is about 10^0c above θ_1.
- The steam chest is removed and the disc is placed on the top of the slab B.
- The temperature of the slab B is recorded at suitable time internals.
- A cooling curve is plotted and the slops of the graph at θ_1 is determine.
- The mass m of slab B of specific heat capacity which is determined $\frac{\theta}{t}=mcs$.

- Thermal conductivity k of the disc is got from $mcs = \frac{k\pi d^2}{4}\frac{(\theta_2 - \theta_1)}{x}$.

(ii) $A = 40\times10^{-4} m^2$ $\qquad x = 20\times10^{-3} m$

$\theta_2 = 30^0 c$ $\qquad \theta_1 = 10^0 c$

$m = 0.25kg$ $\qquad c = 400 Jkg^{-1}k^{-1}$ $\qquad$ k = 0.55

$$S = \frac{0.55 \times 40\times10^{-4} \times (30-10)}{0.25 \times 400 \times 20\times10^{-3}}$$

Rate of temp rise = $0.022ks^{-1}$

(05)

8. (a) (i) Unified atomic mass unit is defined as $^1/_{12}$ of the mass of the carbon -12 atom.

(01)

(ii) Nuclear fusion refers to the process where two atomic nuclei combine to form a single, more massive nucleus with release of energy.

(01)

(b) (i) Decrease in mass $\Delta m = (3.015500 + 2.013553 - 4.001506 - 1.007276)$

$= 0.020271u$

$= 0.020271 \times 1.66\times10^{-27}$

$= 3.365\times10^{-29}kg$ (05)

Energy released = Δmc^2

$= 3.365 \times 10^{-29} \times (3.0\times10^8)^2$

$= 3.028 \times 10^{-12}J$

(ii) Uses of isotiopes

- Carbon – dating – activity of fresh and dead material samples are obtained and age of the dead material obtained. *(Any two uses)*
- Treatment of cancer- a dose of radioactive isotope is administered to a patient. The isotope emits radiation which destroys cancer cells.
- Detection of leakage in underground sewage and water pipes.
- Determining the quality and safety of food products such as detecting the presence of pesticides or contaminants.
- Studying and monitoring environmental processes such as water and air pollution, ocean currents, etc.

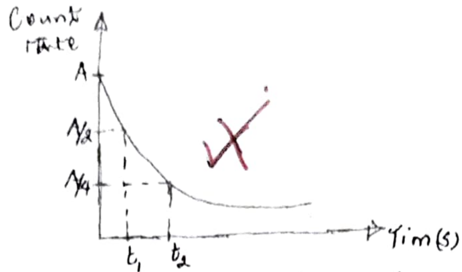
(04)

(c) (i) Half-life of a radioactive material is the time taken for half the number of atoms in the sample to decay. (01)

(ii) Decay constant refers to the fraction of the total number of radioactive nuclei that decay per second. (01)

(d) - The GM -tube is switched on and the background rate is noted and recorded.
- The source of radiation is placed near the window of the GM – tube.
- The count rate at equal interval of time is noted and recorded.
- For each count rated recorded, the background count rate is subtracted to get the actual count rate.

- A graph of count rate against time is plotted.



- The time t_1 taken for the activity reduce to A/2 and the time t_2 taken for the activity to reduce to A/4 are noted and recorded.
- The Half life $T_{\frac{1}{2}}$ is obtaine from $T_{\frac{1}{2}} = \frac{1}{2}$ (t_1+t_2)

(03)

(e) (i) 1 mole contains N_A atoms.

Using $A = \lambda N$

$$\lambda = \frac{A}{N}$$

$$= \frac{8.02\times10^{21}}{6.023\times10^{23}} = 1.33\times10^{-2}\,s^{-1}$$

(02)

(ii) $\lambda t_{\frac{1}{2}} = 0.693$

$$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$$

(02)

$$= \frac{0.693}{1.33x10^{-2}}$$

$$= 52.0S$$

20mks

9. (a) (i) A photon is a packet of energy that is carried by an electromagnetic radiation. **(01)**

(ii)
- For a given metal, there is minimum frequency below which no photoelectric emission can occur.
- The photo current is proportional to the intensity of the incident radiation.
- The time lag between irradiation and emission of electrons is negligible.
- The maximum kinetic energy of emitted electrons depends on the frequency of the incident radiation. **(04)**

(b) (i) $hf = w_0 + eV_s$

$$\frac{hc}{\lambda} = w_0 + eV_s$$

$$\frac{6.60\times10^{-34}\times3.0\times10^{8}}{360\times10^{-9}} = 2.25\times1.6\times10^{-19}V_s) \quad (1.6\times10^{-19})V_s$$

From which $\underline{\mathbf{V_s = 1.188V.}}$ **(03)**

(ii) $Ke = eV_s$

$$\frac{1}{2}mu_{max}^2 = eV_s$$

$$u_{max} = \sqrt{\frac{2eV_s}{m}}$$

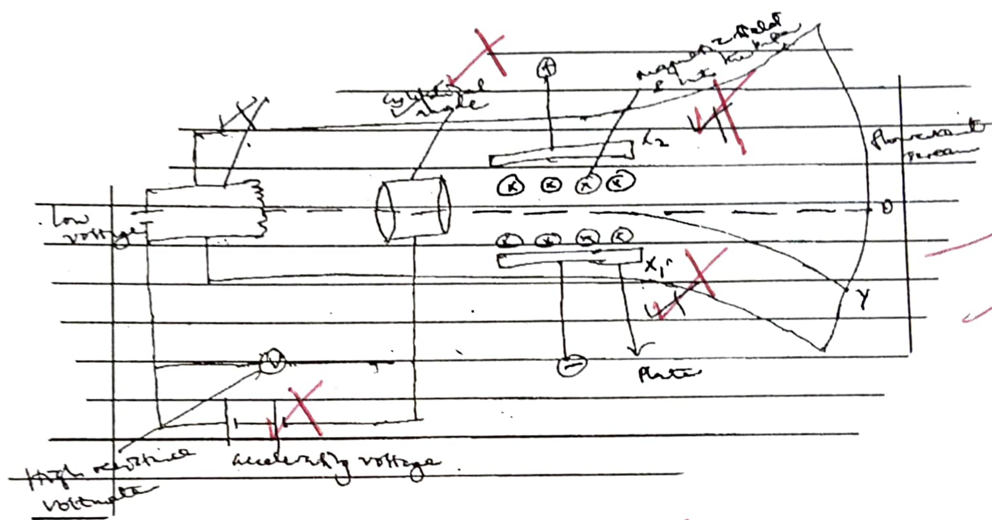
$$= \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 1.188}{9.11 \times 10^{-31}}}$$

(02)

$$u_{max} = 6.46 \times 10^5 \text{ ms}^{-1}$$

(c) (i) Specific change is the ratio of electronic charge to electronic mass. **(01)**

(ii)



(06)

- Electrons are emitted thermionically by the filament and accelerated through the cylindrical anode.
- With no electric and no magnetic fields applied at x_1, the electron bean strikes the scream at a point **O** which is noted.
- A magnetic field of flux density **B** in applied to $\mathbf{x_1}$ to deflect the electron beam to appoint **Y** which is noted.
- An electric field of intensity **E** in applied at $\mathbf{x_2}$ at right angles to the magnetic field **B** at $\mathbf{x_1}$ and adjusted until the position of the beam on the screen in restored to point **O**.
- The **p.d V,** the plates separation **d,** and the velocity **u** of the election beam are noted.
- At this instant, the electric force = magnetic force.

$$eE = Beu$$

$$u = \frac{E}{B}$$

Also $eV = \frac{1}{2}mu^2$

$$\frac{e}{m} = \frac{1}{2}\frac{E^2}{B^2V}$$ from which

the specific change is calculated.

(d) $v = \sqrt{\dfrac{2eV}{m}}$

$v = \sqrt{2 \times 1.8 \times 10^{11} \times 3000}$

$v = 3.29 \times 10^{7}\ ms^{-1}$

from $BeV = \dfrac{mV^2}{m}$

$r = \dfrac{mv}{eB}$

$r = \dfrac{3.29 \times 10^{7}}{0.01 \times 1.8 \times 10^{11}}$

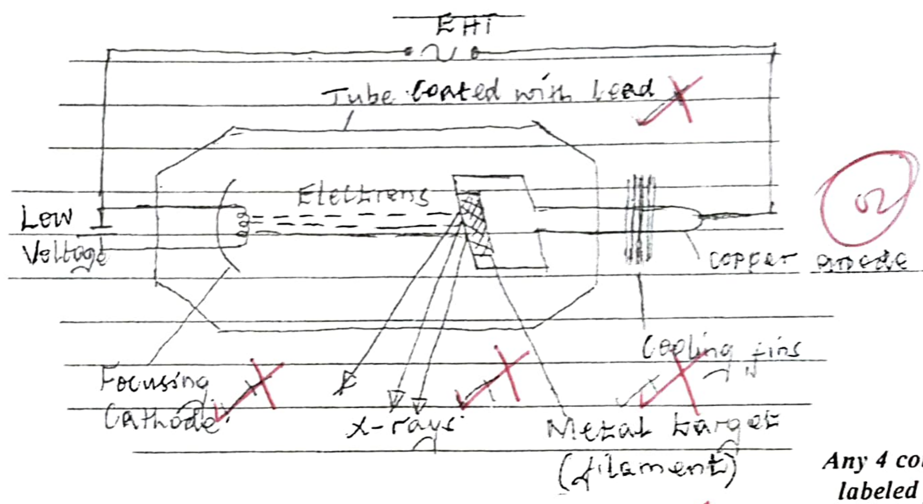
r = 1.83 x10^{-2}m

03

(03)

10. (a) (i) X-rays are electromagnetic radiations of very high frequency produced when high speed electrons strike a metal target. (01)

(ii)



02

(02)

Any 4 correctly labeled parts

- The cathode is heated by a low voltage supply and emits electrons thermionically.
- The emitted electrons are accelerated by extra high tension (EHT) to high kinetic energies.
- On striking the metal target, about 1% of the kinetic energy is converted into x-rays and 99% of the kinetic energy is converted into heat which is conducted away by cooling fins.

03

(03)

(iii) Electric potential Energy $\longrightarrow$ Kinetic energy of electrons $\longrightarrow$ Heat + x-rays energy (01)

(b) (i) Bragg's state that $2d\sin\theta = n\lambda$ where d is the path difference, λ is the wavelength of the radiation and ,n, is the wave number, θ is the glancing angle.

For constructive interference the path difference

(ii) $\dfrac{hc}{\lambda} = ev$

$\lambda = \dfrac{hc}{ev} = \dfrac{6.6 \times 10^{-34} \times 3.0 \times 10^{8}}{1.6 \times 10^{19} \times 1000}$

$= 1.24 \times 10^{-10} m$

(04)

From $2d\sin\theta = n\lambda$

$$d = \frac{n\lambda}{2\sin\theta} = \frac{1\times1.24\times10^{-10}}{2\sin16^0} = 2.49\times10^{-10}m$$

$2.24\times10^{-10}m$

(c) (i) Cathode rays are streams of high energy electrons.

(01)

(ii) The electron experiences a magnetic force which is always at right angles to the magnetic field and the direction of motion. The speed of electrons remains unaltered but the electron is deflected by the magnetic field in a circular path.

according to Fleming's left H.R

(03)

(iii) From $\frac{1}{2}mu^2 = eV$

$$u = \sqrt{\frac{2eV}{m}} = \sqrt{\frac{2\times1.6\times10^{-19}\times100}{9.11\times10-31}} = 5.93\times10^6 ms^{-1}$$

From $Beu = eE$

(04)

$$B = \frac{E}{u} = \frac{10^6}{5.93\times10^6} = 0.0169T$$

END

P510/1
PHYSICS
Paper 1
July/August 2023
2½ hours

WAKISSHA JOINT MOCK EXAMINATIONS

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 – 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 $\frac{1}{4\pi\varepsilon_0}$		=	$9.0 \times 10^{9}\ F^{-1}m$
Density of water		=	$1000 kgm^{-3}$
Gas constant	R	=	$8.31 Jmol^{-1}K^{-1}$
Wien's displacement constant		=	$2.90 \times 10^{-3}\ m\ K$
Surface tension of soap solution		=	$2.0 \times 10^{-2}\ Nm^{-1}$
Electron charge to mass ratio, e/m		=	$1.8 \times 10^{11}\ C\ kg^{-1}$
One electron volt, (eV)		=	$1.6 \times 10^{-19}\ J$

Turn Over

SECTION A

1. (a) (i) What is meant by **dimensions of a physical quantity?** (01 mark)

(ii) Give **two** uses of dimensions of physical quantities. (01 mark)

(iii) The displacement, S, of a body moving with an initial speed, **u**, accelerating at a rate, **a**, to attain a velocity, **v**, is obtained from the expression:

$$S = \frac{v^2 - u^2}{2a},$$

Show that the above expression is dimensionally consistent. (03 marks)

(b) (i) Distinguish between **perfectly elastic** and **perfectly inelastic collisions.** (02 marks)

(ii) A car of mass m makes a head-on collision with another car of mass m_2 initially at rest. If the collision is perfectly elastic, show that;

$\frac{\Delta E}{E_o} = \frac{-4x}{(1+x)^2}$ where $x = \frac{m_2}{m_1}$. ΔE is the loss in kinetic energy of m_1 and E_0 is its initial kinetic energy. (05 marks)

(c) (i) Explain, using molecular theory, the origin of solid friction. (03 marks)

(ii) A car of mass 1 tonne moves along a straight track with a speed of 72 kmh^{-1}. The car comes to a stop when brakes are steadily applied after travelling a distance of 0.09 km.
Calculate the coefficient of friction between the surface of the track and the tyres; and state the energy changes which occur as the car comes to rest. (05 marks)

2. (a) Define the following terms:

(i) **Tensile stress** (01mark)

(ii) **Tensile strain** (01 mark)

(b) A copper wire is stretched until it breaks.

(i) Sketch a stress – strain graph for the copper wire and explain the main features of the graph. (04 marks)

(ii) Explain what happens to the energy used to stretch the copper wire at each stage. (04 marks)

(iii) Derive the expression for the work done to stretch the copper wire by a distance, e, if its force constant is K. (03 marks)

(c) A steel wire of cross-section area 1 mm^2 is cooled from a temperature of 40^0C to 20^0C.
Find the:

(i) strain produced in the wire. (02 marks)

(ii) force needed to prevent it from contracting. (03 marks)

Take Young's modulus of steel = 2.0×10^{11} Pa,
Coefficient of linear expansion = $1.1 \times 10^{-5} K^{-1}$.

(d) What is **work-hardening?** (02 marks)

3. (a) (i) Define **centripetal acceleration.** (01 mark)

(ii) Explain why a racing car can travel faster on a banked track than on an unbanked track of the same radius. (03 marks)

(b) (i) State **Kepler's laws of planetary motion.** (03 marks)

(ii) A satellite of mass 100 kg is launched in a parking orbit above the earth's surface. Calculate the height of the satellite above the earth's surface. (04 marks)

(c) (i) Define **simple harmonic motion.** (01 mark)

(ii) The piston of a car engine performs simple harmonic motion. The piston has a mass of 500 g and its amplitude of vibration is 4.5cm. The revolution counter in the car reads 240 revolutions per minute.
Show that the piston above performs simple harmonic motion and derive an expression for its period. (05 marks)
Hence calculate the maximum force on the piston. (03 marks)

4. (a) (i) **Define surface energy.** (01 mark)

(ii) Explain the effect of temperature on surface tension of a liquid. (03 marks)

(b) Describe an experiment to determine the angle of contact of a liquid using capillary method. (06 marks)

(c) (i) **State Bernoulli's principle.** (01 mark)

(ii) Derive the principle in (c) (i) above. (03 mark)

(d) (i) Air flows over the upper surface of the wings of an aeroplane at a speed of 120 ms^{-1} and past the lower surface of the wings at 110 ms^{-1}. Calculate the lift force on the aeroplane, if it has a total wing area of 20 m^2. (Density of air is 1.29 kgm^{-3}). (03 marks)

(ii) A person standing near a railway line experiences a force towards a fast moving train. Explain the observation. (03 marks)

Turn Over

SECTION B

5. (a) Define the following quantities;
   (i) **Thermometric property** (01 mark)
   (ii) **Heat capacity** (01 mark)

   (b) State the type of thermometer you would use and justify your choice for each of the tasks below.
   (i) A gardener measuring the temperature of a green house. (02 marks)
   (ii) An engineer measuring the temperature at different points on the cylinder head of a car engine. (02 marks)

   (c) (i) Describe an experiment to determine specific heat capacity of a liquid using the method of mixtures. (06 marks)
   (ii) When a current of 2.5 A is passed through a coil of constant resistance 20 Ω immersed in 600 g of water at 0^0C in a vacuum flask, the temperature of water raises to 10^0C in 6 minutes. If instead the flask contained 300 g of water and 300 g of ice, what must current must be passed through the coil if the mixture is to be heated to the same temperature in the same time?
   (05 marks)

   (d) Explain why when starting fire, small pieces of charcoal or wood are required. (03 marks)

6. (a) (i) Define **specific molar heat capacity of a gas at constant pressure.**
   (01 mark)
   (ii) Explain why specific molar heat capacity at constant pressure is greater than specific molar heat capacity at constant volume.
   (02 marks)

   (b) Show that $Cp - Cv = R$, where Cp is molar heat capacity at constant pressure, Cv is molar heat capacity at constant volume, and R is the molar gas constant. (04 marks)

   (c) An ideal gas of specific heat capacity ratio $\gamma = 1.40$ is expanded adiabatically and reversibly from a pressure of 30 cmHg. It then undergoes a reversible isothermal compression to its original pressure. Finally it is expanded isobatically to its original volume.

   (i) Sketch the P – V diagram showing the above processes. (02 marks)
   Calculate;
   (ii) the volume at the end of the adiabatic expansion. (02 marks)
   (iii) the temperature at the end of the isothermal compression.
   (02 marks)

   (d) (i) Define **saturated vapour pressure.** (01 mark)
   (ii) Describe an experiment to determine the temperature dependence of saturated vapour pressure of water by dynamic method. (06 marks)

(a) (i) Define **thermal conductivity.** (01 mark)

(ii) Explain the mechanism of heat transfer in glass. (03 marks)

(b) Describe the flow of heat along a;

(i) fully lagged metal bar. (02 marks)

(ii) un lagged metal bar. (02 marks)

(c) (i) Describe with the aid of a labelled diagram an experiment to determine the thermal conductivity of a poor conductor. (07 marks)

(ii) A piece of glass is cut into a thin disc of cross section area $40cm^2$ and thickness 20 mm. When sandwiched between two slabs and steam is passed through the chest, the temperatures of the disc above and below it are 30^0C and 10^0C respectively. The disc is cooled and placed on a heated slab of mass 250 g and specific heat capacity of $400\ Jkg^{-1}K^{-1}$. It absorbs heat and its temperature rises. Calculate the rate of temperature rise of the disc.
(Thermal conductivity of glass is $0.55\ wm^{-1}K^{-1}$). (05 marks)

SECTION C

8. (a) What is meant by the terms;

(i) **Unified atomic mass unit.** (01 mark)

(ii) **Nuclear fusion.** (01 mark)

(b) (i) The fusion reaction used in the generation of electricity is given by the equation ${}^3_1H + {}^2_1H \longrightarrow {}^4_2He + {}^1_1H$

Calculate the energy released in the reaction in joules.

Mass of ${}^3_1H$ = 3.015500 U

Mass of ${}^2_1H$ = 2.01355 U

Mass of ${}^4_2He$ = 4.001506 U

Mass of ${}^1_1H$ = 1.007276 U

(05 marks)

(ii) Explain **two** uses of isotopes. (04 marks)

(c) Define the following terms as applied to radioactivity.

(i) **Half – life** (01 mark)

(ii) **Decay constant** (01 mark)

(d) Describe briefly how the half-life of a ratio active material may be determined using a G–M tube. (03 marks)

(e) The initial activity of a sample of 1 mole of radon – 220 is $8.02 \times 10^{21}\ s^{-1}$.

Calculate:

(i) the decay constant of radon – 220. (02 marks)

(ii) the half-life of radon – 220. (02 marks)

Turn Over

9\. (a) (i) What is meant by the term "**photon**" (01 mark)

(ii) State the **laws of photoelectric emission.** (04 marks)

(b) The work function of potassium is 2.25 eV. Light having a wavelength of 360 nm falls on the metal. Calculate:

(i) the stopping potential. (03 marks)

(ii) the speed of the most energetic elections emitted. (02 marks)

(c) (i) Define **specific charge.** (01 mark)

(ii) With the aid of a well labelled diagram, describe J.J Thomson's experiment for determination of specific charge of an electron. (06 marks)

(d) Electrons accelerated from rest through a potential difference of 3000 V enter perpendicularly a region of uniform magnetic field. If the flux density is 0.01 T. Calculate the radius of the electron orbit. (03 marks)

10\. (a) (i) What are **x-rays?** (01 mark)

(ii) With the aid of a well labelled diagram, describe how x-rays are produced. (05 marks)

(iii) State the energy changes in the production of x-rays. (01 mark)

(b) (i) State **Bragg's law.** (01 mark)

(ii) An x-ray beam is produced when electrons accelerated through a p.d of 10 kV are stopped by a metal target. When the beam falls on a set of parallel atomic plates of a certain metal, at a glancing angle of 16^0, a first order diffraction maximum occurs. Calculate the atomic spacing of the planes. (04 marks)

(c) (i) What are **cathode rays?** (01 mark)

(ii) Explain the motion of an electron directed into a uniform magnetic field. (03 marks)

(iii) An electron accelerated from rest by a p.d of 100 V, enters perpendicularly into a uniform electric field of intensity 100 Vm^{-1}. Find the magnetic field density, *B*, which must be applied perpendicularly to the field so that the electron passes undeflected through the field. (04 marks)

END