MARKING GUIDE PHYSICS P510/1 2018

UGANDA NATIONAL EXAMINATIONS BOARD
NOVEMBER - DECEMBER, 2017

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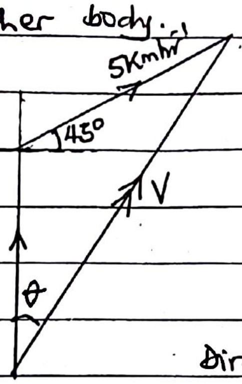
QUESTION 1:

a Is the velocity with which a body moves as observed from another body. ✓ 1

b i)



$V_x = 5\cos 45° = 3.536$ ✓

$V_y = 30 + 5\sin 45° = 33.536$ ✓

$V = \sqrt{V_x^2 + V_y^2}$ ✓

$= \sqrt{5.536^2 + 33.536^2}$ ✓

$\therefore V = 33.72\ Km\,hr^{-1}$ ✓ 4

Direction of V: $\frac{5}{\sin\theta} = \frac{33.72}{\sin 135°}$ ✓

$\theta = 6.0°$ ✓

Velocity of ship is $33.72\ Km\,hr^{-1}$ due $N\,6.0°E$.

OR $V^2 = 5^2 + 30^2 - 2\times5\times30\cos 135°$ ✓✓ → Cosine rule, Substn

$V = 33.72\ km\,hr^{-1}$ ✓ 4

$\frac{33.72}{\sin 135°} = \frac{5}{\sin\theta}$ ✓ $\Rightarrow \theta = 6.0°$ ✓

ii) Distance, $d = V_x \cdot t$ ✓ $= 5\sin 45° \times \frac{40}{60}$ ✓ | or $d = V\sin\theta \times t$ ✓

$= 33.72\sin 6° \times \frac{40}{60}$ ✓

$\therefore d = 2.35 km$ ✓ off the Course. | $= 2.35 km$ ✓ 2

c i) Before the brakes are applied, both the passenger and the car are moving with the same velocity. ✓ When brakes are applied, the force is exerted on the car and not the passenger. ✓ Because of inertia, the passenger tends to continue moving in a straight line. ✓ 3

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

Change in momentum $= mv - mu$

Rate of change of momentum $= (mv - mu)/t$

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From Newton's second law;

$F \propto \frac{(mv - mu)}{t}$; $F = \frac{Km(v-u)}{t}$

But $\frac{v-u}{t} = a$; $F = Kma$ 4

For $F = 1N$, $m = 1kg$, and $a = 1ms^{-2}$, $K = 1$

$\therefore F = ma$ The newton is a force which gives a mass of 1kg an acceleration of $1ms^{-2}$.

d $F_x = 12.5\cos 40° - 8.0\cos 30° + 0 = 2.64736N$

$F_y = 12.5\sin 40° + 8.0\sin 30° - 2.0 = 10.0348N$

Resultant force, $F = \sqrt{2.64736^2 + 10.0348^2}$

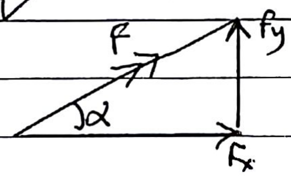
$F = 10.38N$

$F = ma$

$10.38 = 0.7 \times a$ 6

$a = 14.83 ms^{-2}$

Direction :



$\tan\alpha = \frac{10.0348}{2.64736}$

$\alpha = 75.2°$ 20

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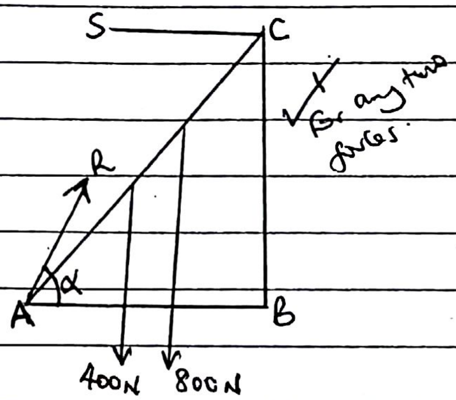
QUESTION TWO

Q2(a) Centre of mass is the point at which the whole mass of a body is considered to be concentrated. 01

(b) Undoing a tight bolt is due to moment of a force. A long spanner provides a greater moment of force than a short one hence less force is applied. 03

(c) (i)



$R\cos\alpha = S$

$R\sin\alpha = 1200$

Taking moments about pt A

$400 \times 5\cos 60^\circ + 800 \times 10\cos 60^\circ = S \times 10\sin 60^\circ$

$\therefore S = \frac{3400}{5\sqrt{3}} = 392.6\,N$ 05

$\tan\alpha = \frac{1200}{392.6}$, $\Rightarrow \alpha = 71.88^\circ$

$R = \frac{1200}{\sin 71.88^\circ} = 1262.6\,N.$

(ii) Taking moments about point A:

$400 \times 5\cos 60^\circ + l\cos 60^\circ \times 600 = 392.6 \times 10\sin 60^\circ$

$\therefore l = 8.0\,m.$ 02

d) (i) Energy can neither be created nor destroyed but can be changed from one form to another. 01

OR In an isolated system total energy is always conserved.

(ii) P.E $\rightarrow$ K.E $\rightarrow$ Heat + sound. 02

P.T.O

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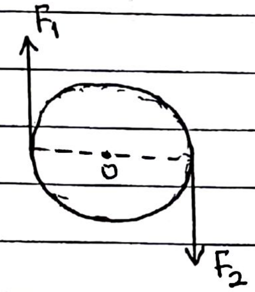
2(e) Power x time $= \frac{1}{2}mv^2 + mgh$ ✓

$\Rightarrow 1471 = \frac{1}{2} \times 2 \times v^2 + 2 \times 9.81 \times 5$ ✓ 03

$v^2 = 49$

$\therefore v = 7.0 ms^{-1}.$ ✓

(f)



O is the centre of mass

$F_1 = F_2$. ✓

Resultant force on the body is zero ✓, $\Rightarrow$ no translational motion. ✓ The couple has a turning moment about the centre of mass O ✓ implying rotation of the rigid body. ✓ 03

20 marks

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QUESTION THREE

3 (a) (i) It is a material that breaks easily when a force is exerted on it. (1)

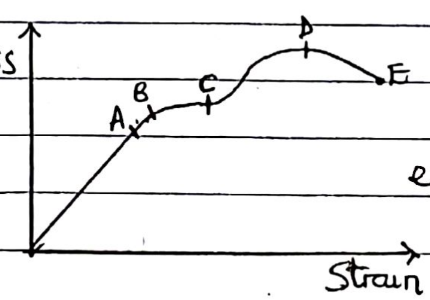
(ii) This is a material that can be hammered, rolled or moulded into different shapes. (1)

(b) Example of brittle material → Glass, Cast-Iron, Stone. Any one ($\frac{1}{2}$)

Example of ductile material → Metal e.g Copper wire Any one ($\frac{1}{2}$)

(c) Bicycle frames are hollow because it makes them lighter, it minimizes the effect of propagating compressive forces and it allows easy fitting. (2)

(d) (i)



Shape.
Any two pts defined
e.g - Limit of proportionality
- Elastic limit
- Yield point
- Breaking stress. (2)

(ii) Point A is the pt up to which Hooke's law is fully obeyed. Between A and B stress is not proportional to strain but the material can regain its length. Beyond B the material becomes permanently stretched and material doesn't regain its original size. Further increase in stress creates dislocations in the atomic structure. Along CD the material undergoes plastic deformation, hence strain increases rapidly for a small increase in the stress till maximum stress ($3\frac{1}{2}$)

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-point D and the material then snaps at E. $\left(\frac{1}{2}\right)$

(e) Energy stored in the rod $= \frac{1}{2}Fe$

$\therefore$ Energy Stored per Unit Volume $= \dfrac{\frac{1}{2}Fe}{AL}$

But $F = \dfrac{YAe}{L}$ (4)

$\therefore$ Energy Stored/Vol $= \dfrac{1}{2}\dfrac{YAe \cdot e}{AL^2}$

$= \dfrac{1}{2}Y\left(\dfrac{e}{L}\right)^2$

OR

For a small extension δx, Work done, $\delta W = F\delta x$

From Hooke's law, $F = Kx$

$\therefore$ $\delta W = Kx\delta x \Rightarrow$ Total Work done, $W = \int dW$

$\therefore$ $W = \int_0^e Kx\,dx$, $\Rightarrow$ Energy stored $= \left.\dfrac{Kx^2}{2}\right|_0^e$ (4)

But $K = \dfrac{YA}{L} \Rightarrow$ Energy Stored $= \dfrac{1}{2}\dfrac{YAe^2}{L}$

$\therefore$ Energy Stored per Unit Vol. $= \dfrac{1}{2}\dfrac{YA \cdot e^2}{AL^2} = \dfrac{1}{2}Y\left(\dfrac{e}{L}\right)^2$

(f) (i) $F = mg = 5 \times 9.81$, $A = \pi r^2 = \pi(10 \times 10^{-3})^2$ (3)

$e = \dfrac{F \cdot L}{AY} = \dfrac{5 \times 9.81 \times 0.5}{\pi(10 \times 10^{-3})^2 \times 3.5 \times 10^{10}} = 2.23 \times 10^{-6}$ m

(ii) Energy stored, $E = \frac{1}{2}Fe = \frac{1}{2} \times 5 \times 9.81 \times 2.23 \times 10^{-6}$ (2)

$= 5.47 \times 10^{-5}$ J

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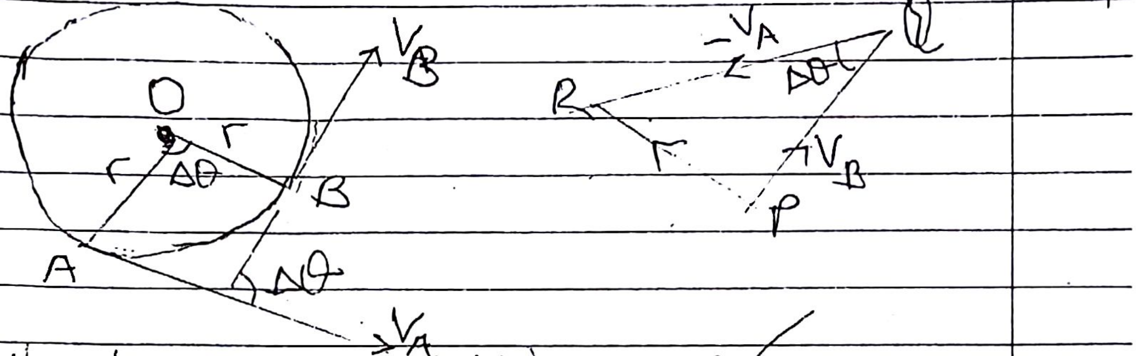
4. a)(i) Angular velocity is the rate of change of angular displacement

(ii) Period is the time taken to make one complete oscillation (2)

b)



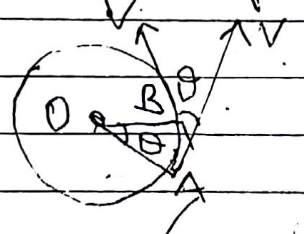
Velocity change $= V_B + (-V_A) = PR$

$a = \frac{\text{Velocity change}}{\text{time}} = \frac{PR}{\Delta t} = \frac{V\Delta\theta}{\Delta t}$ since $PR = V\Delta\theta$

for $\Delta t \to 0$, $\frac{\Delta\theta}{\Delta t} = \omega \Rightarrow a = V\omega$ but $\omega = \frac{V}{r}$

$\therefore a = V \times \frac{V}{r} = \frac{V^2}{r}$ (4)

OR



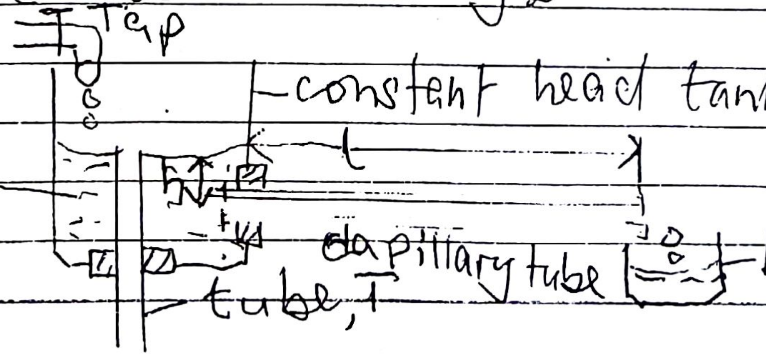
change in velocity along OA, $\Delta V = V\sin\theta$, For a small angle in radians $\sin\theta \simeq \theta$

$\therefore \Delta V = V\theta$

$a = \frac{\Delta V}{t} = \frac{V\theta}{t} = V\omega = \frac{V^2}{r}$ (4)

c) (i) Viscosity of the fluid, Diameter, radius or cross sectional area of tube, pressure difference between its ends. any 2 (2)

(ii)



any 4 @ ½ (2)

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The liquid of density, ρ passes slowly from a constant head tank through a capillary tube of length, l and radius, r. For a height, h of tube, the volume collected in a certain time is measured and recorded. The volume flow rate V is calculated. The experiment is repeated for different values of h. A graph of V against h is plotted and slope s obtained. (6)

$$\eta = \frac{\pi r^4 \rho g}{8 s l}$$

(8)

d)

$$V = \frac{2r^2(\rho - \sigma)g}{9\eta}$$

$$= \frac{2(3.0\times10^{-6})^2(800-1)9.81}{9\times1.8\times10^{-5}} = 8.7\times10^{-4}\,ms^{-1}$$

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

$$= \frac{4\times10^{-2}}{8.7\times10^{-4}}$$

$$= 45.98\,s$$

4

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QN 5

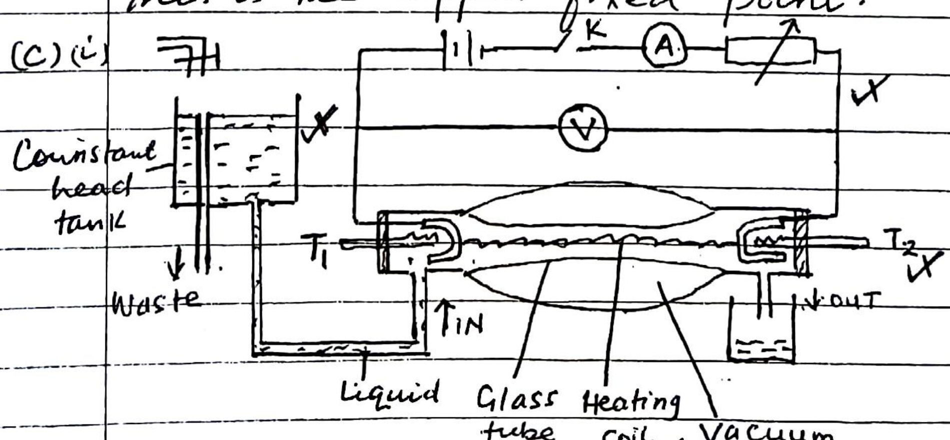
5(a)(i) Is a physical property of a substance which varies linearly and continuosly with change in temperature ✓ 1

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

(b)(i) - resistance of platinum wire ✓
- Pressure of gas at constant volume ✓ 1
- Emf of thermocouple ✓ any 2

ii Bulb of thermometer is immersed in the pure melting ice ✓. Level of mercury column falls and remains constant ✓, level where column remains is marked ✓. This is the lower fixed point. 4
Bulb of thermometer is immersed in steam ✓ above the boiling water. Level of mercury column rises and remains constant at some level ✓. Level where column is constant is marked ✓. This is the upper fixed point.

(c)(i)



any 4 2

Liquid is made to flow through the system at a constant rate ✓. Switch K is closed and

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liquid is heated until temperatures registered by thermometers T_1 and T_2 are steady ✓. Values of temperatures θ_1 and θ_2 are recorded ✓.
The P.d, V and current, I are recorded from the voltmeter and ammeter respectively ✓.
Mass, m of liquid collected in time, t is obtained ✓.
At steady state;
$VIt = mc(\theta_2 - \theta_1) + h$; where h is the heat lost to the surroundings.
The rate of flow of liquid is changed and the rheostat is adjusted until the inflow and outflow temperatures are back to θ_1 and θ_2 as before ✓.
New voltmeter reading, V_1 and ammeter reading, I_1 are recorded ✓. New mass, m_1 of liquid collected in the same time; t is obtained ✓.
$V_1 I_1 t = m_1 c(\theta_2 - \theta_1) + h$
The specific heat capacity $c = \dfrac{(VI - V_1 I_1)t}{(m - m_1)(\theta_2 - \theta_1)}$ ✓ 5

(ii) - No cooling correction required ✓
- Heat capacity of apparatus is not required ✓ any 2 1
- Heat losses are accounted for quantitatively
- Temps are measured at leisure when steady
- Resistance Thermometers can be used
- Vacuum minimises heat losses to the surroundings

(iii) - Large quantity of liquid is used ✓ 1
- Not suitable for all liquids ✓

(d) Mechanical energy = Heat absorbed by the brings
✓ $\frac{1}{2} M v^2 = mc\Delta\theta$ ✓ 4
$\frac{1}{2} \times 800 \times 15^2 = 4.8 \times 1200 \times \Delta\theta \Rightarrow \Delta\theta = 15.6\,°C$ ✓ 20

20/20

(a)(i) Process by which heat flows from the hotter regions of a substance to the colder regions without the bulk movement of the substance as a whole. 1

(ii) Mercury has free electrons capable of transfering energy without any part of mercury moving. 3
Mercury atoms are closer allowing conduction by atomic vibrations while in water there are no free electrons and atoms are further apart.

(iii) During the day the land is heated to a higher temperature than the sea. Hot air expands and rises from the land. A stream of cool air from the sea blows towards the land to replace the uprising air, hence sea breeze occurs.
At night the land cools faster because it is nolonger heated by the sun. The sea still retains its warmth because it was heated deeply. Warm less dense air rises from the sea and cool air from the land replaces it, hence land breeze occurs. 6

(b)(i) $P = A\sigma(T^4 - T_0^4) = 4\pi R^2 \sigma (T^4 - T_0^4)$
$P = 4\pi \times (0.07)^2 \times 5.67 \times 10^{-8}(400^4 - 300^4)$
$P = 61.122\,Js^{-1}$ 4

(ii) Ave. rate of heat loss $= \frac{61.1226 + 0}{2} = 30.6\,Js^{-1}$

$P = mc\,d\theta/dt = \frac{4}{3}\pi r^3 \rho c\,d\theta/dt \Rightarrow 30.6 = \frac{4}{3}\pi(0.07)^3 \times 900 \times 400 \times \frac{d\theta}{dt}$

$\frac{d\theta}{dt} = 0.059\,Ks^{-1}$ Temp of ball $= 127 - 0.059 \times 300$
$= 109.3^{\circ}C$ 4

(c) A given mass of steam gives out more energy than an equal amount of water because of the high specific latent heat. 2

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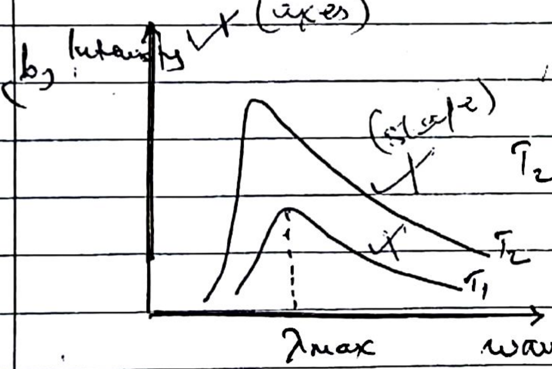
QUESTION 7

7a, i, A black body is a body that absorbs all radiations incident on it and transmits none. 01

ii, Examples of black body;
- The sun
- stars (any two @ ½) 01
- Black holes (remenants of a star after it has used up all its energy).
- An almost enclosed blackened surface with a small hole / Furnace with small hole.

b, (axes)



Intensity increases as temperature increases. The increase is more rapid for shorter wavelength. For each temp T, the distribution curve has a wavelength (λ_{max}) corresponding to maximum intensity. λ_{max} decreases as temp increases. 0.5

c, i, The rate of heat transfer per unit crossectional area per unit temp gradient. 01

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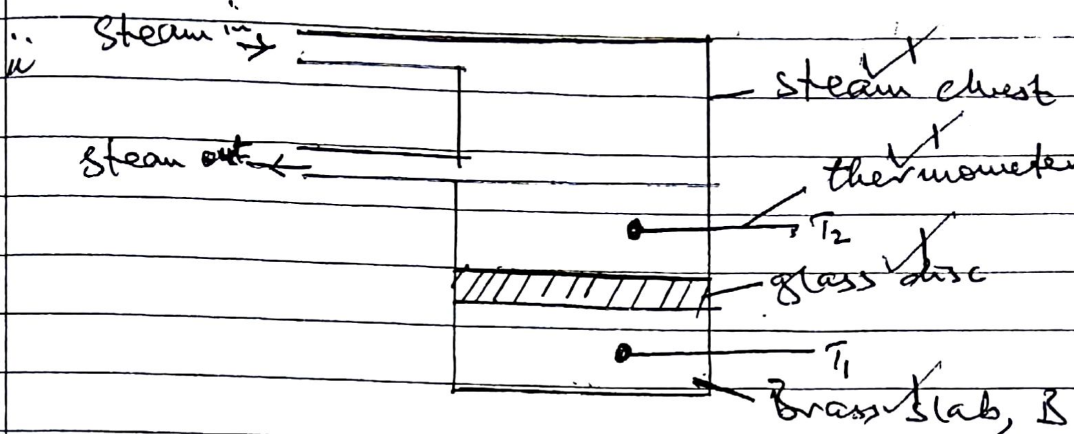
ii



Glass is cut in form of a thin disc of cross sectional area A and thickness x. The disc is sandwitched between the steam chest and the brass slab B of mass m and s.h.c. C. Steam is passed through the chest until the thermometers register steady temperatures. θ_1 and θ_2 are recorded.

$Q/t = KA\frac{(\theta_2 - \theta_1)}{x}$

The glass disc is removed and brass slab is heated directly by the steam chest until its temp is about 10°C above θ_1. Steam chest is removed and the top of the slab is covered by the glass disc. Temp of the slab is recorded at a suitable time interval until its temp is about 10°C below θ_1. 07

A graph of temp against time is plotted and its slope s determined at θ_1.

$Q/t = mcs$.

$\therefore KA\frac{(\theta_2 - \theta_1)}{x} = mcs$ $\therefore K = \frac{mcsx}{A(\theta_2 - \theta_1)}$

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Qn 7 cont.

(d) Power radiated by the sun, $P = A\sigma T^4$

$P = 4\pi r^2 \sigma T^4$

Power incident on sphere, $P_1 = \frac{P}{2} = 2\pi r^2 \sigma T^4$

Power received by roof, $P_R = \frac{A_1}{A} \times P_1$

$= \frac{L \times W}{4\pi R^2} \times 2\pi r^2 \sigma T^4$

$= \frac{1000 \times (7.5\times10^8)^2 \times 5.7\times10^{-8} \times 6000^4}{2(1.5\times10^{11})^2}$ 05

$= 923,400$ W.

Energy incident on roof per minute,

$P' = P_R \times 600$

$= 923,400 \times 60$

$= 5.54\times10^7$ J.

20 marks

QUESTION EIGHT

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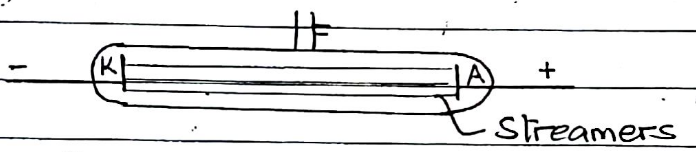
8(a)(i) Binding energy is the energy required to split the nucleus into protons and neutrons ✓ (1)

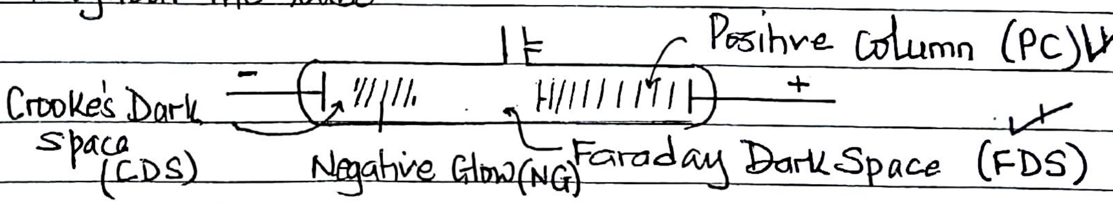
(ii) Unified atomic mass unit is a twelfth of the mass of one atom of carbon-12 isotope ✓ (1)

(b) When two small nuclei combine ✓ the total mass of the two nuclei is greater than the mass of the resulting heavy nucleus ✓ The difference in mass accounts for the energy released ✓ (3)

(c) At normal atmospheric pressure, the tube is clear with nothing observed ✓



At 100 mmHg, thin streamers of luminous gas appear between the electrodes ✓ Between 10mmHg and 0.1mm Hg, the discharge becomes a steady glow spreading throughout the tube ✓



Any two $\frac{1}{2}$ @ (1)

Four regions appear as above with the PC occupying the larger part of the tube ✓ the PC forms striations ✓ When pressure is reduced further, the dark spaces swell and the positive column shrinks ✓ At 0.1mm Hg the cathode dark space becomes distinct and at 0.01 mmHg the CDS fills the whole tube ✓ At this pressure the walls of the tube fluoresce ✓ as the electrons move across the tube. (5)

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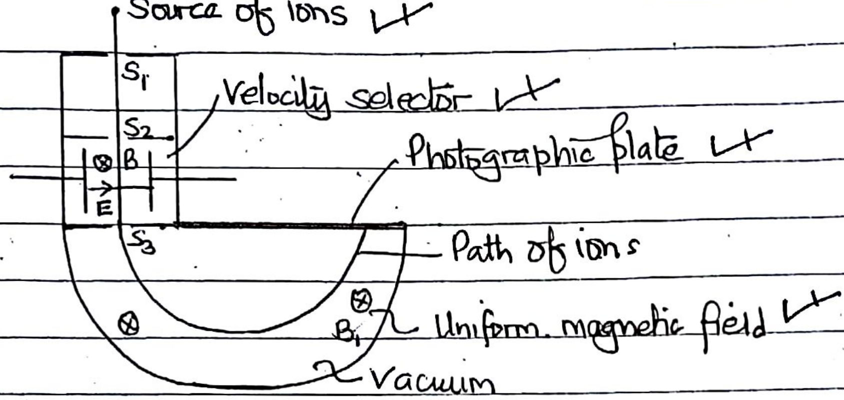
(d)



Any 4 $\frac{1}{2}$ @ (2)

Ions enter through slit S_1 into the velocity selector where an electric field of intensity E is crossed with a magnetic field of flux density B. Ions of same charge, Q pass through the selector undeflected with velocity V given by $EQ = BQV$ $\Rightarrow V = E/B$. The selected ions enter the deflection chamber with uniform magnetic field B_1 and are deflected in a circular path to form an image on the photographic plate. The radius r, of the circular path is obtained. The magnetic force provides the necessary centripetal force; $B_1QV = \frac{mV^2}{r}$ but $V = \frac{E}{B}$

$$\therefore Q/m = E/BB_1r$$ (5)

(e) $BQV = \frac{mV^2}{r}$; $r = \frac{mV}{BQ} = \frac{2.6\times10^{-26}\times4.0\times10^{4}}{0.05\times1.6\times10^{-19}}$

$= 0.13m$ (3)

OR $r = \left(\frac{2.08\times10^{-20}}{Q}\right)m$, since the charge Q of the ion was not provided.

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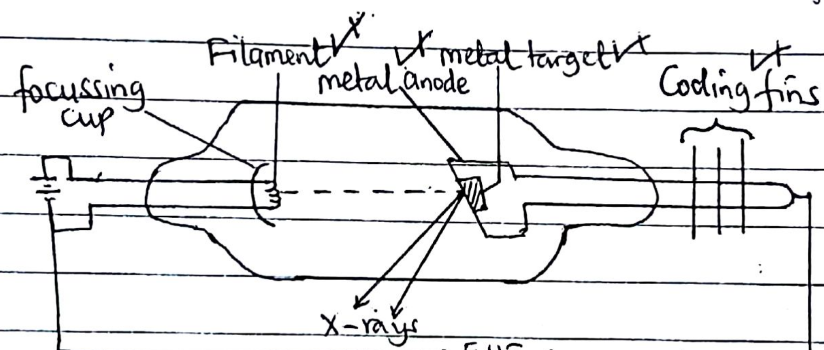
X-RAYS	CATHODE RAYS
9a(i) - Electromagnetic waves of very short wavelength	- streams of fast moving electrons
- Have no charge	- Are negatively charged.
- Are not deflected by electric and magnetic fields	- Are deflected by both fields. (3)
- Move with high speed	- move with low speed. (any 3)
- Affect photographic plates	- Have no effect on photographic plates.

(ii)



(any 4 @ ½ mk)

(2)

Filament is heated by the low voltage. Electrons are emitted and accelerated by a high p.d to strike a target of high melting point. X-rays and heat are produced. ~~and~~ Excess heat is removed by cooling fins (4)

(iii) Hard x-rays are more penetrating than soft x-rays. (1)
Hard x-rays have a shorter wavelength than soft x-rays

b(i) Ionization energy is the minimum energy required to remove its most loosely bound electron from an atom while work function is the minimum energy required to liberage an electron from a metal surface. (2)

(ii) $BeV = \frac{mV^2}{r}$

$\Rightarrow Be = \frac{mv}{r} = \frac{m}{r}(2\pi f r)$

$\therefore f = \frac{Be}{2\pi m}$ (3)

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(c) $\frac{hc}{\lambda} = eV \Rightarrow \lambda = \frac{6.6\times10^{-34} \times 3\times10^{8}}{(1.6\times10^{-19})50000} = 2.48\times10^{-11}m$

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

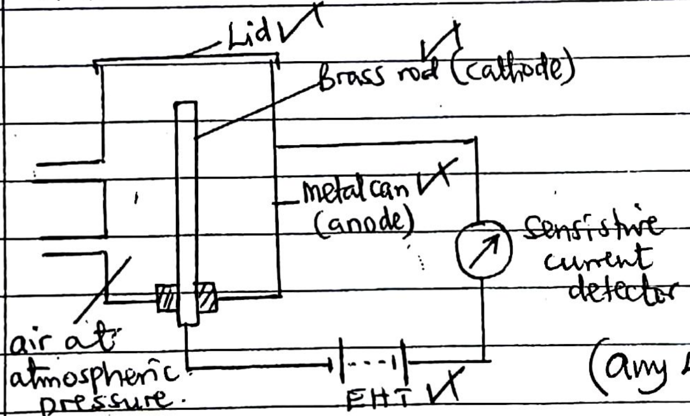
$\Rightarrow d = \frac{1\times2.48\times10^{-11}}{2\sin16^{\circ}} = 4.5\times10^{-11}m$ (5)

(20)

	ALPHA PARTICLES	BETA PARTICLES
10 (a)	Positively charged	Negatively charged
	Low penetrating power	Higher penetrating power
	Higher ionizing power	lower ionizing power.
	Heavier	Lighter.
	Helium Nucleus	~~A~~ An electron

(any two) (2)

(b)



(any 4 @ $\frac{1}{2}$mk) (2)

When the ionizing radiation enters the chamber, it collides with air molecules. Ion pairs are produced. Positive ions move to the cathode and electrons move to the anode. Current flows in the external circuit is detected by the sensitive meter. The p.d is set to such a value that all ions are collected before they recombine. The saturation current produced this way is a measure of the rate of primary ionisation. (4)

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Candidate's Name ....

Signature ....

Subject .... Paper code ..../......

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Personal Number	

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c(i) Carbon-14 is radioactive with half life, $t_{\frac{1}{2}} = 5600$yrs. It is absorbed by plants during photosynthesis. When plants die carbon-14 starts to decay. The activity, A_0 of living plants is measured. The activity A of dead plant is also measured. The age, t of the dead plant is deduced from

$A = A_0 e^{-\lambda t}$ where $\lambda = 0.693/t_{\frac{1}{2}}$ (3)

(ii) $A = A_0 e^{-\lambda t}$ $\Rightarrow 20 = 47.8\, e^{-\lambda t}$

$\therefore \ln\left(\frac{20}{47.8}\right) = -\lambda t = -\left(\frac{0.693}{5600}\right)t$

$\therefore t = 7040.8$ years (3)

d(i) $hf = W_0 + \frac{1}{2}mV_{max}^2$

but $\frac{1}{2}mV_{max}^2 = eV_s$

$\Rightarrow \frac{hc}{\lambda} = W_0 + eV_s$

$\Rightarrow \frac{6.6\times10^{-34}\times 3.0\times10^{8}}{360\times10^{-3}} = 2.25\times1.6\times10^{-19} + 1.6\times10^{-19}V_s$

$\therefore V_s = -2.25\,V$ (4)

(ii) $\frac{1}{2}mV_{max}^2 = eV_s$

$\therefore V_{max} = \sqrt{\frac{2\times1.6\times10^{-19}\times(2.25)}{9.11\times10^{-31}}}$

$= 8.89\times10^{5}\ ms^{-1}$ (2)

TOTAL = (20)

END