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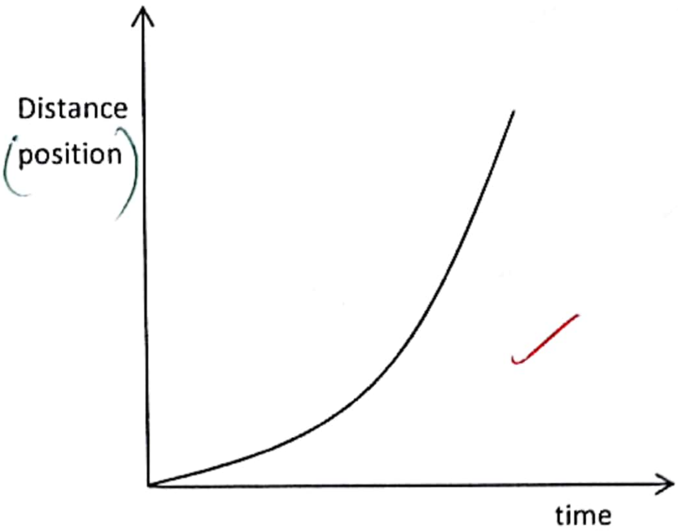
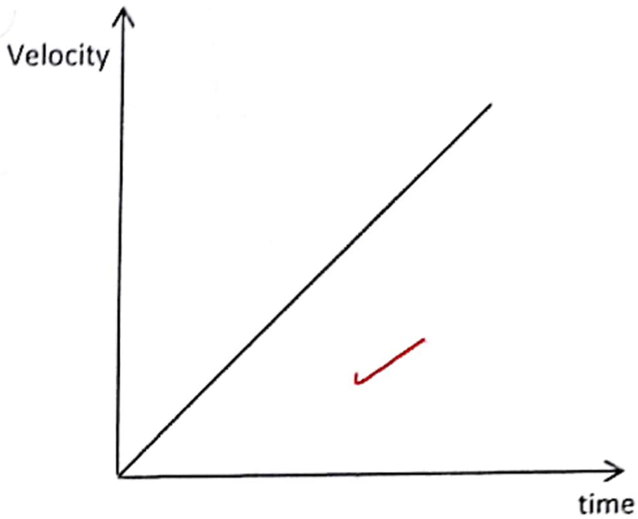
UMTA 2022 S.6 PHYSICS PAPER 1 P510/1

1a (i) This is motion where velocity changes by equal amounts in equal time intervals however small the time interval may be. (1)

IR This is motion where the rate of change of velocity is constant

(II)





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(b) <u>Before Opening</u>

U = 0, s = 40,

$S = ut + ½at^2$

$40 = ½ \times 9.81t^2$

t = 2.86s

v = u + at

= 0 + 9.81 × 2.86

$= 28.06ms^{-1}$

Total time in air =2.86 + 13.03=15.89s

<u>After Opening</u>

u = 28.06, a = -2, v = 2

v = u + at

2 = 28.06 – 2t

t = 13.03s

3

<u>Distance after</u>

$S = ut + ½at^2$

$= 28.06 \times 13.03 - ½ \times 2 \times (13.03)^2$

3

= 195.84 m

Height at which bails out=40+195.84=235.84m

C(i) For a system of colliding objects ,the total momentum before collision is equal to the total momentum after collision provided there are no external forces. 1

OR Total momentum of the objects in a given direction is constant provided there are no external forces.

~~(2)~~

(ii) Before firing,both the bullet and rifle are at rest and their total momentum is Zero.

After firing ,the bullet gains a large momentum in the forward direction. 3

To conserve momentum the rifle gains an equal momentum in the opposite direction,so the rifle gives a backward kick.

(iii) <u>Momentum</u>

$M_1 u_1 = m_1 v_1 + m_2 v_2$

$2.5\, u_1 = 2.5(\frac{u_1}{5}) + m_2 v_2$

$2.5u_1 = 0.5u_1 + m_2 v_2$

$2.0u_1 = m_2 v_2$...(i)

k.e

$\cancel{\frac{1}{2}} m_1 u_1^2 = \cancel{\frac{1}{2}} m_1 v_1^2 + \cancel{\frac{1}{2}} m_2 v_2^2$

$2.5u_1^2 = 2.5\left(\frac{u_1}{5}\right)^2 + m_2 v_2^2$..................................(ii)

$2.4u_1^2 = m_2 v_2^2$ - - - - - (ii)

(ii) ÷ (i)

$$\frac{2.4u_1^2}{2.0u_1} = \frac{m_2 v_2^2}{m_2 v_2}$$ 4

$1.2u_1 = v_2$...(iii)

Put (iii) in (i)

$2.0u_1 = m_2 (1.2u_1)$

$M_2 = 1.67$ kg

d) 

at 0, $K.e = \frac{1}{2}mu^2$

$E = \frac{1}{2}mu^2$

At A, $V_x = u\cos\theta$

$V_y = 0$

$V = \sqrt{V_x^2 + V_y^2}$

$= u\cos\theta$

3

$Ke = \frac{1}{2}mv^2 = \frac{1}{2}mu^2\cos^2\theta = E\cos^2\theta$

20

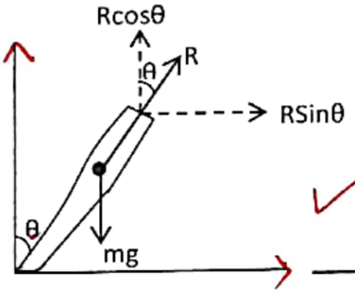
2a(i) This is the raising of the outer edge of a curved path above its inner edge. 1

(ii) The frictional force at the ground provides the centripetal force towards the centre of the circular path.This force provides a moment about the centre of gravity

4

When the rider leans towards the centre of the path,his normal reaction provides a moment about his centre of gravity which counter balances the moment due to friction.

(iii)



→→ Towards centre of circular path

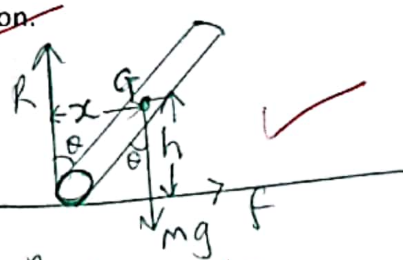
$\rightarrow$: $R\sin\theta = m\frac{v^2}{r}$ ....(i)

$\uparrow$: $R\cos\theta = mg$ ....(ii)

(i) ÷ (ii)

3

OR



$\uparrow$: $R = mg$

$\rightarrow$: $f = \frac{mv^2}{r}$

$\tan\theta = \frac{x}{h}$

take moments about G

$fh = Rx$

$\frac{x}{h} = \frac{f}{R}$

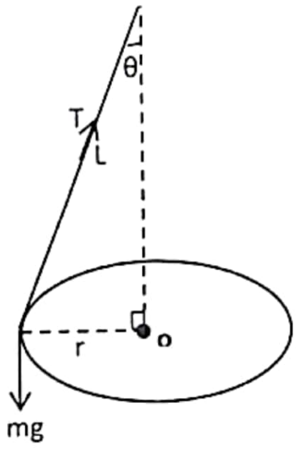
$\tan\theta = \frac{\frac{mv^2}{r}}{mg} = \frac{v^2}{rg}$

$\therefore \tan\theta = \frac{v^2}{rg}$

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

$\tan\theta = \frac{v^2}{rg}$ ~~,0.5,~~ $\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$

b)



$\sin\theta = \frac{r}{l} = \frac{15}{30} = ½$

$\theta = 30^0$

$\uparrow$: $T\cos\theta = mg$..(i)

$\rightarrow$: $T\sin\theta = m\frac{v^2}{r} = mr\omega^2$..(ii)

(ii) ÷ (i)

3

$\tan\theta = r\frac{\omega^2}{g}$

$\omega = \sqrt{\frac{g\tan\theta}{r}} = \sqrt{\frac{9.81\tan 30}{0.15}} = 6.145\ \text{rads}^{-1}$

(ii) $T\cos\theta = mg$

$T = \frac{0.1 \times 9.81}{\cos 30} = 1.133\text{N}$

Or 1.13N

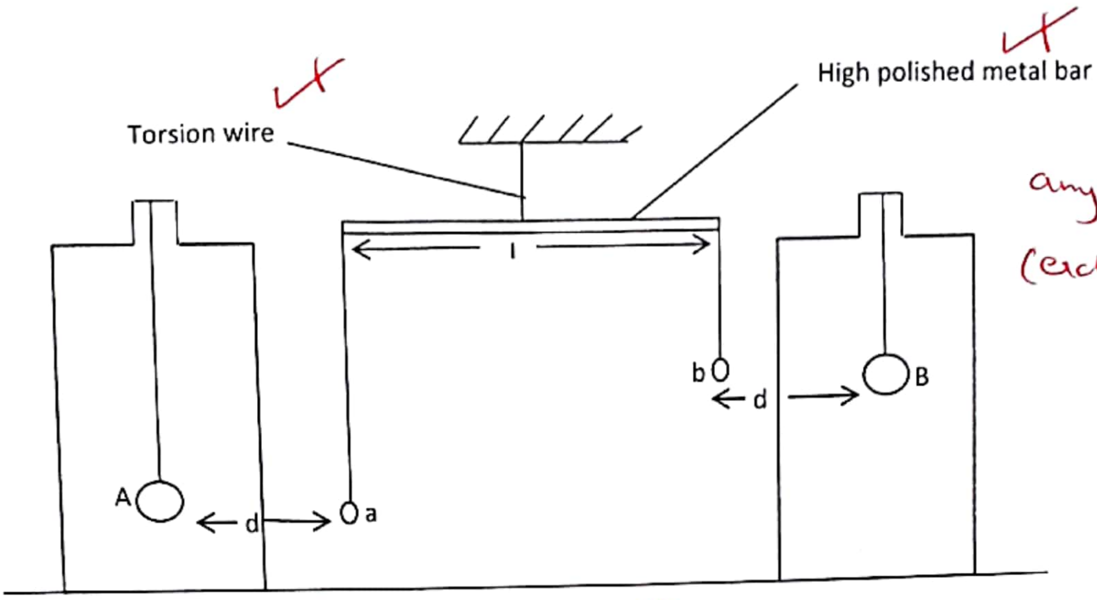
2

c)

(i)G-Force between two bodies each of mass 1kg separated by a distance of 1m.

1

(ii)



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

a,b – Gold sphere

A,B – Lead sphere

C

a,b Gold spheres

A,B- Lead spheres.

-Two identical small gold spheres a and b ,each of mass,m ,are suspended from the ends of a highly polished metal bar of known length,l.

The bar is then suspended by a long torsion wire of known torsional constant,C

Two identical large lead spheres, Aand B each of mass,M ,are respectively brought near a and b.

-Distance ,d,between the spheres is measured.

-a couple is set up at the ends of the polished bar due to attraction of the two spheres.

The bar is deflected through a angle θ ~~(Radius)~~ (radians) and is measured by lamp and scale method

$$G = \frac{C\theta d2}{Mml}$$

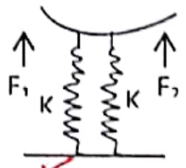
20

3.a(i) It is periodic motion

- Acceleration is directly proportional to the displacement from a fixed point.
- Acceleration is directed towards the fixed point.

2

- Mechanical energy is conserved.



Identical springs
Let K = force constant
x = slight displacement

$F_1 = -Kx$, $F_2 = -Kx$

Total restoring force $F = -Kx - Kx = -2Kx$

But F = ma

$ma = -2Kx$

$a = \frac{-2Kx}{m}$ inform $a = -\omega^2 x$

since $a \propto x$, motion is simple harmonic

where $\omega^2 = \frac{2K}{m}$

3

(ii) $T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{2k}}$

$T^2 = \frac{4\pi^2 M}{2K}$

$K = \frac{4\pi^2 M}{2T^2}$

$= \frac{2 \times (3.14)^2 \times 12}{(1.5)^2}$

$= 105.17\ Nm^{-1}$

2

(iii) When M is placed on tray,

Let T_1 = be period

$T_1 = 2\pi\sqrt{\frac{M+m}{2k}}$

$T_1^2 = \frac{4\pi^2 (M+m)}{2K}$

$3^2 = \frac{4 \times (3.14)^2 (M+12)}{2 \times 105.17}$

3

48 = M + 12

M = 36 Kg

C(i) Suspend a pendulum bob from a retort stand

- Measure the length, L, of the thread /string with a metre rule.
- Displace the bob through small angle and release it to oscillate in the vertical plane

- Measure and record the time taken to make 20 complete oscillations.
- Calculate period ~~and T²~~ T and T^2
- Repeat the experiment with different known length ,L
- Tabulate the results
- Plot a graph of T^2 against L(OR L against T^2) $g=4\pi 2s$
- Calculate slope ,S .

– Plot a graph of L against T^2.
– Calculate slope S; then $g = 4\pi^2 S$

(5)

any $\therefore g = \frac{4\pi^2}{S}$

$\therefore g = \frac{4\pi 2}{s}$

(II) –Air resistance.

- Angle of swing being big
- Uncertainty in measuring length of the thread

any two (1)

Note :a(ii) Free oscillations-These are oscillations which occur in absence of any dissipative forces ,system oscillates indefinitely, no energy loss (energy of system remains constant),amplitude of oscillation remains constant. (2)

Forced oscillations-Oscillations where system is subjected to an external periodic force, thus setting the system in oscillation. (2)

20

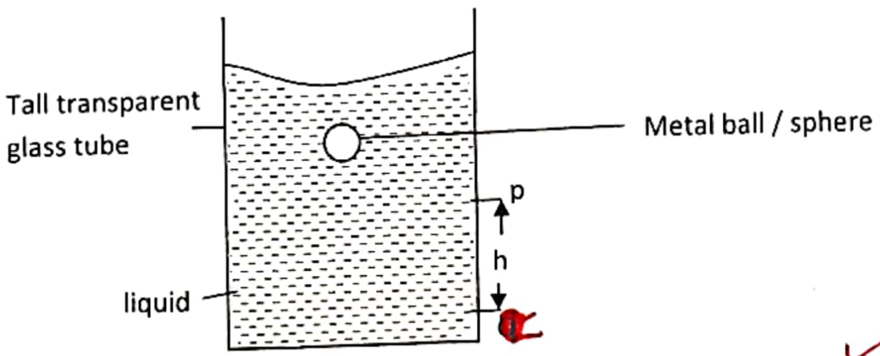
4a(i) Stoke's law: Viscous drag experienced by an object depends on the coefficient of viscosity of the fluid, velocity and radius of the object. (1)

(ii) the body moving in the fluid should be perfectly rigid and smooth

Size of the body is small any two (2)

Motion is streamline

b)(i)



- A viscous liquid of known density, ρ, is put in a tall transparent glass tube
- Two reference marks, P and Q, are marked on the tube

- Distance, h between P and Q is measured
- Diameter / radius of metal ball is measured
- Metal ball of known density, σ, is dropped into the liquid,
- Time, t, taken for the ball to fall from P ~~and~~ to Q is measured
- Terminal velocity, $V_0 = \frac{h}{t}$ is calculated
- Experiment is repeated with different metal balls
- Results are tabulated including, r^2
- Ploy a graph of V_0 against r^2
- Calculate slope, S

6

$\therefore \eta = \frac{2g(\sigma - \rho)}{9s}$

(ii)

- Temperature is kept constant
- Glass tube should be very wide compared to the diameter of the ball bearing
- 1^{st} marked point (P) should be far away from the top of the tube

2 any two

(C)

Let m = mass of copper

(i) 12.9 – m = mass of Zinc

$V = \frac{m}{\rho}$

$V_c = \frac{m}{8.9}$, $V_z = \frac{12.9-m}{7.1}$

$V_{alloy} = V_c + V_z = \frac{m}{8.9} + \frac{12.9-m}{7.1}$

Apparent loss of mass of alloy = 12.9 - 11.3 = 1.6g

4

Volume of water displaced $= \frac{1.6g}{1gcm^{-3}} = 1.6\ cm^3$

Total volume of alloy = volume of water displaced = $1.6\ cm^3$

$1.6 = \frac{m}{8.9} + \frac{12.9 - m}{7.1}$

M = 7.61g

(ii) Density of alloy $= \frac{mass\ of\ alloy}{volume\ of\ alloy}$

$= \frac{12.9}{1.6}$

$= 8.0625\ gcm^{-3}$

Or $8062.5\ Kgm^{-3}$

2

4d) volume of cylinder $= Al$

Volume of liquid displaced $= \cancel{\tfrac{1}{2}}\,\tfrac{1}{2} Al$

Weight of liquid displaced $= V \sigma g$

$\therefore$ Up thrust $= \cancel{\tfrac{1}{2}}\,\tfrac{1}{2} Al \sigma g$

Tension, T, in spring = Ke

at equilibrium,

$$T + U = mg$$

$$Ke + \tfrac{1}{2} Al\sigma g = mg$$

4

$Ke = mg - \tfrac{1}{2} Al\sigma g$

$ke = mg\left(1 - \frac{LA\sigma}{2m}\right)$

20

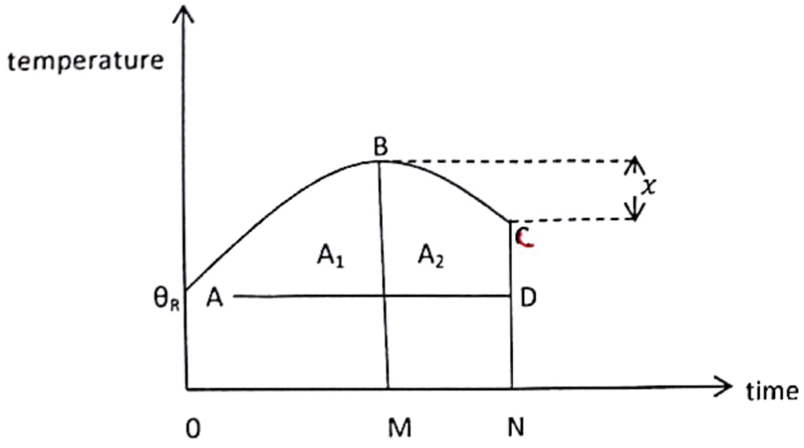
$$\therefore e = \frac{mg}{K}\left(1 - \frac{LA\sigma}{2m}\right)$$

SECTION B

5a(i) cooling correction - Extract temperature / numbers of ^{0}C added to the experiment (observed) maximum temperature of the mixture to cater for heat losses during heating / temperature rise 1

(iii)

- Record the temperature of the surrounding / room temperature, θ_R
- A solid is heated in boiling water for some time and then quickly transferred into water in a calorimeter, stop clock is started immediately
- Stir water and record temperatures after suitable time intervals until temperature of mixture has fallen by $\cong$ 1^0C below observed maximum temperature
- Tabulate the results
- Plot a graph of temperature against time



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- Draw vertical line, BM through the highest temperature
- Draw another vertical line, CN, such that OM $\cong$ MN (OR ON $\cong$ twice OM)
- Draw a horizontal line AD , through room temperature θ_R
- Record the value of temperature, x
- Estimate areas A_1 and A_2 by counting the squares on the graph
- Cooling correction, $\Delta\theta = \frac{A_1}{A_2}x$

b) (i)

- Immerse the thermometer in water at triple point of water
- note the resistance of the platinum wire, R_{tri}
- put the thermometer in the surrounding whose temperature, T is to be determined
- note the resistance of the wire, R_T

3

$T = \frac{R_T}{R_{tri}} \times 273.16K$

(ii)

- platinum has a high melting point
- platinum has a high temperature coefficient of resistance

2

c

$R = R_0[1 + 5 \times 10^{-3}\ (T - T_0\ )]$

When T = 273.16K, R= 101.6Ω

$101.6 = R_0\,[1 + 5 \times 10^{-3}\ (273.16 - T_0)]$……………………………………………………(i)

$165.5 = R_0\,[1 + 5 \times 10^{-3}\ (600.5 - T_0\ )]$……………………………………………………(ii)

(ii) $\div$ (i)

$$\frac{165.5}{101.6} = \frac{1 \times 5\times10^{-3}\ (600.5-T_0)}{1+5\times10^{-3}\ (273.16-T_0)}$$

$T_0 = -47.305K$

Put in (i)

$101.6 = R_0 [1 + 5 \times 10^{-3}(273.16 - {}^{-}47.305)]$

$R_0 = 39.04\Omega$

When $R = 123.4\Omega$ 05

$123.4 = 39.04 [1 + 5 \times 10^{-3} (T + 47.305)]$

$T = 384.90K$

d) i) s.h.c - is the amount of heat energy required to change the temperature of 1kg mass of a substance by 1k 01

(ii) The coolant with high s.h.c absorbs maximum heat (too much heat) from the engine with least/ small rise in its own temperature 02

This prevents the different parts of the engine from getting too hot

6a i) Dalton's law: the total pressure of a mixture of gases that do not react chemically is equal to the sum of the partial pressures of the component gases of the mixture 01

(ii)

$P = \frac{1}{3}\rho \overline{C^2}$

$= \frac{1}{3}\frac{Nm}{V}\overline{C^2}$

$PV = \frac{2}{3}N(\frac{1}{2}m\overline{C^2}$

Consider two gases A and B

$\underline{A}$: $P_1V = \frac{2}{3}N_1(\frac{1}{2}m_1\overline{C_1^2})$..(i)

B : $P_2V = \frac{2}{3}N_2(\frac{1}{2}m_2\overline{C_2^2})$..(ii)

When mixed,

(i) +(ii)

$(P_1 + P_2)V = \frac{2}{3}N_1(\frac{1}{2}m_1\overline{C_1^2}) + \frac{2}{3}N_2(\frac{1}{2}m_2\overline{C_2^2})$

But $\frac{1}{2}m_1\overline{C_1^2} = \frac{1}{2}m_2\overline{C_2^2} = \frac{3}{2}K_BJ$

$(P_1 + P_2)V = \frac{2}{3}N_1(\frac{3}{2}K_BT) + \frac{2}{3}N_2(\frac{3}{2}K_BJ)$

$(P_1+P_2)V = (N_1 + N_2)\, K_BT$

But $N = N_1 + N_2$

$(P_1 + P_2)V = NK_BJ$ but $PV = NK_BJ$

04

$(P_1 + P_2)V\ PV$

$P = P_1 + P_2$

6b) (i)

Saturated vapour	Unsaturated vapour
Vapour which is in dynamic equilibrium with its own liquid	Vapour which is not in dynamic equilibrium with its own liquid max(2)
Don't obey gas laws	Obeys gas laws
Exists at a fixed temperature	Exist at any temperature

(ii)

Consider a liquid heated in a closed container, the most energetic molecules overcome attraction by other molecules and leave the liquid surface to become vapour molecules (evaporation).

As more liquid molecules turn into vapour, vapour density increases.

04

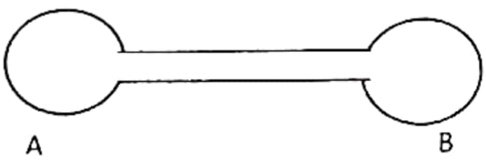
Vapour molecules collide ~~width~~ with the walls of the container giving rise to pressure

Also vapour molecules collide with each other, lose energy they had and re- enter the liquid (condensation)

If the rate of evaporation is equal to the rate of condensation

If ~~the rate of condensation~~, dynamic equilibrium is attained, the vapour is saturated vapour and pressure is called saturated vapour pressure.

c)



$PV = nRT$, $\quad n = \frac{m}{R.M.M}$

$\underline{A}$: $PV = \left(\frac{M_A}{R.M.M}\right) R\times 273$ ....(i)

$\underline{B}$: $PV = \left(\frac{M_B}{R.M.M}\right)^{R\times 373}$ ....(ii)

(i) = (ii)

$273\ M_A = 373\ M_B$

$M_A = \frac{373}{273} M_B$

But $M_A + M_B = 3g$

$\frac{373 M_B}{273} + M_B = 3$

$M_A = 1.27g$ or 1.27×10^{-3} kg

$M_A = 1.73g$ or 1.73×10^{-3} kg

04

(ii)

Total number of moles before = Total number of moles after

$\frac{PV}{RT} + \frac{PV}{RT} = \frac{P^1V}{RTA} + \frac{P^1V}{RTB}$

03

$2 \times \frac{1.01 \times 10^5}{300} = P^1\left(\frac{1}{273} + \frac{1}{373}\right)$

$P^1 = 1.061 \times 10^5$ Pa

d) when the tyre bursts, there is an adiabatic expansion of air because the pressure of air inside is greater than the atmospheric pressure;

02

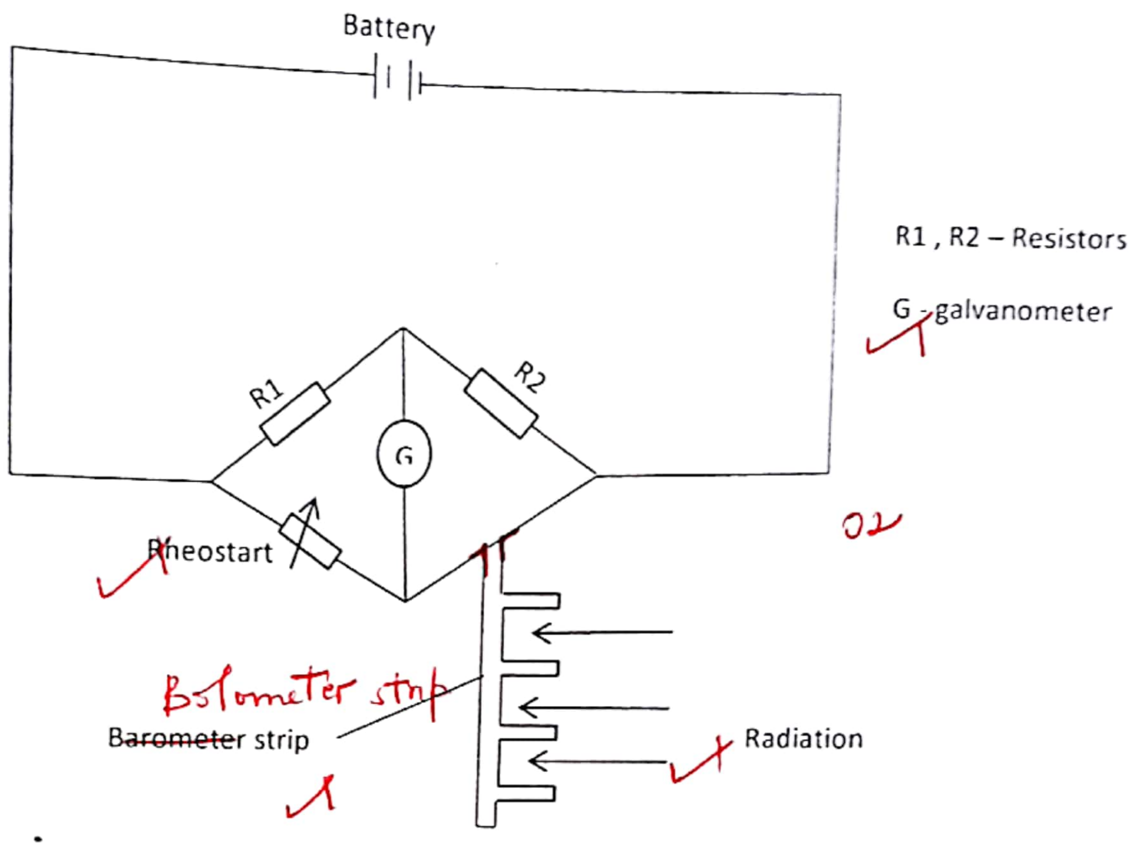
during the expansion, air does some work against the surroundings, therefore internal energy (kinetic energy) decreases,

since $K.e \propto T$, temperature decreases and air cools

7a i)

Solar constant - This is the power per unit surface area received by the earth from the sun

(ii)Temperature gradient – This is the difference in temperature across the ends of a 1m length of conductor b)



The bolometer strip is connected to a wheat stone bridge circuit

The rheostat is adjusted until the galvanometer shows no deflection

03.

When radiation falls on the strip, its absorbed, its temperature increases leading to increase in resistance.

The galvanometer deflects showing presence of radiation

c) power emitted by the sun, P = $A\delta T_S{}^4$

$$= 4\pi r_S^2 \delta\, T_S{}^4$$

Solar constant $= \frac{4\pi r_S^2 \delta\, T_S}{4\pi R^2}$

$$= \left(\frac{r_S}{R}\right)^2 \delta\, T_S{}^4$$

Where r_s = radius of sun

R = distance from sun to earth

Let R_m = distance from sun to mars

R_m radius of mars

T_m = temperature of mars

T_s = temperature of sun

$1400 = (\frac{r_s}{R})^2 \delta T_s^4$ ....(i)

Similarly on mars,

Solar constant $= (\frac{r_s}{Rm})^2 \delta T_s^4$ ....(ii)

(ii)÷ (i)

Solar constant $= 1400 \times (\frac{r_s}{R_m})^2 \times (\frac{R}{r_s})^2$

$= 1400 \times \frac{(1.5 \times 10^{11})^2}{(2.32 \times 10^{11})^2}$

$= 585.24 Wm^{-2}$

03

(ii) power received by mars $= (\frac{r_s}{R})^2 T_s^4 \times \pi r_m^2$

Power emitted by mars $= 4\pi r_m^2 \delta T_s^4 r_m^4$

At equilibrium

03

$4\pi r_m^2 \delta T_m^4 = (\frac{r_s}{R})^2 \delta T_s^4 \pi r_m^2$

$T_m^4 = \frac{1}{4}\left(\frac{7 \times 10^8}{2.32 \times 10^{11}}\right)^2 \times 6000^4$

$T_m = 233.05$ K

d i) thermal conductivity – Rate of heat flow through a material per unit cross – sectional area per unit temperature gradient

(ii) A thin disc reduces heat loss through the sides and enables temperature gradient to measurably steep / high

02

Large diameter makes the rate of heat flow to become measurable

e) $\frac{KA(\theta - 100)}{L} = \frac{M}{t} L_V$ $\qquad A = \pi \frac{d^2}{4}$

$109 \times 3.14 \times \frac{(0.3)}{4} \frac{(\theta - 100)}{1.2 \times 10^{-2}}$

04

$= \frac{1200}{1000 \times 60} \times 2.26 \times 10^6$

θ = 170.43°C

SECTION C

8a) most $\alpha -$ particles passed through the thin gold foil un deflected

This is because the atom of the foil contains a very tiny nucleus and most of the space of the atom is empty

Few $\alpha -$ particles are deflected through small angles less than 90^0

This is due to repulsion by the positive charge of the nucleus

6

Very few $\alpha -$ particles are deflected through large angles greater than 90^0

This is because the nucleus occupies a very small space of the atom thus very few $\alpha -$ particles are incident close to it and those incident close are strongly repelled

b) A bohr atom - is an atom with a small central positive nucleus with electrons moving around it only in a certain allowed circular orbit and while in these orbits, they don't emit electromagnetic radiations but when the electron makes a transition between two orbits, electromagnetic radiations are emitted

1

8b ii)

Electrostatic force F $= \frac{e^2}{4\pi\varepsilon_0 r^2}$

Centripetal force $= \frac{mv^2}{r}$

$\frac{mv^2}{r} = \frac{e^2}{4\pi\varepsilon_0 r^2}$ ~~= kinetic energy~~ $\frac{1}{2}mv^2 = \frac{e^2}{8\pi\varepsilon_0 r}$ = kinetic energy

k.e $= \frac{e^2}{8\pi\varepsilon_0 r}$...(i)

p.e $= \int F dr = \int_{\infty}^{r} \frac{e^2}{4\pi\varepsilon_0 r^2} dr = \frac{-e^2}{4\pi\varepsilon_0 r}$....................(ii)

total energy, E = K.e + P.e

$= \frac{-e^2}{8\pi\varepsilon_0 r} + \frac{-e^2}{4\pi\varepsilon_0 r}$

$E = \frac{-e^2}{8\pi\varepsilon_0 r}$...(iii)

From $mvr = \frac{nh}{2\pi}$, square both sides

$(mvr)^2 = (\frac{nh}{2\pi})^2 \longrightarrow m^2v^2r^2 = \frac{n^2h^2}{4\pi^2}$

$mv^2 = \frac{n^2h^2}{4\pi^2 m r^2}$

$Mv^2 = \frac{n^2h^2}{4\pi^2mr^2}$

$\frac{1}{2}mv^2 = \frac{n^2h^2}{8\pi^2mr^2}$ = kinetic energy..............................(iv)

(i) =(iv)

$\frac{e^2}{8\pi\varepsilon_0 r} = \frac{n^2h^2}{8\pi^2mr^2}$

r $= \frac{n^2h^2\varepsilon_0}{e^2\ m\pi}$ ....(v)

⑤

put (v) in (iii)

$E = \frac{-e^2}{8\pi\varepsilon_0 \frac{n^2h^2\varepsilon_0}{e^2m\pi}}$

$E = \frac{-me^4}{8\varepsilon_0 n^2h^2}$ $E = \frac{-me^4}{8\varepsilon_0^2 n^2 h^2}$

C) ionization energy $= E_\infty - E_1$

$= (0 - -12.8) \times 1.6 \times 10^{-19}$

②

$= 2.048 \times 10^{-18}$J

(ii) ionization energy = kinetic energy = $\frac{1}{2}mv^2$

$2.048 \times 10^{-18} = \frac{1}{2} \times 9.11 \times 10^{-31}\ v^2$

$V = 2.12 \times 10^6\ ms^{-1}$

②

(iii) DE $= \frac{hc}{\lambda}$

$(-1.8 - -12.8) \times 1.6 \times 10^{-19} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{\lambda}$

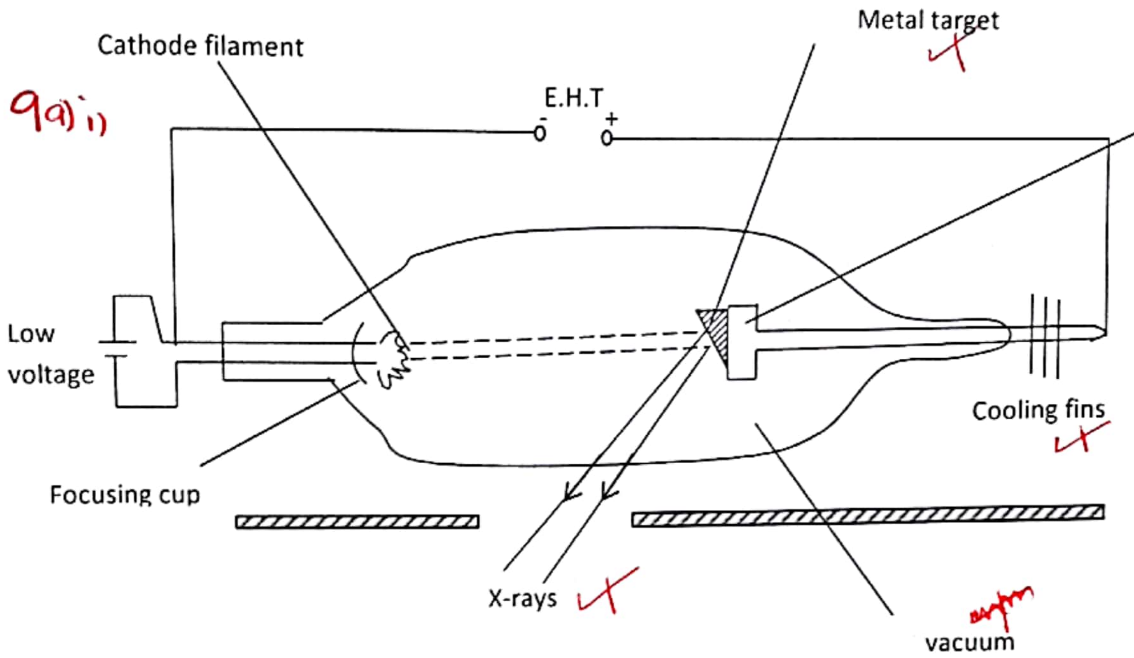
$\lambda = 1.125 \times 10^{-7}$m

③

(iv) Electrons are bound to the nucleus of the atom. Work must be done to remove the ~~electro~~ electron from the atom to infinity where energy is zero and this work is done against the nucleus attraction binding the electron to the atom ①

20

9a) i)



②

any 4 parts (½ each)

9a) ii)

- low voltage source – for heating the cathode filament which produces electrons by thermionic emission
- concave nature of the cathode that focuses electrons to the anode
- accelerating p.d (E.H.T) gives electrons enough kinetic energy to reach the anode
- the metal target of a high melting pont that stays intact with excessive heat generated
- the cooling fins which cool away excess heat
- the vacuum in the tube that prevents collision of electrons with particles which would reduce kinetic energy of the electrons

④

b)

destroying cancer cells

x-rays are directed to the area of the body which is suspected to be with cancer cells. The cells are then killed / destroyed

②

or locate fracture in bones

the x – ray is placed beneath the patients' body part being investigated.

X – ray photograph will indicate the bones that will have more x – rays than the flesh

9c) $\lambda = 1.55 \times 10^{-10}$m, $d = 4.5 \times 10^{-10}$ m

c) $\lambda = 1.55 \times 10^{-10}$ m ; $d = 4.5 \times 10^{-10}$ m

2dsinθ = nλ, for smallest angle, n = 1

$2 \times 4.5 \times 10^{-10} \sin\theta = 1 \times 1.55 \times 10^{-10}$

2

$\theta = 9.92^0$

(ii) let d = original spacing

d^1 = new spacing after increase in temperature

θ_1 = original glancing angle

θ_2 = new glancing angle

$\propto = \frac{expansion}{original\ spacing \times change\ in\ temperature} = \frac{d^1 - d}{d \times 60} = \frac{d' - d}{d \times 60}$

$60d\propto = d^1 - d$

$d^1 = (60\propto + 1)d$

also: $2d\sin\theta_1 = n\lambda$

4

$2d^1\sin\theta_2 = n\lambda$

$\frac{d\sin\theta_1}{d^1\sin\theta_2} = 1 \qquad \frac{d\sin\theta_1}{d(60\propto + 1)\sin\theta_2} = 1$

$\frac{\sin 9.92}{\sin\theta_2} = 60 \times 1.7 \times 10^{-5} + 1 = 1.00102$

$\theta_2 = 9.91^0$

change in angle = 9.92 – 9.91 = 0.01^0

d(i) work function - minimum energy that has to be given to an electron to release it from the metal surface 1

(ii) opening doors automatically in offices

2

Operated burglar alarms / defect intruders

d(iii) $\frac{hc}{\lambda} = k.e_{max} + W_0$ $\left(\frac{hc}{\lambda} = k.e_{max} + W_0\right)$

$= \frac{1}{2}mv^2 + hf_0$

$\frac{6.6 \times 10^{-34} \times 3 \times 10^8}{5.89 \times 10^{-7}} = \frac{1}{2} \times 9.11 \times 10^{-31} \times (3.65 \times 10^5)^2 + 6.6 \times 10^{-34} f_0$

$f_0 = 4.175 \times 10^{15}$ Hz

3

$f_0 = 4.174 \times 10^{14}$ Hz

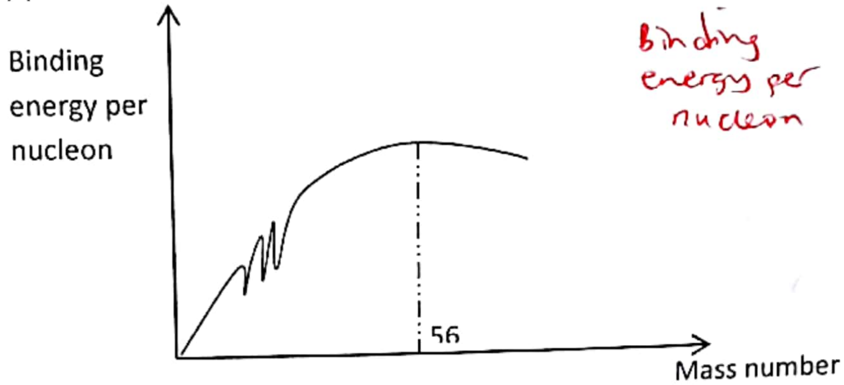
20

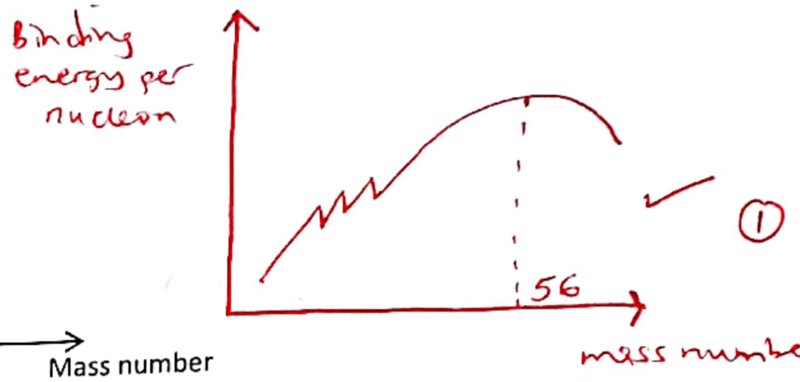
10a) (i) mass defect – difference between the mass of a nucleus and total mass of its nucleons separated

2

Binding energy per nucleon - Ratio of energy required in splitting the nucleus into its protons and neutrons to its mass number

(ii)





1

Binding energy per nucleon of very large and small nuclides is low

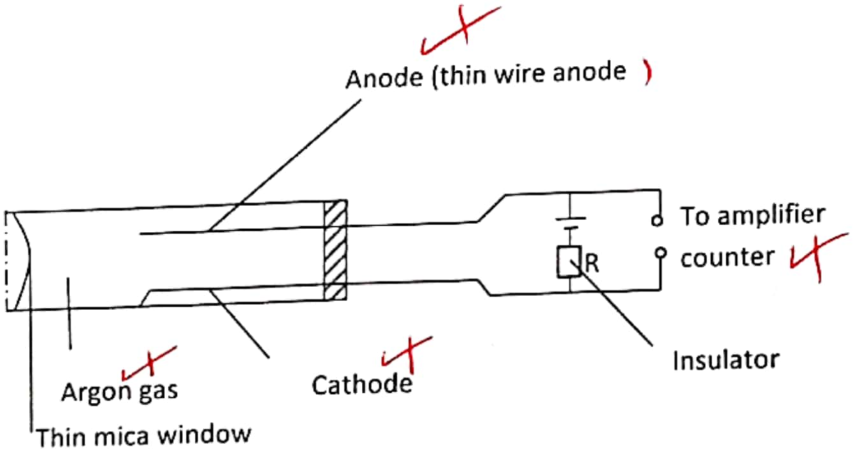
Maximum binding energy per nucleon is obtained at a mass number ≅ 56

3

These are peaks for small nuclides whose number of protons is equal to number of neutrons

10b)

(any 4 parts ½ each)



2

Ionizing radiation enters through the thin mica window, collides with the gas atoms and ionizes it (ion pairs are produced)

The electrons move to the anode and ~~(negative ions)~~ (negative ions)

Positive ions move to the cathode

The fast moving electrons collide with other gas atoms and more ion pairs are produced (avalanche of charge / gas amplification – occurs)

A discharge occurs and current pulse flows through resistor, R

A voltage pulse across R is developed, amplified and operates the counter

The magnitude of the pulse registered gives the extent to which ionization occurs

4

c) i) $\lambda = \frac{ln2}{\frac{t_1}{2}} = \frac{0.693}{3.5} = 0.198\ day^{-1}$

2

OR $\lambda = \frac{0.693}{3.5 \times 24 \times 3600} = 2.292 \times 10^{-6} s^{-1}$

(ii) 226g of $^{226}R_a$ contains 6.02×10^{23} atoms

3.0×10^{-6} kg of ^{226}Ra will contain $\frac{6.02 \times 10^{23}}{226 \times 10^{-3}} \times 3 \times 10^{-6}$

$N_0 = 7.991 \times 10^{+18}$ atoms

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

$= (7.991 \times 10^{18})\ e^{-0.198 \times 7.2} \qquad = 1.921 \times 10^{18}$

Number of decayed atoms $= N_0 - N$

$= (7.991 - 1.921) \times 10^{18}$

$= 6.07 \times 10^{18}$

4

But 1 atom releases energy of 6.2 Mev

Total energy released $= 6.2 \times 6.07 \times 10^{18} = 3.7634 \times 10^{19}$ MeV

$= \frac{3.7634 \times 10^{19}\ MeV}{3.7634 \times 10^{19} \times 10^{6} \times 1.6 \times 10^{-19} J}$

or

$= 6.021 \times 10^{6}$ J

d) determining the thickness of paper / iron sheets. During manufacture, the paper / iron sheet is passed between the gamma ray source and suitable detector. The thicker the paper / sheet, the greater the absorption of gamma rays and the lower the value of activity on the detector.

2

oR

detecting leakages in underground pipes.

A solution of radioactive material is added to oil / water being piped and a defector is to trace the line, At a place where the leakage is, temporary activity takes place which can be defected from above the ground

* etc, like determining rate of wear of metals / tyres