0702179225

UGANDA NATIONAL EXAMINATIONS BOARD
OCTOBER - NOVEMBER, 2013

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PHYSICS P510/1 MOCK 2019

1a i) Work is the product of force and distance moved in the direction of the force ✓

ii) Friction is a force that opposes the relative motion between two surfaces in contact ✓

b i) Conservative force is a force for which the work done to move a body round a closed path is zero ✓ (ME conserved, independent of path taken)

Non-conservative force is a force for which the work done to move a body round a closed path is not zero ✓ (ME not conserved, depends on the path taken)

ii) Conservative - gravitational force, Magnetic force or electric force

Non-conservative - Friction, air resistance or viscous drag.

c i) Friction opposes the relative motion between two surfaces in contact ✓

Limiting frictional force is proportional to the normal reaction ✓

Friction is independent of area of contact provided normal reaction remains constant ✓

ii) Surfaces have projections of small area. When in contact the surfaces rest on each others projections and exert high pressure. The molecules are pushed into close proximity and bonds are formed. For motion to take place these bonds have to be broken hence an opposing force. This explains friction opposes motion.

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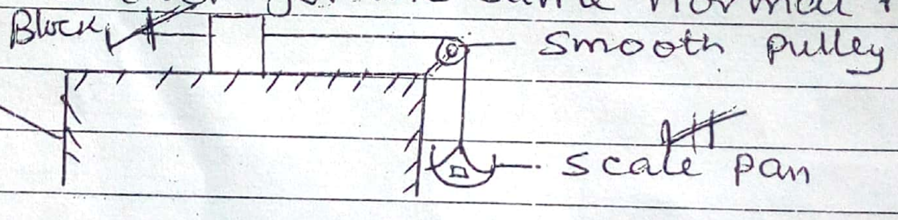
Increase in weight of top surface increases the pressure at the points of contact and stronger bonds are formed. This increases the actual area of contact until the new weight is fully support thus increase in force to break the stronger bonds. 2

When area of contact is changed, the actual contact area remains the same. Thus no change in the frictional force. 2

This explains friction is independent of the area of contact for the same normal rxn.

iii)



07

A block of known mass, M is placed on a flat table and connected to a scale pan using a light string as above. A mass is placed on the scale pan and block given a slight push. More masses are added in bits and block given a slight push until it moves with uniform velocity. Total weight, mg of scale pan and content is obtained. Experiment is repeated with more masses placed on the block to vary the weight, Mg. A graph of mg against Mg is plotted. The slope, s of the graph is calculated. Coefficient of kinetic friction = slope, s 3

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d Work done by force = change in K.E + gain in P.E + work against friction

$F.s = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 + mgh + F_f s$

$F \times 500 = \frac{1}{2} \times 1.2 \times 10^3 (20^2 - 10^2) + 1.2 \times 10^3 \times 9.81 \times 500 \times \frac{1}{20} + 300 \times 500$

$= 1.8 \times 10^5 + 2.943 \times 10^5 + 1.5 \times 10^5$

$\therefore F = 1.25 \times 10^3 N$ — 3

2a i) Surface tension is the force per metre length acting in the surface at right angles to one side of a line drawn in the surface. — 1

ii) Angle of contact is the angle between the solid surface and the tangent plane to the liquid surface measured through the liquid. — 1

b i) A molecule in the bulk of a liquid is subject to intermolecular forces from all directions. The molecules in the surface experience attractive forces on either side due to their neighbours. This puts them in a state of tension and the liquid surface behaves like a stretched skin. When temperature of the liquid is increased, the molecules move farther apart and faster hence the mean kinetic energy increases. The forces of attraction between the molecules decreases hence surface tension of the liquid decreases. — 3

ii) A liquid of density, ρ is poured in a beaker and a capillary tube of radius, r is placed vertically in the beaker. A pin bent at right angles in two parts is attached to the tube using

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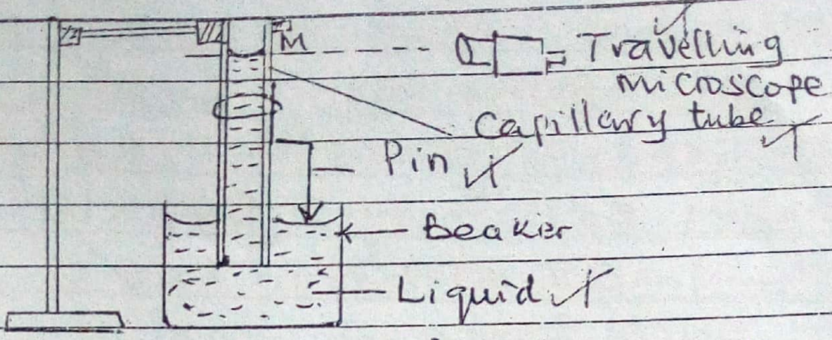

Pin is adjusted until its tip just touches the surface of liquid in the beaker. Travelling microscope is focused on the meniscus, M of liquid in the capillary tube. Scale reading, S_1 is noted and recorded. Beaker is removed and microscope is focused on the tip of the pin. New scale reading, S_2 is recorded. Capillary rise $h = |S_2 - S_1|$ is calculated. Surface tension, γ is given by $\gamma = \frac{\rho r h g}{2\cos\theta}$ where

θ is the angle of contact.

c i) Laminar flow is the flow of fluid where equidistant layers from axis of flow have the same velocity, the flow lines are parallel and the flow is orderly.

Turbulent flow is the flow of fluid where equidistant layers from axis of flow have varied velocities, the flow lines are not parallel and the flow is disorderly.

ii) For a non-viscous, incompressible fluid flowing steadily, the sum of the pressure, kinetic energy per unit volume and potential energy ~~energy~~ per unit volume is constant.

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d) i) Upthrust, U = weight of liquid displaced

$= V\rho g$ ✓

$= 5.0\times10^{-3} \times 1.2\times10^{3} \times 9.81$ ✓

$\therefore U = 58.86N$ ✓ 3

ii) Weight of body, $W = V\delta g = 5\times10^{-3} \times 900 \times 9.81 = 44$

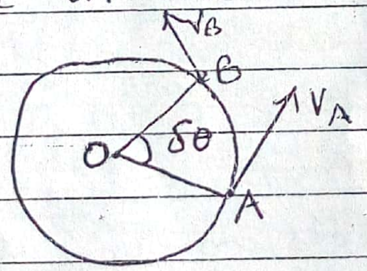
Tension, $T = U - W = 58.86 - 44.15$ ✓

$\therefore T = 14.71N$ ✓ 3

3a) i) Angular velocity is the rate of change of angular displacement ✓

ii) Frequency is the number of complete oscillations (cycles) made in one second. ✓

b



Acceleration, $a = \dfrac{\text{change in velocity}}{\text{time taken}} = \dfrac{\delta v}{\delta t} = \dfrac{V_B - V_A}{\delta t}$ ✓

But $V_B - V_A = V\delta\theta$ ✓

$a = \dfrac{V\delta\theta}{\delta t}$; $\dfrac{\delta\theta}{\delta t} = w$ ✓; $a = Vw$

$w = \dfrac{V}{r} \Rightarrow a = \dfrac{V^2}{r}$ ✓ and $F = ma$

$\therefore F = \dfrac{mV^2}{r}$ ✓ 2

c i) Newton's law of gravitation states that the force of attraction between any two bodies is proportional to the product of the masses and inversely proportional to the distance between the bodies. ✓ 1

SECTION B:

5a i) Isothermal change is the change in volume and pressure of a gas at constant temperature.

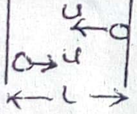
ii) Critical temperature is the temperature above which a gas cannot be liquefied by only compression.

b) a/V^2 is the pressure defect which accounts for the existence of intermolecular forces of attraction. b is a constant that accounts for the finite volume of the molecules themselves. 2

c) i) Kinetic theory of matter states that all matter contains tiny particles in a state of motion and the motion increases when temperature increases.

ii) Smoke is confined in a smoke cell using glass. The inside of the cell is strongly illuminated using an arc lamp. Smoke particles are seen moving randomly and haphazardly within the cell. 4
The continuous random motion of the smoke particles is because of unequal force of collision with invisible air molecules.

iii)



For molecule of mass, m moving at speed, u between walls of a cube; change in momentum, $\Delta m = 2mu$

Force on each wall $F = 2mu / \frac{2l}{u} = \frac{mu^2}{l}$

Pressure on wall, $P = \frac{mu^2}{l} \times \frac{1}{l^2} = \frac{mu^2}{l^3}$

For N molecules moving at $u_1, u_2, \ldots u_N$; total

Pressure, $P = \frac{mu_1^2}{l^3} + \frac{mu_2^2}{l^3} + \ldots + \frac{mu_N^2}{l^3}$

$$= \frac{m}{l^3}(u_1^2 + u_2^2 + \ldots + u_N^2)$$

Mean square speed $\overline{u^2} = \frac{u_1^2 + u_2^2 + \ldots + u_N^2}{N}$ 4

$\Rightarrow u_1^2 + u_2^2 + \ldots + u_N^2 = N\overline{u^2}$

$P = \frac{Nm\overline{u^2}}{l^3}$; $\frac{Nm}{l^3} = \frac{\text{mass of gas}}{\text{Volume}} = \text{density}, \rho$

$P = \rho\overline{u^2}$

For $\overline{u^2} = \overline{v^2} = \overline{w^2}$ we've $\overline{c^2} = \overline{u^2} + \overline{u^2} + \overline{u^2} = 3\overline{u^2}$

$\overline{u^2} = \frac{1}{3}\overline{c^2}$ $\therefore P = \frac{1}{3}\rho\overline{c^2}$

Cross-sectional area $A = \frac{4\pi d^2}{4}$ is calculated. Various loads are added onto the test wire in turns and corresponding extensions obtained. For each load used wire must be able to go back to its original length. A graph of load against extension is plotted. Slope, S of the graph is got.
Young's modulus, Y is got from $Y = \frac{SL}{A}$ 4

C Extension, $e = \frac{FL}{YA}$.
For wire 1; $e_1 = \frac{FL_1}{Y_1A_1}$; For wire 2; $e_2 = \frac{FL_2}{Y_2A_2}$
Total extension $e = e_1 + e_2$

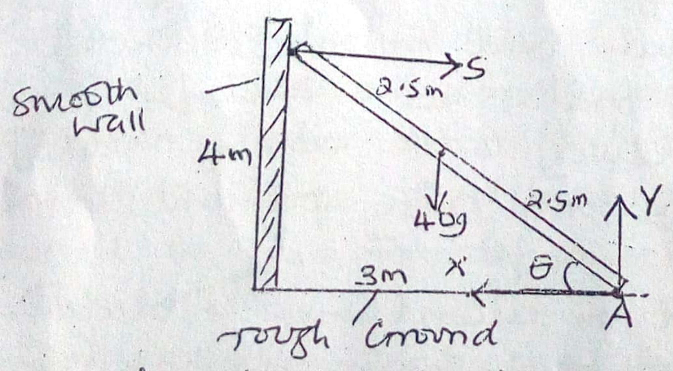
$$e = \frac{FL_1}{Y_1A_1} + \frac{FL_2}{Y_2A_2} = \frac{FL_1Y_2A_2 + FL_2Y_1A_1}{Y_1A_1Y_2A_2}$$

$$e = \frac{F(A_2Y_2L_1 + A_1Y_1L_2)}{A_1A_2Y_1Y_2}$$ 4

$$\therefore F = \frac{A_1A_2Y_1Y_2}{A_1Y_1L_2 + A_2Y_2L_1}e$$

d) i) Stable equilibrium is when a body is tilted slightly its c.o.g is raised and returns to the original position when released. 1
Unstable equilibrium is when a body is tilted slightly its c.o.g is lowered and falls over when released. 1

ii)



$\cos\theta = 3/5$
$\sin\theta = \frac{4}{5}$

Taking moments about point A;
$S \times 4 = 40g \times 2.5\cos\theta$
$4S = 40 \times 9.81 \times 2.5 \times 3/5$
$S = \frac{588.6}{4} = 147.15$

$X = 147.15\,N$
$Y = 392.4\,N$

4

$F = \sqrt{147.15^2 + 392.4^2} = 419.1\ N$
$\tan\alpha = \frac{Y}{X} = \frac{392.4}{149.15}$; $\alpha = 69.2°$

d i) Saturated vapour pressure is the pressure of vapour exerted by vapour which is in dynamic equilibrium with its own liquid. 1

Partial pressure is the pressure a component gas would exert if it alone occupied the volume containing the mixture. 1

ii) A vapour is saturated when rate of vaporization is equal to rate of condensation and the pressure exerted is the saturated vapour pressure (SVP). Increase in temperature of a liquid increases the average K.E of the molecules and more of the molecules escape into vapour. This increases the vapour density and rate of condensation. Equilibrium is re-established at a higher vapour pressure thus increase in temperature increases SVP. 3

e $T_1 = T_2 = 27 + 273 = 300\,K$, $V_1 = 2V$, $V_2 = V$, $V_3 = 2V$

$T_2 V_2^{\gamma-1} = T_3 V_3^{\gamma-1}$

$300 (V)^{1.4-1} = T_3 (2V)^{1.4-1}$

$T_3 = 300 \left(\frac{V}{2V}\right)^{0.4} = 300\left(\frac{1}{2}\right)^{0.4}$ 3

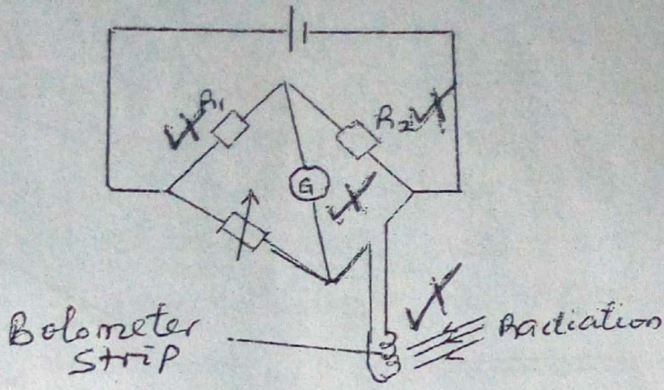
$T_3 = 227.4K$

6 a) i) Conduction is the process of heat transfer from region of high temperature to region of low temperature and occurs without actual movement of matter as a whole. 1

ii) Thermal conductivity is the rate of heat flow per unit cross-sectional area per unit temperature gradient. 1

b) When liquid in a container is heated, it expands and becomes less dense. The cool more dense liquid moves down as the warm less liquid rises. This movement generates a convection current that transfers heat from the hot section of the liquid to the cold section. 3

c) A bolometer strip is connected to one arm of a wheatstone bridge circuit with resistors R_1, R_2 and a rheostat.



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The rheostat is adjusted until the galvanometer shows no deflection when no radiation falls on the bolometer strip. Radiation is now directed onto the bolometer strip and is absorbed. Temperature of strip rises leading to an increase in resistance. Increase in resistance of the strip 3 causes lack of balance in the wheatstone bridge circuit and the galvanometer deflects. The deflection of galvanometer shows presence of radiation

ii) When a metal bar is fully lagged, no heat is lost to the surrounding and quantity of heat flowing along the bar is constant giving a uniform rate of temperature fall. Graph of temperature against distance along metal bar is a straight line 3

di) Black body is a body which absorbs all radiations incident on it and transmits none 1

ii) Stefan's law states that the power radiated per unit surface area of a black body is proportional to the fourth power of its absolute temperature.

Wien's law states that the wavelength for 2 which intensity is maximum is inversely proportional to the absolute temperature of black body

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

$\frac{66.0\times 0.04(\theta_2-100)}{2\times10^{-3}} = \frac{0.09}{60}\times 2.26\times10^{6}$

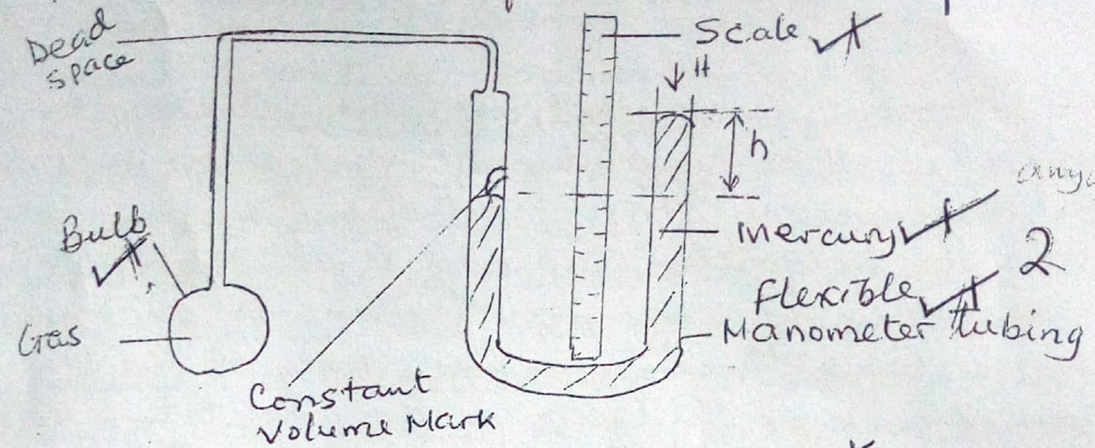
4

$\therefore \theta_2 = 102.6\,^{\circ}C$

7a) i) Thermometric property is the property that varies linearly and continuously with change in temperature. 1

ii) Triple point of water is the temperature at which pure ice, pure water and water vapour exist in equilibrium. 1

b i)



2

Bulb is immersed in an ice-water mixture and flexible rubber tubing is adjusted to take mercury to the constant volume mark. Difference in levels of mercury, h_0 is noted and recorded. Bulb is transfered to steam above boiling water and later put in contact with body at unknown temperature and values h_{100} and h_θ respectively recorded. The unknown temperature is got from $\theta = \frac{h_\theta - h_0}{h_{100} - h_0} \times 100°C$ 4

ii) Corrections necessary in the constant-volume gas thermometer:

- Expansion of the glass bulb
- Non-uniformity of manometer limbs 3
- Parallax error at glass-mercury contacts
- Non-ideal behaviour of the gas in the bulb

c i) Newton's law of cooling states that the rate of cooling of a body is proportional to the excess temperature over the surrounding under conditions of forced convection. 1

ii) A small body has a large surface area to volume ratio with small linear dimension. Rate of temperature fall is inversely proportional to the linear dimension so the small body loses a large quantity of heat in a short time making it to cool faster. 3

d Total heat absorbed, $H = m_1 c_1 \Delta\theta + m_2 c_2 \Delta\theta$

$= 0.18 \times 2000 \times 10 + 0.1 \times 400 \times 10$

$= 1.64 \times 10^4 J$ 2

ii) Electrical energy supplied = Heat absorbed

$VIt = H$

$V \times 2.5 \times 100 = 1.64 \times 10^4$ 3

$\therefore V = 65.6V$

SECTION C:

8a) i) Mass number is the total number of protons and neutrons in the nucleus

ii) Decay constant is the fraction of number of atoms that decay per second. 2

b Using the decay law; $N = N_0 e^{-\lambda t}$

At half-life, $T_{\frac{1}{2}}$, $N = \frac{N_0}{2}$

$\frac{N_0}{2} = N_0 e^{-\lambda T_{\frac{1}{2}}}$

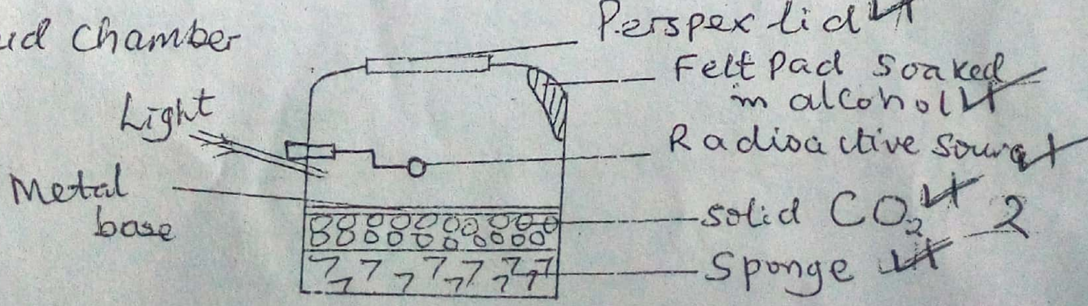
$\frac{1}{2} = \frac{1}{e^{\lambda T_{\frac{1}{2}}}}$ 3

$e^{\lambda T_{\frac{1}{2}}} = 2$

$\lambda T_{\frac{1}{2}} \log_e 2 = \log_e 2$

$T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$

c Cloud chamber



2

Top of chamber is at room temperature and bottom is maintained at very low temperature by the solid CO_2. A temperature gradient is established between the top and bottom of the chamber. Air at the top is saturated with alcohol vapour from the felt pad which diffuses downwards into the cooler region. The air in the cooler region becomes supersaturated. When an ionising radiation passes through the air, the excess vapour condenses on the ions formed that act as nucleating sites forming drops. When the inside of the chamber is illuminated, tracks are seen as a series of droplets. Thickness and length of path show the extent to which ionisation occurred. 4

d i) Binding energy is the energy required to split the nucleus into its protons and neutrons.

ii) Nuclear fusion is a process where two small nuclei combine to form a heavier nucleus accompanied by the release of energy. 1

Nuclear fission is a process where a heavy nucleus splits to form two lighter nuclei accompanied by the release of energy. 1

iii) Fusion is used in the generation of solar energy or production of hydrogen bomb. 1

Fission is used in production of atomic bombs or generation of nuclear energy

e i) Total Mass on RHS $= 205.929 + 4.002 = 209.931$

Difference in mass, $\Delta m = 209.937 - 209.931 = 0.006$

Energy released, $E = \Delta m \times 931 = 0.006 \times 931$

$\therefore E = 5.59\,MeV$ 4

ii) Part of the energy is taken by the Pb-nucleus as it recoils with smaller velocity hence small energy.

9.a) i) Photoelectric emission is a process by which electrons are ejected from a metal surface when electromagnetic radiation of high energy falls on the metal

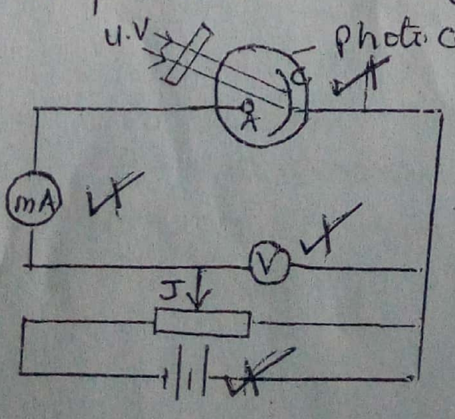
ii) Threshold frequency is the minimum frequency below which no electrons are emitted ✓

b Quantum theory postulates that light energy exists in discrete packets called quanta and each quantum of energy E is carried by photon ✓ ie $E = hf$. When incident on a metal surface each photon interacts with only one electron - giving it all its energy ✓ If the energy is equal or greater than the work function, the energy is absorbed and an electron is immediately ✓ ejected. This explains the fact that photoelectric emission is instantaneous and that there exists a minimum frequency ✓ f_0 for $W_0 = hf_0$. Increasing frequency increases the energy, E of each photon and thus the K.E of the photoelectrons increases ✓ Increasing intensity of radiation does not change the energy of the photons thus intensity does not affect K.E of photoelectrons ✓ This explains K.E is proportional to frequency and independent of intensity. ✓

Increasing intensity increases the number of photons striking the metal surface per second ✓. Thus more electrons are emitted per second and photocurrent increases ✓ This explains the fact that photocurrent ∝ intensity ✓

5

c



2

Monochromatic beam of U.V radiation is directed onto the cathode of a photocell. The cathode, C is made positive with respect to the anode, A. The slider, J is moved along the potential divider until the milliammeter reading is zero. Stopping potential, V_s is read from the voltmeter. 3

d $K.E = \frac{1}{2}mv^2$, $E.P.E = \frac{2ze^2}{4\pi\varepsilon_0 r}$

At distance of closest approach, r all the K.E is lost at the expense of the E.P.E.

$$\frac{1}{2}mv^2 = \frac{2ze^2}{4\pi\varepsilon_0 r}$$ 3

$$mv^2 = \frac{ze^2}{\pi\varepsilon_0 r}$$

$$\therefore r = \frac{ze^2}{\pi\varepsilon_0 mv^2}$$

e i) Ionisation energy is the energy required to completely remove an electron from an atom in ground state 1

Excitation energy is the energy required to remove an electron from a lower energy level to a higher energy level. 1

ii) $\frac{1}{2}mv^2 = (E_\infty - E_0)$

$10^{-31} \times \frac{1}{2} \times 9.11 \times v^2 = (0 - -10.4) \times 1.6 \times 10^{-19}$

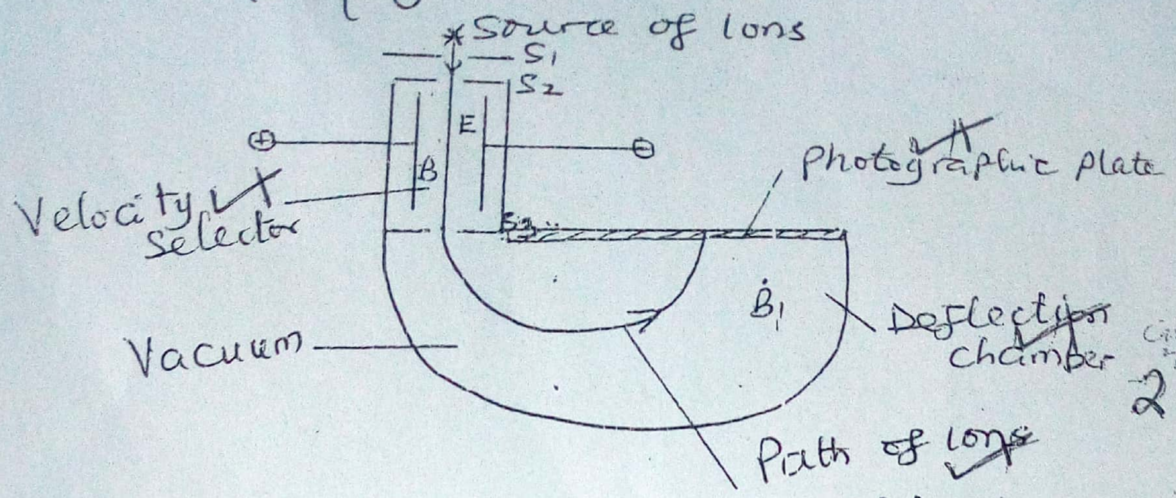
$$v^2 = \frac{2 \times 10.4 \times 1.6 \times 10^{-19}}{9.11 \times 10^{-31}}$$ 3

$$\therefore v = 1.91 \times 10^6 ms^{-1}$$

10 a) i) Positive rays are streams of positively charged ions which are the remaining parts of atoms that have lost atleast one electron

ii) Thermionic emission is the ejection of electrons from a metal surface when heated 2

b Bainbridge mass spectrometer:



2

Ions from source are directed into the velocity selectors through slits S_1 and S_2. The selector has crossed electric field of intensity, E and magnetic field of flux density B. Ions of same charge, Q pass through the selector undeflected with velocity, $V = \frac{E}{B}$. The selected ions pass thru slit S_3 and enter a region of uniform magnetic field of flux density B_1. The ions are deflected and move a circular path and fall on a photographic plate. The diameter, d. hence radius, r of path is obtained. Centripetal force on the ions is provided by B_1: $B_1QV = \frac{mv^2}{r}$. Charge to mass ratio of the ions is $Q/m = \frac{E}{BB_1r}$ 5

c Electron beam is acted on by electron force $F = Ee$ in the vertical direction. There is no force in the horizontal direction and velocity remains constant but the verticalz velocity changes with time. The resultant motion of the beam is along a parabola. Thus motion of beam within the field is along a parabolic path.

d i) $eV_a = \frac{1}{2}mv^2$ ✓✓

$1.6\times10^{-19} \times 4\times10^3 = \frac{1}{2}\times9.11\times10^{-31}v^2$ ✓✓

$\therefore v =$ ✓ 2

ii) In the magnetic field;

$Bev = \frac{mv^2}{r}$ ✓

$r = \frac{mv}{Be}$

$= \frac{9.11\times10^{-31}\times}{0.12\times1.6\times10^{-19}}$ ✓ 3

$\therefore r =$ ✓

e i) Time base is an in-built p.d in the CRO that sweeps the electron beam across the screen ✓ 1

ii) Advantages;

The CRO measures both direct and alternating voltages ✓ 1

The CRO has no coil to burn incase of excess current ✓ 1

20

-END-

NB: Marks for literature are independent of the diagram.

For some defn/laws; (without conditions); a formula is still accepted. eg $\frac{P}{A} \alpha T^4$

p → power radiated

A - s.A

T^4 - absolute temp.