JINJA JOINT EXAMINATIONS BOARD

MOCK EXAMINATIONS 2024

PHYSICS P510/1

MARKING GUIDE

1. (a) (i) Free fall is the motion of a body under the influence of earth's gravitational pull in the 01 absence of any dissipative forces. (ii) Gravitational field strength is the force per unit mass in a gravitational field.

01

(b)(i) From the conservation of linear momentum m_1u_1 □M_2u_2 □m_1v_1 □m_2v_2

m^1 □ u_1 □v_1 □□(v_2 □u_2)□□□ u_1 □v_1

For □□

m_2 v_2 □u_2

For the conservation of kinetic energy 1 $m_1u_1^2$ □ $^1M_2u_2^2$ □ $\frac{1}{2}m_1v_1^2$ □ $^1m\ v^2$

2 2 2 2 2

2 2

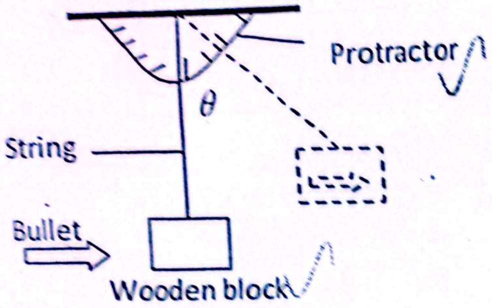
□ u_{12} □v_{12} □□(v_{22} □u_{22})□□□ u_1 □v_1 $\frac{04}{v_2^2 \square u_2^2}$

$\overline{u_{122}}$ □v_{122} □ $\overline{vu_{21}}$ □□u v 12 □ u_1 □u_2 □v_2 □v 1 v_2 □u_2

(ii) The hands of the player move very fast such that time for which it is in contact with the bricks is 03 very short. This increases the impulsive force on the bricks hence breaking the brick with ease.

(c) A massive wooden block of known mass M is suspended from a fixed point by a string fleshly blackened with charcoal.

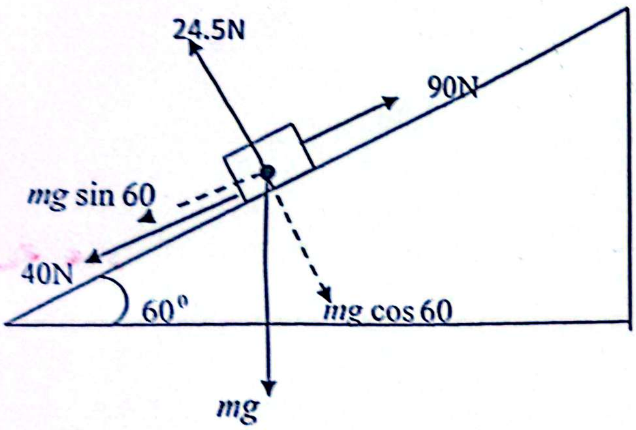
- A protractor is fixed at the point of the suspension of the string as shown below



- A bullet of mass m ~~is fixed~~ fired from close range so that it gets embedded in the block and the first angle of swing from the vertical is read and recorded. The length l of the string is measured and recorded.

05

- The velocity of the bullet u is got from u $\frac{(m \; M)}{m}\sqrt{2gl(1 \; \cos)}$



(i) $mg\cos 60 \; 24.5$

$mx9.81\cos 60 \; 24.5$

$m \; 5kg$

$90 \; mg\sin 30 \; ma$

$90 \; 5x9.81\sin 30 \; 5a$

03

$a \; 1.5ms^{-2}$

(ii) $v \; u \; at$

v□ 0□ a1.5x5 □ 7.5ms□1

$\frac{1}{2}$ 2 — 1 2 x5x7.5 03

KE □mv □

2 KE □140.63J

2. (a)(i) Work hardening is the process of increasing the metals resistance to plastic deformation by repeatedly bending it.

Yield point is the load beyond which the material starts undergoing plastic deformation. 02

□ EA□

(ii) Force F □□□ l_o □□□ e but e □□l_o(□₂ □□₁)

□ 2

□ EA□ 02

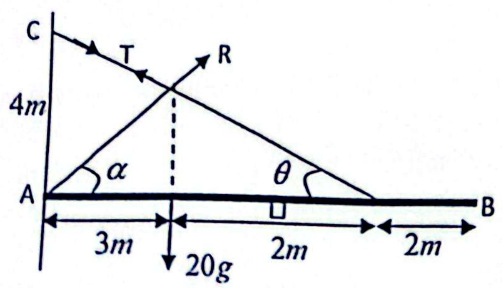
□ F □□□ l_o □□□ □□l_o(□₂ □□₁)□ F □ EA□(□ □□)

□

(b)(i) The algebraic sum of forces is zero or the resultant force acting on the system is zero 02

Sum of the clockwise moments must be equal to the sum of anticlockwise moments.

(ii)



□□ tan□₁□□ 4 □□□ 38.7₀

□5□

Taking moments about A; T □5sin□□ 20g □3□ T □188.3N

EAe □l □l□□ □

But T □ l_o□ EA□□□ l_o□□

EAe 2 5^2□ $6.40m$

□l_o□ But l □ 4 □

(T □ EA)

$$\square l_o \square \frac{(1.2\times10^7\times12\times10^{-4}\times6.40)}{(188.3+1.2\times10^7\times12\times10^{-4})} \square\ 6.32m$$

Resolving vertically; $R\sin$□□$T\sin$□□ $20g$ □ $R\sin$□□ 20□9.81□188.3sin38.2

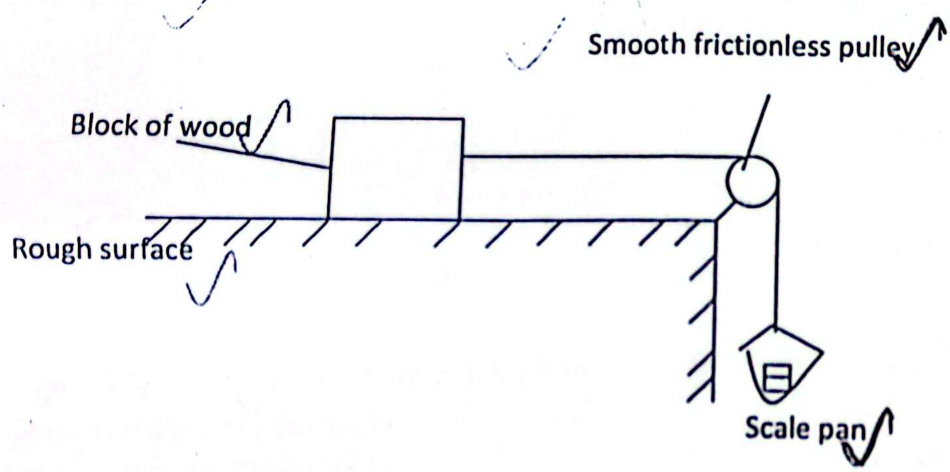
$R\sin$□□ 78.5..........................(i)

Resolving horizontally; $R\cos$□□$T\cos$□□188.3cos32.7 **05**

$R\cos$□□147.0................................(ii)

From the two equations $R^2(\sin^2$□□ $\cos^2$□) □ 78.5^2 □147^2 □R□166.6N □□ 28.1^0

(c)(i) Conservative field is the field for which the work done by a force to move a body round a close



path is zero while Conservative field is the field for which the work done by a force to move a **02** body round a close path is not zero.

(ii) Frictional forces oppose relative motion between two surfaces in contact

Friction is independent of area of contact of the surfaces provided the normal reaction is constant.

Limiting frictional force is directly proportional to the normal reaction. Explanation

Surfaces rest on each other's tiny projection; actual area of contact is very small; pressures are very high at the points of contacts hence the projections are welded at the points and a force that opposes the motion is created hence law 1 **06**

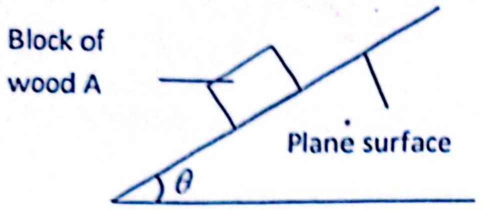
The actual area of contact is the sum of the areas of the tiny projections that adhere to each other which is nearly independent of the surface area hence law 2

Normal force determines the actual area of contact. When the force increases the interlocking of projections is stronger hence the frictional force increases. (d)

□ Known masses are added to the scale pan in bits until the block is just about to slide on its own.

- The weight, w of the scale pan and its contents is measured and recorded.
- Limiting friction = W

alternatively



- A block of wood A is placed on the horizontal surface.
- One end of the plane surface is tilted gently until the block just begins to move on its own.
- Measure the angle of tilt, θ and record.
- Measure and record the mass, m of block A.
- Limiting friction $= mg\sin\theta$ where g = acceleration due to gravity.

3. (a)(i) When a body is wholly or partially immersed in the fluid it experiences an up thrust equal to the weight of the fluid displace.

(ii)
mass of the body $= \frac{W}{g}$

$$\text{volume of the body } = \frac{W}{\sigma g}$$

$$\text{volume of the fluid displaced} = \frac{W}{\sigma g}, \text{so weight of displaced fluid} = \frac{W\rho}{\sigma g} \times g = \frac{W\rho}{\sigma g}$$

$$\text{resultant force on the body} = \text{weight} - \text{upthrust} = W - \frac{W\rho}{\sigma g} = \frac{W(\sigma-\rho)}{\sigma}$$

(b)(i) mass of hydrometer in gram; $m = (3+4+h)1 = (7+h)g$

where h is the height of x above the bulb.

$$m = (7+h)1 \ldots\ldots\ldots\ldots\ldots (1)$$

$$m = (9+h)0.9 \ldots\ldots\ldots\ldots\ldots (2)$$

$$m = (3+x+h)1.1 \ldots\ldots\ldots\ldots\ldots (3)$$

03

Equating (1) and (2) $\quad (7+h) = (9+h)0.9$

$(7+h) = 8.1 + 0.9h \qquad$ thus $1.1 = 0.1h \qquad \leftrightarrow h = 11\text{cm}$

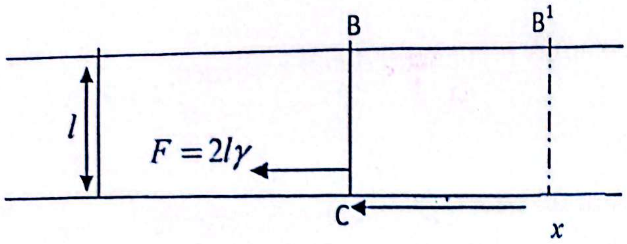
(ii) Equating (3) and (2)

$18 \quad = (3+x+11)1.1 \qquad \leftrightarrow x = 2.36\text{cm}$ 02 (c)(i)

Surface energy is the work done in creating a unit area of new surface.

Surface tension is the force per unit length acting on the surface perpendicular to one side of line drawn in the surface. 02

(ii) Consider a liquid film stretched with a rectangular metal frame



Suppose the film is stretched isothermally so that the edge $B^{I}C^{I}$ moves through a distance x to BC

Work done to stretch the film is given by

Work done = force x distance

□2l□x

$2lx$ Is the increase in the area of the film (the film has two surfaces) **03**

$$\text{surfce energy } \delta = \frac{\text{workdone}}{\text{area created}} = \frac{2l\gamma x}{2lx} = \gamma$$

$$\text{surface energ } \delta = \text{surface tension } \gamma$$

(d)(i) Area created $= 2(4\pi r^2)$

work done $= 8\pi r^2\gamma = 8 \times 3.14 \times (7.5 \times 10^{-3})^2 \times 3 \times 10^{-3} = 4.239 \times 10^{-6}\text{J}$

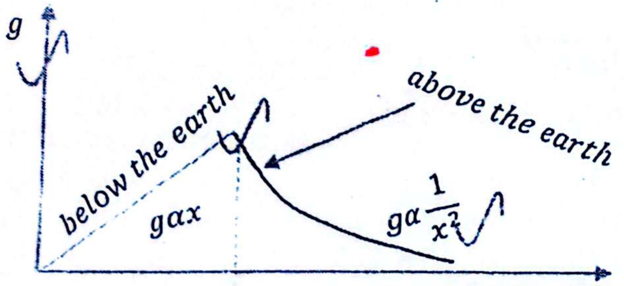
(iii) $\Delta P = \frac{4\gamma}{r} = \frac{4\times3\times10^{-3}}{7.5\times10^{-3}} = 1.6\text{Pa}$ **02**

03

4. (a) Planets describe ellipses about the sun as one focus
- The line joining a planet to the sun sweeps out equal areas in equal time intervals. **03**
- The squares of the period of the revolution of the planet around the sun is proportional to the cube of

their mean distance of separation.

(b)(i)



02

(ii) $\frac{GMm}{r^2} = mg' \Rightarrow M = \frac{r^2 g'}{G}$ And from equation (i), $M_e = \frac{r_e\ g}{G}$ if the Earth is assumed to have uniform density, ρ, then ; $M = \frac{4}{3}\pi r_e^{\ 3}\rho$

Therefore, $\frac{M}{M_e} = \frac{r^3}{r_e^3}$ Substituting for Me and M: 03

$$\frac{r^2 g'}{G} \times \frac{G}{r_e^2 g} = \frac{r^3}{r_e^3} \Rightarrow g' = \frac{r}{r_e} g$$

(c)

effective mass of the earth M

$$= \frac{4}{3}\pi(Re - r)^3\rho$$

$$g = G\frac{4}{3}\frac{\pi(Re - r)^3\rho}{(Re - r)^2}$$

$$= \frac{4}{3}\pi G(Re - r)\rho$$

$$\frac{GMm}{r^2} = mg \quad \text{thus} \quad g = \frac{GM}{r^2}$$

$$\frac{r_m}{r_e} = 0.93, \qquad \text{and } \frac{m_m}{m_e} = 0.14$$

$$g_m = \frac{Gm_m}{r_m^{\ 2}} \quad , \quad g_e = \frac{Gm_e}{r_e^{\ 2}}$$

$$\frac{g_m}{g_e} = \frac{m_m}{m_e} \times \frac{r_e^{\ 2}}{r_m^{\ 2}} = 0.14 \times \left(\frac{1}{0.93}\right)$$ 03

$$g_m = 0.14 \times \left(\frac{1}{0.93}\right) \times 9.81 = 1.59\text{ms}^{-2}$$

(d) Weather forecast, global communication, study universe. 02 □ scientific research, miltary support, navigation, earth imaging.

(e)(i) $M.E = -\frac{GMm}{2R}$, but $R = 6.4 \times 10^6 + 3.59 \times 10^7$

$$R = 4.23 \times 10^7 m \qquad 04$$

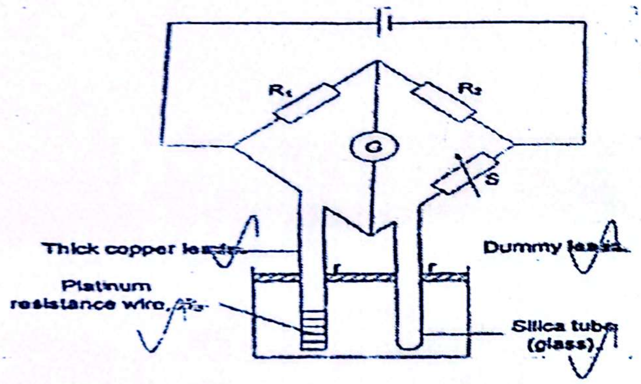
$$M.E = -\frac{6.67 \times 5.97 \times 10^{24} \times 10^{-11} \times 100}{2 \times 4.22 \times 10^7} = -4.71 \times 10^8 J$$

(ii) Satellite move to an orbit of smaller radius

Velocity or kinetic energy increases 02

5. (a)(i) A thermometric substance is a physical property of a substance that varies linearly and continuously with temperature. 01

(ii)



R_1 and R_2 are fixed resistors.

The silica tube is placed in an enclosure under test.

Variable resistor is adjusted until galvanometer shows no deflection.

The value of S at balance point is recorded as R_T.

The silicon tube is the placed in an enclosure at triple point of water and the procedure above repeated.

The value of S at the balance point is recorded as R_{tr}.

The unknown temperature T is got from $T = \frac{R_T}{R_{tr}} \times 273.16K$

(iii) $\theta = \frac{R_\theta - R_0}{R_{100} - R_0} \times 100^0C$ 03

$$-5 = \frac{R_\theta - 2.4}{3.34 - 2.4} \times 100^0C$$

$47R_\theta = 1128$, $R_\theta = 2.4\Omega$

(b)(i) This is the quantity of heat required to change a 1kg mass of a substance from solid stat to liquid state without change in temperature. 01

(ii) Ice absorbs latent heat of fusion from the substance to be cooled as it melts and the temperature initially remains at 0°C. Temperature of water at 0°C rises as it absorbs heat from the substance. 01

(c) (i)

$$Q = mc\Delta\theta$$

$$\frac{Q}{t} = m^1c\Delta\theta$$

Heat supplied per second from O to B

$$\frac{Q}{t} = \frac{m \times 1.6 \times 10^3 \times 10}{160}$$

Along BC

$$Q = ml_f$$

$$\frac{Q}{t} = \frac{ml_f}{240} \quad \mathbf{04}$$

$$\frac{ml_f}{240} = \frac{m \times 1.6 \times 10^3 \times 10}{160}$$

$$l_f = 2.4 \times 10^4 Jkg^{-1}$$

(ii) Along CD $\frac{Q}{t} = \frac{mc \times 10}{200}$ hence $\frac{ml_f}{240} = \frac{mc \times 10}{200}$

2. **03** $\frac{4 \times 10^4}{240} = \frac{c \times 10}{200}$

$c = 2000 Jkg^{-1}K^{-1}$

(d) Water has high specific heat capacity compared to other liquids hence absorbs a lot of heat from engine before its temperature rises appreciably. **01**

CamScanner

6. (a) (i) Molar heat capacity at constant pressure is the heat required to raise the temperature of one mole of a gas by 1K at constant pressure.

S.I units $Jmol^{-1}K^{-1}$ 02

(ii) $\Delta Q = \Delta U + \Delta W$

At constant volume, $nC_v\Delta T$ is the heat required to raise the temperature of n moles by ΔT and $\Delta W = 0$.

$\rightarrow nC_v\Delta T = \Delta U$

At constant pressure, $nC_p\Delta T = \Delta U + \Delta W$ but, $\Delta u = nC_v\Delta T$

$$nC_P\Delta T = nC_v\Delta T + \Delta W$$

And $\Delta W = Fdx = PAdx = P\Delta V$

$P\Delta V = nR\Delta T$ Thus: $nC_P\Delta T = nC_v\Delta T + nR\Delta T$ 04

Hence: $C_P = C_v + R$

(b)(i) $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $V_2 = \frac{1.5 \times 10^5 \times 1.0 \times 10^{-2} \times 285}{300 \times 1 \times 10^5} = 0.01425$

Mass $=$ Density $\times$ $Volume = 1.2 \times 0.01425 = 1.7 \times 10^{-2}$ 03

(ii) $\frac{1.5 \times 10^5}{300} = \frac{1.8 \times 10^5}{T}$ $\leftrightarrow T = \frac{1.8 \times 10^5 \times 300}{1.5 \times 10^5} = 360K$

$Temperature\ rise = (360 - 300) = 60K$

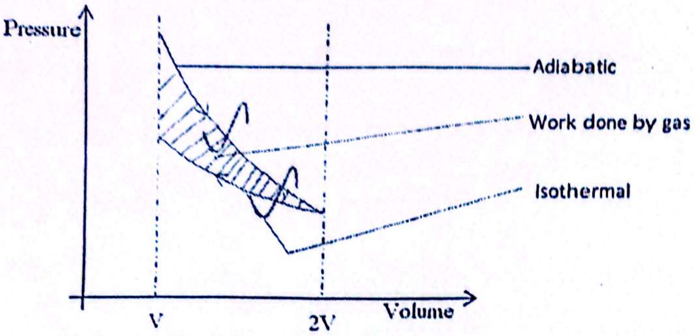
$\leftrightarrow 750 = mC_v\Delta T$ $\therefore C_V = \frac{750}{1.71 \times 10^{-2} \times 60} = 731Jkg^{-1}K^{-1}$

kg

(c) When the gas is heated its temperature rises and its molecules gain kinetic energy. As they collide with the walls of the container there is a higher rate of change of momentum due to increased velocity. Therefore a higher force is exerted on the walls hence higher pressure. Secondly, since the volume remains constant and the molecules are moving faster, the number of collisions made per second increases hence higher pressure.

(d)(i) Isothermal change is the expansion or compression of a gas at constant temperature whereas an adiabatic change is the compression or expansion of a gas without exchange of heat energy between the system and the surrounding.

(ii) 03



02

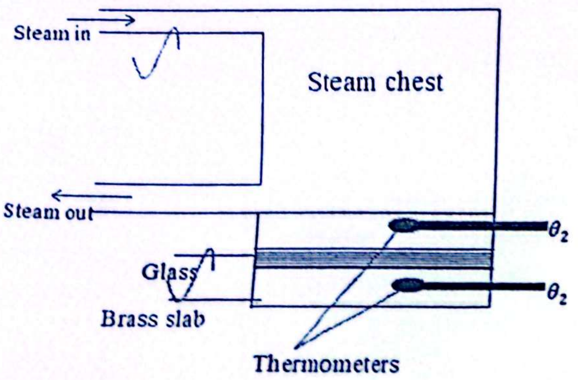
7. (a)(i) factors;

- ✓ Area of cross section of the conduct 02
- ✓ Length of conduct
- ✓ Temperature difference between the ends of the conduct
- ✓ Nature of the conductor

(ii). When one end of the conductor is heated the molecules at that end gain energy and vibrate faster with bigger amplitudes .They lose some of their energy to neighboring molecules after gaining energy vibrate faster with bigger amplitudes, The process continues until molecules at the cooler 03 end and vibrate faster with bigger amplitudes.

Good conducting solids such as metals have free mobile electrons which drift to cooler end when heated they collide with other electrons and atoms at the cooler and making them to vibrate faster with bigger amplitudes.

(b)



- ✓ Glass is made into a thin disc and its diameter and thickness x are measured and recorded.
- ✓ The apparatus is arranged as shown above.
- ✓ Steam is passed through the steam chest until temperatures θ_1 and θ_2, are constant.
- ✓ The glass disc is removed and brass slab is heated directly until its temperature rises by about 5^0C.
- ✓ The glass disc is placed back on top of the brass slab of specific heat capacity, c and its temperature is recorded at every half minute interval.

$$mcs = k\pi \frac{d^2}{4}\left\{\frac{\theta_2 - \theta_1}{x}\right\}$$ 06

Thus coefficient, $k = \frac{4xmcs}{\pi d^2(\theta_2 - \theta_1)}$

c) (i) $Electric\ energy = Heat\ energy\ absorbed\ by\ water\ and\ calorimeter$

$P(7 \times 60 + 16) = 25 \times 4200 \times (100 - 20) + 1 \times 400 \times 80$

$P(436) = (840000 + 32000),\ Thus;\ P = 2000W$ 02

(ii) $Power = mass\ rate \times l$

$2000 = m \times 2.26 \times 10^6\ thus;\ m = 8.85 \times 10^{-4} kgs^{-1}$ 02 »

(iii) $\frac{Q}{t} = kA\quad Thus:\ 2000 = \frac{40 \times 0.1 \times ((\theta_2 - 100)}{3 \times 10^{-3}}$ hence, $\theta_2 = 101.5°C$ 03

d). Metals are good conductors of heat while wood is a poor conductor of heat. When a metal is touched, it quickly conducts heat away leaving it at a lower temperature hence feeling cold.
02

8. (a) (i) photoelectric emission is the emission of electrons from a metal surface when electromagnetic radiation of high frequency is incident on it.
01

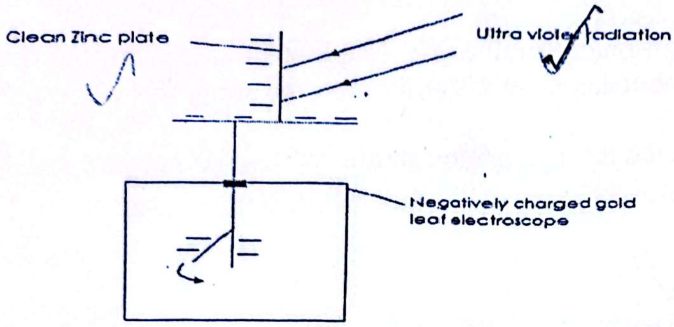
(ii) For every metal, there is a minimum (threshold) frequency of incident radiation below which photoelectric emission will not take place.

There is no detectable time lag between irradiation of the metal and emission of electrons.

The number of electrons emitted per second (photocurrent) is proportional to the intensity of the incident radiation for a given frequency. 04

Photoelectrons are emitted with kinetic energies ranging from zero to definite maximum which is proportional to the frequency of the incident radiation.

(b)



04

A clean zinc plate is placed on a negatively charged gold leaf electroscope. When ultra-violet radiation falls on the plate, the leaf collapses indicating that electrons are being lost by the plate. When the ultra violet radiation is obstructed the collapsing stops.

(c) (i) $hf_o = 2.3 \times 1.6 \times 10^{-19}$

$$f_o = \frac{2.3\times1.6\times10^{-19}}{6.6\times10^{-34}} = 5.58 \times 10^{14} Hz$$ 02

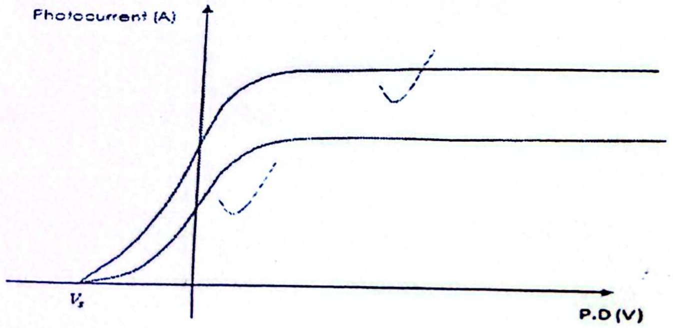
(ii) $hf - hf_o = \frac{1}{2}mv^2 \rightarrow v = \sqrt{2h\frac{(f-f_o)}{m}}$ 02

$$v = \left(\frac{2\times6.6\times10^{-34}}{9.11\times10^{-31}}\left(\frac{3\times10^{8}}{5\times10^{-7}} - 5.58 \times 10^{-14}\right)\right)^{\frac{1}{2}} = 2.479 \times 10^{5} ms^{-1}$$ 02

(d)(i) Burglar alarm

When a burglar intercepts the infra-red radiation falling on a photocell. The photocurrent is intercepted and an alarm is set off.

(ii)



02

9. (a)(i) Most α −particles pass through the foil undeflected. This means that most of the atom is empty

Some α −particles are deflected through small angles less than 90^0. This implies that the atom contains a centre which is positively charged and contains most of the mass of the atom, that is the nucleus

Very few α −particles are deflected through angles greater 90^0 and do not go through the foil. This implies that the nucleus occupies only a small proportion of the available space **06**

(ii) Electric potential energy $= \frac{q_1 q_2}{4\pi\varepsilon_o r_o}$

$$\Rightarrow 4.2 \times 10^6 \times 1.6 \times 10^{-19} = \frac{(2 \times 1.6 \times 10^{-19}) \times (79 \times 1.6 \times 10^{-19}) \times 9 \times 10^9}{r_0}$$

$$r_0 = \frac{(2 \times 1.6 \times 10^{-19}) \times (79 \times 1.6 \times 10^{-19}) \times 9 \times 10^9}{4.2 \times 10^6 \times 1.6 \times 10^{-19}} \qquad r_0 = 5.42 \times 10^{-14} m$$

(b) (i) Bohr's atom – electrons revolve around the nucleus only in certain allowed orbits.

While in these orbits, electrons do not emit radiations

The required centripetal force is provided by the electrostatic force of attraction between the electrons and the nucleus.

0

3 An electron can only emit radiation when it falls from a higher energy level to a lower energy level.

(ii) **Emission line spectrum.** When a gas is heated to a high temperature, its atoms may collide violently. An electron may gain energy and move from its normal orbit to one of higher energy level. The atom becomes unstable and the atom soon returns to its original orbit. It then emits radiation equivalent to **03** the difference in the two energy levels.

When a large number of atoms are involved, radiation of different wavelengths is produced and the various wavelengths constitute line spectrum.

Absorption spectrum; when a radiation is passed through a gas some wavelengths are absorbed by the gas.

When the energy is absorbed by the gas electrons to move from a low to a high energy levels, the resulting radiation with some wavelengths missing is the absorption line spectrum.

(c)(i) $ut \cos 30 = 0.1 \Rightarrow u = \frac{0.1}{3.85 \times 10^{-8} \times \cos 30} = 3 \times 10^6 ms^{-1}$ **02**

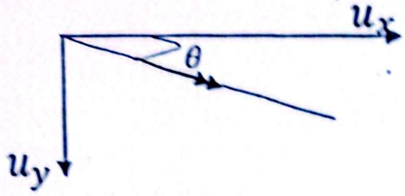
(ii) $u_x = 3 \times 10^6 \cos 30 = 2.598 \times 10^6 ms^{-1}$

$$V = u + at$$

$$u_y = 3 \times 10^6 \sin 30 - \frac{250 \times 1.6 \times 10^{-19} \times 3.85 \times 10^{-8}}{0.05 \times 9.11 \times 10^{-31}} = 3.23 \times 10^7 ms^{-1}$$

$V = \sqrt{u_x^2 + u_y^2} \quad = \sqrt{(2.597 \times 10^6)^2 + (3.23 \times 10^7)^2}$

$V = 3.24 \times 10^7 ms^{-1}$



$\tan\theta = \frac{u_y}{u_x} = \frac{3.24\times10^7}{2.597\times10^6}$

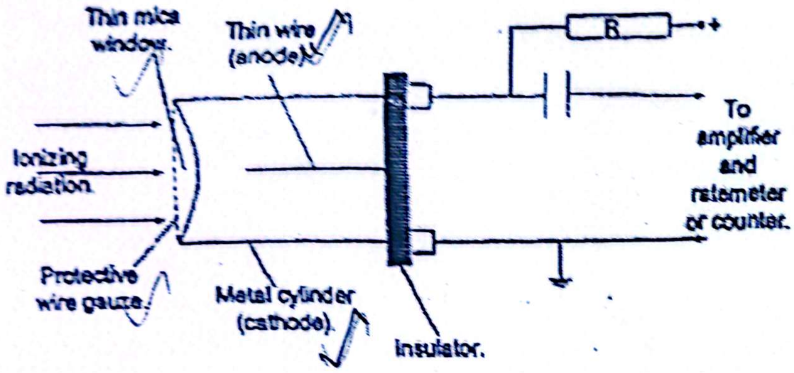
03

$\theta = 85.4^0$

10. (a)(i) Is the time taken for half the number of the nuclei present to disintegrate or decay 01 (ii) Is the fraction of the number of radioactive atoms disintegrating per second.

01

(b)(i)



05

Radiations enter the GM tube through the thin mica window and it ionizes the argon gas molecules through collision. The electrons move very fast to the anode and the positive ions drift to the cathode. Gas discharge occurs and a pulse of current flows through the external load and sets up a voltage across it. The voltage is amplified and fed into the rate meter for recording. Magnitude of pulse recorded shows the extent to which ionization has occurred.

(ii) $Total\ energy = 5.0MeV = 5 \times 10^6 \times 1.6 \times 10^{-19} = 8.0 \times 10^{-13}J$ $I =$

$150 \times 10^{-3} = 0.15A$

$I = ne, \qquad n = \frac{I}{e} = \frac{0.15}{1.6 \times 10^{-19}} = 9.375 \times 10^{17}\ alpha\ particles$

$9.375 \times 10^{17}\ alpha\ particles\ produce\ 8.0 \times 10^{-13}J$

$Energy\ of\ an\ alpha\ particle = \frac{8.0 \times 10^{-13}}{9.375 \times 10^{17}} = 8.53 \times 10^{-31}J$

04

(d)(i) $238g\ contain\ 6.02 \times 10^{23}\ alpha\ particles$

$$1kg\ contain\ \frac{6.02 \times 10^{23}}{238 \times 10^{-3}}\ alpha\ particles$$

$$2.0 \times 10^{4} kg\ contain\ \frac{6.02 \times 10^{23}}{238 \times 10^{-3}} \times 2.0 \times 10^{4}\ alpha\ particles$$

$$energy\ of\ an\ alpha\ particle = 2MeV = 2 \times 10^{6} \times 1.6 \times 10^{-19} = 3.2 \times 10^{-13}J$$

$$Total\ energy\ of\ alpha\ particles = 5.059 \times 0^{20} \times 3.2 \times 10^{-13} = 1.619 \times 10^{8} J$$

$$Energy = hf \quad f = \frac{E}{h} = \frac{1.619 \times 10^{8}}{6.6 \times 10^{-34}} = 2.453 \times 10^{41} Hz$$ 04

(d)(i)

$$M = Moe{-\lambda t}$$

$$At\ t = T_{\frac{1}{2}},$$

$$M = \frac{M_0}{2} = \frac{0.5}{2} = 0.25g$$

$$0.25 = 0.5e^{-\lambda T_{\frac{1}{2}}}$$

$$0.5 = e^{-\lambda T_{\frac{1}{2}}},$$

$$\therefore 2^{-1} = e^{-\lambda T_{\frac{1}{2}}},$$ 03

$$thus - ln2 = -\lambda T_{\frac{1}{2}}$$

$$T_{\frac{1}{2}} = \frac{ln2}{\lambda}$$

(ii) $T_{\frac{1}{2}} = \frac{ln2}{\lambda}$

$$\leftrightarrow \lambda = \frac{ln2}{200} = 3.44657 \times 10^{-3}\ per\ year$$

$$A_0 = 19,$$

$$A = \frac{56}{4} = 14$$

$$but\ t = \frac{1}{\lambda} ln\left(\frac{A_0}{\lambda}\right),$$

$$t = \frac{ln\left(\frac{19}{14}\right)}{3.44657 \times 10^{-3}}$$ 03