JINJA JOINT EXAMINATIONS BOARD

MOCK EXAMINATIONS 2022PHYSICS P510/1

MARKING GUIDE

1. (a) (i) Perfectly elastic collision – is one where kinetic energy is conserved and bodies separate after collision while perfectly inelastic collision is one where kinetic energy is not conserved and bodies stick together and move with a common velocity after collision.

(ii) Examples;

– Perfectly elastic – collisions between ideal gas molecules

– Perfectly inelastic - Ballistic pendulum

- A bullet fired into a wooden block

- Head on collision between cars that stick together after collision

(b) (i) It states that for a system of colliding bodies, the total momentum in a given direction remains constant provided no external forces act.

(ii) When a gun fires a bullet, the bullet moves forward with a certain velocity, and therefore, the bullet has a certain momentum. According to Newton's third law and conservation of linear momentum, the gun has now equal momentum to that of the bullet but in opposite direction. The gun therefore recoils but the recoil velocity is very small because of the mass of the gun is large compared to that of the bullet.

(c) (i) By conservation of linear momentum

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$0.02\,x\,150 + 0 = 0.02\,x\,90 + 2\,x\,v_2$

$v_2 = 0.6\,ms^{-1}$

(ii) Heat generated = loss in kinetic K.E

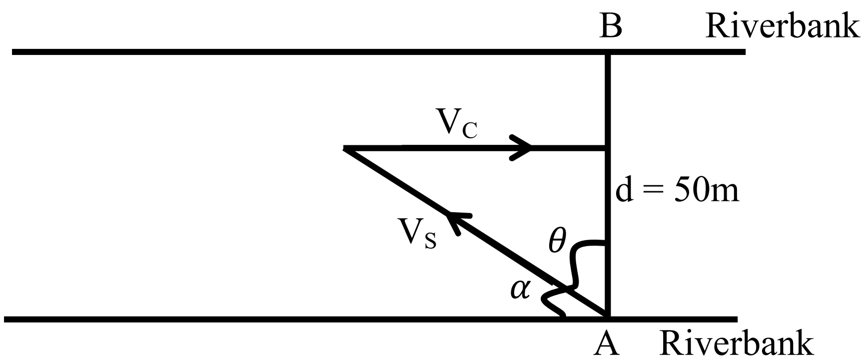
$= \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \left(\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2\right)$

$= \frac{1}{2}x\,0.02\,x\,150^2 + 0 - \left(\frac{1}{2}\,x\,0.02\,x\,90^2 + \frac{1}{2}\,x\,2\,x\,0.6^2\right)$

$=$

(d) (i) Relative velocity – is the velocity of a body as measured by an observer from another body assumed to be at rest.

(ii)



$v_s = 10ms^{-1}$

$v_c = 8ms^{-1}$

Let the course set be at θ

$v_s \sin\theta = v_c$

$\theta = \sin^{-1}\left(\frac{8}{10}\right) = 53.1^0$

$\therefore \alpha = 90 - 53.1 = 36.9^0$,

Hence course is 36.9^0 to the river banks.

Time taken $= \frac{d}{v_s \cos\theta} = \frac{50}{10\cos 53.1} = 8.33\ seconds.$

2. (a) S.H.M – is a periodic motion whose acceleration is directly proportional to the displacement from a fixed point and it is directed towards that point.

(b) – It is periodic

– Its acceleration is directly proportional to displacement from a fixed point

– Its acceleration is always directly towards a fixed point in the lime of motion

– Mechanical energy is always conserved

(c) (i) The displacement of Q from O, $x = r\cos\theta$. But $\theta = \omega t$

Velocity, $v = \frac{dx}{dt} = -\omega r \sin \omega t$ and

Acceleration, $a = \frac{dv}{dt} = -\omega^2 r \cos \omega t = -\omega^2 x$

Hence Q executes S.H.M along AOB.

(ii) From $v^2 = \omega^2(r^2 - x^2)$

$v^2 = \left(\frac{\pi}{8}\right)^2 [1^2 - 0.8^2]$

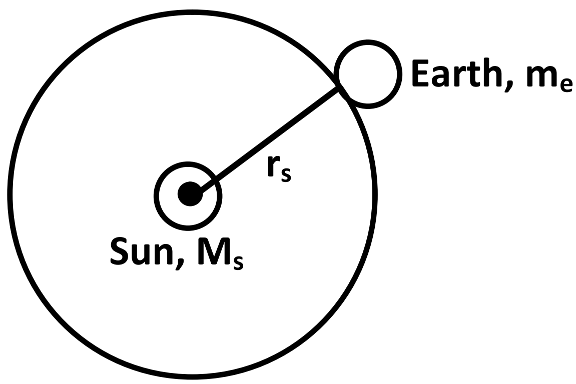
$\therefore v = 0.24ms^{-1}$

(d) (i) Weightlessness – condition of zero normal reaction experienced by an astronaut in an accelerating space craft. At a particular height of the orbit, it is possible for the space craft to move such that its centripetal acceleration is equal to the acceleration due to gravity, at that height; $mg - R = ma, a = g$.

$\Rightarrow mg - R = mg$

$\therefore R = 0N$ (The astronaut therefore experience no reaction from the space craft and so becomes weightless)

(ii) Consider the earth orbiting the sun, with r_s as the radius of the earth's orbit about the sun.



Centripetal force = Gravitational force of attraction

$$\frac{m_e v^2}{r_s} = \frac{G M_s m_e}{r_s^2}$$

But $v = \frac{2\pi r_s}{T}$

$$\Rightarrow M_s = \frac{4\pi^2 r_s^3}{GT^2}$$

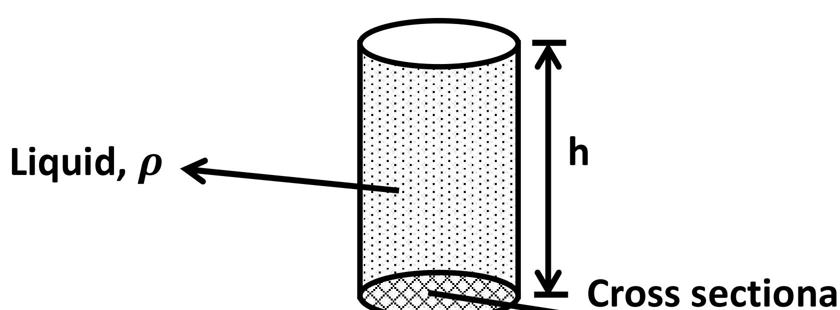
$$= \frac{4\pi^2 (1.5 \times 10^{11})^3}{6.67 \times 10^{-11} \times (365 \times 24 \times 60 \times 60)^2}$$

$$\therefore M_s = 2.0 \times 10^{30}\ kg$$

(ii) Due to friction of the earth's atmosphere, the satellite does work against friction and thus its total energy reduces and the radius of the orbit reduces. From $p.e = -\frac{GM_e m}{r}$, potential energy reduces as well. From $k.e = \frac{GM_e m}{2r}$, k.e increases and since $k.e = \frac{1}{2}mv^2$, then velocity of satellite increases. If the total energy is decreased to an extent that it can not overcome the friction, the satellite may burn due to the heat produced by friction.

3. (a) (i) Pressure – force acting normally on a surface of area $1m^2$. S.I unit is Nm^{-2}.

(ii)



– weight of liquid above A = mg, But $m = Ah\rho$

– weight = $Ah\rho g = force$

– pressure, $P = \frac{F}{A} = \frac{Ah\rho g}{A} = h\rho g$

$\therefore P = h\rho g$

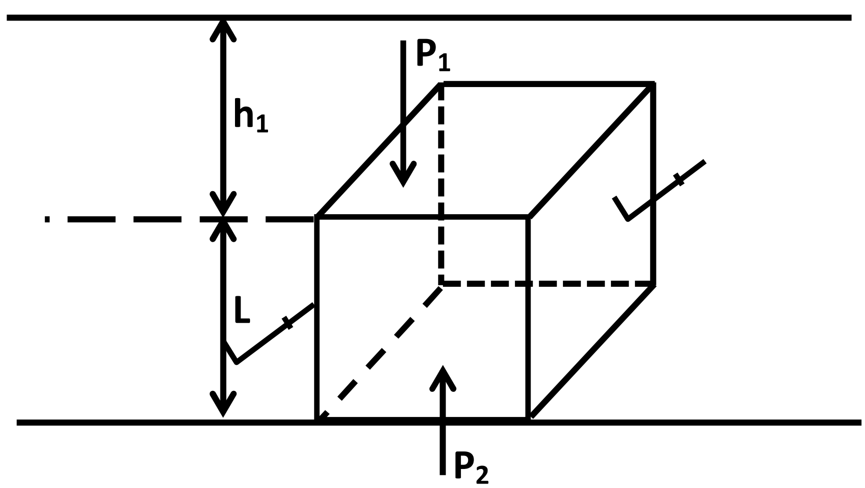
(iii) Gas pressure = $P_A + h\rho g$

$= 1.01\ x\ 10^5 + \frac{25}{100}\ x\ 897\ x\ 9.81$

$\therefore\ Gas\ pressure\ =\ 1.032\ x\ 10^{5} Nm^{-2}$

(b) (i) Static pressure – pressure which the fluid would have if it were at rest. While dynamic pressure is the pressure due to the fluid in motion

(ii) Consider an object of uniform cross sectional area A, and length, *l* in a liquid of density ρ.



– The pressure on the top surface, $P_1 = h_1\rho g$

$\Rightarrow Force\ from\ the\ top = h_1\rho g A$

– The pressure on the lower surface, $P_2 = (h_1 + l)\rho g$

– Force on the lower surface $= (h_1 + l)\rho g$A

– The upthrust $= (h_1 + l)\rho gA - h_1\rho gA = \rho gAl$;

Al is the volume of the displaced liquid.

– Weight of liquid displaced $= mg = \rho vg = \rho(Al)g = \rho gAl$

Therefore, the upthrust is equal to the weight of the liquid displaced.

(c) Initially, the drop has zero velocity. As it falls downwards three forces act on it; the weight (w) (downwards), upthrust (upwards) and viscous drag (upwards). Its velocity increases implying that it is accelerating but $F = 6\pi\eta vr$, viscous drag opposing its fall in air also increases. This means that the net force $= w - (F + u)$, decreases hence hitting the ground with a less force than they should.

4. (a) (i) For a body in mechanical equilibrium, the sum of clockwise moments about a point is equal to the sum of the anti – clockwise moments about the same point.

(ii) Three holes are made near the edge of the cardboard. The cardboard is then suspended from one of the holes and allowed to swing freely. A pendulum bob is hung from the same point of suspension and the outline of the pendulum is traced on the sheet.The procedure is repeated for cardboard suspended from the other holes.

The point of intersection of the three lines is the center of gravity of the board.

(b) (i) Angle of projection; Angle between the direction of the projectile and the horizontal

(ii) From $s = ut + \frac{1}{2}at^2$,

$-60 = 0\,x\,t + \frac{1}{2}(-9.81)t^2$

$t = 3.50\ seconds$

Also $x = \frac{144}{3.6}\ x\ 3.50 = 139.9m$

(c) Fromstrain $= \alpha(\theta_2 - \theta_1) = 1.1\ x\ 10^{-5}\ x\ (60 - 25)$

$\therefore Strain =$

Force, $F = EA\alpha\theta = 2.0\ x\ 10^{11}\ x\ 1.0\ x\ 10^{-6}\ x\ 1.1\ x\ 10^{-5}\ x\ (60 - 25)$

$\therefore F\ =$

(d) Scalars – are physical quantities that have only magnitude

Vectors – are physical quantities that have both magnitude and direction

(e) When a rider moves round a circular path, the friction at the ground provides the centripetal force. This provides a moment about its center of gravity. The rider would therefore have a tendency to fall off in a direction away from the center of the path if this moment is not counter balanced. The rider therefore leans towards the center of the path so that his reaction provides a moment about the center of gravity, which counter balances the moment due to friction.

5. (a) (i) Isothermal change – Is one which takes place at a constant temperature while an adiabatic change is one for which no heat is allowed to enter or leave the system.

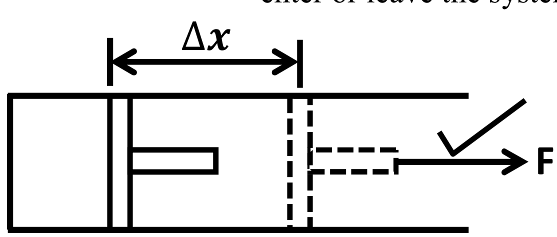
(ii) Isothermal change - Gas system enclosed in a thin walled, highly conducting vessel.

- Gas system is enclosed in a thick walled, poorly conducting vessel. **Any two each ½**
- Carried out in slow steps to allow for heat exchange.

Adiabatic change - Gas enclosed in a thick walled, poorly conducting vessel.

- Carried out rapidly so that there is no time for heat to enter or leave the system.

(b)



When the gas expands by moving the piston through a small distance, Δx such that pressure remains constant, F = PA where P – pressure,

A – cross-sectional area

– work done, $\Delta w\ =\ F\Delta x\ =\ PA\Delta x,$ but $A\Delta x = \Delta V$ = change in volume

$-\Delta w\ =\ P\Delta V$

Total work done from V_1 to V_2 is got by;

$$W = \int_{V_1}^{V_2} PdV$$

$\therefore W = \int_{V_1}^{V_2} PdV$

(c) (i) $n = \frac{m}{M} = \frac{2000}{8} = \frac{500}{7}\ moles$

For an ideal gas; PV = nRT

$\Rightarrow\ 2.0\ x\ 10^6\ x\ V = \frac{500}{7}\ x\ 8.31\ x\ 293$

$\therefore V = 0.087\ m^3$

(ii) For adiabatic expansion, $P^{1-\gamma}V^{\gamma} = constant$

$(2.0\ x\ 10^6)^{-0.4}\ x\ (293)^{1.40} = (1\ x\ 10^5)^{-0.40}\ x\ T^{1.40}$

$\therefore T = 124.5K$

(d) (i) States that matter consists of tiny particles which are always in constant vibration for solids, continuous and random motion in liquids or gasses. If heat is supplied, the energy of the particles increase hence their random velocity increases.

(ii) Smoke is confined in a smoke cell and viewed through a microscope. The smoke is seen to be in continuous random motion. Something must be knocking the smoke particles and this is something is the molecule of air.

6. (a) (i) S.h.c – amount of heat energy required to raise the temperature of 1kg by 1K.

(ii) Cooling correction; Is the extra temperature difference to be added to the observed maximum temperature of the mixture to cater for heat lost to the surrounding during heating.

(b) Let *x* = the expected new temperature

Assuming no heat losses to the surroundings,

$$\begin{matrix} Heat\ given \\ out\ by\ liquid \end{matrix} = \begin{matrix} Heat\ absorbed \\ by\ calorimeter \end{matrix} + \begin{matrix} heat\ absorbed \\ by\ cold\ liquid \end{matrix}$$

$$\frac{21}{1000}\ x\ 4000(60 - x) = \frac{100}{1000}\ x\ 4200\ x\ (x - 12.5) + \frac{70}{1000}\ x\ 400\ x\ (x - 12.5)$$

$5040 - 84x = 420x - 5250 + 28x - 350$

$\therefore x = 20^0C$

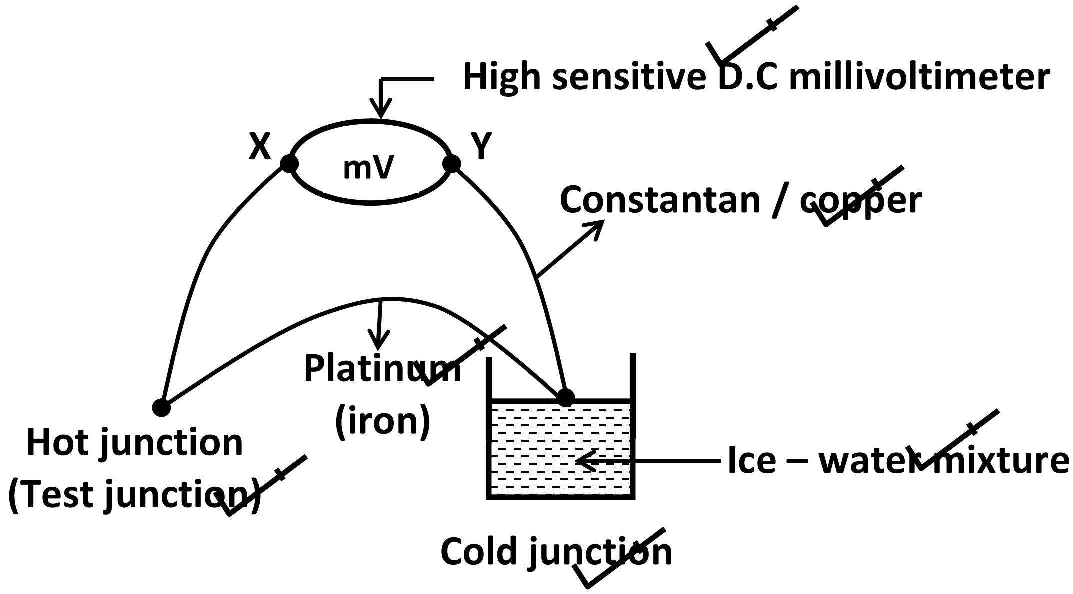
(c) – Surrounding the calorimeter with a vacuum to prevent heat loss by conduction

– Lagging the calorimeter using an insulating material.

– Surrounding the apparatus with a layer of still air

– Supporting the calorimeter on an insulating stand to reduce conduction.

(d) (i)



(ii) Neutral point of a thermocouple; – maximum temperature of a thermocouple just below which its e.m.f vary linearly with temperature

(iii) The hot junction of the thermocouple is immersed in a mixture of pure ice, pure water and pure steam existing in equilibrium. The voltmeter reading E_{tr} is read and recorded.

The above procedure is repeated when the hot junction of the thermocouple is immersed in a liquid of unknown temperature, T, such that the voltmeter reading E_T is also read and recorded.

Assuming e.m.f generated to vary linearly with temperature; then;

$$T = \frac{E_T}{E_{tr}} \times 273.16\,K$$

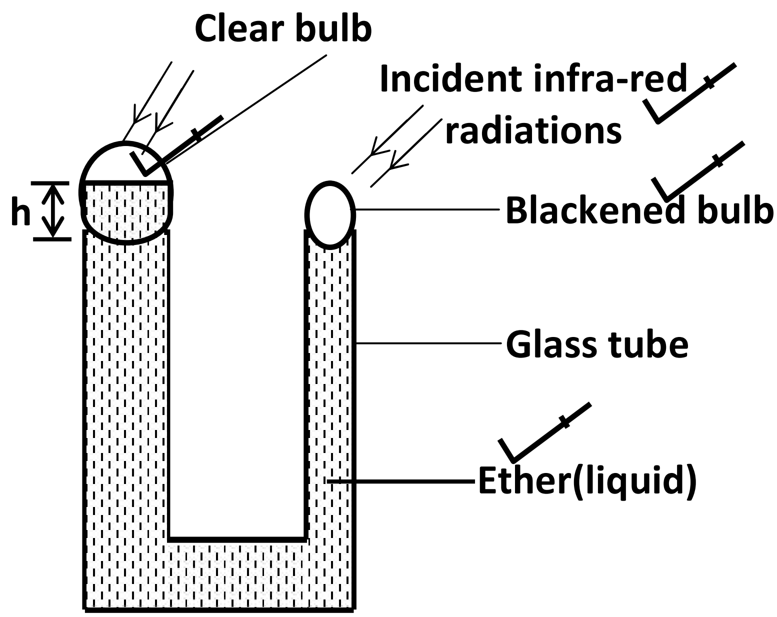
(e) – It is not accurate and only used where high degree of accuracy is not required.

– E.m.f set up does not vary linearly with temperature (above neutral point).

7. (a) (i) The total power radiated per unit area is directly proportional to the fourth power of the absolute temperature of a body.

(ii) The wavelength, λ_{max} at which maximum energy is radiated is inversely proportional to the absolute temperature.

(b)



– A blackened and clear bulb are connected to a tube partially filled with ether; each bulb contains a mixture of air and ether vapour.

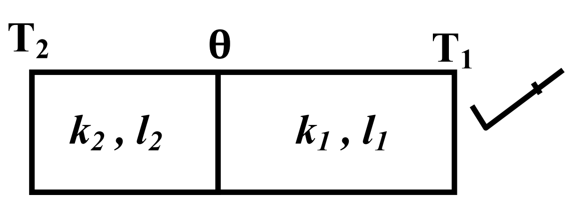
– When the arrangement is exposed to infrared radiations absorbed by the blackened bulb than those absorbed by the clear bulb.

– This raises the pressure inside the blackened bulb causing the ether liquid to be raised in the clear bulb. The rise "h" is directly proportional to the incident radiation.

(c) (i) Solar constant: This is the energy (power per unit area) received from the sun to the earth per second

(ii) Metals have free electrons. When heated the electrons at the hot end gain more energy and transfer energy as they collide with atoms in solid lattice. The mechanism of heat transfer by atomic vibrations also occurs in metals but its effect is much smaller.

(d)



Assuming that the rate of heat flow is uniform;

$$\frac{dQ}{dt} = \frac{k_2A}{l_2}(T_2 - \theta) = \frac{k_1A}{l_1}(\theta - T_1)$$

$$\Rightarrow k_2l_1(T_2 - \theta) = k_1l_2(\theta - T_1)$$

$$\therefore \theta = \frac{k_1l_1T_1 + k_2l_2T_2}{k_2l_1 + k_1l_2}$$

Substituting for θ in $\frac{dQ}{dt} = \frac{k_2A}{l_2}(T_2 - \theta)$ and simplifying,

$$\therefore \frac{dQ}{dt} = \frac{A(T_2 - T_1)}{{}^{l_1}/_{k_1} + {}^{l_2}/_{k_2}}$$

(e) $l = 0.1cm,\ A = 5.0\ x\ 10^{-4}m^2,\ \theta_1 = 100^0C, \theta_2 = 0^0C, k = 400Wm^{-1}k^{-1}$

Rate of heat flow through the metal = Rate at which ice gain heat

$$\frac{kA}{l}(\theta_1 - \theta_2) = ml_f$$

$$\frac{400\ x\ 5.0\ x\ 10^{-4}}{0.1}(100 - 0) = m\ x\ 3.36\ x\ 10^5$$

$$\therefore m = 5.95\ x\ 10^{-4}kgs^{-1}$$

8. (a) (i) Photoelectric effect – is the emission of electrons from a clean metal surface when it is illuminated to electromagnetic radiation of high frequency.

(ii) It postulates that light is emitted and absorbed in discrete packets called quanta. A quanta of light is called a photon. When light is incident on a metal surface, each photon of energy E = hf interacts with only one electron on the surface of the metal giving it all its energy. The photon is absorbed if its energy is greater than the work function and if it is less, the photon is rejected. Increasing intensity of light only increases the number of photons in the radiation but the energy of each photon remain the same, so maximum k.e is independent of the intensity.
Increasing the intensity increases the number of photons striking the surface per second. Therefore, more electrons are emitted per second and the current increases with intensity.
Increasing the frequency increases the energy of each photon, therefore, maximum k.e increases with the frequency.

(iii) From $hf = \omega_0 + \frac{1}{2}mv_{max}^2$. But $= {}^{c}/_{2}$.

$$\frac{6.6 \, x \, 10^{-34} \, x \, 3.0 \, x \, 10^{8}}{450 \, x \, 10^{-9}} = 0.76 \, x \, 1.6 \, x \, 10^{-19} + 6.6 \, x \, 10^{-34} f_0$$

$$\therefore f_0 = 4.83 \, x \, 10^{14} Hz$$

(b) (i)

x – rays	**Cathode rays**
- Electromagnetic radiation	- Are fast moving electrons
- Have no charge	- Negatively charged
- Can easily penetrate matter	- Does not penetrate matter
- Are fast ($3.0 \, x \, 10^8 ms^{-1}$)	- Slow ($1.0 \, x \, 10^8 ms^{-1}$)
- Eject electrons from matter	- Produce x – rays on striking matter

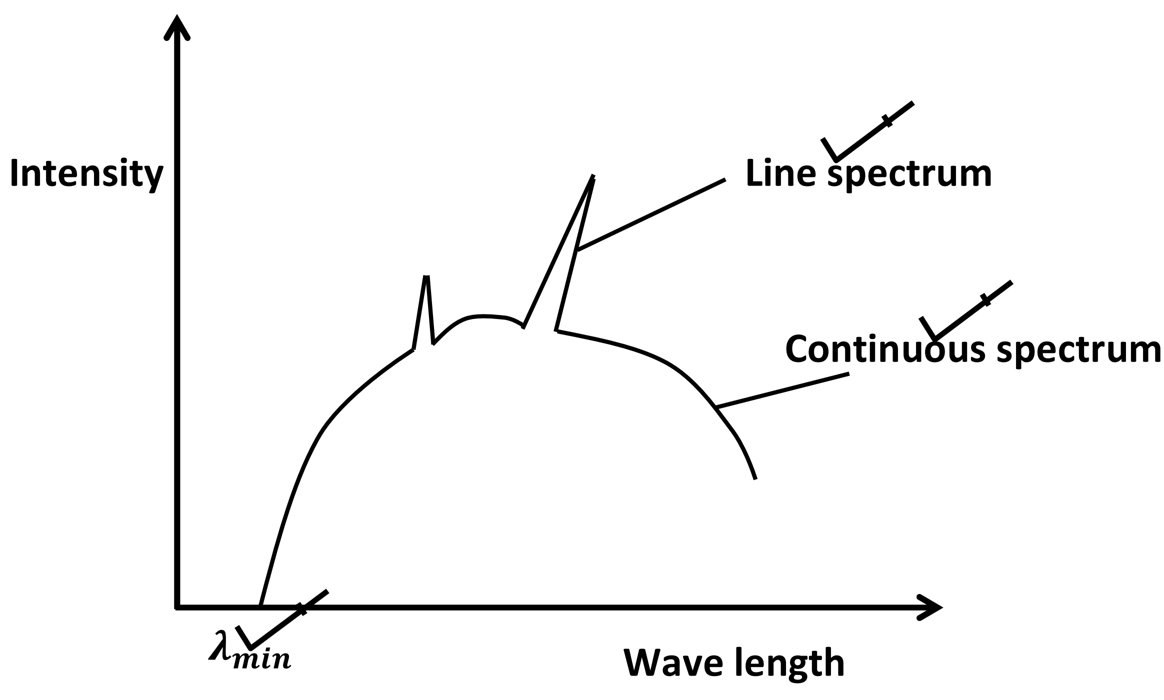
Any 2 each 1

(ii) $\frac{99}{100} IV = \frac{m}{t} c(\theta_2 - \theta_1)$

$$\frac{99}{100} \, x \, 6.0 \, x \, 10^3 \, x \, 30 \, x \, 10^{-3} = 0.060 \, x \, 4200 \, x \, \Delta\theta$$

$\therefore \Delta\theta = 7.07 \, ks^{-1}$

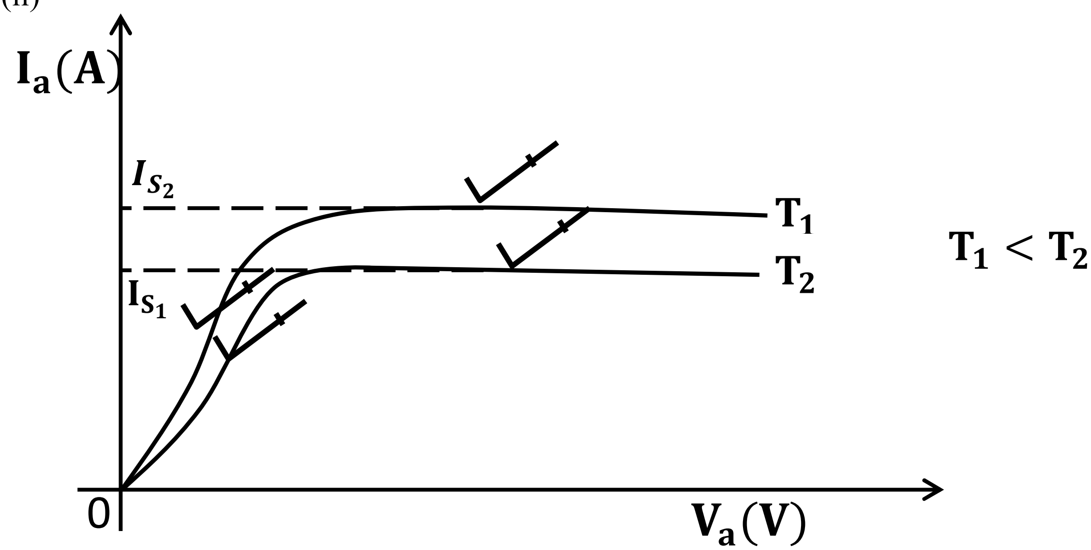
(c)



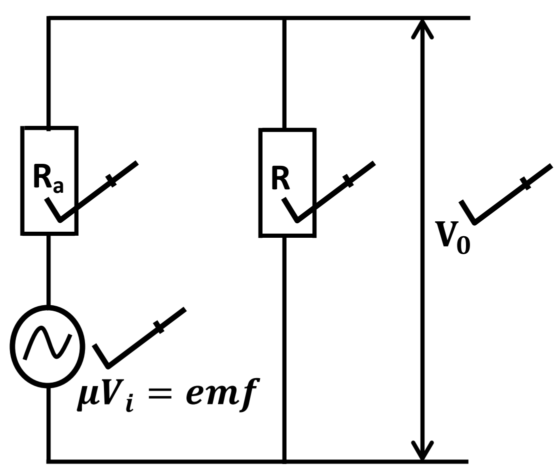
- Continuous spectrum – Electrons make repeated collisions with the metal target are decelerated losing energy in a continuous manner.
- Line spectrum – An electron loses all its energy to another in the inner shell of the target metal atom. The recipient electron moves to a higher energy level making the atom unstable when an electron falls from higher to occupy the vacancy in lower energy, it loses energy form of line spectrum.

9. (a) (i) Thermionic emission – is the ejection of electrons from a metal surface of relatively low work function when the metal is heated.

(ii)



(iii)



- Total resistance in the circuit $= R_a + R$

- The e.m.f generated by the triode value $= \mu V_i$ where μ is called the amplification factor
- The alternating current $I = \frac{e.m.f}{total\ resistance}$

$$\Rightarrow I = \frac{\mu V_i}{R_a + R}$$

But the output voltage $V_0 = IR = \frac{\mu V_i R}{R_a + R}$

$$\therefore \frac{V_0}{V_i} = voltage\ \ gain\ = \frac{\mu R}{R_a + R}$$

(b) Centripetal force = magnetic force

$$\frac{mu^2}{r} = Beu$$

$$u = \frac{Ber}{m} \ldots\ldots\ldots\ldots(i)$$

Work – energy theorem; k.e = workdone

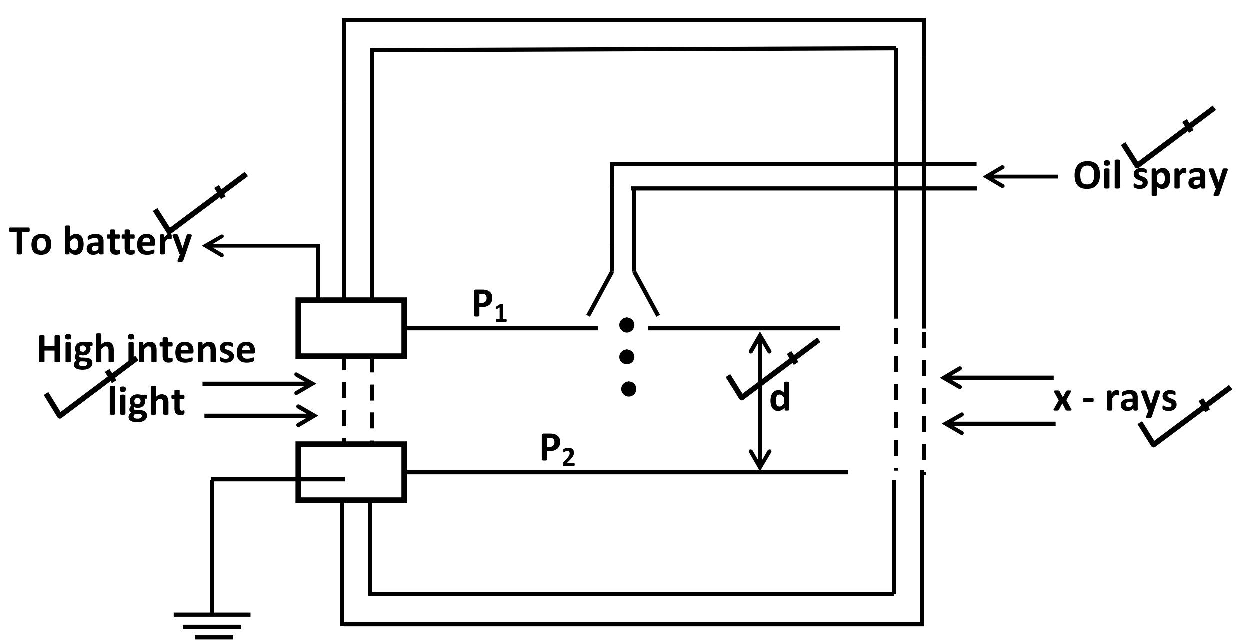
$$\Rightarrow \frac{1}{2}mu^2 = eV \ldots\ldots\ldots\ldots(ii)$$

$$\frac{1}{2}m\left(\frac{Ber}{m}\right)^2 = eV$$

$$\frac{e}{m} = \frac{2V}{r^2B^2} = \frac{2\ x\ 4\ x\ 10^3}{(6.4\ x\ 10^{-2})^2(3.25\ x\ 10^{-3})^2}$$

$$\therefore \frac{e}{m} = 1.91\ x\ 10^{11}Ckg^{-1}$$

(c)



- Oil drops are spread through a hole into the upper of the two parallel plates separated by a known distance d,. the drops acquire a charge by friction/x – rays.
- A suitable drop is selected and its terminal velocity V_0 is measured.
- With the electric field off;

  $\frac{4}{3}\pi r^3 g(\rho - \sigma) = 6\pi\eta V_0 r \dots\dots\dots\dots\dots\dots (i)$
- The P.d is applied and varied so that drop remains stationary in an electric field.

$$\frac{4}{3}\pi r^3 g(\rho - \sigma) = \frac{VQ}{d} \dots\dots\dots\dots\dots\dots. (ii)$$

$$Equation\ (i) \quad \div \quad Equation\ (ii)$$

$$1 = \frac{6\pi\eta V_0 r}{VQ/d}$$

$$\Longrightarrow Q = \frac{6\pi\eta V_0 rd}{V}$$

$$\therefore e = Q/n$$

(d)

- Are negatively charged
- Travel in straight lines
- Cause fluorescence In certain substances
- Produce x – rays when stopped suddenly by high density matter

10. (a) (i) These are streams of positively charged ions moving towards the cathode in discharge tube.

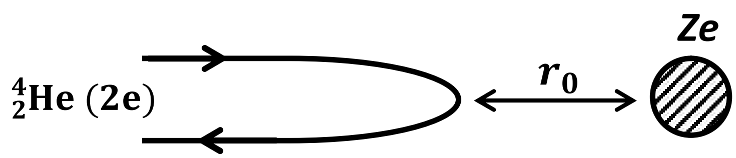
(ii) Positive rays are produced when cathode rays in a discharge tube collide with the gaseous atoms and strip off (knock out) some electrons from the atoms. The positive ions formed are accelerated to the cathode and these streams of positive ions constitute positive rays.

(b) – Most of the alpha particles passed through the gold foil undeflected. This implies that most of the space of an atom is empty.

– Few alpha particles were scattered through small angles. The small deflections were as a result of electrostatic repulsion between the alpha particles and the positive charge at the center of the atom.

– Very few alpha particles were scattered through angles greater than 90^0. It means that the positive charge of the atoms is concentrated in a small region.

(c)



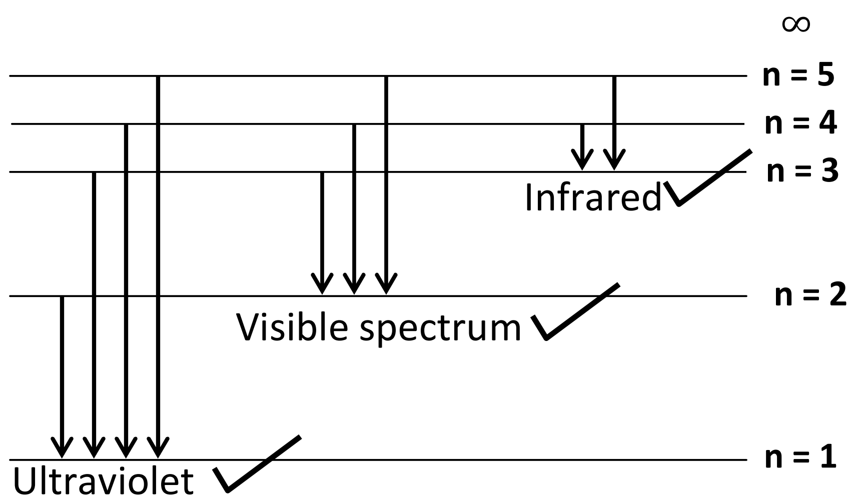
At distance of closest approach;

$k.e\ of\ ^4_2He\ =\ electrostatic\ p.e\ of\ ^4_2He\ - nucleus\ system$

$$\frac{1}{2}mV^2 = \frac{(2e)(Ze)}{4\pi\varepsilon_0 r_0}$$

$$\therefore\ r_0\ =\ \frac{Ze^2}{\pi\varepsilon_0 mV^2}$$

(d) (i)



(ii) $\lambda\ =\ 660\ x\ 10^9 m\ =\ 6.6\ x\ 10^7 m$

$\Delta E = \frac{hc}{\lambda}\ =\ \frac{6.6\ x\ 10^{-34}\ x\ 3\ x\ 10^8}{6.6\ x\ 10^7}\ =\ 3.0\ x\ 10^{-19}J\ =\ 1.875eV$

$\Delta E = E_2 - E_1$

$$1.875\ =\ E_2 + 3.4$$

$$E_2\ =\ -1.525eV$$

END