P510/1

PHYSICS 1

$2^1/_2$hours

UGANDA ADVANCED CERTIFICATE OF EDUCATION
RESOURCEFUL EXAMS 2022
PHYSICS 1
2 hours 30 minutes

Instructions to candidates:

- Attempt any **five** questions, including at least one from each of the sections A,B and C .
- Where necessary assume;

Acceleration due to gravity, (g)	$= 9.81ms^{-2}$
Electronic charge, (e)	$= 1.6x10^{-19}C$
Electron mass	$= 9.11x10^{-31}kg$
Mass of the earth,	$= 5.97x10^{24}kg$
Plank's constant, (h)	$= 6.6x10^{-34}Js$
Stefan's constant, (σ)	$= 5.67x10^{-8}Wm^{-2}K^{-4}$
Radius of earth	$= 6.4x10^{6}m$
Radius of the sun	$= 7.0x10^{8}m$
Radius of earth 's orbit about the sun	$= 1.5x10^{11}m$
Speed of light in a vacuum (C)	$= 3.0x10^{8}ms^{-1}$
Specific latent of fusion of ice (L_f)	$= 3.36x10^{5}Jkg^{-1}$
Specific heat capacity of water (c)	$= 4200Jkg^{-1}K^{-1}$
Universal Gravitation constant, (G)	$= 6.67x10^{-11}\ Nm^{2}kg^{-2}$
Avogadro's number, (N_A)	$= 6.02x10^{23}mol^{-1}$
Density of water, (ρ)	$= 1000kgm^{-3}$
Gas constant , R	$= 8.31\ Jmol^{-1}K^{-1}$
Surface tension of water (γ)	$= 7.0x10^{-2}Nm^{-1}$
Charge to mass ration, (e/m)	$= 1.8x10^{11}Ckg^{-1}$

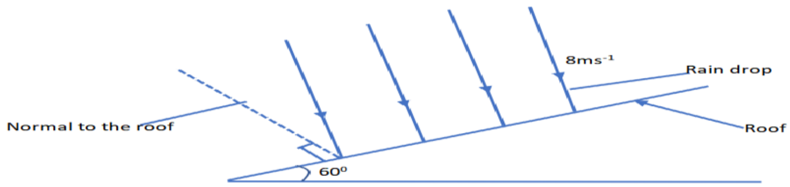
Section A

1. (a) Define **impulse and** state its **S.I units** (02 marks)

(b) (i) State the law of conservation of linear momentum (01 mark)

(ii) Use Newton's laws of motion to show that total momentum is conserved by a system of two colliding bodies (04 marks)

(c) In the figure below, rain drops falling vertically on a flat roof with a vertical velocity of 8m/s rebound at the same angle with the normal to the roof as their incident angle as shown below.



The roof is inclined at $60°$ to the horizontal and $2 \times 10^{-3} m^3$ of water per second is collected. Calculate the force on the roof due to the impact of the rain drops. (05marks)

(d) Explain why a martial artist breaks a pile of bricks with ease. (03marks)

(e) (i) What is **a projectile** (01mark)

(ii) A ball is kicked with a velocity of 30m/s at an angle of 40° above the horizontal plane. Find the horizontal distance covered by the ball (04marks)

2. (a) State **Kepler's laws** of planetary motion (03 marks)

(b) Derive the dimensions of the gravitational constant according to Newton's law of gravitation (03marks)

(c) (i) The moon moves round the earth in a circular orbit of radius $3.83x10^5 km$ with a period of 27.3 days calculate the value of acceleration due to gravity g at the earth's surface. (04 marks)

(ii) Explain why the moon has no atmosphere. (02marks)

(d) Explain briefly how satellites are used in world wide radio or television communication. (04marks)

(d) (i) What is angular velocity. (01mark)

(ii) A motor cyclist moving at a speed of $18kmh^{-1}$ takes a curve of radius 16.0m. At what angle to the vertical must the cyclist lean without overturning or toppling. (03marks)

3. (a) (i) State the **laws** of **solid friction**. (03marks)

(ii) With the aid of a well labelled diagram, describe an experiment to determine the coefficient of static friction. (04marks)

(b) A car of mass 1000kg moves from rest with it's engine switched off down a road which is inclined at an angle 60^0 to the horizontal

(i) Calculate the normal reaction (02marks)

(ii) If the coefficient of friction between the tyres and surface of the road is 0.32. Find the acceleration of the car (03marks)

(c) (i) What is meant by viscosity of a fluid (01mark)

(ii) Explain the effect of temperature on viscosity of a liquid. (03marks)

(d) Derive an expression for the terminal velocity of a steel-ball bearing of radius r and density ρ falling through a liquid of density σ and coefficient of viscosity η. (04marks)

4. (a) Define the terms

(i) tensile stress (01mark)

(ii) tensile strain (01mark)

(b) Determine the dimensions of young's modulus (3 marks)

(c) With the aid of a labelled diagram, describe an experiment to young's modulus of a steel wire. (7 marks)

(d) Two identical cylindrical steel bars each of radius 3.00m and length 7m rest in a vertical position hanging from a rigid horizontal support. A mass of 4.0kg is hang on one bar. The temperature of the other bar is to be altered so that the two bars are once again of equal length. By how much should the temperature be altered . (Coefficient of linear expansivity of steel is= $1.2x10^{-5}K^{-1}$ and young's modulus for steel as $2.0x10^{11}Nm^{-2}$) (4 marks)

(e) Explain the energy changes which occur during plastic deformation (4 marks)

Section B

5. (a) The thermometric property of a thermocouple thermometer is change in e.m.f between the junctions

(i) What is meant by thermometric property? (01mark)

(ii) Give two conditions necessary for the thermocouple thermometer to work (02 marks)

(iii) State **two** thermometric properties (02marks)

(b) One junction of a thermocouple thermometer is placed in a melting ice, while the other is inserted into a bath whose temperature as measured by a high temperature mercury in glass thermometer is T°C. The following reading were obtained

T°C	0	100
Emf, $E(mV)$	0	0.64

Find the e.m.f in the thermocouple scale corresponding to 380°C in the mercury in glass thermometer (04marks)

(c) Define the term **Specific Latent heat** and state its units. (02marks)

(d) (i) Describe an experiment to determine specific latent heat of vapourization of a liquid using electrical method (07marks)

(ii) Explain why two sets of results are necessary in performing the experiment described in (i) above (02marks)

6. (a) (i) State **Newton's** law of **cooling** (01mark)

(ii) Describe a suitable experiment to verify to verify the law in (a)(i) above (06marks)

(b) (i) What is meant by an adiabatic process. (01mark)

(ii) State the conditions necessary for isothermal and adiabatic process to occur (04marks)

(c) A gas at a pressure of $2 \times 10^5 Pa$ and a temperature 17°C is compressed adiabatically to half its volume and then allowed to expand isothermally to its original volume. Calculate the final pressure of the gas. (Assume the ratio of the principal specific heat capacities $\frac{C_P}{C_V} = 1.4$) (06marks)

(d) What are the differences between a real gas and an ideal gas. (02marks)

7. (a) What is meant by thermal conductivity of a material. (01mark)

(b) Describe an experiment to measure the thermal conductivity of a metal. (06marks)

(c) A sheet of rubber and a sheet of wood each 2mm thick are pressed together and their outer faces are maintained respectively at $0°\mathrm{C}$ and $25°\mathrm{C}$. If the thermal conductivities of rubber and wood are respectively 0.13 $Wm^{-1}K^{-1}$ and $0.05\ Wm^{-1}K^{-1}$, find the quantity of heat which flows in 1 hour across this composite given that its cross-sectional area is $100cm^2$. (05marks)

(d) (i) Define the term **convection** as applied to heat transfer (01mark)

(ii) Describe how the mechanism of heat convection maintains good air circulation in a modern class room. (03marks)

(e) Explain green how effect and how its related to global warming. (04marks)

Section C

8. (a) (i) What are cathode rays. (01mark)

(ii) An electron gun operating at 3kV is used to shoot electrons into the space between two oppositely charged parallel plates. The plate spacing is 50mm and its length is 100 mm. Calculate the deflection of the electrons at the point where they emerge from the field when the plate p.d is 1kV. (05mark)

(b) With the aid of a diagram, describe an experiment to show that cathode rays carry a negative charge (04marks)

(c) State why

(i) the apparatus in Millikan's experiment is surrounded with a constant temperature enclosure (01marks)

(ii) low vapour pressure oil is used (01mark)

(c) A spherical oil drop of radius of $2x10^{-6}$m is held stationery between two parallel metal plates to which a $p.d$ of 4500V is applied , the separation of the plates is 1.5cm, calculate the number of electronic charges on the drop if the density of oil is $800kgm^{-3}$. Assume no air resistance. (04marks)

(d) Describe how Millikan's oil drop experiment can be used to determine the radius, r of an oil drop of mass m and density ρ moving freely with a terminal velocity V on air of viscosity η. (04marks)

9. (a) (i) What is meant by **photoelectric emission** (01mark)

(ii) State the condition under which photo electric emission occurs (02marks)

(iii) Explain how the photo electric effect provides evidence for the quantum theory of light (03marks)

(b) With aid of a well labeled diagram, describe a simple experiment to measure stopping potential of a metal. (05marks)

(c) (i) What are **x-rays** (01mark)

(ii) State **two** properties of x-rays (02marks)

(iii) State the energy changes that occur in an x-ray tube during production of x-rays (02marks)

(d) In an x-ray tube, 99% of the electrical power supplied to the tube is dissipated as heat at a rate of 742.5W. If the x-ray tube voltage is 80kV, find the number of electrons arriving at the target per second. (04marks)

10. (a) State **Bohr's model** of an atom (02 marks)

(b) (i) The total energy of an electron, E_n in a hydrogen atom is expressed as $E_n = \frac{-k}{n^2}$ where a constant $k = \frac{me^4}{8\varepsilon_0^2 h^2}$. Identify the quantities **m** and **n** in the expression and hence show that $E_n = \frac{-2.18\times10^{-18}}{n^2}J$ (03marks)

(ii) Calculate the ionization energy in MeV of the hydrogen atom in b(i) above (03marks)

(c) (i) what is meant by **nuclear binding energy** (01mark)

(ii) Sketch a graph showing the variation of binding energy per nucleon with mass number and use it to explain the nuclear fusion and fission reactions. (04marks)

(d) Calculate in MeV, the energy released when $^{235}_{92}U$ under goes fission according to

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{148}_{57}La + ^{85}_{35}Br + 3\,^{1}_{0}n + Q$$

Mass of $235U = 235.051U$, Mass of $148La = 148.016U$, Mass of $^{1}_{0}n = 1.009U$, Mass of 85$Br = 84.903U$ and $1U = 1.66 \times 10^{-27}kg$ (05marks)

(e) Explain briefly how a nuclear reaction can aid the production of electricity in a nuclear plant (02marks)

END

Question one

(a) **Impulse** is the product of the force and time for which the force acts on a body. S.I units is Ns

(b) (i) It states that for a system of colliding bodies, their total linear momentum remains constant in a given direction provided no external forces acts on them.

(ii) consider two bodies with masses m_1 and m_2 moving with initial velocities u_1 and u_2 and let their velocities after collision be v_1 and v_2 respectively for time t with $(v_1 < v_2)$

By Newton's 2^{nd} law:

Force on m_1: $F_1 = \frac{m_1(v_1-u_1)}{t}$

Force on m_2: $F_2 = \frac{m_2(v_2-u_2)}{t}$

By Newton's 3rd law: $\boldsymbol{F_1} = -\boldsymbol{F_2}$

$$\frac{m_1(v_1-u_1)}{t} = -\frac{m_2(v_2-u_2)}{t}$$

$$m_1v_1 - m_1u_1 = -m_2v_2 + m_2u_2$$

$$\therefore m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

Hence $m_1u_1 + m_2u_2 =$ **constant**

(c) $F = \frac{m}{t}(v-u) = \frac{\rho \times volume}{t}(v-u) = 1000 \times 2 \times 10^{-3}(8cos60° - -8cos60°) = 16N$

(d) The martial artist moves his hands very fast such that the time for which the hands are in contact with the bricks is very short. This increases the impulsive force on the bricks hence breaking the bricks with ease

(e) (i) This is the motion of a body which after being given an initial velocity moves freely under the influence of gravity

(ii) For vertical motion: $y = usin\theta t - ½\, gt^2$

$$0 = 30sin40° \times T - ½ \times 9.81 \times T^2$$

$$T = 3.9s$$

horizontal motion : $x = ucos\theta xt$

$$x = 30cos40° \times 3.9$$

$$x = 22.9m$$

Question two

(a) -Planets describe elliptical orbits with the sun at one focus
-The imaginary line joining the sun and a planet sweeps out equal areas in equal time intervals
-The squares of the periods of revolution of a planet about the sun is directly proportional to the cube of the mean distance from the sun to the planet.

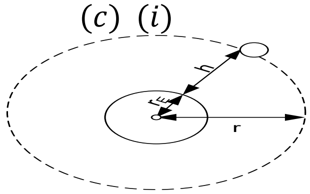
(b) F$= \frac{Gm_1m_2}{r^2}$

G $= \frac{F\,r^2}{m_1m_2}$

$$[G] = \frac{[F][r^2]}{[m_1][m_2]} = \frac{M\,L\,T^{-2}L^2}{M^2}$$

$$[G] = M^{-1}L^3T^{-2}$$

(c) (i)



$$m\omega^2R = \frac{Gm_Em}{R^2} \text{ but } \omega = \frac{2\pi}{T}$$

$$\frac{m\,4\pi^2R}{T^2} = \frac{Gm_Em}{r^2}$$

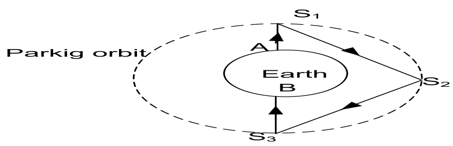
But $G\,m_E = g\,{r_E}^2$

$$g = \frac{4\pi r^3}{T^2{r_E}^2}$$

$$g = \frac{4x\left(\frac{22}{7}\right)^2x\left(3.83x10^8\right)^3}{(27.3x24x60x60)^2x(6.4x10^6)^2} = 9.73ms^{-2}$$

(ii)The moon doesn't have an atmosphere because, molecules of air around the moon move at average velocities much greater than the escape velocity of the moon, they escape from the moon leaving it with no atmosphere

(d)



- A set of three satellites are launched into geostationary or parking orbit
- Radio signals from A are transmitted to a geosynchronous satellite 1.
- These are re-transmitted from 1 to geosynchronous satellite 2.
- Then to geosynchronous satellite 3 which transmits to B

(e) (i) This is the rate of change of the angle for a body moving in a circular path.
Or rate of change of angular displacement

(iii) $\mathrm{v}^2 = \mathrm{rgtan}\theta$

$$\theta = \tan^{-1}\left[\left(\frac{18 \times 1000}{3600}\right)^2 \Big/ 16 \times 9.81\right] = 9.05°$$

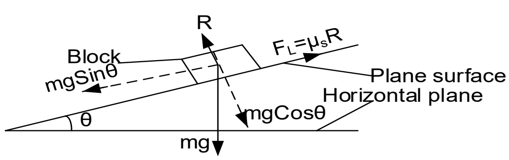
Question three

(a) (i) - Frictional forces between two surfaces in contact oppose their relative motion.

- Frictional forces are independent of the area of contact of the surfaces provided that normal reaction is constant.
- The limiting frictional force is directly proportional to the normal reaction but independent of relative velocity of surfaces.

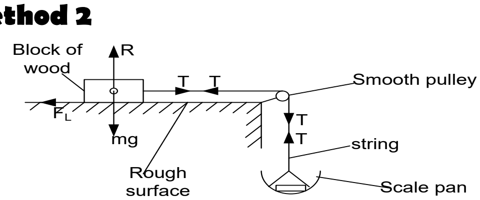
(ii)

Method I



- Place a block on a horizontal plane.
- Tilt the plane gently, until it **<u>just begins</u>** to slide.
- Measure and record the angle of tilt θ
- Coefficient of static friction is $\mu_s = tan\theta$
- Repeat the experiment with blocks of different masses
- Find the average value of μ_s

Method 2



- The mass m of the wooden block is determined and placed on a horizontal plane surface.
- A string is attached to the block and passed over a smooth pulley carrying a scale pan at the other end.
- Small masses are added to the scale pan one at a time, till the block just slides
- The total mass M of the scale pan and the masses added is obtained.
- Coefficient of static friction $\boldsymbol{\mu} = \frac{\boldsymbol{M}}{\boldsymbol{m}}$

$(b)(i)$ $R = mgcos60°$
R= $1000x9.81cos60° = 4905N$

(ii) Using $F = ma$

$mgsin49 - \mu R = ma$
$1000x9.81sin60° - 0.32x49057 = 1000a$

$a = 6.93ms^{-2}$

(c) **(i) Viscosity** is the frictional force between adjacent layers of a fluid.

(ii) In liquids, viscosity is due to intermolecular forces of attraction between layers moving at different speeds. Increase in temperature reduces(weakens) intermolecular forces which increases molecular separation and speed, consequently viscosity in liquids decreases rapidly with increase in temperature

(d)At the terminal velocity, V_o: $Mg = U + F$

$\frac{4}{3}\pi r^3 \rho g = \frac{4}{3}\pi r^3 \sigma g + 6\pi \eta rV_o$

$6\pi \eta rV_o = \frac{4}{3}\pi r^3 g(\rho - \sigma)$

$V_o = \frac{4\pi r^3 g(\rho-\sigma)}{3x6\pi\eta r}$

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

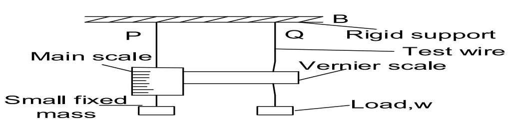
Question four

(a) (i) **Tensile stress** is force acting per unit area of cross-section of a material.

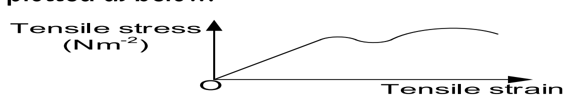
(ii) Tensile strain is the extension per unit original length of the material.

(b) $[E] = \frac{[F][L]}{[A][e]} = \frac{(MLT^{-2})(L)}{L^2 L} = ML^{-1}T^{-2}$

(c)



- Two long, thin identical steel wires are suspended besides each other from the same rigid support B
- The wire P is kept taut and free of kinks by weight attached to its end
- The original length l of test wire Q is measured and recorded.
- The mean diameter d of test wire is determined and cross-sectional area $A = \frac{\pi d^2}{4}$ is found.
- Known weight, W is added to the free end of test wire and the corresponding extension e is read from the vernier scale.
- The procedure is repeated for different weights and for each extension, the load is removed to ensure that the wire goes back to the original length
- Results are tabulated including values of tensile stress $\left(\frac{W}{A}\right)$ and tensile strain $\left(\frac{e}{L}\right)$
- The graph of tensile stress versus tensile strain is plotted as below.



(d)

from $E = \frac{stress}{strain}$ ⇒Strain $= \frac{stress}{E}$

Strain $= \frac{F}{AE} = \frac{mg}{\pi r^2 E}$

Strain $= \frac{4x9.81}{\pi(3x10^{-3})^2 x1x10^{11}} = 6.94x10^{-6}$

but strain $= \alpha\theta$

$\theta = \frac{6.94x10^{-6}}{1.2x10^{-5}} = 0.578K$

B should be raised by a temperature of **0.578K**

(e) When the wire is stretched beyond the elastic limit, permanent displacement of atoms occurs. Crystals planes slide over each other. The movement of dislocations take place and on removing the stress, the original shape and size is not recovered due to energy loss in form of heat. At the breaking point the energy is used to break interatomic bonds

Question five

(a) (i) A thermometric property is a physical property which varies linearly and continuously with change in temperature.

(ii) Two different wire materials must be joined together to form two junctions and,

Two junctions must be maintained at different temperatures

(iii)

- length of a liquid column
- electrical resistance of a wire
- pressure of a fixed mass of a gas
- volume of a fixed mass of a gas

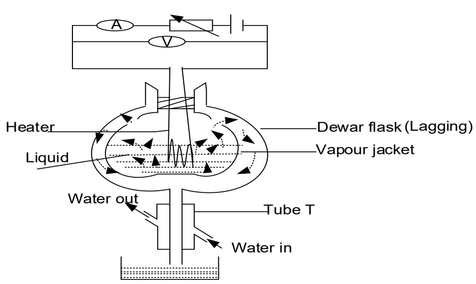
$(b)(ii)$ $\theta = \left(\frac{E_\theta - E_0}{E_{100} - E_0}\right) x100°C$

$$380°C = \left(\frac{E_\theta - 0}{0.64 - 0}\right) \times 100°C$$

$E_\theta = 2.432V$

$(c)(i)$ Is the quantity of heat required to change **1kg** mass of a substance to another state at **constant temperature**. It's unit is Jkg^{-1}

(ii)



- The liquid is heated until it starts boiling
- A stop clock is started and mass m_1 of liquid collected in a time t noted
- The Ammeter reading, I_1 and Voltmeter reading V_1 are recorded.
- At steady state, $I_1 \ V_1 \ t \ = m_1 \text{x} \ l_V + h$ ...(1) where $h = ht$ heat lost to surrounding
- The Rheostat is adjusted and a new Ammeter reading I_2 and Voltmeter reading V_2 are recorded
- New mass m_2 of the liquid collected in the same time t is obtained

$I_2 \ V_2 \ t \ = m_2 \text{x} \ l_V + h$ ....(2)

The specific latent heat of vapourization is obtained from

$$\boxed{L_V = \frac{(I_2V_2 - I_1V_1)t}{(M_2 - M_1)}}$$

(ii) two sets of readings are taken to account for heat lost to the surrounding at steady state

Question six

$(a)(i)$It states that under conditions of forced convection, the rate of heat loss is directly proportional to excess temperature over the surrounding $\frac{dQ}{dt} \propto (\theta - \theta_R)$,

(ii)

- Hot water in a calorimeter is placed near an open window.
- Temperature θ of the water is recorded at suitable time intervals
- A graph of temperature θ against time t is plotted.
- Different slopes at different temperatures θ_1,θ_2, θ_3...........θ_A are determined.

- For each temperature the excess temperature, $(\theta - \theta_R)$ is calculated, where θ_R is room temperature
- A graph of slope against excess temperature is plotted
- A straight line graph through the origin verifies Newton's law of cooling.

$(\boldsymbol{b})$ (i) An adiabatic process is a change (expansion or compression) in which there is no heat exchange between the gas and the surrounding.

(ii) **isothermal**

- The gas must be contained in cylinder with very thin, highly conducting walls so that heat can easily be transferred to a gas.
- The gas cylinder must be surrounded by constant temperature bath
- The process must be carried slowly to allow enough time for heat transfer

adiabatic

- The gas must be contained in thick walled poorly conducting vessel
- The process must be carried out rapidly such that no heat leaves or enter system.

(c)

Adiabatic $P_1V_1\,T_1 \rightarrow P_2V_2T_2$

$$P_1V_1^{\gamma} = P_2V_2^{\gamma}$$

$$2x10^5\,x(V)^{1.4} = P_2x\left(\frac{V}{2}\right)^{1.4}$$

$P_2 = 5.28x10^5Pa$

$$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$$

$$(17 + 273)x(V)^{0.4} = T_2x\left(\frac{V}{2}\right)^{0.4}$$

$$T_2 = 382.66K$$

Isothermal $P_2V_2\,T_2 \rightarrow P_3V_3T_2$

Isothermal obey Boyles law

$$P_2V_2 = P_3V_3$$

$$5.28x10^5x\frac{V}{2} = P_3xV$$

$$P_3 = 2.64x10^5Pa$$

Therefore final temperature is $382.66K$ and final pressure is $2.64x10^5Pa$.

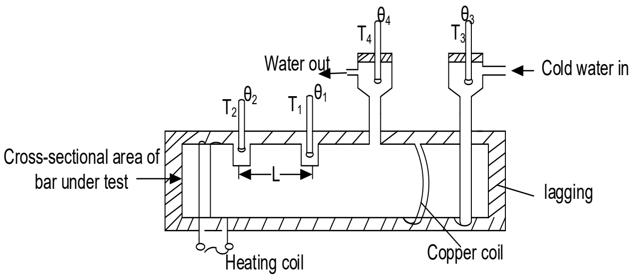
(d)

- In real gases Intermolecular forces of attraction and repulsion are not negligible while for an ideal gas they are negligible.
- In real gases Volumes of molecules are not negligible compared to volume of container while for an ideal gas they are negligible.
- The collisions in real gases are inelastic while fore an ideal gas collisions are elastic.
- Real gases only obey gas laws at high temperature and low pressures while an ideal gas obeys gas laws at all temperatures.

Question seven

(a) Thermal conductivity is the rate of heat flow through material per unit cross-sectional area per unit temperature gradient.

(b)



- ❖ A long copper rod of cross-sectional area A is used.
- ❖ It carries a heater at one end and copper coil soldered at the other end.
- ❖ Two thermometers are inserted in the holes drilled in the bar at a known separation l
- ❖ The holes are smeared with mercury for good thermal contact
- ❖ Water is allowed to flow through the copper coil and the heater is switched on.
- ❖ When the thermometers read steady temperatures θ_1, θ_2, θ_3 and θ_4, recorded from thermometers T_1, T_2, T_3 and T_4 respectively.
  $\frac{Q}{t} = \frac{KA(\theta_2-\theta_1)}{l}$ where k is thermal conductivity of copper metal
- ❖ The mass m of water flowing out per second through the coil is measured and recorded.
  $\frac{Q}{t} = mc(\theta_4 - \theta_3)$ where c is specific heat capacity of water
- ❖ Therefore thermal conductivity, k of a good conductor is got from

$$\boxed{K = \frac{MCL(\theta_4-\theta_3)}{A(\theta_2-\theta_1)}}$$

(c) $\frac{Q}{t} = \frac{K_R A(\theta-0)}{L_R} = \frac{K_B A(25-\theta)}{L_B}$

$$\frac{Q}{t} = \frac{0.13A(\theta-0)}{2x10^{-3}} = \frac{0.05A(25-\theta)}{2x10^{-3}}$$

$$\frac{0.13A(\theta-0)}{2x10^{-3}} = \frac{0.05A(25-\theta)}{2x10^{-3}}$$

$$\theta = 7°C$$

$$\frac{Q}{t} = \frac{0.13A(\theta-0)}{2x10^{-3}}$$

$$Q = \frac{0.13x100x10^{-4}(\theta-0)}{2x10^{-3}}x1x60x60$$

$$Q = 1.64x10^4 J$$

(d) (i) convection is the process of heat transfer through a fluid from high temperature to low temperature due to actual movement of medium.

(iv) Modern class rooms are constructed such that the windows and near the ground while ventilators are high up, during the day hot air expands, rises and escapes from the ventilators while cool air from out blows towards the class to replace up rising air, hence proper aeration.

(e)

- ❖ Short wavelength radiation from the sun passes through the atmosphere and is absorbed by plants and sand leading to higher earth temperature.
- ❖ Earth re-radiates long wavelength which is trapped by green house gases. Continued accumulation of this radiation implies higher earth temperature and with time may lead to global warming.

Question eight

(a) (i) These are streams of fast moving electrons that travel from cathode to anode when a $p.d$ is connected across the plate.

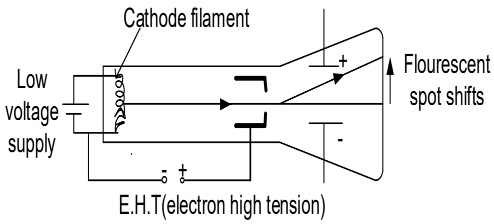
(ii)

$$u = \sqrt{2V_a x\frac{e}{m}} = \sqrt{\frac{2x3000x1.6x10^{-19}}{9.11x10^{-31}}} = 3.24x10^7 ms^{-1}$$

$$y = \frac{Vel^2}{2mdu^2}$$

$$y = \frac{1000x1.6x10^{-19}x0.1^2}{2x9.11x10^{-31}x0.05x(3.24x10^7)^2} = 0.017m$$

(b)



- ❖ The cathode ray tube is modified to include parallel plates connected to the terminals of a battery.

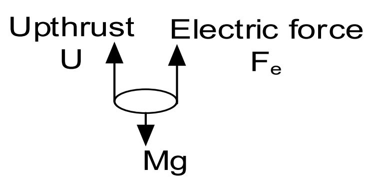
- ❖ When cathode rays are produced thermionically and passed through the plate, the fluorescent spot is seen to shift upwards from its initial position before the plates were applied. The spot moves towards the positive plate and away from the negative plate, this shows that cathode rays carry a negative charge.

(c)

(i) A constant temperature enclosure surrounded Millikan's apparatus in order to eliminate convection currents.

(ii) Millikan used low- vapour pressure oil to reduce problems due to evaporation

(d)



At terminal velocity: $\frac{4}{3}x\pi r^3\rho_o g = \frac{4}{3}\pi r^3\rho_a\, g + EQ$

ρ_a=0 (no air resistance): $Q = \dfrac{\frac{4}{3}\pi r^3\rho_0 g}{E}$

But $E = \frac{V}{d}$

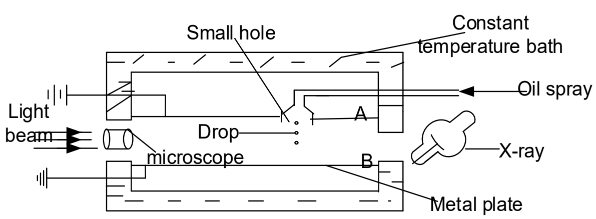
$$Q = \frac{4\pi r^3\rho_0 gd}{3v}$$

$$Q = \frac{4\pi(2x10^{-6})^3x800x9.81x0.015}{3x4500}$$

$$Q = 8.77x10^{-19}C$$

$$n = \frac{Q}{e} = \frac{8.77x10^{-19}}{1.6x10^{-19}} = 5\ electrons$$

(e)



- ❖ Oil is sprayed above the upper metal plate.
- ❖ With no P.d between the plates, one oil drop is observed as it falls between the plates.

- ❖ The distance, x fallen in time, t is obtained and te1rminal velocity V_t of the drop is determined.

At terminal velocity: $\frac{4}{3}x\pi r^3\rho_o g = \frac{4}{3}\pi r^3\rho_a\, g + 6\pi\eta r V_t$

$$r = \left[\frac{9\eta v_t}{2g(\rho_o - \rho_a)}\right]^{\frac{1}{2}}$$

ρ_o is density of oil

ρ_a is density of air

η viscosity of air

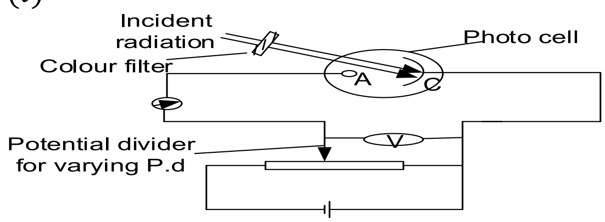
Question nine

(a) (i) It's defined as a process by which electrons are released from a clean metal surface when irradiated by electromagnetic radiations (light) of <u>high enough</u> frequency (energy).

(ii)

- The incident radiation must have a frequency above the threshold frequency of the metal surface.
- A clean metal surface must be use

(b) (i)



- The cathode C is made positive with respect to the anode by the potential divider.
- The beam of radiation is passed through a colour filter on to the cathode.
- The ammeter gives the photocurrent due to emitted electrons
- The applied p.d is increased negatively until the ammeter register zero reading.
- The $p.d$ (V_s) for which the photocurrent is zero is recorded from the voltmeter
- This p.d V_s is known as the stopping potential

(ii)

- Quantum theory considers radiations to be emitted and absorbed in discrete packets or quanta's called photons each of energy $\boldsymbol{E = hf}$.
- When a single photon interacts with an electron in the metal surface, it gives it all, when its frequency is higher than the threshold frequency of the metal or none of its energy when its frequency is lower than the threshold frequency of the metal.
- Each electron can only absorb the energy of one photon. Therefore the number of photo electrons is proportional to the number of incident photons (intensity of radiation)
- Of the photon energy, part is used to overcome attraction of the electron by the metal surface and the rest appears as kinetic energy of the emitted electron. This K.E ranges from zero to maximum. Maximum K.E of the photo electrons is proportional to the frequency of the incident radiation and independent of intensity.
- Minimum energy required to emit an electron $W_o=hf_o$. Below f_o no photo emission occurs

$(\boldsymbol{c})$ $(\boldsymbol{i})$ X-rays are electromagnetic radiations of very high frequency (short wavelength) produced when cathode rays strike a metal target.

$(\boldsymbol{ii})$ **properties of x-rays**

(1) They travel in straight lines at the velocity of light.
(2) They cannot be deflected by electric or magnetic field
(3) They readily penetrate matter, penetration is least with materials of high density
(4) They ionize gases through which they pass
(5) They affect photographic film
(6) They can produce fluorescence
(7) They can produce photoelectric emission

$(\boldsymbol{iii})$The energy changes in an x-rays tube are; electrical energy →kinetic energy → heat + x-rays.

(d) $\frac{99}{100}\ of\ IV = 742.5$

$$\frac{99}{100}xIx80x10^3 = 742.5$$
$$I = 9.375x10^{-3}A$$

Question ten

(a) **A bohr** atom is one with a small central positive nucleus with electrons revolving around it in only certain allowed circular orbits and while in these orbits they do not emit radiations.

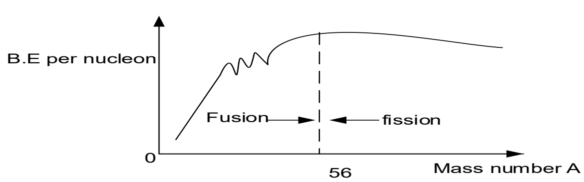
$(b)(i)$ n is quantum number and M is mass of the electron

$$E_n = \frac{-e^4\, m}{8n^2h^2{\varepsilon_0}^2} = \frac{-(1.6\times10^{-19})^4\times9.11\times10^{-31}}{8n^2(6.6x10^{-34})^2(8.85x10^{-12})^2} = \frac{-2.18\times10^{-18}}{n^2}$$

$$(ii)\ E = 0 - \frac{-2.18\times10^{-18}}{1^2} = 2.18\times10^{-18}\text{J} = \frac{2.18\times10^{-18}}{10^6\times1.6\times10^{-19}} = 1.36\times10^{-5}\text{MeV}$$

(c) **(i) Binding energy** of the nucleus is the energy required to break up the nucleus into it's constituent nucleons

(ii)



- **During nuclear fusion** two light nuclei unite to form a heavier nucleus of a smaller mass but a higher binding energy per nucleon. The mass difference is accounted for by the energy released.
- **During Nuclear fission**, a heavy nucleus splits to form two lighter nuclei of smaller masses but a higher binding energy per nucleon. The mass difference is accounted for by the energy released

(ii) $\Delta m = (148.016 + 84.903 + 3x1.009) - (235.051 + 1.009) = 0.114$

E $= \Delta mc^2 \quad = 0.114x1.66x10^{-27}\ x(3x10^8)^2 = 1.703x10^{-11}J$

(d) The heat energy produced by the fission reaction is removed by passing a coolant such as carbon dioxide through the reactor. The coolant then passes through the heat exchanger, where it heats water producing steam used to drive turbines which in turn generate electricity

END