P510/1
Physics
Paper 1
June/July, 2024
$2\frac{1}{2}$ *Hours*

MATIGO EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

PHYSICS
Paper 1
2 Hours : 30 Minutes

INSTRUCTIONS TO CANDIDATES

*Attempt not more than **five** questions including at least one but **not more than two** from each of the sections **A**, **B** and **C**.*
Any additional question(s) answered will not be marked

Where necessary, assume the following constants:

Acceleration due to gravity, g	=	$9.81\ m\ s^{-2}$
Electronic charge, e	=	$1.6 \times 10^{-19} C$
Electronic mass	=	$9.11 \times 10^{-31} kg$
Avogadro's number, N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Mass on earth	=	$5.97 \times 10^{24} kg$
Charge to mass ratio of an election	=	$1.8 \times 10^{11} C K g^{-1}$
One electron volt, eV	=	$1.6 \times 10^{-19}\ J$
Planck's constant, h	=	$6.6 \times 10^{-34}\ J\ s$
Radius of the earth	=	$6.4 \times 10^{6} m$
Specific heat capacity of water	=	$4.2 \times 10^{3}\ J\ kg^{-1} K^{-1}$
Specific latent heat of fusion of ice	=	$3.36 \times 10^{3} JKg^{-1}K^{-1}$
Stefan's – Boltzmann's constant, δ	=	$5.67 \times 10^{-8}\ W\ m^{-2} K^{-4}$
Speed of light in Vacuum, c	=	$3.0 \times 10^{8}\ m\ s^{-1}$
Unified mass unit, U	=	$1.66 \times 10^{-27}\ kg$
Universal gravitational constant, G	=	$6.67 \times 10^{-11} NM^2Kg^{-2}$
Gas constant, R	=	$8.31 Jmol^{-1}K^{-1}$
Permittivity of free space, $\in_o$	=	$8.85 \times 10^{-12} Fm^{-1}$

Specific latent heat of vaporization of water = $2.26 \times 10^{6} Jkg^{-1}$

Turn Over

SECTION A

1. (a) Define **angular velocity**. (01 mark)

(b) A car of mass, M, travels round a banked circular bend of radius, r. if the car is moving with maximum speed, V_{max} and co-efficient of kinetic friction on the track is μ.

(i) Draw a diagram to show the forces acting on the car. (02 marks)

(ii) Obtain an expression for the maximum speed at which the car will negotiate the bend without skidding. (04 marks)

(c) (i) Show that for small mass, m, attached to the free end of a suspended vertical helical spring executes simple harmonic motion when displaced through a small distance down wards and released, is of period $T= 2\pi\sqrt{\frac{m}{k}}$ where k is the force constant of the spring. (05 marks)

(ii) Describe an experiment to determine the acceleration due to gravity using a helical spring. (04 marks)

(d) Explain the following;

(i) Damped oscillations. (02 marks)

(ii) Forced oscillations. (02 marks)

2. (a) (i) State the factors that affect the rate of flow of a liquid in a pipe. (2 marks)

(ii) With aid of a diagram, describe an experiment to measure the co-efficient of viscosity of water using poisseulle's formular. State any assumption made. (07marks)

(b) Explain why you should blow over a piece of paper and not under in order to keep it horizontal. (03marks)

(c) A horizontal pipe of cross sectional area $0.4m^2$ tapers to cross sectional area $0.2m^2$ The pressure at the large section of the pipe is $8.0 \times 10^4 Nm^{-2}$ and the velocity of water through the pipe is $1.2ms^{-1}$ If atmospheric pressure is $1.01 \times 10^5 Pa$Find the :

(i) Velocity at the small section of the pipe. (04marks)

(ii) Pressure at the small section of the pipe. (02marks)

(d) Explain the effect of temperature on viscosity of liquids. (02marks)

3. (a) (i) State **Newton's Universal law of gravitation**. (01 mark)

(ii) A satellite is launched at a height h, above the earth's surface of radius, R and density, ρ .show that the time period, T of the satellite is given by:

$$T = \sqrt{\frac{3\pi(R+h)^3}{G\rho R^3}}$$

Where G is the gravitational constant. (04marks)

(b) (i) What is meant by a **parking orbit** ? (01 mark)

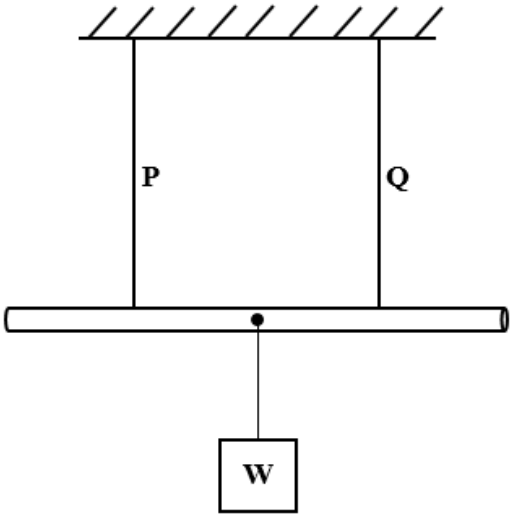
(ii) Explain briefly how satellites are used in world -wide radio or television communication. (04marks)

(c) A body of mass 1200kg raised to a height of 500km above the earth's surface. Calculate

(i) the acceleration due to gravity at that point. (03marks)

(ii) Its mechanical energy. (02marks)

(d) A piece of rod 1.05m long whose weight is negligible is supported at it's ends by wires Q and P of equal lengths as shown below.



The cross-sectional area of P is $1mm^2$ and that of Q is $2mm^2$. At what point along the bar should the weight be suspended in order to produce;

(i) Equal stress of P and Q (03 marks)

(ii) Equal strain of P and Q (03 marks)

4. (a) (i) Distinguish between **surface tension** and **surface energy**. (2marks)

(ii) Show that surface energy and surface tension are numerically equal. (3marks)

(iii) Explain why a drop of liquid under no external force is always spherical in shape? (3marks)

(b) One end of a clean capillary tube having internal diameter 0.6mm is dipped into a beaker containing water which rises up to a vertical height 5.0cm above the water surface in the beaker.

(i) Derive an expression for surface tension of water in terms of radius, r of the capillary tube, density,ρ of water, angle of contact, θ and length, h of water in the capillary tube. (3 marks)

(ii) Calculate the surface tension of water assuming angle of contact is zero. (2marks)

(iii) If the length of the capillary tube above the water surface is 3.0cm. Explain what would happen to the liquid in the capillary tube. (2 marks)

(c) (i) State **Archimedes principle**. (1mark)

(ii) Briefly describe how density of a liquid can be obtained using Archimedes principle. (4marks)

SECTION B

5. (a) (i) Define the terms **absolute zero** and **specific heat capacity**. (2marks)

(ii) Explain why temperature less than absolute zero is not possible (3marks)

(iii) Explain why the coolant used in car should have high specific capacity. (2marks)

(b) (i) State **Newton's law of cooling**. (1mark)

(ii) Describe an experiment to verify Newton's law of cooling. (6marks)

(c) An electrical heater of 2KW is used to heat 500g of water initially at 20°C in a kettle of heat capacity $400Jk^{-1}$

(i) How long will it take to heat the water to its boiling point? (3marks)

(ii) Calculate the mass of water boiled away in 5 minutes. (3marks)

6. (a) (i) State the assumptions of kinetic theory of an ideal gases. (2marks)

(ii) Using those assumptions in a (i) above derive an expression for pressure, p exerted by a gas of density ρ, and mean square speed $\overline{C^2}$ of its molecules. (5marks)

(b) Helium gas of relative molecular mass 4 occupies a volume of $0.004m^3$ at a pressure of $2 \times 10^5 Pa$ and temperature 27°C .Calculate the

(i) Root mean square speed of its molecules. (3marks)

(ii) Total kinetic energy. (3marks)

(iii) root mean as square speed when the gas is heated at constant pressure to a temperature of 159°C (3marks)

(c) (i) Define **saturated vapour pressure**. (1mark)

(ii) Explain the effect of temperature on saturated vapour pressure of a liquid. (3mark)

7. (a) (i) State Dalton's law of **Partial pressure**. (1 mark)

(ii) Using the expression of $P = \frac{1}{3}\rho\overline{C^2}$ where p is the pressure of a gas of density **P** and mean square speed $\overline{C^2}$, derive Dalton's law of partial pressures for two gases. (5 marks)

(b) (i) Define a **black body**. (1 mark)

(ii) Sketch and explain graphs of intensity versus wave length for three temperatures for a black body. (3 marks)

(c) Describe with the aid of labeled diagram how an optical pyrometer is used to measure temperature. (5 marks)

(d) A circular disc of glass 3mm thick and 110mm diameter is placed between two brass slabs x and y, the temperature of the lower slab becomes constant at 92^0c while the temperature of x is 96^0c. Y is warmed above 92^0c when insulated on top, its cooling pattern studied. The rate of cooling at 92^0c is found to be 0.42k/s. Calculate the thermal conductivity of the glass if the mass of y is 0.94kg and its SHC is 400J/kg/k. (5 marks)

SECTION C

8. (a) Explain the main observations made in Rutherfords α -particle scattering experiment. (6marks)

(b) (i) Show that when an α -particle collides head on with an atom of atomic number Z, the least distance of approach to the nucleus, $x_0$is given by

$$x_0 = \frac{Ze^2}{\pi\varepsilon_0 mV^2}$$

Where, e, is electronic charge ε_0 is permittivity of free space m is mass of -particle and V is initial speed of the α –particles. (3marks)

(ii) In a head of collision between an α - particle and gold nucleus of atom, Z number 79 the minimum distance of approach is 5.2×10^{-14}. Calculate the energy of the α -particle in Mev (3marks)

(c) (i) With help of a diagram , describe the mode of operation of an x-ray tube. (5marks)

(ii) When $x - ray$ beam of wavelength 2.3Å fills on sodium chloride crystal of molar mass 58.5 and density $2.18 \times 10^3 kgm^{-3}$, a second order diffraction maxima occurs. Calculate the glancing angle. (3mark)

9. (a) (i) What are **positive rays**? (01mark)

(ii) State two differences between positive rays and cathode rays. (02marks)

(b) (i) With aid of a diagram, describe Millican's experiment to determine the charge on an oil drop. (06marks)

(ii) Explain why the size of oil drops should be small. (01mark)

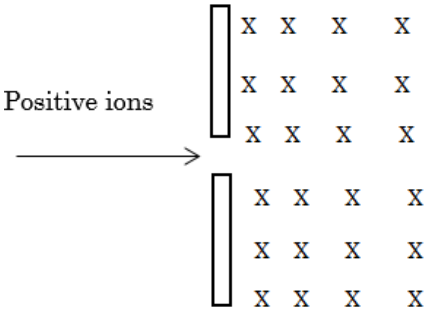
(c) Oil droplets are introduced into the space between two horizontal plates 5mm apart. when the plate voltage is 780V, one of the droplets is held stationary, when the plate voltage is switched off, the selected droplet is observed to fall a distance of 1.50mm in 11.2 seconds. Given that the density of oil is $900 kgm^{-3}$ and viscosity of air at 20°C is $1.8 \times 10^{-5} pa$.

Calculate the:

(i) mass of the droplet (4marks)

(ii) charge of droplet (3marks)

(d)



The figure above shows a beam of positive ions each mass, m and charge, q accelerated from rest by electric field of p.d, V and enter normally into a region of uniform magnetic field of flux density, B. Show that the radius of the path described in magnetic field is given by (3 marks)

$$r = \sqrt{\frac{2Vm}{qB^2}}$$

10. (a) (i) Differentiate **natural radioactivity** and **artificial radioactivity**. (02 marks)

(ii) State **two** conditions for instability of nucleus. (03 marks)

(b) (i) What is meant by **thermionic emission**. (01mark)

(ii) Describe an experiment to show that cathode rays convey negative charge. (05 marks)

(c) (i) Derive an expression for the half-life using the radioactive decay law. (04 marks)

(ii) Living wood has an activity of 16.0 counts per minute per gram of carbon. A certain sample of dead wood is found to have an activity of 18.4 counts per minute for 4.0 grams. Calculate the age of the sample of dead wood. Assume the half-life of carbon 14 is 5568 years (05 marks)

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