P510/1
PHYSICS
Paper 1
8 August 2023
2 ½ hours

ENTEBBE JOINT EXAMINATION BUREAU

Uganda Advanced Certificate of Education

PHYSICS

Paper 1

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

Attempt **FIVE** questions including at least **one but not more than two** from each of the Sections **A**, **B** and **C**.

Any extra question shall **not** be assessed.

Assume where necessary:

Acceleration due to gravity, g	=	$9.81\ ms^{-2}$
Speed of light in a vacuum, c	=	$3 \times 10^{8}\ ms^{-1}$
Electron charge, e	=	$1.6 \times 10^{-19}\ C$
Electron mass	=	$9.11 \times 10^{-31}\ kg$
Density of water	=	$1000\ Kgm^{-3}$
Avogadro's number N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Planck's constant, h	=	$6.63 \times 10^{-34}\ Js$
Radius of the earth	=	$6.4 \times 10^{6} M$
Wien's displacement constant	=	$2.90 X 10^{-3} mK$
Radius of Earth's orbit about the sun	=	$1.5 \times 10^{11} M$
Specific heat capacity of water	=	$4200 JKg^{-1}K^{-1}$
Stefan Boltzmann's constant δ	=	$5.67 \times 10^{-8} Wm^{-2}K^{-4}$
Universal gravitational constant G	=	$6.67 \times 10^{-11} Nm^{-2}Kg^{-2}$
Gas constant R	=	$8.31 Jmol^{-1}K^{-1}$
The constant $\frac{1}{4\pi\varepsilon_0}$	=	$9.0 \times 10^{9}\ mF^{-1}$
One electron volt (eV)	=	$1.6 \times 10^{-19}\ J$
Charge to mass ratio, $\frac{e}{m}$	=	$1.8 \times 10^{11}\ CKg^{-1}$

SECTION A

1. (a) (i) What is meant by **dimensions of a physical quantity**? *(01 mark)*

(ii) The volume rate, $^{V}/_{t}$ of a liquid flowing through a horizontal pipe of length l, depends on the pressure gradient, P/l, the radius, r of the pipe and the coefficient of viscosity ç *(of dimensions $ML^{-1}T^{-1}$)* of the liquid. Use dimensions to derive an expression for $^{V}/_{t}$ in terms of P/l, r and ç. *(take $K = \pi/8$)*. Hence find the volume, per second of a liquid of viscosity $1.2 \times 10^{-3}NS^{-1}\ m^{-2}$ at 25°C that flows through a pipe of length 20m and radius 80 cm when the pressure difference across its ends is $24.5Nm^{-2}$. *(07 marks)*

(b) (i) State **Newton's second law of motion.** *(01 mark)*

(ii) What is meant by the term **impulse**? *(01 mark)*

(iii) A tennis ball of mass 75g struck by a racket moves horizontally at a speed of $120ms^{-1}$ and hits a vertical wall. It rebounds and moves horizontally at a speed of $80ms^{-1}$. Given that the ball is in contact with the wall for 0.04s and the area of contact with the wall is $28.5cm^2$, find the pressure the ball exerts on the wall. *(04 marks)*

(iv) Explain briefly why the ball rebounds with a reduced speed. *(02 marks)*

(c) A stone is projected vertically upwards from the top of a table. If the store finally lands on the flow below the table,

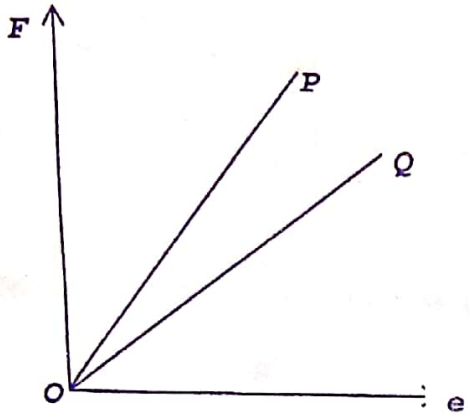
(i) Sketch a speed-time graph for the motion of the stone. *(01 mark)*

(ii) Describe briefly the features of the graph in (c). *(02 marks)*

2. (a) Differentiate between the terms **ductility** and **malleability**. Give **two** examples of materials that exhibit each of these properties. *(04 marks)*

(b) A body is supported by a spiral spring and causes the spring to stretch by 1.5cm. If the mass is now set into vertical oscillation of small amplitude, calculate the periodic time of the oscillation. *(04 marks)*

(c) The graph in figure 1 shows the variation of ***F***, the load applied to two wires ***P*** and ***Q*** and then extension, ***e***. Both wires are made of iron and have the same length.



Which of the wires has a smaller diameter? Explain your answer. *(04 marks)*

(d) (i) Define **simple harmonic motion.** *(01 mark)*

(ii) State **two** practical examples of simple harmonic motion. *(02 marks)*

(iii) A small mass rests on a horizontal platform which vibrates vertically 2 in simple harmonic motion with a period of 0.5s. Find the maximum amplitude of motion which will allow the mass to remain in contact with the platform throughout the motion. *(03 marks)*

(e) Describe briefly how the force constant of a spiral spring can be estimated in a laboratory. *(02 marks)*

3. Define the following terms as used in circular motion.

(i) **angular velocity** *(01 mark)*
(ii) **centripetal acceleration** *(01 mark)*

(b) A metallic bob of mass *m* is tied to a string of length *l* so that it is free to oscillate in a vertical plane, as shown in figure 2.

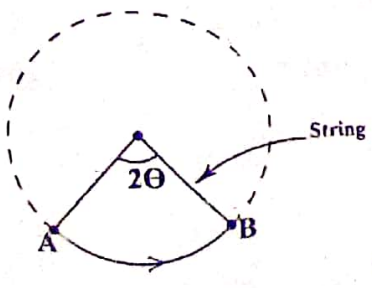


Fig 2

When pushed from position A, the bob moves describing a path as shown. If ***O*** is the centre of the path taken:

$T = 2\pi$

$V = \frac{\Delta\theta}{t} \times 2\pi r$

$\Delta\theta 2\pi r$

(i) Show that the acceleration of the bob along the line AB is zero and that its acceleration along AO is V^2/l. *(04 marks)*

(c) An object of mass 0.5kg is rotated in a horizontal circle using a string of length 1 *m*. The maximum tension in the string before it breaks is 316 N. What is the greatest number of revolutions made by the object in one second? *(04 marks)*

(d) (i) What is meant by **a parking orbit of a satellite?** *(02 marks)*

(ii) Calculate the height of a communication satellite above the earth's surface. *(04 marks)*

(iii) Show that a satellite close to the earth's surface takes about 84 minutes to move round the earth once. *(04 marks)*

4. (a) (i) Define **surface tension** in terms of **surface energy.** *(01 mark)*

(ii) Explain using the kinetic theory the temperature dependence of surface tension. *(03 marks)*

(b) (i) Describe an experiment to determine surface tension of a liquid using a capillary tube. *(06 marks)*

(ii) When a capillary tube is placed vertically in a beaker containing water, water rises in the tube 5.8 cm above that in the beaker. The tube is removed, dried and placed vertically in a trough of mercury. Calculate the depression of mercury in the tube. *(Angle of contact for water and mercury are 0^0 and 130^0 respectively)* *(04 marks)*

(c) State **Bernoulli's principle of fluid flow.** *(01 mark)*

(d) Water flows steadily along a horizontal pipe at a volume rate of 8×10^{-3} m^3s^{-1}. If the area of cross section of the pipe is $40cm^2$, determine the:

(i) flow velocity of the water. *(02 marks)*

(ii) total pressure in the pipe if the static pressure is 3×10^4 Pa. *(03 marks)*

SECTION B

5. (a) (i) Define **specific heat capacity** of a substance. *(01 mark)*

(ii) In reference to a continuous flow calorimeter for determining specific heat capacity of a liquid, explain why two sets of readings are used and the temperature difference for inflow and outflow liquid is made the same. *(02 marks)*

(iii) Oil at 15.6^{0}C enters a long glass tube containing an electrically heated platinum wire and leaves it at 17.4^{0}C. The rate of flow of the oil is 25cm^3, per minute and electrical energy supplied by the coil per second is 1.30J. When the rate of flow is reduced by 10cm^3 per minute and the electrical energy supplied per second is reduced by 40%, the same temperature difference is again achieved. Calculate the specific heat capacity of the oil given that its density is 870 kgm^3. *(06 marks)*

(b) State **two** disadvantages of the method in (a) (ii) above. *(02 marks)*

(c) (i) Define **specific latent heat of vaporization.** *(01 mark)*

(ii) With the aid of a labelled diagram, describe how specific latent heat of a liquid can be determined by method which involves a constant rate of evaporation. *(06 marks)*

(iii) Explain briefly why it is much colder in the valley than at the top of the hills at night. *(02 marks)*

6. (a) (i) Define **thermal conductivity.** *(01 mark)*

(ii) Explain the mechanism of heat transfer in non metal solid. *(03 marks)*

(b) Describe an experiment to determine thermal conductivity of iron. *(06 marks)*

(c) A boiler with a steel bottom 1.5 cm thick rests on a hot stove. The area of the boiler's bottom is 1500 cm^2. The water inside the boiler is at a temperature of 100°C and 750g evaporates every 5 minutes. Find the

(i) temperature of the lower surface of the boiler. *(04 marks)*

(ii) amount of heat passing through 80cm^2 area of the bottom of the boiler per hour. *(03 marks)*

(d) (i) What is meant by **a black body**? *(01 mark)*

(ii) State **two** examples of black bodies. *(01 mark)*

(iii) Explain briefly why black body radiation is sometimes called temperature radiation. *(01 mark)*

7. (a) (i) Define the terms **absolute zero** and **an ideal gas.** *(02 marks)*

(ii) State **two** differences between an ideal gas and a real gas. *(02 marks)*

(b) (i) State and derive **Dalton's law of Partial pressures.** *(05 marks)*

(ii) What is meant by **saturated vapour**? *(01 mark)*

(iii) The Saturated Vapour Pressure (SVP) of a certain liquid vapour at 0°C is 18.5 mm of mercury, and at 30°C it is 54.2mm of mercury. The volume of the closed vessel is kept constant and contains dry air and sufficient liquid for saturation. If the observed pressure is 100mmHg at 30°C, what will its value be at 0°C? *(04 marks)*

(c) (i) Define **molar heat capacity of gas at constant pressure.** *(01 mark)*

(ii) Explain why the distinction between specific heat capacity at constant pressure and that at constant volume is important for gases but less important for solids and gases. *(03 marks)*

(iii) The temperature of a gas in an expandable container is raised from -15°C to 65°C at constant pressure. The total heat added to the gas is $5.8X10^4J$. Find the number of moles of the gas. *(02 marks)*
(Molar heat capacity of the gas at constant pressure = 29.0 $Jmol^{-1}K^{-1}$)

SECTION C

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

(ii) State **four** properties of cathode rays. *(02 marks)*

(iii) Explain briefly the term **thermionic emission.** *(03 marks)*

(b) Describe briefly how frequency of an *a.c.* signal can be determined using a Cathode Ray Oscilloscope. (CRO) *(03 marks)*

(c) A C·R·O has its *y*-sensitivity set to $6Vcm^{-1}$. A sinusoidal input voltage is suitably applied to give a steady *p.d.*

The time base switched on so that the electron beam takes 0.01s to traverse the screen. If the trace seen has a peak-to-peak height of 4cm, and contains two complete cycles, determine:

(i) root-mean-square value of the input voltage. *(03 marks)*

(ii) frequency of the signal. *(02 marks)*

(d) In an experiment to determine change of an electron using Millikan's oil drop method; state why
(i) a constant temperature bath is used. *(01 mark)*
(ii) a non-volatile oil is used. *(01 mark)*

(e) In a Millikan oil drop experiment, a single negatively-charged drop of radius 6×10^{-3} mm was found to fall under gravity at a terminal velocity of $0.004 cms^{-1}$ and to rise at $0.012 cms^{-1}$ when a field of $2 \times 10^{5} Vm^{-1}$ was suitably applied. Given that the viscosity of the medium was $2.122 \times 10^{-5} Nsm^{-2}$, determine the number of electrons of the drop. *(neglect air buoyancy) (04 marks)*

9. (a) (i) State any **two** processes of ejecting electrons from a metal surface. *(02 marks)*

(ii) Describe a simple experiment to determine Plank's Constant. *(05 marks)*

(b) When light of wave length 450nm falls on a certain metal surface, it ejects photo-electrons with maximum velocity of $6.0 \times 10^{5} ms^{-1}$. Calculate the

(i) work function of the metal.
(ii) threshold frequency of the metal surface. *(04 marks)*

(c) (i) State **Bragg's law of x-ray diffraction.** *(01 mark)*

(ii) A beam of x-rays of frequency $3.56 \times 10^{18} Hz$ is incident on a Potassium chloride (KCl) crystal, and the first order Bragg's reflection occurs at $7^{0}41'$. The density of KCl is $1.98 \times 10^{3} kgm^{-3}$ and its molecular mass is 74.5. Calculate the value of Avogadro's number. *(05 marks)*

(d) (i) Define **Faraday Constant.** *(01 mark)*

(ii) Use the Avogadro's constant and Faraday constant to calculate the charge on an ion of a monovalent element. *(02 marks)*

10. (a) Define the terms:

(i) radioactivity. *(01 mark)*
(ii) nuclear fission. *(01 mark)*

(b) (i) State **one** condition for nuclear fission to occur. *(01 mark)*

(ii) Why are neutrons preferred to alpha particles for inducing nuclear reactions? *(01 mark)*

(c) With the aid of a labeled diagram, describe how a diffusion cloud chamber is used to detect ionizing radiation. *(06 marks)*

(d) Lanthanum has a stable isotope La-139 and radioactive isotope La-138 of half-life 1.1×10^{0} years whose atoms are 0.1% of the stable isotope. Estimate the rate of decay of La-138 with 1kg of La-139. *(04 marks)*

(e) Uranium ${}^{238}_{92}U$ nucleus decays according to the equation

$$ {}^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He $$

Determine the kinetic energy of the emitted alpha-particle given that, mass of the nucleus of ${}^{238}_{92}U$ = 3.85395×10^{-25} kg, ${}^{234}_{90}Th$ = 3.78737×10^{-25} kg; mass of alpha particle = 6.64807×10^{-27} kg.

(05 marks)