UACE

P510/1
PHYSICS
Paper 1
July/August, 2024
2 ½ hours

ACHOLI SECONDARY SCHOOLS EXAMINATIONS COMMITTEE

Uganda Advanced Certificate of Education

Joint Mock Examinations, 2024

PHYSICS

Paper 1

2 HOURS 30 MINUTES

INSTRUCTIONS TO CANDIDATES:

- ✓ Answer **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.
- ✓ Non-programmable scientific calculators may be used.
- ✓ Assume where necessary:
  - Acceleration due to gravity, g = $9.81\ ms^{-2}$
  - Electron charge, e = $1.6 \times 10^{-19}\ C$
  - Electron mass = $9.11 \times 10^{-31}\ Kg$
  - Mass of the earth = $5.97 \times 10^{24}\ Kg$
  - Plank's constant, h = $6.6 \times 10^{-34}\ Js$
  - Stefan Boltzmann's constant, δ = $5.67 \times 10^{-8} Wm^{-2} K^{-4}$
  - Radius of the earth = $6.4 \times 10^{6}\ m$

- Radius of the sun $= 7 \times 10^{8}$ m
- Radius of earth's orbit about the sun $= 1.5 \times 10^{11}$ m
- Speed of light in a vacuum, c $= 3.0 \times 10^{8}$ ms^{-1}
- Thermal conductivity of aluminium $= 210$ Wm^{-1} K^{-1}
- Thermal conductivity of copper $= 390$ Wm^{-1} K^{-1}
- Specific heat capacity of water $= 4200$ J Kg^{-1} K^{-1}
- Universal gravitation constant, G $= 6.67 \times 10^{-11}$ Nm^{2} Kg^{-2}
- Avogadro's number, N_A $= 6.02 \times 10^{23}$ mol^{-1}
- Surface tension of water $= 7.0 \times 10^{-2}$ Nm^{-1}
- Density of water $= 1000$ Kgm^{-3}
- Gas constant, R $= 8.31$ J mol^{-1} K^{-1}
- Charge to mass ratio, e/m $= 1.8 \times 10^{11}$ C Kg^{-1}
- The Constant, $\frac{1}{4\pi\varepsilon_0}$ $= 9.0 \times 10^{9}$ F^{-1}m
- Faraday's Constant, F $= 9.65 \times 10^{4}$ Cmol^{-1}
- Specific latent heat of fusion of ice $= 3.36 \times 10^{5}$ J Kg^{-1}
- Young's Modulus of Steel $= 2.0 \times 10^{11}$ Nm^{-2}
- Specific heat capacity of aluminium $= 910$ J Kg^{-1} K^{-1}

SECTION A:

Question 1:

(a) (i) Explain the terms **free fall** and **terminal velocity**. (03 marks)

(ii) The weight of a body is measured using a spring balance which is suspended from the roof of a lift. Explain the values of the weight obtained when the lift accelerates downwards and when it accelerates upwards.

(04marks)

(b)(i) Derive an expression relating the distance, s, the initial velocity, u, the time of acceleration, t, and the acceleration a, for a body moving in a straight line with uniform acceleration. (02 marks)

(ii) Show that the equation in (b) (i) above is dimensionally correct. (02 marks)

(c) An old car of mass 1.5×10^3 kg and tractive pull of 3.5×10^3 N climbs a track which is inclined at an angle of 30^0 to the horizontal. The velocity of the car at the bottom of the incline is 20 m s-1 and the coefficient of sliding friction is 0.25.

Calculate;

(i) The distance travelled along the incline before the car comes to a halt. (04 marks)

(ii) The time taken travelling along the incline before the car comes to a halt. (02 marks)

(d) A ball is projected upwards at an angle of 30^0 to the horizontal. If the initial velocity of the ball is 35m s^{-1}, calculate the maximum height and the range of the ball reached. (04 marks)

Question 2:

(a) (i) State the characteristics of simple harmonic motion. (02 marks)

(ii) Distinguish between damped and forced oscillations. (02 marks)

(iii) Draw a force-displacement graph for a body executing simple harmonic motion. (01 mark)

(b) When a body of mass 0.2kg is attached to the lower end of a light helical spring and the upper end of which is fixed, the spring extends by 0.16m. The body is then pulled down a further 0.08m and then released. Find:

(i) the period of vertical oscillations. (03 marks)

(ii) the kinetic energy the body possesses when it passes through its mean position. (04 marks)

(c) (i) State the work-energy theorem. (01 mark)

(ii) Prove the work-energy theorem for a body moving with constant acceleration. (03 marks)

(d) A body of mass 2kg is released from rest 6m from the bottom of a slope which makes an angle of 30° to the horizontal. The constant frictional force opposing the body is 4N. If the body then moves along a horizontal table, at the bottom of the plane, which has the same frictional force, how far along the table will the body travel before coming to rest? (04 marks)

Question 3:

(a) (i) State Bernoullis' principle and the law of floatation. (02 marks)

(ii) Explain the origin of the lift force on the wings of an aeroplane at take-off. (03 marks)

(iii) Water flows through a horizontal pipe of varying cross-section. If pressure of water is 8cm of mercury where the velocity of flow is $0.3ms^{-1}$, what is the pressure at another point where the velocity of flow is $0.8ms^{-1}$? (04 marks)

(b) (i) Define surface tension and surface energy. (02 marks)

(ii) Show that surface tension and surface energy are numerically equal. (03 marks)

(c) Two soap bubbles, one of radius 50mm and the other of radius 80mm, are brought together so that they have a common interface.

(i) Calculate the radius of curvature of this interface. (04 marks)

(ii) Explain whether it is convex towards the larger or smaller bubble. (02 marks)

Question 4:

(a) (i) Define elastic limit and Young's Modulus. (02 marks)

(ii) Show that the energy stored in a rod of length l when it is extended by a length x, is $\frac{1}{2}E\left(\frac{x}{l}\right)^2$ per unit volume, where E is Young's Modulus of the material. (04 marks)

(b) The end of a copper wire of diameter 0.30mm and length 1.50m is fused to one end of a steel wire of the same diameter and 1.20m in length. The wire is then hung vertically by attaching the free copper end to a fixed point and a

small weight of 30N to the lower end of the steel wire. The attachments reduced the length of each wire by 20mm. Calculate;

(i) the total extension of the two wires. (03marks)

(ii) the strain in each wire. (03 marks)

(Young's Modulus for steel is 2.0×10^{11} Nm^{-2} and for copper is 1.3×10^{11} Nm^{-2})

(c) (i) Define angular velocity. (01 mark)

(ii) Derive an expression for the speed of a body moving uniformly in a circular path (03 marks)

(iii) Derive an expression for the angle of inclination to the horizontal necessary for a rider moving round a circular track of radius, r, without skidding at a speed V, in terms of g, r and V. (04 marks)

5

SECTION B

Question 5:

(a) (i) What is a black body? (01 mark)

(ii) Describe how you can approximate a black body in a school laboratory. (04 marks)

(iii) Explain how a welder can protect the eyes from damage. (03 marks)

(b) (i) State Stefan's law of black body radiation. (01 mark)

(ii) A tungsten filament of an electric lamp has a length of 0.5m and a diameter of 5×10^{-5}m. The power rating of the lamp is 65W. Assuming the radiation from the filament is equivalent to 80% that of a black body radiator at the same temperature, estimate the steady temperature of the filament. (04 marks)

(c) With the aid of a diagram explain how a barometer is used to detect thermal radiation. (06 marks)

Question 6:

(a) (i) State **Boyle's law**. (01 mark)

(ii) Describe an experiment that can be used to verify Boyle's law. (06 marks)

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(b) Explain the following observations using kinetic theory.

(i) A gas fills any container in which it is placed, and exerts a pressure on its walls. (03 marks)

(ii) The pressure of a fixed mass of gas rises when its temperature is increased at constant volume. (02 marks)

(c) (i) State Dalton's law of partial pressures. (01 mark)

(ii) Use the expression in (b) above to deduce Dalton's law of partial pressures. (04 marks)

(d) Using the kinetic theory expression for pressure of an ideal gas deduce the ideal gas equation if $\frac{1}{2}m\overline{C^2} = \frac{3}{2}K_BT$. (03 marks)

Question 7:

(a) (i) Define the term thermometric property and give four examples. (03 marks)

(ii) State two qualities of a good thermometric property. (02 marks)

(b) (i) State two advantages and two disadvantages of the constant volume gas thermometer. (02 marks)

(ii) Describe with the aid of a labelled diagram how a constant volume gas thermometer may be used to measure temperature. (06 marks)

(c) (i) Define specific heat capacity. (01 mark)

(ii) An electric kettle with a 2.0kW heating element has a heating capacity of $400JK^{-1}$. 1.0kg of water at 20°C is placed I the kettle. The kettle is switched on and it is found that 13 minutes later the mass of water in it is 0.5kg. ignoring heat losses, calculate the value for specific latent heat of water. (06 marks)

SECTION C

Question 8:

(a) (i) What are radioisotopes? (01 mark)

(ii) Why is radioactivity described as a random process? (02 marks)

(b) With the aid of a labelled diagram, describe the operation of an ionisation chamber. (05 marks)

(c) (i) State two similarities between nuclear fission and nuclear fusion. (02 marks)

(ii) Sketch a graph of binding energy per nucleon against nucleon number. (02 marks)

(d) A Uranium nucleus $^{238}_{92}U$ emits an alpha (α) particle. Calculate the;

(i) total energy in joules released in the process. (04 marks)

(ii) kinetic energy of the α-particle if the uranium nucleus was originally at rest. (Take mass of $^{238}_{92}U$ = 238.125u, of $^{234}_{90}Th$ = 234.117u, of $^{4}_{2}He$ = 4.004u, 1u = 1.66×10^{-27} Kg) (04 marks)

Question 9:

(a) (i) With the aid of a diagram, describe how cathode rays are produced. (04 marks)

(ii) Explain how the sign of the charge of cathode rays may be determined. (02 marks)

(b) With the aid of a labelled diagram, describe the operation of the Bainbridge Mass Spectrometer in the measurement of specific charge of positive ions. (06 marks)

(c) A beam of positive ions is accelerated through a potential difference of 1 x 10^3 V into a region of uniform magnetic field of flux density 0.2T. While in the magnetic field it moves in a circle of radius 2.3cm. Calculate charge to mass ratio of these ions. (03 marks)

(d) When light of wavelength 250nm falls on a certain metal surface, it ejects photoelectrons with maximum velocity of 6.0×10^5 ms^{-1}. Calculate the work function and the threshold frequency for the metal surface. (05 marks)

Question 10:

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

(ii) Describe a simple experiment to demonstrate photoelectric effect. (04 marks)

(b) (i) Describe briefly the steps involved in the determination of the charge

of an electron by Millikan's oil drop experiment. (07 marks)

(ii) Why are large sized oil drops not suitable for the above experiment? (02 marks)

(c) A beam of X-rays of frequency 3.56×10^{18} Hz is incident on a potassium chloride (KCl) crystal and the first order Bragg reflection occurs at $7^{o}\,41^{1}$. The density of KCl is 1.98×10^{3} Kgm^{-3} and its molecular mass is 74.5. Calculate the value of Avogadro's number. (05 marks)

"GOOD LUCK"

****THE END****