P510/1
PHYSICS
Paper 1
July/August, 2023
2 ½ hours

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GLORISO EXAMINATIONS BOARD (GEB)-KAMPALA

SECONDARY SCHOOLS JOINT MOCK EXAMINATIONS, 2023

Uganda Advanced Certificate of Education

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 x 10^{-19} C
Electron mass	= 9.11 x 10^{-31} Kg
Mass of the earth	= 5.97 x 10^{24} Kg
Plank's constant, h	= 6.6 x 10^{-34} Js

Stefan Boltzmann's constant, δ	= $5.67 \times 10^{-8} Wm^{-2} K^{-4}$
Radius of the earth	= 6.4×10^{6} m
Radius of the sun	= 7×10^{8} m
Radius of earth's orbit about the sun	= 1.5×10^{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	= 1.8×10^{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	= 3.36×10^{5} J Kg^{-1}
Young's Modulus of Steel	= $2.0 \times 10^{11} Nm^{-2}$
Specific heat capacity of aluminium	= 910 J $Kg^{-1} K^{-1}$

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SECTION A:

Question 1:

(a) (i) What is meant by acceleration due to gravity? (01 mark)

(ii) A ball is dropped from a height of 20m and rebounds with a velocity which is ¾ of the velocity with which it hit the ground. What is the time interval between the first and second bounces? (04 marks)

(b) (i) What is meant by impulse? (01 mark)

(ii) Explain why a batsman strikes a cricket ball and follows through. (03 marks)

(iii) An object A of mass 0.5kg and velocity $10ms^{-1}$ collides with a stationary identical object B and they move off at right angles to each other. Calculate the velocity of B after collision if the velocity of A is $8ms^{-1}$ after the collision. (04 marks)

(c) (i) Define vector and scalar quantities and give one example of each. (02 marks)

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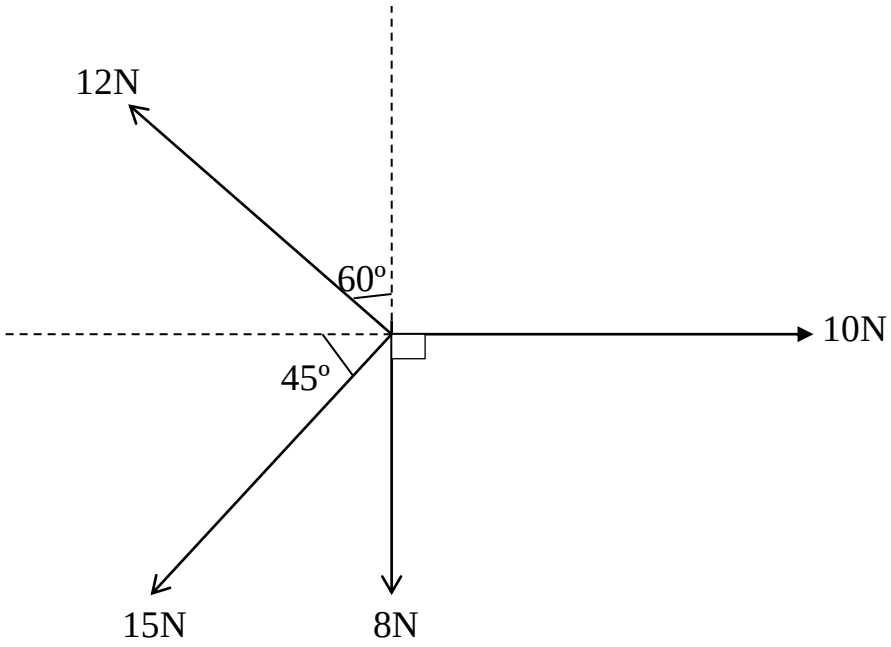
(ii) An object O of mass 5kg is acted upon by forces 10N, 8N, 15N and 12N as shown below.



Find the displacement of the object after 4s. (05 marks)

Question 2:

(a) Define the following terms:

(i) **Angular velocity** (01 mark)

(ii) **Centripetal acceleration** (01 mark)

(b) (i) Explain why a racing car can travel faster on a banked track than on a horizontal track of same radius of curvature. (04 marks)

(ii) Derive an expression for the speed with which a car can negotiate a bend

on a banked track without skidding. (03 marks)

(c) Show how to estimate the mass of the sun if the period and orbital radius of one of the sun's planets are known. (03 marks)

(d) The gravitational potential, *V*, at the surface of a planet of mass *M* and radius *R* is given by $V = -\frac{GM}{R}$, where *G* is the universal gravitational constant.

(e) (i)Derive an expression for the lowest velocity, *u*, which an object of mass *m* has at the surface of the planet if it is to escape from the planet. (04 marks)

(ii) Communication satellites orbit the earth in synchronous orbits.

(iii) Calculate the height of a communication satellite above the earth. (04 marks)

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Question 3:

(a) Define the following terms as used in the study of elasticity;

(i) Young's modulus

(ii) Plastic deformation

(iii) **Work hardening** (03 marks)

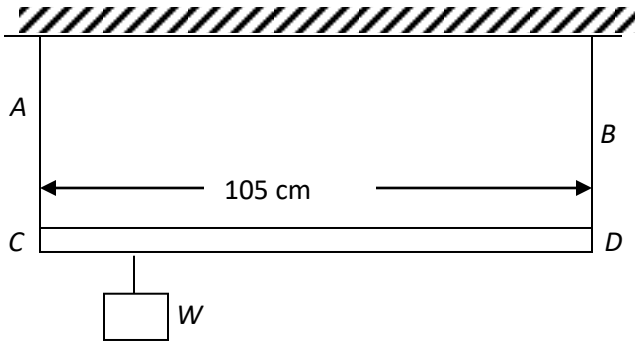
(b) Derive the expression for the energy stored per unit volume when a metal wire of Young's modulus *E* and length *l* is stretched through extension *e*. (03 marks)

(c) A mass of 400 g is hung from a steel wire of length 0.8 m and diameter 3.0×10^{-4} m. The mass is given a small vertical displacement and released.

a. (i) Show that the mass moves with simple harmonic motion.(03 marks)

b. (ii) Calculate the force constant for the wire. (03 marks)

c. (iii) Find the frequency of oscillation. (03 marks)



(d) A rod CD 105 cm long whose weight is negligible, is supported at its ends by wires A and B of equal length as shown in the above diagram. The cross sectional areas of A and B are 1.0×10^{-4} m^2 and 2.0×10^{-6} m^2 respectively. Young's modulus for A is 2.4×10^{11} Pa and for B is 1.6×10^{11} Pa. At what point along the rod should a weight *W* be suspended in order to produce

(i) equal stresses in A and B (02 marks)

(ii) equal strains in A and B? (02 marks)

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Question 4:

(a) (i) Define the term ***coefficient of surface tension***? (01 mark)

(ii) Derive the *dimensions* of coefficient of surface tension. (02 marks)

(b) Describe and explain briefly two phenomena caused by surface tension. (06 marks)

(c) Show that the excess pressure inside an air bubble of radius r in a liquid of surface tension γ is $\frac{2\gamma}{r}$ (04 marks)

(d) The lower end of a capillary tube of internal diameter 0.8 mm is 20 cm below the surface of mercury whose coefficient of surface tension is 0.5 N m^{-1}. Calculate;

(i) the depression of the mercury (03 marks)

(ii) the rise of the mercury if the pressure in the tube is 9.1×10^4 N m^{-2} (04 marks)

(Angle of contact of mercury with glass = 180^0,

Atmospheric pressure = 1.01×10^5 N m^{-2}, Density of mercury = 13600 kg m^{-3})

SECTION B

Question 5:

(a) What assumptions are necessary in the derivation of the kinetic theory expression for the pressure of an ideal gas? (04 marks)

(b) A beam of 2×10^{22} nitrogen atoms each of mass 2.32×10^{-26} kg is incident

normally on a wall of a cubical container of edge length 10.0 cm. The beam is reflected through 180^0. If the mean speed of the atoms is 480 m s^{-1}, find the pressure exerted by the nitrogen gas. (04 marks)

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

(ii) Two containers A and B of volumes 3×10^3 cm^3 and 6×10^3 cm^3 respectively contain helium gas at a pressure of 1×10^3 Pa and a temperature of 27^0C. container A is heated to 100^0C while container B is cooled to 0^0C. Find the final pressure of the helium gas. (05 marks)

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(d) Explain the following in terms of the kinetic theory:

(i) A gas fills all the space in a vessel in which it is enclosed. (02 marks)

(ii) When the volume of a saturated vapour is decreased, the pressure remains constant. (02 marks)

(iii) A gas cools when it undergoes an adiabatic expansion. (02 marks)

Question 6:

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

(ii) Use the expression for the pressure of an ideal gas in terms of density and mean square speed of the molecules of a gas to derive Boyle's law. (04 marks)

(b) (i) Explain using kinetic theory, why nitrogen and oxygen are gases found in the atmosphere close to the earth's surface. (02 marks)

(ii) State the first law of thermodynamics. (01 mark)

(iii) Derive the relation between the principal molar heat capacities of gases using the first law of thermodynamics. (04 marks)

(c) Show that the work done by a gas against atmospheric pressure during expansion is the product of pressure and change in volume. (03 marks)

(d) An ideal gas of volume 1.0 litre at S.T.P. expands at constant pressure to a volume of 3.0 litres. Calculate

(i) the work done by the gas. (03 marks)

(ii) the final temperature of the gas. (02 marks)

(At STP, $T = 273$ K, $P = 1.0 \times 10^5$ Pa.)

Question 7:

(a) Define a black body. (01 mark)

(b) Assuming that the sun is a sphere of radius 7.0×108 m at a temperature of 6000 K, estimate the temperature of mars if its distance from the sun is 2.26×10^{11} m. (04 marks)

(c) The heat radiation received by the earth from the sun is 1.4×10^{3} W m^{-2}. Assuming that this is 90% of what the sun emits as a black body, estimate the temperature of the sun. (04 marks)

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(d) (i) Draw sketch graphs to show the variations of relative intensity of black body radiation with wavelength for three different temperatures.(02 marks)

(ii) Describe the features of the sketch graphs in (d) (i) above. (03 marks)

(e) (i) Distinguish between high grade and low grade energy, giving two examples of each. (03 marks)

(ii) Explain how green house effect causes global warming. (03 marks)

SECTION C

Question 8:

(a) (i) With the aid of a labelled diagram, describe how an ***X* – rays** are produced. (05 marks)

(ii) How do *X* – rays differ from beta particles? (02 marks)

(iii) Distinguish between *X* – ray production and the photo electric effect. (02 marks)

(b) A beam of cathode rays is directed midway between two parallel metal plates of length 4.0 cm and separation 1.0 cm. The beam is deflected through 10.0 cm on a fluorescent screen placed 20.0 cm beyond the nearest edge of the plates when a potential difference of 200 V is applied across the plates. If this deflection is annulled by a magnetic field of flux density 1.14×10^{-3} T applied normally to the electric field between the plates, find the charge to mass ratio of cathode rays. (06 marks)

(c) With the aid of a labelled diagram, describe and give the theory of a mass spectrometer for measuring the charge to mass ratio of positive ions. (05 marks)

Question 9:

(a) (i) What is meant by the term **Binding energy of a nucleus**? (01 mark)

(ii) Calculate the binding energy per nucleon of an alpha particle, expressing your result in MeV.

- Mass of a proton = 1.0080 u
- Mass of a neutron = 1.0087 u
- Mass of an $\alpha-$particle = 4.0026 u
- 1 u = 931 MeV (04 marks)

(ii) Sketch a graph of binding energy per nucleon against mass number and use it to explain liberation of energy by nuclear fusion and nuclear fission. (06 marks)

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(b) Derive an expression relating the half-life of a radioactive material, $T_{½}$ and the decay constant, λ. (03 marks)

(c) When $^{238}_{92}U$ decays, the end product is $^{206}_{82}Pb$. The half-life is 1.4×10^{17} s.

(d) Suppose a rock sample contains $^{206}_{82}Pb$ and $^{238}_{92}U$ in the ratio 1 : 5 by weight, calculate

(i) the number of $^{206}_{82}Pb$ atoms in 5.0 g of rock sample. (03 marks)

(ii) the age of the rock. (03 marks)

Assume decay law, $N = N_0 e^{-\lambda t}$

Question 10:

(a) State the laws of **photoelectric effect**. (04 marks)

(b) Describe an experiment to determine the stopping potential of a metal surface. (05 marks)

(c) A 100 mW beam of light of wavelength 4.0×10^{-7} m falls on caesium surface of a photocell.

(i) How many photons strike the caesium surface per second? (03 marks)

(ii) If 16% of the photons emit photoelectrons, find the resulting photocurrent. (03 marks)

(iii) Calculate the kinetic energy of each photon if the work function of caesium is 2.20 eV. (03 marks)

(d) Distinguish between continuous and line spectra in X-ray tube. (02 marks)

"GOOD LUCK"

****THE END****