P510/1
PHYSICS
Paper 1
July/August 2023
2½ hours

WAKISSHA JOINT MOCK EXAMINATIONS

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 silent 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 earth		=	$5.97 \times 10^{24} kg$
Planck's constant,	h	=	$6.6 \times 10^{-34} Js$
Stefan – Boltzmann's constant,	σ	=	$5.67 \times 10^{-8}\ Wm^{-2}K^{-4}$
Radius of the earth		=	$6.4 \times 10^{6} m$
Radius of the sun		=	$7.0 \times 10^{8} m$
Radius of earth's orbit about the sun		=	$1.5 \times 10^{11} m$
Speed of light in a vacuum		=	$3.0 \times 10^{8} m$
Specific heat capacity of water		=	$4{,}200 Jkg^{-1}K^{-1}$
Specific latent heat of fusion of ice		=	$3.34 \times 10^{5}\ Jkg^{-1}$
Universal gravitational constant,	G	=	$6.67 \times 10^{-11} Nm^{2}kg^{-2}$
Avogadro's number	N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Density of mercury		=	$13.6 \times 10^{3} kgm^{-3}$
Charge to mass ratio,	e/m	=	$1.8 \times 10^{11}\ Ckg^{-1}$
The constant $\frac{1}{4\pi\varepsilon_0}$		=	$9.0 \times 10^{9}\ F^{-1}m$
Density of water		=	$1000 kgm^{-3}$
Gas constant	R	=	$8.31 Jmol^{-1}K^{-1}$
Wien's displacement constant		=	$2.90 \times 10^{-3}\ m\ K$
Surface tension of soap solution		=	$2.0 \times 10^{-2}\ Nm^{-1}$
Electron charge to mass ratio, e/m		=	$1.8 \times 10^{11}\ C\ kg^{-1}$
One electron volt, (eV)		=	$1.6 \times 10^{-19}\ J$

Turn Over

SECTION A

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

(ii) Give **two** uses of dimensions of physical quantities. (01 mark)

(iii) The displacement, S, of a body moving with an initial speed, **u**, accelerating at a rate, **a,** to attain a velocity, **v,** is obtained from the expression:

$$S = \frac{v^2 - u^2}{2a},$$

Show that the above expression is dimensionally consistent.

(03 marks)

(b) (i) Distinguish between **perfectly elastic** and **perfectly inelastic collisions.**

(02 marks)

(ii) A car of mass m makes a head-on collision with another car of mass m_2 initially at rest. If the collision is perfectly elastic, show that;

$\frac{\Delta E}{E_o} = \frac{-4x}{(1+x)^2}$ where $x = \frac{m_2}{m_1}$. ΔE is the loss in kinetic energy of m_1 and E_0 is its initial kinetic energy. (05 marks)

(c) (i) Explain, using molecular theory, the origin of solid friction.

(03 marks)

(ii) A car of mass 1 tonne moves along a straight track with a speed of 72 kmh^{-1}. The car comes to a stop when brakes are steadily applied after travelling a distance of 0.09 km.
Calculate the coefficient of friction between the surface of the track and the tyres; and state the energy changes which occur as the car comes to rest.

(05 marks)

2. (a) Define the following terms:

(i) **Tensile stress** (01mark)

(ii) **Tensile strain** (01 mark)

(b) A copper wire is stretched until it breaks.

(i) Sketch a stress – strain graph for the copper wire and explain the main features of the graph. (04 marks)

(ii) Explain what happens to the energy used to stretch the copper wire at each stage. (04 marks)

(iii) Derive the expression for the work done to stretch the copper wire by a distance, e, if its force constant is K. (03 marks)

(c) A steel wire of cross-section area 1 mm^2 is cooled from a temperature of 40^0C to 20^0C.
Find the;
   (i) strain produced in the wire. (02 marks)
   (ii) force needed to prevent it from contracting. (03 marks)
   Take Young's modulus of steel = 2.0×10^{11} Pa,
   Coefficient of linear expansion = $1.1 \times 10^{-5} K^{-1}$.

(d) What is **work-hardening?** (02 marks)

3. (a) (i) Define **centripetal acceleration.** (01 mark)
   (ii) Explain why a racing car can travel faster on a banked track than on an unbanked track of the same radius. (03 marks)

(b) (i) State **Kepler's laws of planetary motion.** (03 marks)
   (ii) A satellite of mass 100 kg is launched in a parking orbit above the earth's surface. Calculate the height of the satellite above the earth's surface. (04 marks)

(c) (i) Define **simple harmonic motion.** (01 mark)
   (ii) The piston of a car engine performs simple harmonic motion. The piston has a mass of 500 g and its amplitude of vibration is 4.5cm. The revolution counter in the car reads 240 revolutions per minute.
   Show that the piston above performs simple harmonic motion and derive an expression for its period. (05 marks)
   Hence calculate the maximum force on the piston. (03 marks)

4. (a) (i) **Define surface energy.** (01 mark)
   (ii) Explain the effect of temperature on surface tension of a liquid. (03 marks)

(b) Describe an experiment to determine the angle of contact of a liquid using capillary method. (06 marks)

(c) (i) **State Bernoulli's principle.** (01 mark)
   (ii) Derive the principle in (c) (i) above. (03 mark)

(d) (i) Air flows over the upper surface of the wings of an aeroplane at a speed of 120 ms^{-1} and past the lower surface of the wings at 110 ms^{-1}. Calculate the lift force on the aeroplane, if it has a total wing area of 20 m^2. (Density of air is 1.29 kgm^{-3}). (03 marks)
   (ii) A person standing near a railway line experiences a force towards a fast moving train. Explain the observation. (03 marks)

Turn Over

SECTION B

5. (a) Define the following quantities;
   (i) **Thermometric property** (01 mark)
   (ii) **Heat capacity** (01 mark)

(b) State the type of thermometer you would use and justify your choice for each of the tasks below.
   (i) A gardener measuring the temperature of a green house. (02 marks)
   (ii) An engineer measuring the temperature at different points on the cylinder head of a car engine. (02 marks)

(c) (i) Describe an experiment to determine specific heat capacity of a liquid using the method of mixtures. (06 marks)
   (ii) When a current of 2.5 A is passed through a coil of constant resistance 20 Ω immersed in 600 g of water at O^0C in a vacuum flask, the temperature of water raises to 10^0C in 6 minutes. If instead the flask contained 300 g of water and 300 g of ice, what current must be passed through the coil if the mixture is to be heated to the same temperature in the same time? (05 marks)

(d) Explain why when starting fire, small pieces of charcoal or wood are required. (03 marks)

6. (a) (i) Define **specific molar heat capacity of a gas at constant pressure.** (01 mark)
   (ii) Explain why specific molar heat capacity at C_p constant pressure is greater than specific molar heat C_v capacity at constant volume. $C_p > C_v$ (02 marks)

(b) Show that $Cp - Cv = R$, where Cp is molar heat capacity at constant pressure, Cv is molar heat capacity at constant volume, and R is the molar gas constant. (04 marks)

(c) An ideal gas of specific heat capacity ratio $\gamma = 1.40$ is expanded adiabatically and reversibly from a pressure of 30 cmHg. It then undergoes a reversible isothermal compression to its original pressure. Finally it is expanded isobatically to its original volume.

   (i) Sketch the P – V diagram showing the above processes. (02 marks)
   Calculate;
   (ii) the volume at the end of the adiabatic expansion. (02 marks)
   (iii) the temperature at the end of the isothermal compression. (02 marks)

(d) (i) Define **saturated vapour pressure.** (01 mark)
   (ii) Describe an experiment to determine the temperature dependence of saturated vapour pressure of water by dynamic method. (06 marks)

7. (a) (i) Define **thermal conductivity.** (01 mark)
(ii) Explain the mechanism of heat transfer in glass. (03 marks)

(b) Describe the flow of heat along a;
(i) fully lagged metal bar. (02 marks)
(ii) un lagged metal bar. (02 marks)

(c) (i) Describe with the aid of a labelled diagram an experiment to determine the thermal conductivity of a poor conductor. (07 marks)

(ii) A piece of glass is cut into a thin disc of cross section area $40cm^2$ and thickness 20 mm. When sandwiched between two slabs and steam is passed through the chest, the temperatures of the disc above and below it are 30^0C and 10^0C respectively. The disc is cooled and placed on a heated slab of mass 250 g and specific heat capacity of 400 $Jkg^{-1}K^{-1}$. It absorbs heat and its temperature rises. Calculate the rate of temperature rise of the disc.
(Thermal conductivity of glass is 0.55 $wm^{-1}K^{-1}$). (05 marks)

SECTION C

8. (a) What is meant by the terms;
(i) **Unified atomic mass unit.** (01 mark)
(ii) **Nuclear fusion.** (01 mark)

(b) (i) The fusion reaction used in the generation of electricity is given by the equation ${}^3_1H + {}^2_1H \longrightarrow {}^4_2He + {}^1_1H$
Calculate the energy released in the reaction in joules.
Mass of ${}^3_1H$ = 3.015500 U
Mass of ${}^2_1H$ = 2.01355 U
Mass of ${}^4_2He$ = 4.001506 U
Mass of ${}^1_1H$ = 1.007276 U
(05 marks)

(ii) Explain **two** uses of isotopes. (04 marks)

(c) Define the following terms as applied to radioactivity.
(i) **Half – life** (01 mark)
(ii) **Decay constant** (01 mark)

(d) Describe briefly how the half-life of a ratio active material may be determined using a G–M tube. (03 marks)

(e) The initial activity of a sample of 1 mole of radon – 220 is $8.02 \times 10^{21} s^{-1}$.
Calculate:
(i) the decay constant of radon – 220. (02 marks)
(ii) the half-life of radon – 220. (02 marks)

Turn Over

9. (a) (i) What is meant by the term **"photon"** (01 mark)

(ii) State the **laws of photoelectric emission.** (04 marks)

(b) The work function of potassium is 2.25 eV. Light having a wavelength of 360 nm falls on the metal. Calculate;

(i) the stopping potential. (03 marks)

(ii) the speed of the most energetic elections emitted. (02 marks)

(c) (i) Define **specific charge.** (01 mark)

(ii) With the aid of a well labelled diagram, describe J.J Thomson's experiment for determination of specific charge of an electron. (06 marks)

(d) Electrons accelerated from rest through a potential difference of 3000 V enter perpendicularly a region of uniform magnetic field. If the flux density is 0.01 T. Calculate the radius of the electron orbit. (03 marks)

10. (a) (i) What are **x-rays?** (01 mark)

(ii) With the aid of a well labelled diagram, describe how x-rays are produced. (05 marks)

(iii) State the energy changes in the production of x-rays. (01 mark)

(b) (i) State **Bragg's law.** (01 mark)

(ii) An x-ray beam is produced when electrons accelerated through a p.d of 10 kV are stopped by a metal target. When the beam falls on a set of parallel atomic plates of a certain metal, at a glancing angle of 16^0, a first order diffraction maximum occurs. Calculate the atomic spacing of the planes. (04 marks)

(c) (i) What are **cathode rays?** (01 mark)

(ii) Explain the motion of an electron directed into a uniform magnetic field. (03 marks)

(iii) An electron accelerated from rest by a p.d of 100 V, enters perpendicularly into a uniform electric field of intensity 100 Vm^{-1}. Find the magnetic field density, *B*, which must be applied perpendicularly to the field so that the electron passes undeflected through the field. (04 marks)

END