P510/1
PHYSICS
Paper 1
Nov./Dec. 2025
2½ hours

UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

PHYSICS

Paper 1
(Theory)

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

This paper consists of ***three*** *Sections;* **A**, **B** *and* **C**.
Answer **five** *questions in all including at least* **one**, *but not more than* **two** *from each of the sections.*
Any additional question(s) answered will **not** *be marked.*
Begin answering each question on a fresh page.
Silent, non-programmable scientific calculators may be used.
Assume where necessary:

Acceleration due to gravity, g	$= 9.81\ m\ s^{-2}$
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	$= 6.6 \times 10^{-34}\ J\ s$
Stefan's – Boltzmann's constant, σ	$= 5.67 \times 10^{-8}\ W\ m^{-2}\ K^{-4}$
Radius of the earth	$= 6.4 \times 10^{6}\ m$
Radius of the sun	$= 7.0 \times 10^{8}\ m$
Radius of the earth's orbit about the sun	$= 1.5 \times 10^{11}\ m$
Speed of light in a vacuum, c	$= 3.0 \times 10^{8}\ m\ s^{-1}$
Thermal conductivity of copper	$= 390\ W\ m^{-1}\ K^{-1}$
Thermal conductivity of aluminium	$= 210\ W\ m^{-1}\ K^{-1}$
Specific heat capacity of water	$= 4{,}200\ J\ kg^{-1}\ K^{-1}$
Universal gravitational constant, G	$= 6.67 \times 10^{-11}\ N\ m^{2}\ kg^{-2}$
Surface tension of water	$= 7.0 \times 10^{-2}\ N\ m^{-1}$
Density of water	$= 1{,}000\ kg\ m^{3}$
Gas constant, R	$= 8.31\ J\ mol^{-1}\ K^{-1}$
Charge to mass ratio, e/m	$= 1.8 \times 10^{11}\ C\ kg^{-1}$
Avogadro's number, N_A	$= 6.02 \times 10^{23}\ mol^{-1}$

Turn Over

SECTION A

1. (a) Define **surface tension** in terms of;

(i) force. (*01 mark*)

(ii) work. (*01 mark*)

(b) (i) Derive an expression for excess pressure inside a soap bubble of radius, r. (*04 marks*)

(ii) Calculate the total pressure inside an air bubble of radius 1.0×10^{-5} m at a depth of 0.3 m below the surface of water. (*Atmospheric pressure is* 1.0×10^5 N m^{-2}.) (*03 marks*)

(iii) Find the height to which the mercury rises if the bubble in (b) (ii) is introduced into a manometer containing mercury. (*02 marks*)

(c) Two soap bubbles of radii, r_1 and r_2 are brought together so that the *combined bubble has a common interface of radius,* R_T. Given that $r_1 < r_2$, show that the radius of the interface is given by:

$$R_T = \frac{r_1 r_2}{r_2 - r_1}$$ (*05 marks*)

(d) Figure **1** shows sections of a capillary tube at pressures P_1, P_2 and P_3 as indicated in the figure **1**:

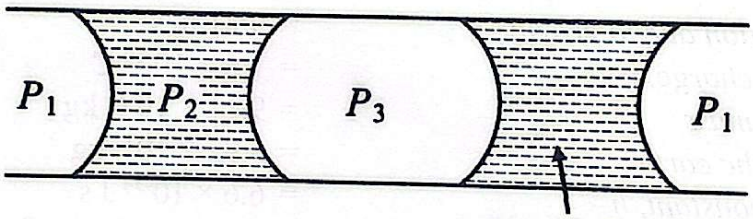

Fig. 1

If the radius of the tube is r, derive an expression for P_3 in terms of P_1. (*04 marks*)

2. (a) Derive the principle of conservation of energy using Newton's laws of motion. (*06 marks*)

(b) A particle of mass 5 g moving with a velocity of 10 m s^{-1} in a straight line strikes a stationery particle of mass 4 g. If the two particles collide inelastically, find their final velocity. (*02 marks*)

(c) (i) Two balls, A and B of masses m_1 and m_2, initially approaching each other with velocities u_1 and u_2 respectively, had a head-on collision. A continued in its original direction with velocity v_1 and B moved opposite to its original direction with a velocity v_2. If the collision is perfectly elastic, show that:

$$u_1 + u_2 = v_1 + v_2.$$

(05 marks)

(ii) Given that the mass of A is 2 kg and the mass of B is 3 kg, initially moving with velocities of 15 m s^{-1} and 20 m s^{-1} respectively, find the final velocity of A if the final velocity of B is 10 m s^{-2}. *(02 marks)*

(iii) State any **one** application of inelastic collision. *(01 mark)*

(d) Explain the motion of a rocket using the principle of conservation of momentum. *(04 marks)*

3. (a) Define Simple Harmonic Motion (S.H.M). *(01 mark)*

(b) Sketch the graphs for a body performing S.H.M for the following;
(i) velocity against displacement. *(02 marks)*
(ii) mechanical energy against displacement. *(02 marks)*

(c) A small bob of mass 0.2 kg is suspended by an inextensible string of length 0.8 m. If the bob is whirled in a horizontal circle of radius 0.4 m, find the;
(i) angular speed of the bob. *(03 marks)*
(ii) tension in the string. *(02 marks)*

(d) (i) State the law of floatation. *(01 mark)*
(ii) An object is immersed in a fluid. Show that the weight of the fluid displaced is equal to the upthrust exerted by the fluid on the object. *(04 marks)*

(e) A cylindrical vessel of cross-sectional area A, contains air of volume V at a pressure P trapped by a frictionless airtight piston of mass M. If the piston is pushed down and released;

(i) show that the resulting motion is simple harmonic.

(ii) find the frequency of the piston. *(05 marks)*

4. (a) State **Kepler's laws** of planetary motion. *(03 mark)*

(b) Derive Kepler's third law using Newton's law of gravitation. *(03 marks)*

(c) Describe the circumstances under which a body is said to be in a state of weightlessness. *(04 marks)*

(d) What is meant by **uniform velocity**? *(01 mark)*

(e) A bus travelling at a uniform velocity of 30 m s^{-1} passes a stationary car, which begins to move 10 s later with uniform acceleration of 4 m s^{-2} in the same direction as the bus. How far does the car travel before it catches up with the bus? *(04 marks)*

(f) A stone is projected from a level ground with a speed u, at an angle θ to the horizontal. Derive an expression for the horizontal distance the stone travels to the point of landing on the ground. *(05 marks)*

SECTION B

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

(ii) Explain the mechanism of heat conduction in an insulator. *(03 marks)*

(b) (i) With the aid of a labelled diagram, describe an experiment to determine the thermal conductivity of a poor conductor. *(08 marks)*

(c) (i) Explain how a black body may be approximated. *(03 marks)*

(ii) Solar radiation is incident on a planet whose distance from the sun is 2.3×10^{11} m. If the sun is a sphere of radius 7.0×10^{8} m and its temperature is 6,000 K, calculate the temperature of the surface of the planet. *(05 marks)*

6. (a) (i) State any **two** thermometric properties used in gas thermometers. *(01 mark)*

(ii) Why are different values of temperature obtained when a platinum resistance and liquid-in-glass thermometers are used to measure the same temperature of a liquid? *(01 mark)*

(b) In a constant-volume gas thermometer, the difference in the levels of mercury is -100 mm at melting pure ice, 140 mm at the temperature of steam at standard atmospheric pressure, and 30 mm at unknown temperature of a liquid. Calculate the temperature of the liquid. *(02 marks)*

(c) Define the following;

(i) specific heat capacity,

(ii) specific latent heat of vaporization, of a substance. *(02 marks)*

(d) (i) Describe, with the aid of a labelled diagram, the continuous-flow method for determining the specific heat capacity of a liquid. *(05 marks)*

(ii) When a potential difference (p.d) across a coil immersed in water is 5.25 V and the current through it is 2.58 A, a mass of 6.85 g of water evaporates in 20 minutes. Suppose a mass of 2.38 g of water evaporates in the same time duration when the p.d and current are maintained at 3.20 V and 1.57 A respectively, what is the specific latent heat of vaporisation of water? *(05 marks)*

(e) Explain the occurrence of;

(i) sea breeze, *(02 marks)*

(ii) land breeze. *(02 marks)*

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

(ii) Using a labelled diagram, describe an experiment to verify Boyle's law. *(05 marks)*

(b) (i) State **four** differences between real and ideal gases. *(04 marks)*

(ii) Using the same axes, sketch graphs of pressure against volume for an ideal gas at three different temperatures. *(02 marks)*

(c) (i) Define **saturated vapour pressure.** *(01 mark)*

(ii) A sealed container at a temperature of 27 °C contains air and saturated water vapour. The total pressure inside the container is 1.01×10^5 Pa. If the saturated vapour pressure of water at 27 °C is 2.0×10^3 Pa and at 80 °C is 3.51×10^3 Pa, calculate the total pressure inside the container at 80 °C, assuming the vapour pressure remains saturated. *(04 marks)*

(d) The root mean square speed of molecules of one mole of a gas is 44.72 m s^{-1}. Find the temperature of the gas if its density and volume are 9.0×10^{-2} kg m^{-3} and 42.0 m^3 respectively. *(03 marks)*

SECTION C

8. (a) (i) What is meant by cathode rays? *(01 mark)*

(ii) Distinguish between cathode rays and gamma rays. *(02 marks)*

(iii) Explain how cathode rays are produced. *(04 marks)*

(b) With the aid of a labelled diagram, describe an experiment to determine specific charge of an electron. *(06 marks)*

(c) An electron with energy of 480 eV moves at right angles to a uniform magnetic field of flux density 1.5×10^{-3} T:

(i) Show that the path of the electron is circular. *(03 marks)*

(ii) Find the radius of the circular path followed by the electron. *(04 marks)*

9. (a) Define the following;

(i) threshold frequency. *(01 mark)*

(ii) work function. *(01 mark)*

(b) Ultra violet (UV) light is directed onto a cleaned Zinc plate connected to the cap of a gold leaf electroscope. Explain the observations made when the gold leaf electroscope is;

(i) negatively charged, *(03 marks)*

(ii) positively charged. *(03 marks)*

(c) When a metal surface is illuminated by light of wavelength 0.50 μm, photoelectrons of maximum velocity 6.0×10^5 m s^{-1} are emitted. Calculate the;

(i) work function for the metal. *(04 marks)*

(ii) threshold frequency. *(02 marks)*

(d) (i) Sketch a graph to show a typical X-ray spectrum. *(02 marks)*

(ii) Explain the main features of the graph in (d) (i). *(04 marks)*

10. (a) (i) Define **radioactivity**. *(01 mark)*

(ii) With the aid of a labelled diagram, describe how a diffusion cloud chamber is used to detect the type of radioactive radiations. *(06 marks)*

(b) (i) Sketch a graph showing how current varies with applied voltage in an ionisation chamber. *(01 mark)*

(ii) Explain the main features of the sketched graph in (b) (i). *(03 marks)*

(iii) A source of α-particles has an initial activity of 2×10^5 disintegrations per second. When the α-particles enter an ionisation chamber, a saturation current of 2.0×10^{-7}A is obtained. If the energy required to produce an ion pair is 32 eV, find the energy of one α-particle. *(04 marks)*

(c) (i) State **four** uses of radio isotopes. *(02 marks)*

(ii) A small amount of radio isotope ^{24}Na is smeared on to a card and its activity falls by 87.5% in 45 hours. Find the half-life of ^{24}Na. *(03 marks)*

END