P510/1
PHYSICS
Paper 1
(Theory)
Nov./Dec. 2024
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, 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	=	$9.81\ ms^{-2}$
Electron charge, e	=	1.6×10^{-19} C
Electron mass	=	9.11×10^{-31} kg
Mass of the earth	=	5.97×10^{24} kg
Planck's constant, h	=	6.6×10^{-34} Js
Stefan's-Boltzmann's constant, σ	=	$5.67 \times 10^{-8}\ W\ m^{-2}\ K^{-4}$
Radius of the earth	=	6.4×10^{6} m
Radius of the sun	=	7.0×10^{8} m
Radius of the 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 copper	=	$390\ Wm^{-1}\ K^{-1}$
Thermal conductivity of aluminium	=	$210\ Wm^{-1}\ K^{-1}$
Specific heat capacity of water	=	$4{,}200\ J\ kg^{-1}\ K^{-1}$
Universal gravitational constant, G	=	$6.67 \times 10^{-11}\ N\ m^{2}\ kg^{-2}$
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	=	$1000\ kg\ m^{-3}$
Gas constant, R	=	$8.31\ J\ mol^{-1}\ K^{-1}$
Charge to mass ratio, e/m	=	$1.8 \times 10^{11}\ C\ kg^{-1}$

Turn Over

SECTION A

1. (a) What is meant by the following:

   (i) Momentum, *(01 mark)*

   (ii) Force, *(01 mark)*

   (iii) Elastic collision? *(01 mark)*

   (b) State Newton's laws of motion. *(03 marks)*

   (c) A car travelling at 108 kmh^{-1} collides head on with a massive wall and stops virtually instantly. A passenger of mass 80 kg, seated in the car and wearing a seat belt is brought to rest in 0.1 s.

   Find the;

   (i) force exerted by the seat belt on the passenger. *(03 marks)*

   (ii) energy absorbed in the seat belt system as a result. *(03 marks)*

   (d) (i) What is a dimensionless quantity? Give one example. *(02 marks)*

   (ii) Define impulse and derive its dimensions. *(03 marks)*

   (iii) Derive the relationship between power, force and velocity. *(03 marks)*

2. (a) Define the following:

   (i) Gravitational field strength. *(01 mark)*

   (ii) Parking orbit. *(01 mark)*

   (b) A rocket of mass *m,* is fired from the earth's surface so that it just escapes from the gravitational influence of the earth. If the radius of the earth is r, show that the velocity of escape *V,* is given by

   $V = \sqrt{2gr}$ *(03 marks)*

   (c) State **three** differences between free oscillations and damped oscillations. *(03 marks)*

   (d) Describe an experiment to determine the acceleration due to gravity, *g* using a helical spring, slotted masses, stop clock and a metre rule. *(06 marks)*

   (e) A communications satellite of mass 100 kg moves in a circular orbit round the earth at a distance of 3.2×10^6 m from the earth's surface. Calculate the;

   (i) period of revolution of the satellite. *(03 marks)*

   (ii) kinetic energy of the satellite. *(03 marks)*

3. (a) (i) Define the terms **static pressure** and **dynamic pressure** as applied to fluid flow. *(02 marks)*

(ii) Describe how the speed of flowing water can be obtained using Pitot-Static tubes. *(05 marks)*

(iii) State the assumptions made in (a) (ii). *(01 mark)*

(b) (i) State Bernoulli's principle. *(01 mark)*

(ii) Explain why gas in a Bunsen burner does not escape from the base of the burner but continues burning at the top. *(03 marks)*

(iii) A large tank contains water to a depth of 1.0 m. If a small hole is drilled in the tank at a depth of 20 cm below the top surface of the water, calculate the speed at which the water emerges from the hole. *(03 marks)*

(c) (i) State Archimedes' principle. *(01 mark)*

(ii) An alloy of mass 588 g and volume 100 cm^3 is made of iron of relative density 8.0 and aluminium of relative density 2.7. Find the proportion by volume of the alloy. *(04 marks)*

4. (a) (i) What is an elastic material? *(01 mark)*

(ii) Show that the energy, E, stored in a stretched elastic material of elastic constant, k, is given by

$E = \frac{1}{2}k\left(e_2^2 - e_1^2\right)$, where e_2 and e_1 are the extensions produced.

(04 marks)

(iii) Explain the energy transformations which occur during elastic deformation. *(03 marks)*

(b) (i) State the measurements taken in an experiment to determine Young's Modulus of a material in form of a wire. *(02 marks)*

(ii) Explain why in the experiment in (b) (i), two identical wires are used. *(02 marks)*

(c) Two wires each 2.0 m long, one of steel and the other of brass are suspended vertically from two points 0.10 m apart in the same horizontal plane. Their lower ends are fixed to a light horizontal bar at points 0.10 m apart. When a force of 100 N is applied vertically downwards to the centre of the bar, the bar tilts by 2° to the horizontal due to the brass wire stretching more than the steel.

Assuming that the wires are vertical and the diameter of each wire is 0.80 mm, calculate the;

(i) difference between the extensions in the wires. *(02 marks)*

(ii) extension produced in the brass wire.
[*Young Modulus for steel* = 2.0×10^{11} Nm^{-2}] *(06 marks)*

SECTION B

5. (a) Define the following:

   (i) Specific heat capacity. *(01 mark)*

   (ii) Latent heat. *(01 mark)*

   (b) (i) Describe an experiment to determine the specific heat capacity of a solid using the method of mixtures. *(06 marks)*

   (ii) State two precautions taken in (b) (i). *(02 marks)*

   (c) An electric heater of 2.2 kW was used to heat 2 kg of water, initially at 25 °C, in a kettle of heat capacity 400 J K^{-1} until the water boiled at 100 °C. The heating was continued for 3 more minutes and it was found that the mass of the water in the kettle was 1.802 kg.

   Calculate;

   (i) how long it took the water to boil.

   (ii) the specific latent heat of vapourisation of water. *(05 marks)*

   (d) Explain why the specific latent heat of vaporization is much higher than the specific latent heat of fusion for the same substance. *(05 marks)*

6. (a) Define the following;

   (i) saturated vapour. *(01 mark)*

   (ii) partial pressure of a gas. *(01 mark)*

   (b) (i) Explain the effect of increase in temperature on the saturated vapour pressure of a liquid. *(04 marks)*

   (ii) Describe an experiment to determine the saturated vapour pressure and boiling point of water. *(05 marks)*

   (c) (i) Define an ideal gas. *(01 mark)*

   (ii) What assumptions of the kinetic theory of an ideal gas need to be modified to account for the behaviour of real gases? *(02 marks)*

   (d) A sealed flask of volume 80 cm^3 contains argon gas at a pressure of 10 kPa and a temperature of 27 °C. Calculate the;

   (i) number of molecules of argon gas in the flask. *(03 marks)*

   (ii) root mean square speed of the molecules in the flask. (Molar mass of argon is 0.018 kg) *(03 marks)*

7. (a) State:

(i) Stefan's law of thermal radiation. *(01 mark)*

(ii) Wien's displacement law. *(01 mark)*

(b) Describe an experiment to show how the rate of heat loss from a body depends on the nature of the surface. *(04 marks)*

(c) (i) Describe an experiment to detect thermal radiation. *(03 marks)*

(ii) Explain the mechanism of heat transfer in fluids. *(03 marks)*

(d) Explain;

(i) what is meant by a perfect black body. *(01 mark)*

(ii) what is meant by quality of radiation. *(01 mark)*

(iii) why a black body at 1000 K is red hot whereas it is white hot at 2000 K. *(02 marks)*

(e) The element of an electric fire with an output of 0.5 kW, is a cylinder 20 cm long. The element behaves as a black body and when in use its temperature is 693.5 °C. Calculate the diameter of the element. *(04 marks)*

SECTION C

8. (a) What is meant by the following as applied to photoelectric effect:

(i) Threshold frequency, *(01 mark)*

(ii) Work function? *(01 mark)*

(b) Explain how the classical wave theory fails to account for the observation that photoelectric emission is an instantaneous process. *(03 marks)*

(c) In a laboratory demonstration of photoelectric effect, a freshly cleaned zinc plate is connected to a cup of a gold-leaf electroscope.

Explain what is observed when;

(i) the electroscope is given a negative charge and the zinc plate is illuminated by ultraviolet light. *(03 marks)*

(ii) the electroscope is given negative charge and the zinc plate is illuminated by infrared radiation. *(02 marks)*

(d) A narrow and parallel beam of monochromatic light of wavelength 546 nm and power of 0.080W is incident on a metal plate. Assuming 2.0% of the photons incident on the metal plate cause electron emission from the metal, find the photo current produced. *(05 marks)*

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(e) (i) State how the intensity and quality of X-rays produced in an X-ray tube can be controlled. *(02 marks)*

(ii) Calculate the smallest glancing angle at which X-rays of wavelength 7.0×10^{-11} m will be reflected from a crystal whose atomic plane spacing is 2.0×10^{-10} m. *(03 marks)*

9. (a) Define the following:

(i) Avogadro's constant. *(01 mark)*

(ii) Specific charge. *(01 mark)*

(b) With the aid of a labelled diagram, describe Thomson's experiment for determining specific charge. *(06 marks)*

(c) In Millikan's experiment, an oil drop falls with a steady velocity of 2.5×10^{-4} ms^{-1} when the p.d across the plates is zero. When the p.d between the plates is 2387 V, with the upper plate being positive, the oil drop just remains stationary. Given that the density of oil is 900 kgm^{-3}, viscosity of air is 1.8×10^{-5} Nsm^{-2} and the separation of the plates is 1.5 cm apart, calculate;

(i) the number of electronic charges on the drop. *(05 marks)*

(ii) the velocity with which the drop will move when it has collected two more electrons if the p.d between the plates remains unchanged. *(04 marks)*

(d) Explain how a Cathode Ray Oscilloscope can be used to measure an a.c voltage. *(03 marks)*

10. (a) Define the following:

(i) Mass number. *(01 mark)*

(ii) Half-life. *(01 mark)*

(b) State the law of radioactivity and use it to derive the decay law expression, $N = N_o^{-\lambda t}$. *(05 marks)*

(c) State two;

(i) uses of radioisotopes. *(02 marks)*

(ii) hazards due to radiations emitted by radioisotopes. *(01 mark)*

(d) (i) With the aid of a labelled diagram, describe how a diffusion cloud chamber works. *(07 marks)*

(ii) Sketch the nature of path formed by each of the ionising radiations in the cloud chamber. *(03 marks)*

END