P510/1
PHYSICS
(Theory)
Paper 1
Nov. /Dec. 2022
2½ hours

UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

PHYSICS

(THEORY)

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	$= 9.81\ \text{ms}^{-2}$.
Electron charge, e	$= 1.6 \times 10^{-19}\ \text{C}$.
Electron mass	$= 9.11 \times 10^{-31}\ \text{kg}$.
Mass of the earth	$= 5.97 \times 10^{24}\ \text{kg}$.
Plank's constant, h	$= 6.6 \times 10^{-34}\ \text{Js}$.
Stefan's Boltzmann's constant, σ	$= 5.67 \times 10^{-8}\ \text{Wm}^{-2}\ \text{K}^{-4}$
Radius of the earth	$= 6.4 \times 10^{6}\ \text{m}$.
Radius of the sun	$= 7 \times 10^{8}\ \text{m}$.
Radius of the earth's orbit about the sun	$= 1.5 \times 10^{11}\ \text{m}$.
Speed of light in a vacuum, c	$= 3.0 \times 10^{8}\ \text{m s}^{-1}$.
Thermal conductivity of copper	$= 390\ \text{Wm}^{-1}\ \text{K}^{-1}$.
Thermal conductivity of aluminium	$= 210\ \text{Wm}^{-1}\ \text{K}^{-1}$.
Specific heat capacity of water	$= 4200\ \text{J kg}^{-1}\ \text{K}^{-1}$.
Universal gravitational constant, G	$= 6.67 \times 10^{11}\ \text{Nm}^{2}\ \text{kg}^{-2}$.
Avogadro's number, N_A	$= 6.02 \times 10^{23}\ \text{mol}^{-1}$.
Surface tension of water	$= 7.0 \times 10^{-2}\ \text{Nm}^{-1}$.
Density of water	$= 1000\ \text{kgm}^{-3}$.
Gas constant, R	$= 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$.
Charge to mass ratio, e / m	$= 1.8 \times 10^{11}\ \text{C kg}^{-1}$.
The constant $\frac{1}{4\pi\varepsilon_0}$	$= 9.0 \times 10^{9}\ \text{F}^{-1}\ \text{m}$.
Faraday constant, F	$= 9.65 \times 10^{4}\ \text{C mol}^{-1}$.

SECTION A

1. (a) Define the following:

(i) Brittleness. *(01 mark)*

(ii) Elasticity. *(01 mark)*

(b) State **Hooke's law**. *(01 mark)*

(c) Figure **1** shows graphs of stress against strain for two metals ***X*** and ***Y***.

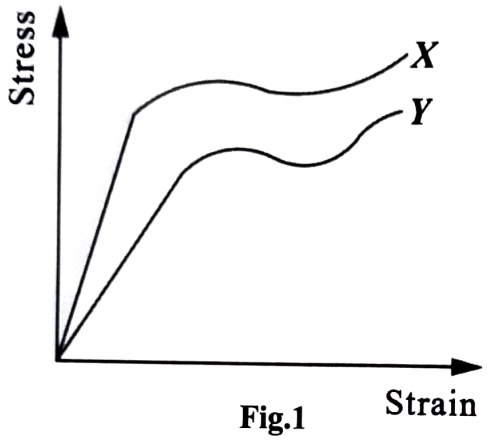

Fig.1

State and explain which metal;

(i) has a greater Young's modulus, *(02 marks)*

(ii) is more ductile, *(02 marks)*

(iii) is stronger than the other. *(02 marks)*

(d) Two wires P and Q of the same material have equal length but the radius of P is twice that of Q. Which wire;

(i) can withstand the greater load before breaking? *(02 marks)*

(ii) has the greater strain for a given load? *(02 marks)*

(e) A copper wire of length 4 m and cross sectional area 1.0×10^{-3} mm^2 is fixed between two rigid supports A and B, 4 m apart. What mass, when suspended at the middle of the wire will produce a sag of 1.5 m at that point? (*Young's modulus of copper* $= 1.2 \times 10^{11}$ *Pa*). *(04 marks)*

(f) Explain why water flowing out of a small hole at the bottom of a wide tank results in a backward force on the tank. *(03 marks)*

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

(ii) The velocity, v of a wave of wavelength, λ on the surface of a liquid of surface tension, γ and density, ρ, is given by $v^2 = \frac{\lambda g}{2\pi} + \frac{2\pi\gamma}{\lambda\rho}$, where g is the acceleration due to gravity. Show that the equation is dimensionally consistent. (*03 marks*)

(b) Figure **2** shows acceleration-time graph for a body of mass 10 kg which starts from rest and moves in a straight line.

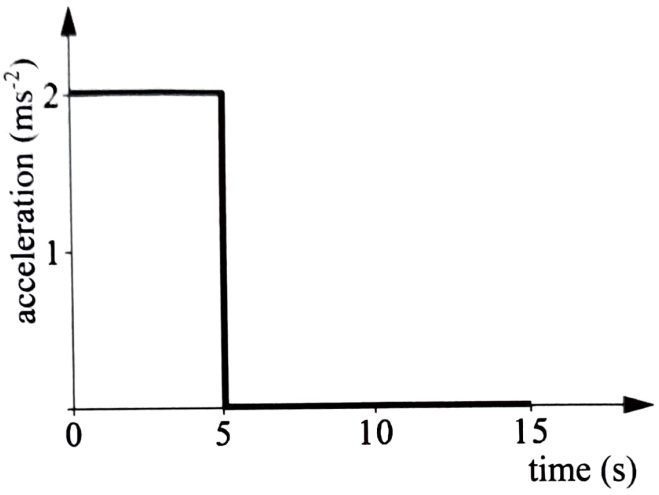

Fig.2

Use the graph to find the;

(i) distance travelled in 15 s. (*04 marks*)

(ii) average force acting on the body over the 15 s. (*03 marks*)

(c) With examples, explain any **two** of Newton's laws of motion. (*04 marks*)

(d) (i) State the principle of conservation of linear momentum. (*01 mark*)

(ii) A particle of mass, M_1 moving with a velocity, U_1 collides with a stationary particle of mass, M_2. The collision is elastic and the velocities of M_1 and M_2 after impact are v_1 and v_2 respectively. If the particles move in the same direction and $\alpha = \frac{M_2}{M_1}$, show that $U_1 = v_1 \frac{(1+\alpha)}{(1-\alpha)}$. (*04 marks*)

3. (a) (i) State **Bernoulli's principle**. (*02 marks*)

(ii) Explain with the aid of a diagram, why air flows over the wings of an aircraft causes a lift. (*02 marks*)

(b) Air flows over the upper surfaces of an aircraft's wings at a speed of 135 m s^{-1} and passed the lower surfaces of the wing at a speed of 120 m s^{-1}. (*04 marks*)

(i) Calculate the pressure difference due to the flow. (*02 marks*)

(ii) Determine the lift force on the air craft if the total wing area is 28 m^2. (*Assume density of air is 1.2 kg m^{-3}.*) (*02 marks*)

(c) (i) What is meant by **streamline flow**? (*02 marks*)

(ii) With the aid of a labelled diagram, describe how the velocity of a fluid flow can be measured. (*05 marks*)

(d) The depth of water in a tank of a large cross-sectional area is maintained at 2.0 m. If the water emerges out of the tank continuously through a hole of diameter 5 mm drilled at a height of 10.0 cm above the base of the tank, calculate the;

(i) speed at which water emerges out from the hole. (*03 marks*)

(ii) rate of mass flow of water from the hole. (*02 marks*)

4. (a) (i) Define **angular velocity**. (*01 mark*)

(ii) Explain why a body moving with constant speed along a circular path has an acceleration. (*03 marks*)

(iii) Derive an expression for the acceleration of a body moving in a circular path of radius r with a constant speed v. (*04 marks*)

(b) Define the following:

(i) Projectile motion. (*01 mark*)

(ii) Angle of projection. (*01 mark*)

(c) An object P is projected vertically upwards from the ground with a speed of 36 m s^{-1}. If object Q is dropped vertically above P from a height of 90 m above the ground after 2 s, find the;

(i) time when P and Q collide, from the time P was thrown upwards. (*07 marks*)

(ii) height above the ground where P and Q collide. (*03 marks*)

SECTION B

5. (a) Define the following:

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

(ii) specific latent heat of vaporisation. (*01 mark*)

(b) With the aid of a labelled diagram, describe an experiment to determine the specific latent heat of vaporization of a liquid. (*07 marks*)

(c) The inlet and outlet temperatures of water flowing in a continuous flow method are 15.2°C and 17.4°C respectively. A flow rate of 20 g min^{-1} is obtained when a current of 2.3 A flows and a p.d of 3.3 V is applied. When oil, which flows in and out at the same temperature as water is used, the flow rate obtained is 70.0 g min^{-1}. Calculate the specific heat capacity of oil, if a p.d 3.9 V is applied and a current of 2.7A flows. (*05 marks*)

(d) Explain the effect of pressure on:

(i) boiling point of a liquid. (*03 marks*)

(ii) melting point of ice. (*03 marks*)

6. (a) Define the following:

(i) Molar heat capacity of a gas at constant pressure. (*01 mark*)

(ii) Molar heat capacity of a gas at constant volume. (*01 mark*)

(b) Derive the expression $C_p - C_V = R$, where C_p is the molar heat capacity of a gas at constant pressure and C_V is the molar heat capacity of a gas at constant volume and R is the gas constant. (*05 marks*)

(c) (i) Differentiate between **adiabatic** and **isothermal** expansions. (*02 marks*)

(ii) State **two** examples of adiabatic changes. (*01 mark*)

(d) A fixed mass of an ideal gas of volume 400 cm^3 at 15 °C expands adiabatically and its temperature falls to 0 °C. It is then compressed isothermally until the pressure returns to its original value. If the molar heat capacity at constant pressure is 28.6 J $mol^{-1}K^{-1}$, calculate the final volume after isothermal compression. (*05 marks*)

(e) (i) What is **saturated vapour pressure** of a liquid? *(01 mark)*

(ii) Describe an experiment to show that a liquid boils when its saturated vapour pressure equals to the atmospheric pressure. *(04 marks)*

7. (a) Define the following: *(01 mark)*

(i) Temperature gradient. *(01 mark)*

(ii) Thermal conductivity.

(b) Explain why a poor conductor whose thermal conductivity is to be determined, must be thin and fairly of large surface area. *(03 marks)*

(c) With the aid of a labelled diagram, describe how the presence of radiation is detected by a bolometer connected to Wheatstone bridge. *(06 marks)*

(d) A metal sphere whose surface acts as a black body, is placed at the principal focus of a concave mirror of diameter 60 cm, which is directed towards the sun. If the solar radiation falling normally on the earth is 1400 Wm^{-2}, and the mean temperature of the surroundings is 30 °C, find the diameter of the sphere when the maximum temperature it attains is 1870 °C. *(06 marks)*

(e) State **three** properties of radiant energy. *(03 marks)*

SECTION C

8. (a) State any **four** properties of cathode rays. *(02 marks)*

(b) Show that the path of an electron projected at right angles to a uniform electric field is a parabola. *(05 marks)*

(c) Two metal plates each 5.0 cm long are held horizontally 4.0 cm apart in a vacuum, one being vertically above the other. The upper plate is at a potential of 400 V while the lower one is earthed. Electrons having a velocity of 1.0×10^7 ms^{-1} enter horizontally mid-way between the plates and in a direction parallel to the 5.0 cm edge. Calculate the vertical deflection of the electron as it emerges from the plates. *(04 marks)*

(d) (i) With the aid of a labelled diagram, describe how the specific charge of positive rays may be determined. *(06 marks)*

(ii) Explain how the set up in (d) (i) can be used to determine the abundance of isotopes. *(03 marks)*

9. (a) What is meant by **thermionic emission**? *(01 mark)*

(b) (i) Sketch the anode current versus anode voltage characteristics of thermionic diode. *(02 marks)*

(ii) Explain the main features of the curves. *(05 marks)*

(c) (i) With the aid of a diagram, describe the operation of a Cathode ray oscilloscope (C.R.O). *(06 marks)*

(ii) Describe the use of a time base in a C.R.O. *(02 marks)*

(d) Explain the wave form obtained on a C.R.O connected across the resistor R in the circuit shown in Figure **3**. *(04 marks)*

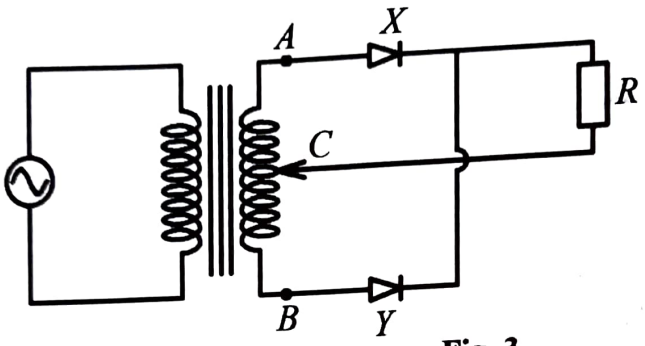

Fig. 3

10. (a) State **two** characteristics of a photo electric emission. *(02 marks)*

(b) (i) State **three** advantages of nuclear fusion over nuclear fission as a potential source of energy. *(03 marks)*

(ii) Why does nuclear fusion take place only at high temperatures? *(01 mark)*

(c) Given that;

mass of a proton = 1.0073 U,
mass of an electron = 0.0005 U,
mass of a neutron = 1.0087 U and
mass of $^{227}_{87}Fr$ = 223.0198 U.

(i) Calculate the difference in the mass between $^{227}_{87}Fr$ nucleus and the sum of the masses of its nucleons. *(05 marks)*

(ii) How is the difference in the masses in (c) (i) accounted for? *(02 marks)*

(d) (i) State **three** uses of X - rays. *(03 marks)*

(ii) Explain how quantum theory provides an explanation for the photoelectric effect. *(04 marks)*

END