P510/1
PHYSICS
(Theory)
Paper 1
Nov./Dec.2019
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	$= 9.81\ ms^{-2}$
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	$= 6.6 \times 10^{-34}\ Js$
Stefan's - 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	$= 7 \times 10^{8}\ m$
Radius of the earth's orbit about the sun	$= 1.5 \times 10^{11} m$
Speed of light in a vacuum, c	$= 3.0 \times 10^{8}\ ms^{-1}$
Thermal conductivity of copper	$= 390\ Wm^{-1}K^{-1}$
Thermal conductivity of aluminium	$= 210\ Wm^{-1}K^{-1}$
Specific heat capacity of water	$= 4{,}200\ Jkg^{-1}K^{-1}$
Universal gravitational constant, G	$= 6.67 \times 10^{-11}\ Nm^{2}\ kg^{-2}$
Avogadro's number, N_A	$= 6.02 \times 10^{23}\ mol^{-1}$
Surface tension of water	$= 7.0 \times 10^{-2}\ Nm^{-1}$
Density of water	$= 1000\ kgm^{-3}$
Gas constant, R	$= 8.31\ Jmol^{-1}\ K^{-1}$
Charge to mass ratio, e / m	$= 1.8 \times 10^{11}\ Ckg^{-1}$
The constant $\frac{1}{4\pi\varepsilon_0}$	$= 9.0 \times 10^{9}\ F^{-1}m$
Faraday constant, F	$= 9.65 \times 10^{4}\ Cmol^{-1}$

SECTION A

1. (a) (i) Distinguish between **scalar quantity** and **vector quantity**. (*01 mark*)

(ii) Give **two** examples of each type of quantity. (*02 marks*)

(b) A body of mass 0.2 kg at rest is acted on by four forces of 2.8 N, 6.0 N, 4.5 N and 1.2 N as shown in figure **1**.

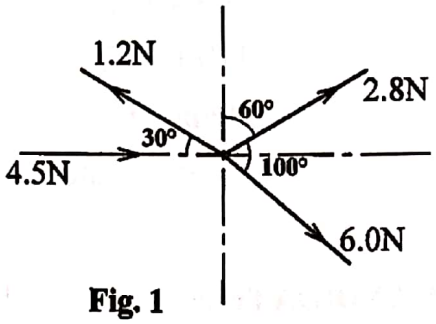

Fig. 1

Calculate the;

(i) resultant force on the body. (*04 marks*)

(ii) distance moved in 4s. (*02 marks*)

(c) State **Newton's laws of motion** and use them to derive the law of conservation of momentum. (*06 marks*)

(d) A body of mass 800 kg moving at 30 ms^{-1} collides with another body of mass 1400 kg moving in the same direction at 25 ms^{-1}. The two bodies stick together after collision. Calculate the;

(i) common velocity just after collision. (*02 marks*)

(ii) kinetic energy lost during the collision. (*03 marks*)

2. (a) Define **moment of a force** and give its SI unit. (*02 marks*)

(b) Explain briefly how to locate the centre of gravity of an irregular sheet of cardboard. (*04 marks*)

(c) State the conditions necessary for equilibrium of a rigid body under the action of a system of forces. (*02 marks*)

(d) A wheel of radius 0.5 m rests on a level surface at point ***C*** and makes contact with edge ***E*** of a block of height 0.2 m as shown in figure **2**.

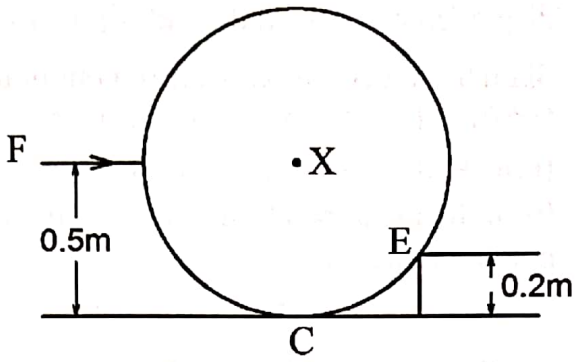

Fig. 2

A force ***F*** is applied horizontally through the axle of the wheel at ***X*** to just move the wheel over the block. If the weight of the wheel is 180 N, find the;

(i) force exerted at point ***E***. (*02 marks*)

(ii) force ***F***. (*04 marks*)

(e) State the **laws of solid friction** and explain each of them. (*06 marks*)

3. (a) Define the following as applied to circular motion:

(i) Centripetal acceleration. (*01 mark*)

(ii) Period. (*01 mark*)

(b) (i) Explain why a cyclist bends inwards while going round a curved path. (*03 marks*)

(ii) Show that if θ is the angle of inclination of the cyclist to the vertical and μ is the coefficient of limiting friction between the ground and the bicycle tyres, then for safe riding $\tan\theta \leq \mu$. (*04 marks*)

(iii) A body of mass 1.5 kg moves once round a circular path to cover 44.0 cm in 5.0 s. Calculate the centripetal force acting on the body. (*04 marks*)

(c) Define **simple harmonic motion**. (*01 mark*)

(d) A body executes simple harmonic motion with amplitude A and angular velocity ω.

(i) Write down the equation for the velocity of the body at a displacement x from the mean position. (*01 mark*)

(ii) Sketch the velocity - displacement graph for the body in (d) (i) for $\omega < 1$. (*02 marks*)

(iii) If the body moves with amplitude 14.142 cm, at what distance from the mean position will the kinetic energy be equal to potential energy? (*03 marks*)

4. (a) State and illustrate **Archimedes Principle**. (*05 marks*)

(b) (i) State the **law of floatation**. (*01 mark*)

(ii) Describe an experiment to verify the law in (b) (i). (*05 marks*)

(c) (i) Write **Bernouli's equation** and define each term in the equation. (*02 marks*)

(ii) Explain the origin of the lift force on the wing of a plane. (*03 marks*)

(iii) Air flows over the upper surfaces of the wings of an aeroplane at a speed of 120 ms^{-1}, and past the lower surfaces 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 = 1.29 kgm^{-3}*) (*04 marks*)

SECTION B

5. (a) (i) State any **three** properties of ultraviolet radiation. (*03 marks*)

(ii) What is a **black body**? (*01 mark*)

(b) A cylindrical metal rod with a well insulated curved surface has one end blackened and then exposed to thermal radiation from a body at a temperature 500 K. If the equilibrium temperature of the blackened end is 400 K and the length of rod is 10 m, calculate the temperature of the other end. (*Thermal conductivity of the metal = 500 $Wm^{-1}K^{-1}$*). (*04 marks*)

(c) (i) Describe an electrical method of determining the specific heat capacity of a good conducting solid. (*06 marks*)

(ii) Give any **two** reasons why the value obtained using the method in (c)(i) may **not** be accurate. (*02 marks*)

(d) Explain why cloudy nights are warmer than cloudless ones. (*04 marks*)

6. (a) (i) What is meant by a **reversible** process? *(02 marks)*

(ii) Distinguish between a **saturated** vapour and **unsaturated** vapour. *(02 marks)*

(iii) Explain why evaporation causes cooling. *(03 marks)*

(b) Describe an experiment to determine the temperature dependence of saturated vapour pressure of water. *(07 marks)*

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

(ii) A sealed container has liquid water, water vapour and air all at 27 ^{o}C. The total pressure inside the container is 69 cmHg.

When the temperature is raised to 85 ^{o}C, the total pressure changes to 96 cmHg.

If the saturation vapour pressure of water at 27 ^{o}C is 5 cmHg and the water vapour remains saturated, calculate the saturated vapour pressure of water at 85 ^{o}C. *(05 marks)*

7. (a) Define the following:

(i) Thermal conductivity, *(01 mark)*

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

(b) A boiler with a base made of steel 15 cm thick, rests on a hot stove. The area of the bottom of the boiler is 1.5×10^3 cm^2.
The water inside the boiler is at 100 ^{o}C. If 750 g of water is evaporated every 5 minutes, find the temperature of the surface of the boiler in contact with the stove.
(*Thermal conductivity of steel* = 50.2 Wm^{-1}K^{-1}, *Specific latent heat of vaporisation of water* = 2.26×10^6 Jkg^{-1}). *(04 marks)*

(c) Hot water in a metal tank is kept constant at 65 ^{0}C by an immersion heater in the water.
The tank has a lagging all round it of thickness 20 mm and thermal conductivity 0.04 Wm^{-1}K^{-1} and its surface area is 0.5 m^2.
The heat lost per second by the lagging is 0.8 W per degree excess above the surroundings.

Calculate the power of the immersion heater if the temperature of the surrounding is 15 ^{o}C. *(05 marks)*

(d) (i) Define a **thermometric** property. *(01 mark)*

(ii) Describe how a liquid-in-glass thermometer can be used to measure temperature in degrees Celsius. *(04 marks)*

(iii) A thermometer is constructed with a liquid which expands according to relation;

$$V_t = V_0(1+\alpha t+\beta t^2)$$

Where V_t is the volume at t °C and V_0 is the volume at 0 °C on the scale of the gas thermometer and α and β are constants.

Given that $\alpha = 1000\beta$, what will the liquid thermometer read when the gas thermometer reads 50 °C? *(04 marks)*

SECTION C

8. (a) (i) What are **cathode rays**? *(01 mark)*

(ii) State **two** properties of cathode rays. *(01 mark)*

(iii) Explain **two** disadvantages of using the discharge tube in producing cathode rays. *(02 marks)*

(b) With the aid of a diagram, describe **Millikan's experiment** to determine the charge on an oil drop. *(07 marks)*

(c) A beam of electrons is accelerated through a potential difference of 1.98 kV and directed mid-way between two horizontal plates of length 4.8 cm and separated by a distance of 2.0 cm. The potential difference applied across the plates is 80.0 V.

(i) Calculate the speed of the electrons as they enter the region between the plates. *(03 marks)*

(ii) Explain the motion of the electrons between the plates. *(02 marks)*

(iii) Find the speed of the electrons as they emerge from the region between the plates. *(04 marks)*

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

(ii) Describe how full-wave rectification of a.c can be achieved using four semiconductor diodes. *(04 marks)*

(b) (i) Draw a labelled diagram to show the main parts of a cathode ray oscilloscope (C.R.O). *(03 marks)*

(ii) Describe how a C.R.O can be used as an a.c voltmeter. *(02 marks)*

(c) (i) An electron of charge $-e$ and mass m moves in a circular orbit round a central hydrogen nucleus of charge $+e$. Derive an expression for the total energy of the electron in an orbit of radius r. *(05 marks)*

(ii) Why is the energy always negative? *(01 mark)*

(d) (i) What is meant by **excitation potential** of an atom? *(01 mark)*

(ii) Some of the energy levels in the mercury spectrum are shown in figure **3**.

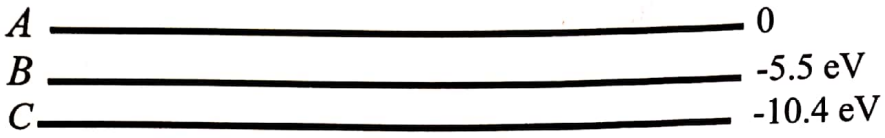

Figure 3

Calculate the wavelengths of the radiation emitted when electron makes a transition from level A to level C. *(03 marks)*

10. (a) What is meant by the following as applied to radioactivity?

(i) Activity. *(01 mark)*

(ii) Half-life of a radioactive material. *(01 mark)*

(b) Using the radioactive decay law $N=N_0 e^{-\lambda t}$, show that the half-life $T_{½}$ is given by;

$$T_{½} = \frac{0.693}{\lambda}.$$

(02 marks)

(c) With the aid of a labelled diagram, describe the action of an ionisation chamber. *(05 marks)*

(d) What is meant by **unified atomic mass unit** and **electron volt**. *(02 marks)*

(e) (i) The nucleus ${}^{212}_{83}Bi$ decays by alpha emission as follows;

$${}^{212}_{83}Bi \longrightarrow {}^{208}_{81}Tl + {}^{4}_{2}He$$

Calculate the energy released by 2 g of ${}^{212}_{83}Bi$. *(05 marks)*

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

END