P510/1
PHYSICS
(Theory)
Paper 1
Mar. 2021
2½ Hours

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	=	1.6×10^{-19}C
Electron mass	=	9.11×10^{-31} kg
Mass of the earth	=	5.97×10^{24}kg
Plank's constant, h	=	6.6×10^{-34}Js
Stefan's – Boltzmann's constant, σ	=	$5.67 \times 10^{-8}W\text{m}^{-2}\text{K}^{-4}$
Radius of earth	=	6.4×10^{6} m
Radius of the sun	=	7×10^{8} m
Radius of earth's orbit round the sun	=	1.5×10^{11} m
Speed of light in vacuum, c	=	3.0×10^{8} ms^{-1}
Specific heat capacity of water	=	4200 Jkg^{-1}K^{-1}
Specific heat capacity of copper	=	400 Jkg^{-1}K^{-1}
Young's modulus of steel	=	2.0×10^{11}Nm^{-2}
Young's modulus of copper	=	1.2×10^{11} Nm^{-2}
Avogadro's number, N_A	=	6.02×10^{23} mol^{-1}
Surface tension of water	=	7.0×10^{-2} Nm^{-1}
Density of water	=	1000 kgm^{-3}
Gas constant, R	=	8.31 J mol^{-1} K^{-1}
The constant $\frac{1}{4\pi\varepsilon_0}$	=	9.0×10^{9}F^{-1}m

SECTION A

1. (a) Define the terms
   - (i) Impulse (*01 mark*)
   - (ii) Power (*01 mark*)

   (b) (i) State Newton's laws of motion. (*03 marks*)
   - (iii) Explain how the law of conservation of energy applies to a simple pendulum pulled to one side and released. (*03 marks*)

   (c) (i) Distinguish between static friction and kinetic friction. (*02 marks*)
   - (ii) Describe briefly an experiment to determine the coefficient of static friction between a wooden block and a flat table. (*04 marks*)
   - (iii) List **two** ways by which the friction between the surfaces can be reduced. (*02 marks*)

   (d) A vehicle of mass 2000 kg travelling at 10 ms^{-1} along a horizontal surface is brought to rest in a distance of 12.5 m against a constant retarding force. Calculate the;
   - (i) retardation on the vehicle (*02 marks*)
   - (ii) power the engine must develop to take the vehicle up an incline of 1 in 10 at a constant speed of 10 ms^{-1} given that the frictional resistance to motion is 200N. (*02 marks*)

2. (a) Define the terms;
   - (i) Young's modulus (*01 mark*)
   - (ii) Elasticity (*01 mark*)

   (b) (i) State Hooke's law. (*01 mark*)
   - (ii) Sketch a graph of stress against strain for a ductile material and rubber on the same axes. (*02 marks*)
   - (iii) Explain the features of the curve for rubber. (*02 marks*)

   (c) (i) With the aid of a labeled diagram, describe an experiment to determine the Young's modulus of steel wire. (*06 marks*)
   - (ii) State **four** precautions necessary in the experiment in (c)(i) to ensure accuracy. (*02 marks*)

   (d) A copper wire and steel wire, each of length 1.5 m and diameter 2 mm are joined end-to-end to form a composite wire of length 3 m. The wire is loaded and its length becomes 3.003 m. Calculate the;
   - (i) strain in each of the wires (*03 marks*)
   - (ii) force applied (*02 marks*)

3. (a) Define the following;

(i) Gravitational potential. (*01 mark*)

(ii) Escape velocity. (*01 mark*)

(b) (i) State Kepler's laws of planetary motion. (*03 marks*)

(ii) A satellite of mass, m, is in a circular orbit around the earth at a distance, r, from the centre of the earth. Show that r is given by;

$r = \left(\frac{gT^2R^2}{4\pi^2}\right)^{\frac{1}{3}}$ where R is the radius of the earth and T is period of satellite? (*03 marks*)

(c) (i) Distinguish between **free oscillations** and **damped oscillations**. (*02 marks*)

(ii) Describe an experiment to determine the acceleration due to gravity using a simple pendulum. (*05 marks*)

(d) A spring of force constant 1200 Nm^{-1} is mounted on a horizontal frictionless table. One end of the spring is fixed and to the other end is attached a mass of 3.0 kg. The mass is pulled sideways to a distance of 2.0 cm and released. If the mass of the spring is negligible, calculate the;

(i) speed of the mass when the spring is compressed by 1.0 cm. (*03 marks*)

(ii) total energy of the oscillation. (*02 marks*)

4. (a) (i) Account for the existence of intermolecular forces. (*02 marks*)

(ii) Sketch a graph of potential energy against separation of two molecules in a substance and explain the main features of the graph. (*03 marks*)

(b) (i) Define *surface tension* in terms of surface energy. (*01 mark*)

(ii) Use the molecular theory to account for the surface tension of a liquid. (*03 marks*)

(iii) Show that the excess pressure, p, in an air bubble inside a liquid over outside pressure is given by $P = \frac{2\gamma}{r}$ where r is the radius of the bubble and γ its surface tension. (*04 marks*)

(c) A soap bubble of diameter 1 cm is formed at the top of a capillary tube of diameter 1 mm dipping into a beaker of water. If the surface tensions of water and soap solution are 7.0×10^{-2} and 3.0×10^{-2} Nm^{-1} respectively, calculate the height of the water in the capillary tube above the water and state any assumptions you have made. (*05 marks*)

(d) Explain why large mercury drops flatten out where as small ones assume spherical shapes. (*02 marks*)

SECTION B

5. (a) (i) Define the term **specific latent heat of vaporization**. (*01 mark*)

(ii) Explain briefly why temperature is constant when a solid is changing into a liquid. (*02 marks*)

(b) Describe with the aid of a labelled diagram, an electrical method for determination of specific latent heat of vaporization of a liquid. (*07 marks*)

(c) (i) Define the term **specific heat capacity of a substance**. (*01 mark*)

(ii) An electrical heater rated 500 W is immersed in a liquid of mass 2.0 kg contained in a large thermos flask of heat capacity 840 JK^{-1} at 28°C. Electrical power is supplied to the heater for 10 minutes. If the specific heat capacity of the liquid is 2.5×10^3 J kg^{-1}K^{-1}, its specific latent heat of vaporization is 8.54×10^3 Jkg^{-1}and its boiling point is 78°C, estimate the amount of liquid which boils off stating any assumptions made. (*06 marks*)

(d) (i) What is **boiling point of a liquid**? (*01 mark*)

(ii) Explain why extra pressure increases the boiling point of a liquid. (*02 marks*)

6. (a) (i) Explain the fact that the heat required to raise the temperature of a fixed mass of gas by 1 K at constant volume is different from that required when the pressure is kept constant. (*02 marks*)

(ii) Describe an experiment to verify Boyle's law. (*04 marks*)

(b) (i) State the conditions necessary for a reversible isothermal process. (*02 marks*)

(ii) A fixed mass of gas at a pressure P_1 and volume V_1 expands isothermally to a pressure P_2 and volume V_2. Derive an expression for the work done by the gas. (*04 marks*)

(c) A gas of volume 2 litres at a temperature of 27°C and pressure of 1.5×10^5 Pa is heated at constant pressure until its volume doubles. It is then cooled at constant volume back to its original temperature before finally being compressed isothermally to its original volume.
Draw a P-V diagram of the whole cycle and find the net work done by the gas. (*05 marks*)

(d) The pressure P of an ideal gas of density ρ is given by

$P = \frac{1}{3}\rho\overline{c^2}$ where $\overline{c^2}$ is the mean-square speed of its molecules.

Using this expression, show Avogadro's hypothesis. (*03 marks*)

7. (a) (i) Draw sketch graphs to show the variation of relative intensity of black body radiation with wavelength for three different temperatures. (*02 marks*)

(ii) Explain the appearance of a metal ball placed in a dark room when its temperature is progressively raised from room temperature to just below melting. (*03 marks*)

(iii) Explain why cavities in a fire look brighter than the rest of the fire. (*02 marks*)

(b) (i) State Wien's and Stefan's laws of black body radiation. (*02 marks*)

(ii) The intensity of radiant energy from a black body is a maximum at a wavelength of 1.5×10^{-6} m. Calculate the temperature of the black body. (*02 marks*)

(iii) Describe an experiment to compare surfaces as absorbers of radiation. (*04 marks*)

(c) The energy intensity received by a spherical planet from a star is $1.4 \text{ x } 10^3$ Wm^{-2}. The star is of radius $7.0 \text{ x } 10^5$ km and is $1.4\text{x}10^8$ km from the planet from the planet.

(i) Calculate the surface temperature of the star. (*04 marks*)

(ii) State any assumptions you have made in (c) (i) above. (*01 mark*)

SECTION C

8. (a) (i) Define the term **specific charge** of an electron. (*01 mark*)

(ii) Describe a laboratory experiment to determine the specific charge of an electron. (*06 marks*)

(b) The deflecting plates in a Thomson's set up are 5 cm long and 1.5 cm apart. The plates are maintained at a p.d of 240 V. Electrons accelerated to energy 2 KeV enter from one edge of the plates midway in the direction parallel to the plates. Calculate the vertical deflection on a screen placed 30 cm away from the other end of the plates. (*05 marks*)

(c) Explain the motion of an electron beam in a region of uniform magnetic field. (*03 marks*)

(d) (i) What is a **time base** as applied to a Cathode Ray Oscilloscope? (*01 mark*)

(ii) Draw a sketch graph showing the variation of time-base voltage with time. (*01 mark*)

(iii) An alternating $p.d$ applied to the Y-plates of an oscilloscope produces five complete waves on a 10 cm length of the screen when the time base setting is 10 mscm^{-1}. Find the frequency of the alternating voltage. (*03 marks*)

9. (a) (i) Ultraviolet radiation falls on Zinc plate placed on the cap of a neutral electroscope. Explain what is observed. (*03 marks*)

(ii) State the features of photoelectric effect. (*04 marks*)

(b) (i) Outline the processes involved in the production of X-rays in a modern X-ray tube. (*04 marks*)

(ii) How do **X-rays** differ from **positive rays**? (*02 marks*)

(iii) Distinguish between X-ray production and the photoelectric effect. (*02 marks*)

(c) In an X-ray tube operated at 1.5×10^5V, the target is made of material of specific heat capacity 2.5×10^2 J kg^{-1} K^{-1} and has a mass of 0.25 kg. Given that one percent of the electric power supplied is converted into X –rays and the rest dissipated as heat in the target. If the temperature of the target rises by 8 Ks^{-1}, find:

(i) the number of electrons which strike the target every second. (*03 marks*)

(ii) the shortest wavelength of X- rays produced. (*02 marks*)

10. (a) Define the following;

(i) mass defect. (*01 mark*)

(ii) isotopes. (*01 mark*)

(b) (i) Sketch a graph of binding energy per nucleon against mass number. (*02 marks*)

(ii) Explain how energy is released during nuclear fusion. (*03 marks*)

(c) (i) With the aid of a labeled diagram, describe the operation of a Geiger Muller (GM) tube. (*05 marks*)

(ii) What is meant by **background count rate**? (*01 mark*)

(iii) State **two** sources of background count rate. (*01 mark*)

(d) A freshly prepared sample of a radioactive isotope contains 10^{20} atoms. The half-life of the isotope is 12 hours. Calculate the

(i) initial activity. (*03 marks*)

(ii) number of radioactive atoms remaining after one hour. (*03 marks*)

END