UGANDA TEACHERS' EDUCATION CONSULT (UTEC)

Uganda Advanced Certificate of Education

PHYSICS

Paper 1

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

Attempt **FIVE** *questions, including at least* **one,** *but not more than* **two** *from each of the Sections* ***A, B*** *and* ***C.***

Assume where necessary:

Acceleration due to gravity	g	=	$9.81\ ms^{-2}$
Electron charge	e	=	$1.6 \times 10^{-19}\ C$
Electron mass		=	$9.11 \times 10^{-31} kg$
Radius of earth		=	$6.4 \times 10^{6}\ m$
Planck's constant	h	=	$6.6 \times 10^{-34} Js$
Speed of light in vacuum, c		=	$3.0 \times 10^{8} ms^{-1}$
Stefan's – Boltzmann's constant, σ		=	$5.67 \times 10^{-8}\ Wm^{-2}K^{-4}$
Wien's displacement constant		=	$2.90 \times 10^{-3}\ m\ K$
Specific heat capacity of water		=	$4.2 \times 10^{3}\ J\ kg^{-1}\ K^{-1}$
Universal gravitational constant, G		=	$6.67 \times 10^{-11} N\ m^{-2} kg^{-2}$
Charge to mass ratio, e/m		=	$1.8 \times 10^{11} C\ kg^{-1}$
Avogadro's number, N_A		=	$6.02 \times 10^{23} mol^{-1}$
The constant $\frac{1}{4\pi\varepsilon_o}$		=	$9.0 \times 10^{9} F^{-1} m$
One electron volt, (eV)		=	$1.6 \times 10^{-19} J$
Mass of the earth		=	$5.97 \times 10^{24} kg$
Mass of the sun		=	$2.0 \times 10^{30} kg$
Radius of the sun		=	$7.0 \times 10^{8} m$
Radius of earth's orbit round the sun		=	$1.5 \times 10^{11} m$
Density of water		=	$1000 kgm^{-3}$
Young's modulus of steel		=	$1.9 \times 10^{11} Pa$
Specific latent heat of vaporization of water		=	$2.3 \times 10^{6} Jkg^{-1}$

Turn Over

SECTION A

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

(ii) Use Newton's laws of motion to show how the principle in (a) (i) above is derived using to colliding bodies. *(04 marks)*

(b) A bullet of mass 25g, travelling horizontally at a speed of 200 ms^{-1}, imbeds itself in a wooden block of mass 5kg suspended by a cord 3m long. Find how far the string swings from its position of rest before beginning to return. *(04 marks)*

(c) A mass of 4kg lies on a rough plane which is inclined at 30° to the horizontal. A light inextensible string whose one end attached to this mass, passes up the line of greatest slope, over a smooth pulley fixed at the top of the plane and carries a freely hanging mass of 1kg at its other end. The tension in the string is just sufficient to prevent the 4kg mass from sliding down the slope.

(i) Explain why the pulley is smooth, the string is light and inextensible. *(04 marks)*

(ii) Find the coefficient of friction between the 4kg mass and the plane. *(04 marks)*

(d) Explain why a high jumper is advised to jump on a soft material instead of a hard ground. *(03 marks)*

2. (a) (i) Define simple harmonic motion. (s.h.m). (01 mark)

(ii) State two applications of s.h.m. (01 mark)

(b) (i) Mention the characteristics of simple harmonic motion. (02 marks)

(ii) Sketch a combined graph of kinetic energy and potential energy with Displacement for s.h.m. (02 marks)

(c)

The system above shows two springs S_1 and S_2 of force constants K and 2K respectively connected in series with the free end of S_1 fixed and the free end of S_2 attached to an object of mass **m** and lying in a horizontal position on a smooth table surface.

(i) If the mass is given a small horizontal displacement and released, show that it oscillates with a frequency $f = \frac{1}{2\pi}\sqrt{\frac{2K}{3m}}$ (05 marks)

(ii) Given that $K_1 = 80Nm^{-1}$, $K_2 = 100Nm^{-1}$ and that a horizontal pulling force of 4N is applied to the mass, calculate the total energy developed in the springs. (03 marks)

(d) (i) Explain the behavior of a speeding bodaboda cyclist on a level circular track. (03 marks)

(ii) A conical pendulum has a period of $\frac{\pi}{2}$ seconds when the string is inclined at an angle 30^{o} to the horizontal while carrying an object of mass 120g. Calculate the radius of the circle described. (03 marks)

3. (a) (i) Define the term *simple harmonic motion* (shm). *(01 mark)*

(ii) State four properties of simple harmonic motion. *(02 marks)*

(b) Sketch the following graphs for a body performing shm.

(i) Velocity against displacement. *(01 mark)*

(ii) Acceleration against displacement. *(01 mark)*

(i) Displacement against time. *(01 mark)*

(c) A U – tube is filled with oil to a height of 20cm in each limb. The liquid is set to oscillate between the two limbs by depressing one side.

(i) Show that the liquid oscillates with shm. *(04 marks)*

(ii) Calculate the period of oscillation given that the tube has uniform cross sectional area A m^2 and density of liquid is ϱ kgm^{-3}. *(02 marks)*

(d) (i) A small mass suspended from a light helical spring is drawn 1.5cm from its equilibrium position and released from rest. After 3 seconds the mass reaches this position once more. Find the position of the particle after 2 seconds from instant of release. *(04 marks)*

(ii) Explain why the oscillations in (d) (i) above finally dies. *(02 marks)*

4. (a) Define;

(i) A satellite (01 mark)

(ii) A parking orbit (01 mark)

(b) State the laws that govern motion of planets round the sun in the universe. (03 marks)

(c) (i) Explain how world – wide communication is received using satellites. (03 marks)

(ii) An artificial satellite orbits the Earth at a height of 42227km above the earth's surface. Calculate its period and comment on the result. (05 marks)

(d) Show that the height of artificial satellite while in a circular orbit round the earth in a region where acceleration due to gravity is one – nineth the acceleration due to gravity on the earth is $2r_2$ where r_2 is radius of the earth. (04 marks)

(e) The satellite in (d) above can be forced to reduce radius of orbit towards the earth. Explain the cause and resultant effect on it. (03 marks)

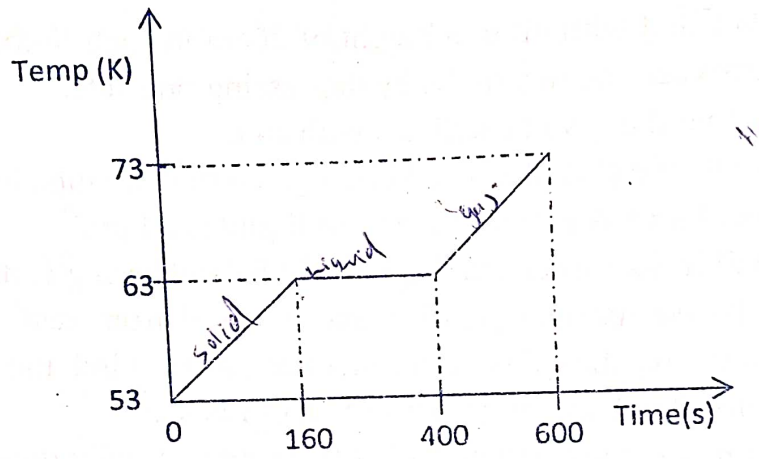
SECTION B

(a) Define the terms **latent heat** and **specific heat capacity** as applied to heat. *(02 marks)*

(b) (i) Describe how specific latent heat of vapourisation of a liquid can be obtained by an electric method. *(05 marks)*

(ii) Explain how heat loses from the liquid in (b) (i) is minimized. *(02 marks)*

(c) Figure 2 shows a graph of an experiment in which initially solid specimen of nitrogen absorbs heat at a constant rate. Nitrogen melts at 63K.



Calculate the;

(i) Specific latent heat of fusion of nitrogen. *(03 marks)*

(ii) Specific heat capacity of liquid nitrogen. *(02 marks)*

(d) (i) Define the terms molar heat capacity and principal specific heat capacity of a gas. *(02 marks)*

(ii) Derive the expression for the difference between molar heat capacities at constant pressure and constant volume with the Avogadro's number **R**. *(04 marks)*

6. (a) What is meant by the terms;

(i) *Adiabatic change.* *(01 mark)*

(ii) *Isothermal change* *(01 mark)*

(iii) State the conditions for each of the terms in (i) and (ii) above to occur. *(02 marks)*

(b) (i) What is meant by *saturated pressure*? *(01 mark)*

(ii) Describe an experiment in which the variation of the saturated pressure of water vapour with temperature can be determined. *(05 marks)*

(iii) Sketch the isothermal curve of pressure and volume for water vapour at 100°C. *(01 mark)*

(c) A closed vessel contains a mixture of air and water vapour at 27°C at a total pressure of 1.070×10^5 Nm^{-2}. The water vapour is just saturated at this temperature.
Calculate the;
(i) Pressure exerted by the air alone in the vessel when the temperature is raised to 40°C. *(02 marks)*
(ii) Total pressure in the vessel when the temperature is lowered to 12°C. *(02 marks)*

(d) Explain the following observations;
(i) When some water is introduced in an evacuated flask, some of the water evaporates but subsequently the volume of water present remains constant. *(02 marks)*
(ii) Water can be heated by stirring. *(02 marks)*

7. (a) (i) What is meant by *black body radiation.* *(01 mark)*
(ii) Explain why a hollow sphere with a pinhole outlet approximates a black body. *(03 marks)*
(iii) Describe the characteristic features of a relative intensity distribution curves for a black body. *(03 marks)*

(b) (i) Describe with the aid of a labeled diagram, the structure of a sensitive infra-red detector and explain how it works. *(04 marks)*
(ii) Calculate the frequency of maximum intensity of the radiation produced by an element of an electric fire at 1150 K. *(03 marks)*

(c) (i) Define *thermal conductivity* and state its dimensions. *(02 marks)*
(ii) A sheet of rubber and a sheet of cardboard, each 2mm thick, are pressed together and their out faces maintained at 0°C and 25°C respectively. Find the quantity of heat which flows in 1 hour across a piece of the composite sheet of area $100cm^2$. (Thermal conductivities' of rubber and card board are respectively 0.13 and 0.05 $Wm^{-1}K^{-1}$). *(04 marks)*

SECTION C

8. (a) Define;
(i) Atomic number (01 mark)
(ii) Activity (01 mark)
(b) Describe how a Geiger Muller tube (G.M) is used to detect ionizing radiations. (05 marks)

(c) Alpha particles of total energy 5Mev enter a GM – tube and cause ionization. If each ion pair requires 50eV of energy to be formed. Calculate the number of ionizations per millimeter in a range of 20mm. (03 marks)

(d) (i) A radioactive sample has original mass 1g. show that $T_{\frac{1}{2}} = \frac{0.693}{\lambda}$ where $T_{\frac{1}{2}}$ is half life and λ is decay constant. (03 marks)

(ii) Mention the two factors which determine activity of a radioactive material. (02 marks)

(e) An atom $^{235}_{92}U$ is bombarded by a neutron and splits to form two atoms $_{42}X - 144$, $_{50}Y - 84$ and releases eight neutrons with release of energy. Given that;

$^{235}_{92}U = 233.132U$

$^{144}_{42}X = 144.212U$

$^{84}_{50}Y = 81.413U$

$^{1}_{0}n = 1.009U$

$^{1}_{1}P = 1.007U$

$1U = 931\ MeV$

(i) Write the equation of the reaction. (01 mark)

(ii) Calculate the energy released by 50g of $U - 235$. (05 marks)

9. (a) (i) What is meant by the terms **ionization energy** and **excited state of an atom**? *(02 marks)*

(ii) Calculate the wave length of the photon emitted when a hydrogen atom returns to the ground state from the first excited state at 3.4eV. *(03 marks)*

(b) (i) Describe Rutherford's experiment and explain the conclusion. *(06 marks)*

(ii) An alpha particle with initial kinetic energy of 1.6 x 10-13J is directed towards the nucleus of nuclear charge +50e. Calculate the nearest distance of approach of the alpha particle to the nucleus. *(03 marks)*

(c) Explain why the emission spectrum of the hydrogen atom consists of a series of lines. *(04 marks)*

(d) What is meant by **absorption spectrum?** *(02 marks)*

10. (a) (i) What are *energy levels*? *(01 mark)*

(ii) Explain how a characteristic emission spectrum of an element is formed. *(03 marks)*

(b) With the aid of a labeled diagram, explain the observations made in a gas-tube at constant p.d when pressure is gradually reduced. *(06 marks)*

(c) In an X-ray tube, operated at 1.3×10^3 V, the target is made of a material of specific heat capacity of 2.3×10^2 J kg^{-1} and has a mass of 0.23 kg. One percent of the electric power supplied is converted into X-rays and the rest is dissipated as heat in the target. If the temperature of the target rises by 8 Ks^{-1}, find the;

(i) number of electrons which strike the target every second. *(04 marks)*

(ii) shortest wavelength of X-rays produced. *(01 mark)*

(d) (i) State Bragg's law of X-ray diffraction. *(01 mark)*

(ii) Describe an experiment to show the wave nature of X-rays. *(03 marks)*

END