P510/1
PHYSICS
Paper 1
July/August, 2023
2½ hours

MATIGO MOCK EXAMINATIONS BOARD
Uganda Advanced Certificate of Education
PHYSICS
Paper 1

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

*Attempt not more than **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

Where necessary, assume the following constants:

Acceleration due to gravity, g	=	$9.81\ m\ s^{-2}$
Electronic charge, e	=	$1.6 \times 10^{-19}C$
Electronic mass	=	$9.11 \times 10^{-31}kg$
Avogadro's number, N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Mass on earth	=	$5.97 \times 10^{24}kg$
Charge to mass ratio of an election	=	$1.8 \times 10^{11}CKg^{-1}$
One electron volt, eV	=	$1.6 \times 10^{-19}\ J$
Planck's constant, h	=	$6.6 \times 10^{-34}\ J\ s$
Radius of the earth	=	$6.4 \times 10^{6}m$
Specific heat capacity of water	=	$4.2 \times 10^{3}\ J\ kg^{-1}K^{-1}$
Specific latent heat of fusion of ice	=	$3.36 \times 10^{3}JKg^{-1}K^{-1}$
Stefan's – Boltzmann's constant, δ	=	$5.67 \times 10^{-8}\ W\ m^{-2}K^{-4}$
Speed of light in Vacuum, c	=	$3.0 \times 10^{8}\ m\ s^{-1}$
Unified mass unit, U	=	$1.66 \times 10^{-27}\ kg$
Universal gravitational constant, G	=	$6.67 \times 10^{-11}NM^2Kg^{-2}$
Gas constant, R	=	$8.31Jmol^{-1}K^{-1}$
Permittivity of free space, ϵ_0	=	$8.85 \times 10^{-12}Fm^{-1}$

SECTION A

1. **(a)** State:

(i) The law of conservation of linear momentum (1 mark)

(ii) The work energy theorem (1 mark)

(b) Distinguish between elastic and inelastic collisions (2 marks)

(c) A climber is supported by a rope on a vertical wall as shown in figure 1

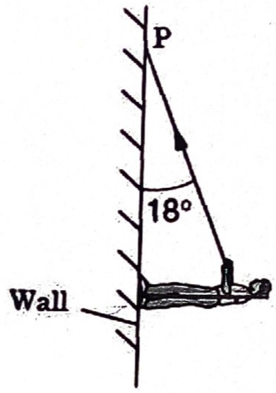

figure 1

The weight of the climber 520N. The rope of negligible weight is attached to the climber and to a fixed point P where it makes an angle of 18^0 to the vertical. The reaction force R acts at right angles to the wall. The climber is in equilibrium

(i) Copy and complete figure 1 by drawing a labelled vector triangle to represent the forces acting on the climber

(ii) Calculate the tension, T in the rope (4 marks)

(iii) Find the reaction force, R (4 marks)

(iv) The climber moves up the wall and the angle the rope makes with vertical increases. Explain why the magnitude of the tension in the rope increases (3 marks)

(d) A ball of mass 100g is attached to the end of a string and is swung in a circle of radius 100cm at a constant velocity of 200cms^{-1} while in motion the string is shortened to 50cm. calculate;

(i) the new velocity of the motion

(ii) the new period of the motion (2 marks)

(2 marks)

2. **(a)** State **Newton's law of universal gravitation** and hence determine the dimensions of G, the universal gravitational constant. (3 marks)

(b) Derive the relationship between the acceleration due to gravity and the mean distance from the centre of the earth:

(i) Inside the earth (4 marks)
(ii) Outside the earth (3 marks)
(iii) Hence show the relationship graphically (3 marks)

(c)(i) What do you understand by the term escape velocity? (1 mark)

(ii) Calculate the escape velocity from the moon's surface given that a man on moon has $\frac{1}{6}$ his weight on earth. The radius of the moon is 1.75×10^6m

(4 marks)

(d) Explain why the gravitational force of attraction between two bodies of ordinary mass is not noticeable in everyday life. (2 marks)

3. **(a)** Define simple harmonic motion. (1 mark)

$9.81 \times 1/6$

29fen.

(b) Two simple pendulums of length 0.4m and 0.6m respectively are set oscillating in step.
(i) After what further time will the two pendulum be in step again. (3 marks)

(ii) Find the number of oscillations made by each pendulum during the time in **(i)** above. (2 marks)

(c) Give two examples of S.H.M which are of importance to everyday life experience (1 mark)

(d)(i) State **Hooke's law** (1 mark)

(ii) A uniform steel rod of cross sectional area $0.002m^2$ and length1.5m is stretched steadily until it breaks. The rod is found to break at stretching force of 250,000N. Explain why the stress at the section of the rod where the break occurs is likely to be much greater than $125{,}000 KNm^{-2}$ (4 marks)

(e)(i) Distinguish between static and dynamic friction (2 marks)

(ii) Briefly explain how you will determine the coefficient of viscosity of a liquid by a constant pressure head apparatus in the laboratory. (6 marks)

4. **(a)(i)** State **Archimedes' Principle** (1 mark)

(ii) Use a block of wood of cross sectional area A which is immersed in a liquid of density ρ to prove the principle in (a)(i) above. (3 marks)

(b)(i) State the **law of flotation** (1 mark)

(ii) Air flows over the upper surfaces of the wings of an aeroplane at a speed of $120ms^{-1}$ and past the lower surfaces of the wings at $115ms^{-1}$. Calculate the lift force on the aeroplane if it has a total wing area of $15m^2$.
(Density of air= $1.28kgm^{-3}$) (4 marks)

(c)(i) Write down **Bernoulli's Equation.** (2 marks)

(ii) Explain one application of **Bernoulli's principle** (4 marks)

(iii) Explain why we should blow over a piece of paper not under it to keep it horizontal. (5 marks)

SECTION B

5. **(a)(i)** What is meant by black body radiation? (1 mark)

(ii) Write down a formula for the rate of cooling under convection and define all the symbols used. (2 marks)

(b) Heat is supplied at a rate of 80W to one end of a well lagged copper bar of uniform cross section area $10cm^2$ having a total length of 20cm. the heat is removed by water cooling at the other end of the bar. Temperature recorded by two thermometers T_1 and T_2 at distances 5cm and 15 cm from the hot end are 48^0C and 28^0C respectively.

(i) Calculate the thermal conductivity of copper (3 marks)

(ii) Estimate the rate of flow (in g/min) of cooling water sufficient for the water temperature to rise by 5K. (3 marks)

(iii) What is the temperature at the cold end of this bar? (3 marks)

(c)(i) Define specific heat capacity and state its units. (2 marks)

(ii) Describe how would measure by electrical method, the specific heat capacity of a metal (6 marks)

6. **(a)** Define;

(i) Thermal conductivity of a material (1 mark)

(ii) Specific latent heat of vaporization of a substance (1 mark)

(b) What does one require in order to establish a scale of temperature?

(2 marks)

(c) A copper constantan thermocouple with its cold junction at 0^0C had an emf of 4.28mV when its other hot junction was at 100^0C. The emf became 9.29mV when the temperature of the hot junction was 200^0C. if the emf, E is related to the temperature difference θ between hot and cold junctions by the equation

$E = A\theta + B\theta^2$, Calculate:

(i) The values of A and B (4 marks)

(ii) The range of temperature for which, E may be assured proportional to θ without incurring an error of more than 1% (3 marks)

(d) The resistance R_t of a platinum varies with temperature, t according to the equation $R_t = R_0(1 + 8000bt - bt^2)$ where b is a constant. Calculate the temperature on platinum scale corresponding to 400^0C on the gas scale

(5 marks)

(e) Describe the working of a liquid in a glass thermometer. (5 marks)

7. (a)(i) Distinguish between saturated vapour and unsaturated vapour.

(2 marks)

(ii) A uniform bore narrow tube close at one end has some air entrapped by a small quantity of water. If the pressure of the atmosphere is 760mmHg, the equilibrium vapour pressure of water at 15^0C and at 40^0C is 11.2mmHg and 45.0mmHg respectively and the length of the air column at 15^0C is 10cm. calculate its length at 40^0C.

(5 marks)

(c)(i) State Dalton's law of partial pressures (1 mark)

(ii) Use the equation of pressure of an ideal gas, $P = \frac{1}{3}\rho C^2$, to prove the law in (c)(i) above.

(5 marks)

(d) Oxygen is confined at 0^0C and standard pressure. The pressure of a gas is then increased at constant volume until the pressure is doubled. Find the root mean square speed of the molecules of oxygen at this temperature. (5 marks)

(e) Explain the effect of temperature on saturated vapour pressure of a liquid.

(2 marks)

SECTION C

8. (a) what is (1 mark)
   - (i) Nuclear fusion (1 mark)
   - (ii) Nuclear fission

   (b)(i) Sketch the variation of binding energy per nucleon against mass number. (1 mark)

   (ii) Use the curve in (b)(i) above to explain the origin of fusion and fission (4 marks)

   (c) In the following nuclear reactions find the values of x, y and z (3 marks)

   (i) ${}^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{x}_{1}H + {}^{1}_{1}H + 40MeV$

   (ii) ${}^{3}_{1}H + {}^{2}_{1}H \rightarrow {}^{y}_{1}H + {}^{1}_{0}n + 17.6MeV$

   (iii) ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{z}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n + E$

   (d)(i) Define photoelectric emission (1 mark)

   (ii) Write Einstein's equation defining each term in the equation. (2 marks)

   (iii) Describe an experiment to verify the equation for the kinetic energy of photoelectrons and show how plank's constant can be obtained. (7 marks)

9. **(a)(i)** What is meant by a radio isotope? (1 mark)

   (ii) Briefly explain why a radioactive decay is described as a 'spontaneous' process? (2 marks)

   (b) Given that the rate of decay, $\frac{dM}{dt} = -\gamma M$, where M is the number of atoms remaining at time, t and γ is the decay constant. Find the expression for the value of M given that $M = M_0$ when t = 0. (3 marks)

   (c)(i) A sample of radioactive element 'has a half-life of 80 years' what is the meaning of the above statement. (1 mark)

   (ii) Express half-life in terms of the decay constant. (1 mark)

   (iii) A radioactive waste has a half-life of 29200 days, how long will it take for its activity to fall to 20% of its current value. (3 marks)

(d)(i) Describe the operation of a Geiger Muller Tube. (5 marks)
(ii) Sketch the characteristics curve for a G.M.T and explain its shape. (4 marks)

10. (a) Explain what is meant by the Bohr model of the atom. (3 marks)
(b) Draw the main spectral transition of atomic hydrogen. Name the series formed. (3 marks)
(c) Show that the radius, r of allowed Bohr orbits in a hydrogen atom is given by:

$$r = \frac{n^2 h^2 \varepsilon_0}{\pi m e^2}$$

$$where; n = principal\ quantum\ number$$
$$h = plank's constant$$
$$m = mass\ of\ an\ electron$$
$$e = change\ on\ an\ electron$$

(4 marks)

(d) The diagram below represents the lower energy level of the electron in the hydrogen atom.

$n = 5$ ______________ $-0.54eV$
$n = 4$ ______________ $-0.85eV$
$n = 3$ ______________ $-1.50eV$
$n = 2$ ______________ $-3.40eV$
$n = 1$ _ground state_ $-13.6eV$

(i) Define electron Volt (eV) (1 mark)
(ii) Explain why the energy levels labeled with negative energies? (1 mark)
(iii) Calculate the wavelength of the line arising from a transition from $n = 3$ to $n = 2$, indicating the region of the electro- magnetic spectrum in which it occurs. (4 marks)
(iv) Calculate the speed of the electron which could just ionize the hydrogen atom. (4 marks)

END

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