P510/1
PHYSICS
Paper 1
July/August 2019
2½ hours

WAKISSHA JOINT MOCK EXAMINATIONS

Uganda Advanced Certificate of Education

PHYSICS

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 silent 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 earth		=	$5.97 \times 10^{24} kg$
Planck'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		=	$7.0 \times 10^{8} m$
Radius of earth's orbit about the sun		=	$1.5 \times 10^{11} m$
Speed of light in a vacuum		=	$3.0 \times 10^{8} m$
Specific heat capacity of water		=	$4,200 Jkg^{-1}K^{-1}$
Specific latent heat of fusion of ice		=	$3.34 \times 10^{5}\ Jkg^{-1}$
Universal gravitational constant,	*G*	=	$6.67 \times 10^{-11} Nm^{2}kg^{-2}$
Avogadro's number	N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Density of mercury		=	$13.6 \times 10^{3} kgm^{-3}$
Charge to mass ratio,	*e/m*	=	$1.8 \times 10^{11}\ Ckg^{-1}$
The constant $1/4\pi\varepsilon_0$		=	$9.0 \times 10^{9}\ F^{-1}m$
Density of water		=	$1000 kgm^{-3}$
Gas constant	*R*	=	$8.31 Jmol^{-1}K^{-1}$

SECTION A

1. (a) (i) State **Newton's laws of motion.** (03 marks)

(ii) Derive the expression **F = ma,** and define the unit of force. (03 marks)

(b) (i) What is meant by a **perfectly inelastic collision?** (01 mark)

(ii) Give **two** examples of perfectly inelastic collisions. (02 marks)

(iii) Two bodies, each of mass 2.5N move at speeds of 2.0 ms^{-1} and 1.5 ms^{-1} respectively, at right angles to each other. If they make a perfectly inelastic collision, find their final velocity. (05 marks)

(c) (i) What is meant by time of flight as applied to projectile motion? (01 mark)

(ii) Derive an expression for the time of flight T of a projectile in terms of the horizontal range R, angle of projection θ and acceleration due to gravity g. (03 marks)

(iii) If the time of flight for the projectile in (c) (ii) above is 3.5 s, deduce the value for the maximum horizontal range. (02 marks)

2. (a) (i) What is meant by **static friction?** (01 mark)

(ii) Explain briefly, using molecular theory, how normal reaction affects friction between two solid surfaces. (03 marks)

(b) Describe an experiment to determine the coefficient of kinetic friction, and state **one** limitation that may lead to errors in the experiment. (04 marks)

(c) (i) State the **work – energy equation** and derive it. (03 marks)

(ii) A block of wood of mass 3kg rests on a rough horizontal floor. If it is given a horizontal blow and moves with an initial velocity of 4.0 ms^{-1} covering a distance of 6.0 m before coming to rest, find the coefficient of kinetic friction between the wooden block and the floor. (04 marks)

(d) (i) What is meant by the terms **viscosity** and **velocity gradient** as applied to fluid flow? (02 marks)

(ii) Explain how temperature affects viscosity in a gas. (03 marks)

3. (a) (i) What is **simple harmonic motion?** (01 mark)

(ii) Sketch separate graphs showing how velocity and acceleration vary with displacement for a body performing simple harmonic motion. (02 marks)

(b) Suppose you are provided with a helical spring of force constant K, a stop clock, a retort stand with its clamp and masses of different sizes.

(i) Describe an experiment you would carry out to determine the value of the force constant K of the spring. (04 marks)

(ii) State any **three** possible sources of error in the above experiment. (03 marks)

(c) A mass of 2 kg resting on a smooth horizontal surface is attached to one end of a spring lying horizontally, with its one end fixed onto a rigid support. If the force constant of the spring is 100 Nm^{-1} and the mass is pulled through a distance of 4.0cm and released, calculate the:

(i) maximum velocity attained by the attached mass. (03 marks)

(ii) acceleration of the mass when it is half way away from the equilibrium position. (02 marks)

(d) (i) What is meant by **geostationary orbit** as applied to a satellite? (01 mark)

(ii) Calculate the height of a communication satellite above the earth's surface if it is launched in its geostationary orbit. (04 marks)

4. (a) (i) What is meant by the term **relative density?** (01 mark)

(ii) Describe a simple experiment you would carry out to determine relative density of a liquid. (03 marks)

(b) A cylindrical solid of mass 200 g and uniform cross-sectional area 40 cm^3 is floated vertically in water of density 1.0 g cm^{-3}. When a mass of 100 g is carefully placed on top of the cylindrical solid and a certain liquid added to the water, the cylindrical solid floats at the same level as it was floating in water. Calculate the density of the mixture of water and the liquid. (04 marks)

(c) (i) Define **surface tension.** (01 mark)

(ii) A glass capillary tube of radius r is supported vertically in a liquid of density ρ and surface tension γ. Derive an expression for the height h to which the liquid rises in the tube if the angle of contact between the liquid and glass is θ. (04 marks)

(d) Find the work required to break up a drop of water of radius 0.5 cm into drops of water each of radii 1.0mm.
(Take surface tension of water = 7.0×10^{-2} Nm^{-1}). (04 marks)

(e) Explain why when lycopodium powder is sprinkled on water contained in a dish, and the middle of the water is touched with the end of a glass rod which had been previously dipped in soap solution, the powder is carried away to the sides by the water. (03 marks)

SECTION B

5. (a) (i) Define **thermometric property** and give **two** examples. (03 marks)

(ii) What is the lowest possible temperature that a substance can ever have? and under what condition can this temperature be attained? (02 marks)

(b) (i) With the aid of a labelled diagram, describe the structure and mode of operation of the filament - disappearing pyrometer. (05 marks)

(ii) State **one** advantage and **one** disadvantage of a pyrometer. (02 marks)

(c) (i) Define **specific latent heat of fusion** of a substance. (01 mark)

(ii) Explain why the specific latent heat of fusion of a substance is significantly different from its specific latent heat of vaporisation at the same pressure. (03 marks)

(d) Two kilograms of water is converted into steam at a temperature of 100^0C and a pressure of 98.5 kPa. If the density of steam is 0.60 kgm^{-3} and specific latent heat of vaporisation of water is 2.3×10^3 kJ kg^{-1}, calculate the work done to the surroundings. (04 marks)

6. (a) (i) What is an **ideal gas?** (01 mark)

(ii) Explain the conditions under which a real gas can behave like an ideal gas. (03 marks)

(b) The pressure, P, of an ideal gas is given by $P = 1/3\ \rho\overline{c^2}$, where ρ is the density of the gas and $\overline{c^2}$ is the mean square speed of its molecules. Show clearly the steps taken to derive the above expression. (06 marks)

(c) (i) What is meant by **critical temperature** as applied to a gas? (01 mark)

(ii) Sketch the pressure – volume curve for a real gas for temperature above and below the critical temperature. (02 marks)

(d) The masses of hydrogen and oxygen atoms are respectively 1.66×10^{-27} kg and 2.66×10^{-26} kg. What is the ratio of the root-mean-square speed of hydrogen to that of oxygen molecules at the same temperature? (04 marks)

(e) Use kinetic theory to explain how saturated vapour pressure of a liquid increases with temperature. (03 marks)

7. (a) (i) Define **coefficient of thermal conductivity.** (01 mark)

(ii) Explain the mechanism of thermal conduction in glass. (03 marks)

(iii) State any **two** factors that determine the rate of heat transfer through a material. (01 mark)

(b) With the aid of a labelled diagram, describe an experiment to determine the coefficient of thermal conductivity of copper. (06 marks)

(c) Metal rods of copper, brass and steel are welded together to form a Y – shaped figure. The cross – sectional area of each rod is 2 cm^2. The free end of the copper rod is maintained at 100^0C while the ends of brass and steel are maintained at 0^0C. If there is no heat loss from the surfaces of the rods and the rods are respectively 40 cm, 10 cm and 15 cm long, calculate the:

(i) temperature of the junction. (05 marks)

(ii) heat current in the copper rod. (02 marks)

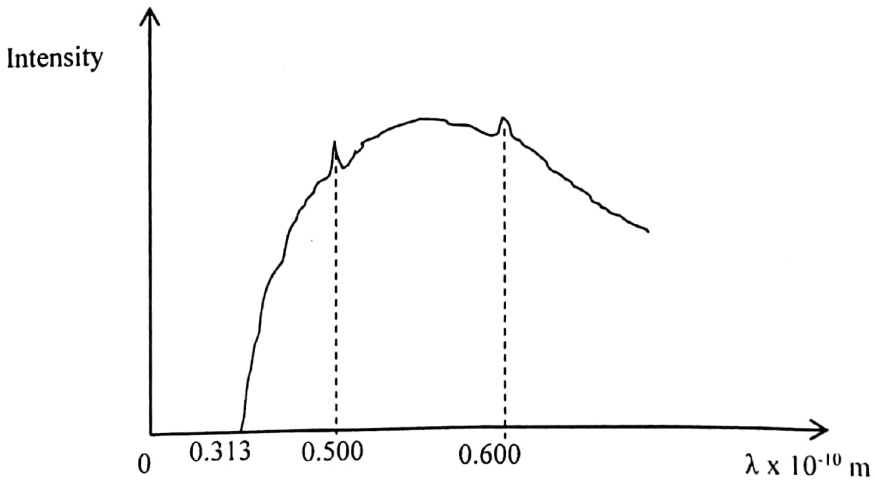
(d) With the aid of a suitable sketch graph, explain the temperature distribution along a well – lagged metal rod heated at one end. (02 marks)

SECTION C

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

(ii) State any **two** differences between x – rays and γ – rays. (02 marks)

(b) The diagram below shows an x – ray spectrum of a metallic target bombarded by 40 kV electron beam.



(i) What features does the spectrum show? (02 marks)

(ii) Calculate the value of *h/e* from the data given on the diagram, where *h* is Planck's constant and *e* is the electronic charge. (03 marks)

(iii) State **two** changes one would expect to be observed if the energy of the bombarding electrons were increased. (02 marks)

Turn Over

(c) An x – ray tube is operated at 35 kV with a electron current 10 mA in the tube. Estimate the:

(i) number of electrons hitting the target per second. (03 marks)

(ii) rate of production of heat assuming 90% of the kinetic energy of electrons is converted to heat. (03 marks)

(d) In the Millikan's oil experiment to determine the charge on an oil drop, explain why:

(i) the apparatus is surrounded in a constant - temperature bath. (02 marks)

(ii) large sized oil drops are not used. (02 marks)

9. (a) What is meant by the following terms:

(i) **radioactive decay.**

(ii) **half – life.**

(iii) **decay constant.**

(03 marks)

(b) Sketch a graph of number of atoms present against time for a radioactive nuclide and use it to explain how decay constant is obtained from it.

(04 marks)

(c) A radioactive source of half – life 60 days initially contains 1.0×10^{20} radioactive atoms and the energy released per disintegration is 8.0×10^{-13} J. Calculate the:

(i) activity of the source after 120 days have elapsed. (04 marks)

(ii) total energy released during this period. (03 marks)

(d) (i) Explain the meaning of **space charge** and an **avalanche** as applied to an ionisation chamber. (03 marks)

(ii) Sketch the count rate – voltage characteristic of the Geiger – Muller tube and explain its features. (03 marks)

10. (a) (i) What is meant by **threshold frequency** and **work function** as applied to photoelectric effect?. (02 marks)

(ii) Briefly explain the mechanism of photoelectric effect. (03 marks)

(b) Describe an experiment to determine the stopping potential of a metal surface. (05 marks)

(c) Ultraviolet and infrared radiations are directed in turn onto a freshly cleaned zinc plate connected to a gold – leaf electroscope which is negatively charged.

Explain what is observed when:

(i) ultraviolet radiation falls on the zinc plate. (02 marks)

(ii) infrared radiation falls on the zinc plate. (02 marks)

(iii) ultraviolet radiation falls on the zinc plate if the gold – leaf electroscope is positively charge. (02 marks)

(d) When a certain metal surface is irradiated with light of wavelength 6.0×10^{-7}m, electrons just emerge from its surface. When light of wavelength 5.5×10^{-7} m is used, electrons each of energy 4.0×10^{-20} J are emitted from the metal surface. Find the value of Planck's constant.

(04 marks)

END