P510/1
PHYSICS
Paper 1
July/August 2018
2½ hours

MAKERERE MODERN SECONDARY SCHOOL

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 additionalquestion(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		=	$9.11 \times 10^{-31}\ kg$
Radius of earth		=	$6.4 \times 10^{6}\ m$
Plank'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		=	$4.2 \times 10^{3}\ J\ kg^{-1}\ K^{-1}$
Specific latent heat of vaporisation of steam		=	$2.0 \times 10^{6} Jkg^{-1}$
Gas constant,	*R*	=	$8.31\ J\ mol^{-1}K^{-1}$
Universal gravitational constant,	*G*	=	$6.67 \times 10^{-11}\ N\ m^{2}kg^{-2}$
Charge to mass ratio,	*e/m*	=	$1.8x10^{11} Ckg^{-1}$
Avogadro's number	N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
One electron volt,	*(eV)*	=	$1.6 \times 10^{-19}\ J$

SECTION A

1. (a) (i) Distinguish between **conservative** and **non-conservative** forces. (2marks)

(ii) Give **two** examples of each of the above types of forces. (2marks)

(b) (i) State the **principle of conservation of mechanical energy.**(1mark)

(ii) Explain how the principle above applies to a body falling from rest. (3marks)

(iii) Sketch a graph to show how kinetic energy of the falling body in (b) (ii) above varies with time. (2marks)

(c) A car of mass 1 tonne accelerates from 36 kmh^{-1} to 72 kmh^{-1} while moving 0.5km up a road inclined at an angle α to the horizontal, where $\sin \alpha = {}^{1}/_{20}$. If the total resistive force to its motion is 0.3kN, find the driving force of the car engine. (4marks)

(d) (i) What is meant by saying that a **body is moving with velocity V relative toanother?** (1mark)

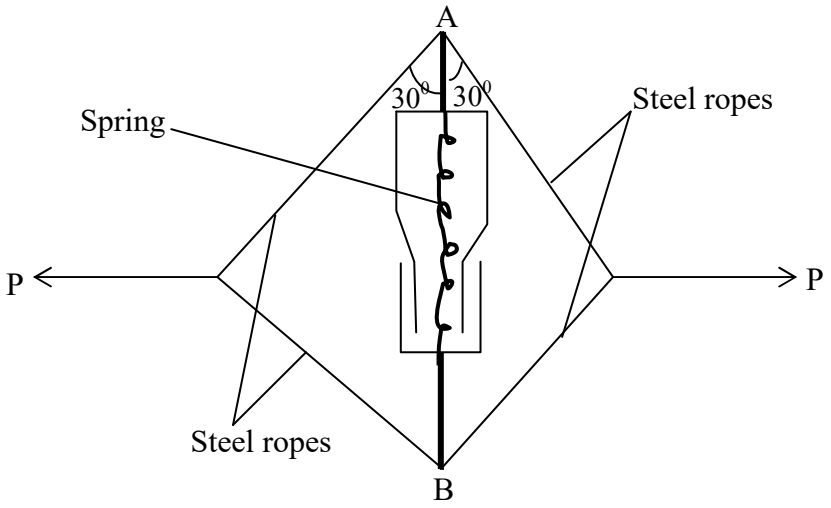
(ii) A car which is moving due west at $4ms^{-1}$ changes direction and starts tomove due north at $3ms^{-1}$. Find the change in velocity of the car. (3mks)

2. (a) (i) State **Hooke's law.** (1 mark)

(ii) What is meant by elastic constant of a material? (1 mark)

(iii) Show that the energy stored per unit volume of a stretched wire is given by ${}^{1}/_{2}E\,(\text{strain})^2$ where E is young's modulus. (4 marks)

(b) A muscle exercising machine consists of two steel ropes attached to the ends of a strong spring of force constant $500Nm^{-1}$ contained in a plastic tube whose length can be adjusted. The spring has an uncompressed length of 0.80m. When the ropes are pulled sideways in opposite directions with a force P, the spring is compressed to a length of 0.60m and the ropes make an angle of 30^0 with the length of the spring as shown.



Calculate the:

(i) tension in each rope. (4 marks)

(ii) force P. (3 marks)

(c) (i) Outline the measurements to be made during an experiment to determine

Young's modulus of a material. (3 marks)

(ii) What precautions are necessary in the above experiment? (2 marks)

(d) Explain briefly why heat is evolved when a material undergoes plastic deformation. (2 marks)

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

(ii) Distinguish between simple harmonic motion and any other motion of a body performing oscillations. (2 marks)

(b) Derive an expression for velocity of a body performing simple harmonic motion in terms of amplitude and displacement from a fixed point. (4 marks)

(c) A body of mass 50g executing, simple harmonic motion has a velocity of $3cms^{-1}$ when it is 4cm from a fixed point and a velocity of $5cms^{-1}$ when it is 2 cm from the fixed point.

Find the:-

(i) period of oscillations. (4 marks)

(ii) total mechanical energy of the body. (4 marks)

(d) (i) What is meant by **centripetal acceleration?** (1 mark)

(ii) Explain, with the aid of a clear diagram why a mass attached to a string

rotating in a vertical plane at a constant speed flies off at a tangent if the string breaks. (3 marks)

(iii) State the condition when the string is likely to break. (1 mark)

Turn Over

4. (a) (i) What is meant by **viscosity?** (1 mark)

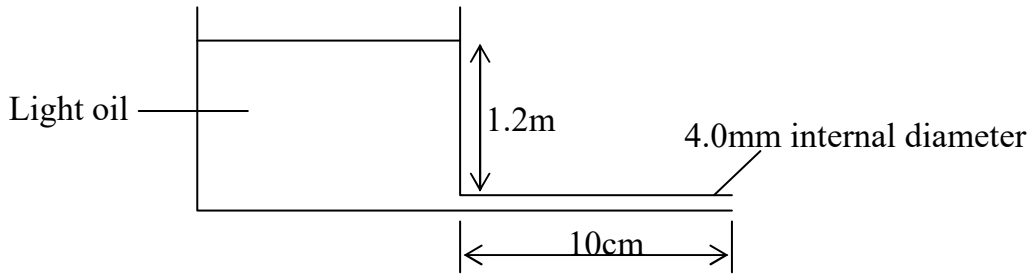
(ii) Explain briefly using Kinetic theory of matter, the effect of temperature on viscosity of a gas. (3 marks)

(b) (i) State **Stoke's law.** (1 mark)

(ii) Describe how the coefficient of viscosity of a liquid can be determined using Stoke's law. (5 marks)

(iii) State and explain the precautions that must be taken in the above experiment. (3 marks)

(c) The figure below shows a tank containing a light lubricating oil. The oil flows out of the tank through a horizontal pipe of length 10cm and internal diameter 4.0mm.



Calculate the volume of oil which flows through the pipe in one minute when the level of oil in the tank is 1.2m above the pipe and does not alter significantly during this time. Take density of oil = $0.92gcm^{-3}$, coefficient of viscosity of oil = $8.4 \times 10^{-2}Nsm^{-2}$. (4 marks)

(d) (i) What is meant by angle of contact as applied to a liquid?(1 mark)

(ii) How does addition of a detergent affect angle of contract of a liquid? (2 marks)

SECTION B

5. (a) Define **latent heat of vaporisation.** (2 marks)

(b) (i) With the aid of a diagram, describe how the specific latent heat of vaporisation of aliquid can be determined by the method of mixtures. (6 marks)

(ii) State two advantages the continuous flow method has over the method of mixtures. (2 marks)

(c) An electrical heater of 2.5kW is used to heat 2 litres of water in a kettle of heat capacity $400Jkg^{-1}$. If the initial temperature of water is 24^0C, and neglecting heat losses to the surroundings, find:

(i) how long it will take to heat the water to its boiling point.(4 marks)

(ii) the mass of water boiled off in 3 minutes, if heating started from 24^0C. (3marks)

(d) (i) State **Newton's law** of cooling. (1 mark)

(ii) Explain why a small body cools faster than a large one if they are made of the same material. (2marks)

6. (a) (i) What is a **supersaturated vapour?** (1 mark)

(ii) Sketch a pressure - volume curve for a real gas undergoing compression below its critical temperature. (2marks)

(iii) Explain the main features of the curve. (3marks)

(b) (i) State **Dalton's law** of partial pressure. (1mark)

(ii) A volume of $4.0x10^{-3}m^3$ of air is saturated with watervapour at 100^0C. The air is cooled to 30^0C at constant pressure of $1.5x10^5Pa$. Calculate the volume of air after cooling, if the saturated vapour pressure of water at 30^0C is $2.5 X10^3Pa$.
Take atmosphere pressure = $1.01x10^5$ Pa. (4marks)

(c) (i) State the **first law of thermodynamics.** (1mark)

(ii) Use the law in (c) (i) above to derive the relation $C_p - C_v=R$

where C_p and C_v are the molar heat capacities at constant pressure and constant volume respectively and R is the universal molar gas constant.
(5marks)

Turn Over

(d) The temperature of a gas in an expandable container is raised from 0^0C to 80^0C at constant pressure of $4.0x10^5$Pa. If the total heat added is $5.0x10^4$J,find the number of moles of the gas.
Take molar heat capacity of the gas at constant pressure = 29.1J $mol^{-1}K$.
(3marks)

7. (a) Define **thermal conductivity** of a material. (1mark)

(b) (i) Explain, using molecular theory of matter, the mechanism of thermal conduction in insulators. (3marks)

(ii) Briefly account for the fact that metals are better conductors of heat than glass. (3marks)

(c) Ice is forming on the surface of water in a swimming pool. When it is 5.0cm thick, the temperature of the surface of the ice in contact with the air is 260K while the surface in contact with the water is at 273K.
Calculate:

(i) the rate of heat loss per m^2 from the water. (3marks)

(ii) the rate at which the thickness of ice is increasing. (3marks)
Take thermal conductivity of ice = $2.3Wm^{-1}K^{-1}$, density of water=$1000kgm^{-3}$, specific latent heat of fusion of ice =$3.25x10^5Jkg^{-1}$.
(4marks)

(d) With the aid of a labelled diagram describe the structure and mode of operation of the ether thermoscope. (4marks)

(e) Explain briefly the greenhouse effect. (3marks)

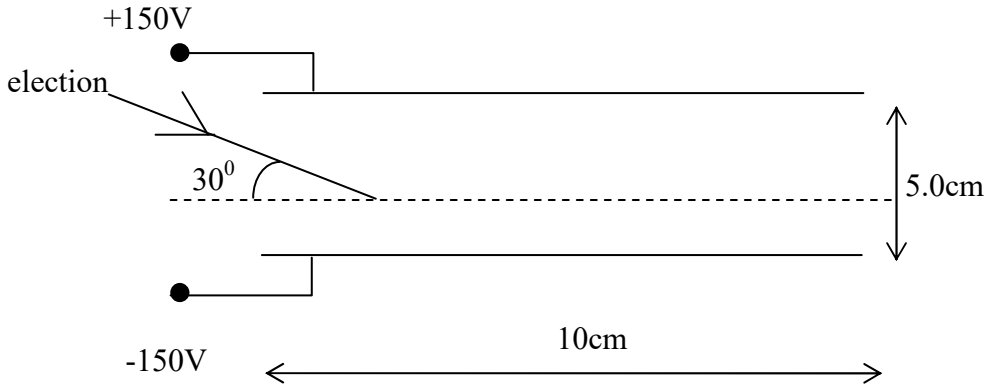
SECTION C

8. (a) (i) Define **specific charge** of an ion. (1mark)

(ii) Describe how the specific charge of a positive ion can be measured using the Bainbridge mass spectrometer. (6 marks)

(iii) State **three** differences between **positive rays** and **cathode rays.** (3 marks)

(b) An election moving with a speed of $2.0 \times 10^{-6} ms^{-1}$ enters midway between two horizontal parallel metal plates at an angle of 30^0 to the horizontal as shown in the diagram below.



The plates are 10cm long and 5cm apart. If the potentials of the upper and lower plates are +150V and -150V respectively,
calculate:

(i) the time taken for the election to traverse the region between the plates. (3marks)

(ii) the velocity of the election as it emerges from the region between the plates. (4marks)

(c) Briefly describe the construction and action of the thermionic diode. (3 marks)

9. What is meant by the terms ;

(i) **Decay constant** (1mark)

(ii) **Radio isotopes?** (1mark)

(b) Show that the half-life, $t_{\frac{1}{2}}$ of a radioactive material is given by $t_{\frac{1}{2}} = \frac{0.693}{\lambda}$, Where λ is decay constant. (3marks)

Turn Over

(c) A mass defect of 8.8×10^{-30}kg occurs in the decay of a $^{226}_{88}$Ra nucleus. In a given sample, most of the nuclei decay by emission of an $\propto$-particle of energy 4.60MeV and a γ ray photon. Calculate the frequency of the γ photon emitted. Neglect recoil energy of the decayed nucleus. (5marks)

(d) (i) With the aid of a labelled diagram, describe the structure and action of an ionisation chamber. (5marks)

(ii) Draw a graph to illustrate the variation of ionisation current and p.d across an ionisation chamber, and explain its salient features. (3marks)

(e) State **two** industrial uses of radioisotopes. (2marks)

10. (a) (i) What are **X-rays?** (1mark)

(ii) Describe with the aid of a labelled diagram how X-rays are produced in an X-ray tube. (5marks)

(b) (i) Draw a sketch graph to show how intensity of X-rays produced in the X-ray tube varies with wavelength of the X-rays. (2marks)

(ii) Explain how the X-ray spectra are formed. (4marks)

(c) Elections in an X-ray tube are accelerated through p.d of 12kV. Calculate the minimum wave length of the X-rays that can be produced. (3marks)

(d) (i) What is meant by **electron energy level in an atom?** (1mark)

(ii) In a simple model of the hydrogen atom, an electron of mass m and charge –e, is considered to move in a nearly circular orbit about a proton. Write down the expression for the electric force on the electron, and show that the total energy of the election is given by $-\frac{e^2}{8\pi\varepsilon_0 r}$ where r is the radius of the electron orbit ε_o and is the permittivity of free space. (4 marks)

END