P510/1
PHYSICS
Paper 1
31 July 2018
2 ½ hours

ENTEBBE JOINT EXAMINATION BUREAU

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****.*

Any extra question shall **not** *be assessed.*

Assume where necessary:

Acceleration due to gravity, g	=	$9.81\ ms^{-2}$
Speed of light in a vacuum, c	=	$3 \times 10^{8}\ ms^{-1}$
Electron charge, e	=	$1.6 \times 10^{-19}\ C$
Electron mass	=	$9.11 \times 10^{-31}\ kg$
Density of water	=	$1000\ Kgm^{-3}$
Avogadro's number N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Planck's constant, h	=	$6.63 \times 10^{-34}\ Js$
Radius of the earth	=	$6.4 \times 10^{6} M$
Wien's displacement constant	=	$2.90X10^{-3} mK$
Radius of Earth's orbit about the sun	=	$1.5 \times 10^{11} M$
Specific heat capacity of water	=	$4200JKg^{-1}K^{-1}$
Stefan Boltzmann's constant δ	=	$5.67 \times 10^{-8}Wm^{-2}K^{-4}$
Universal gravitational constant G	=	$6.67 \times 10^{-11}Nm^{-2}Kg^{-2}$
Gas constant R	=	$8.31Jmol^{-1}K^{-1}$
The constant $\frac{1}{4\pi\varepsilon_0}$	=	$9.0 \times 10^{9}\ mF^{-1}$
One electron volt (eV)	=	$1.6 \times 10^{-19}\ J$
Charge to mass ratio, $\frac{e}{m}$	=	$1.8 \times 10^{11}\ CKg^{-1}$

SECTION A

1. (a) State **the laws of static friction**. *(03 marks)*

(b) Use molecular theory to explain the laws in (a) above. *(06 marks)*

(c) A car of mass 1,000 *kg* moving along a straight road with a speed of 72 kmh^{-1} is brought to rest by a steady application of brakes in a distance of 50 *m*; Find the coefficient of kinetic friction between the tyres and the road. *(04 marks)*

(d) (i) State the conditions for mechanical equilibrium of a rigid body under action of coplanar forces. *(02 marks)*

(ii) A light inextensible string has one end fixed to a wall and the other end tied at the top end of a uniform beam *PQ* of weight 10 g *N* and length 2 *l* as shown in the figure **1** below.

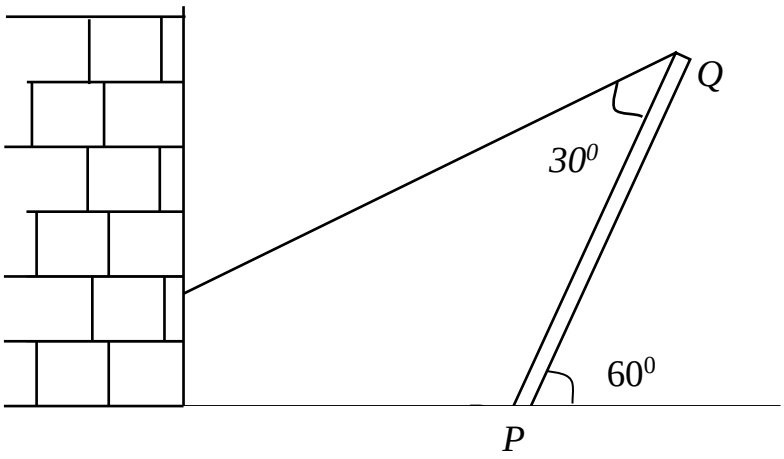


Fig I

Find the tension in the string. *(05 marks)*

2. (a) State **Kepler's laws of planetary motion**. *(03 marks)*

(b) Derive from Newton's laws of gravitation the dimensions of the universal gravitational constant. *(03 marks)*

(c) Calculate the ratio of the mass of the sun to that of the earth, given that the moon moves round the earth in a circular orbit of radius 4.0×10^8 *m* with a period of 27.3 days and the orbital radius of the earth round the sun is 1.5×10^{11} m and its period is 365 days. *(04 marks)*

(c) Account for the following:

(i) Acceleration due to gravity varies with latitude. *(03 marks)*

(ii) The moon has no atmosphere. *(02 marks)*

(d) Explain why any forward resistance to the forward motion of a space satellite results into an increase in kinetic energy. *(05 marks)*

3. (a) (i) What is meant by **terminal velocity**? *(01 mark)*

(ii) Drive an expression for the volume of a liquid flowing per second out of a cylindrical pipe in terms of the coefficient of viscosity, η defining any symbols used. *(05 marks)*

(b) Describe an experiment to determine the coefficient of viscosity of cooking oil placed in a tall jar, stating any precautions undertaken in the experiment. *(06 marks)*

(c) Explain the effect of temperature on the viscosity of a liquid. *(02 marks)*

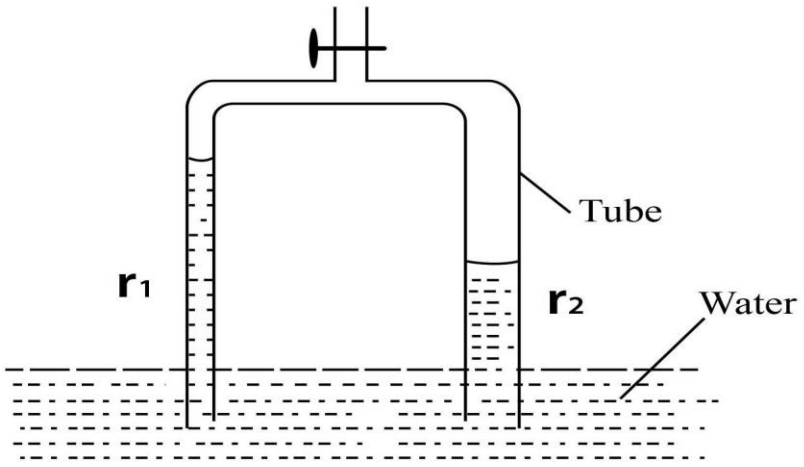
(d) (i) State **Stoke's law**. *(01 mark)*

(ii) A spherical raindrop of radius 2.0×10^{-4} *m* falls vertically in air at 200 *C*. If the densities of air and water are 1.2 kgm^{-3}, and 1,000 kgm^{-3} respectively and that the coefficient of viscosity of air at 20^0 *C* is 1.8×10^{-5} *Pa*. Calculate the terminal velocity of the drop. *(04 marks)*

4. (a) (i) Define **surface tension**. *(01 mark)*

(ii) Explain surface tension using molecular theory. *(04 marks)*

(b) A tube with two arms of radii $r_1 = 4$ mm and $r_2 = 10$ *mm* is immersed in water as shown below;



Turn Over

Determine the difference ***h***, in the water levels in the two arms if the surface tension of water is 0.07 Nm^{-1}. *(03 marks)*

(c) (i) Define **angle of contact.** *(01 mark)*

(ii) Describe an experiment to determine angle of contact of mercury. *(03 marks)*

(d) (i) State **the law of floatation.** *(01 mark)*

(ii) Explain why a balloon filled with helium rises up to a certain height in still air and then stops. *(02 marks)*

(e) A simple hydrometer consisting of a loaded glass stem of uniform cross sectional area 1.0 cm^2 and a bulb of volume 3.0 cm^3 sinks in water so that a certain mark on its stem is 4 *cm* below the water surface. It sinks in a liquid of density 0.9 gcm^{-3} until ***x*** is 6 *cm* below the surface. It is then placed in a liquid of density 1.1 gcm^{-3}, calculate the

(i) distance of ***x*** from the bulb of the hydrometer. *(03 marks)*

(ii) depth of ***x*** below the water surface of the liquid whose density is *1.1* gcm^{-3}. *(02 marks)*

SECTION B

5. (a) (i) State the desirable properties a material must have to be used as a thermometric property. *(02 marks)*

(ii) Explain why a constant – volume gas thermometer is used to calibrate other thermometers. *(02 marks)*

(b) Describe with the aid of a labeled diagram how an optical pyrometer can be used to measure high temperature. *(06 marks)*

(c) What is meant by the following terms?

(i) **Heat capacity** *(01 mark)*

(ii) **Latent heat** *(01 mark)*

(d) 50 g of ice at 0^0 C is added to 200 g of water initially at 70^0 C in a vacuum flask. When all the ice has melted, the temperature of the flask and its contents drops to 40^0 C. On the addition of a further 80 g of ice, the temperature of the whole becomes 10^0 C when all the ice has melted.

(i) Calculate the specific latent heat of fusion of ice. *(07 marks)*

(ii) State the assumption made in the calculation above. *(01 mark)*

6. (a) (i) State the assumptions made in the derivation of the kinetic theory expression for the pressure of an ideal gas. *(02 marks)*

(ii) Which of the assumptions made above have to be modified for real gases?

(iii) The equation of state of one mole of a real gas is given by the expression:

$$\left(P + \frac{a}{v^2}\right)(v - b) = RT$$

Account for the term $\frac{a}{v^2}$ and b. *(03 marks)*

(b) Calculate the root – mean – square speed of the molecules of an ideal gas at 147^0 C given that the density of the gas at a pressure of 1.01×10^5 Nm^{-2} at a temperature of 0^0 C is 1.5 kgm^{-3}. *(05 marks)*

(c) The density of an ideal gas is 1.60 kgm^{-3} at 27^0 C and 1.01×10^5 Nm^{-2} pressure and its specific heat capacity at constant volume, C_r is 312 $JKg^{-1}K^{-1}$. Find the ratio of the specific heat capacity at constant pressure C_p to that at constant volume. *(04 marks)*

(d) Explain, with the aid of a volume against temperature sketch graph, what happens to a gas cooled at constant pressure from room temperature to zero Kelvin. *(04 marks)*

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

(ii) Explain the mechanism of heat transfer by conduction in solids. *(03 marks)*

(b) A flat horizontal rectangular roof of 12 *m* by 10 *m* rests on vertical walls 4 *m* high. The walls and roof are 25 *cm* thick and are made of material of thermal conductivity 0.25 $Wm^{-1}K^{-1}$. The doors and windows cover an area of 16 m^2 and are made of glass of thickness 5 *mm* and thermal conductivity 1.2 $Wm^{-1}K^{-1}$. If the room is maintained at a constant temperature above that of its surroundings, calculate the percentage heat loss by conduction through the windows and doors. *(06 marks)*

(c) (i) Sketch graphs showing the distribution of energy in the spectrum of a black body radiation at three different temperatures. *(03 marks)*

(ii) Use the graphs above to explain the colour changes that occur when a piece of iron is heated from cold to its melting point. *(03 marks)*

(d) A metal sphere with a black surface and radius 30 *mm* is cooled to -73^0 *C* and placed inside an enclosure at a temperature of 27^0 *C*. Calculate the initial rate of rise of temperature of the sphere, assuming the sphere is a black body. *(Take density of the metal to be 800* kgm^{-3}*, specific heat capacity of the metal to be 400* $JK^{-1}K^{-1}$*)* *(04 marks)*

SECTION C

8. (a) Define the terms:

(i) **specific charge** *(01 mark)*

(ii) **positive rays** *(01 mark)*

(b) Explain the mechanism of thermionic emission. *(03 marks)*

(c) (i) Distinguish between **cathode rays** and **positive rays**. *(03 marks)*

(ii) Describe an experiment to determine the specific charge of positive ions. *(06 marks)*

(d) Define the terms **work function** and **stopping potential.** *(02 marks)*

(e) Photoelectric emission is an instantaneous process. Explain how the classical theory fails to account for this observation. *(04 marks)*

9. (a) What is **a radioactive decay**? *(01 mark)*

(b) With the aid of a labeled diagram, describe how an expansion cloud chamber can be used to detect ionising radiation. *(06 marks)*

(c) The diagram below shows some energy levels of hydrogen.

E_{00} —————————————— 0 *eV*
C_4 —————————————— 0.85 *eV*
E_3 —————————————— 1.5 *eV*
E_2 —————————————— 3.4 *eV*
E_1 —————————————— 13.6 *eV*

(i) Copy the diagram and indicate the electron transition for the emission of the visible spectrum and ultra violet radiation. *(02 marks)*

(ii) Calculate the highest possible frequency of radiation emitted from the hydrogen atom. *(02 marks)*

(d) (i) State **Bragg's law of crystal diffraction**. *(01 mark)*

(ii) A beam of monochromatic *x* – rays of wavelength 0.1 *nm* is incident on a crystal. The third order reflections are observed at a Bragg's angle of 32.4^0. Find the spacing of atomic planes. *(03 marks)*

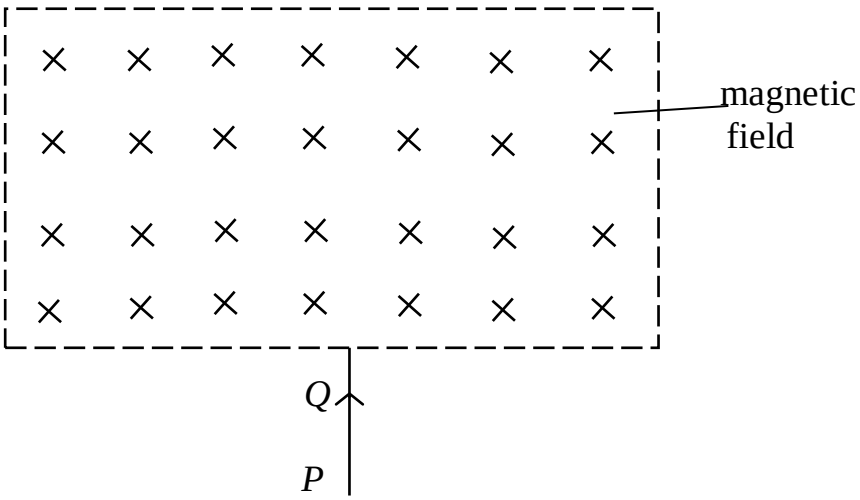
(e) (i) Sketch a graph of binding energy per nucleon against nuclear number. *(02 marks)*

(ii) Use the graph in *(e) (i)* above to explain why stability of the nucleus of an atom increases with binding energy per nucleon. *(03 marks)*

10. (a) (i) Describe briefly the steps involved in the determination of the change of an electron by Milkan oil drop experiment. *(07 marks)*

(ii) An oil drop of mass 4×10^{-18} *kg* is held stationery between horizontal plates when the drop carries 6 electric charges each of the value 1.6×10^{-19} *C*. Calculate the value of the electric field intensity. *(04 marks)*

(b)



An electric beam is incident normally to a region of magnetic field intensity B that is in a direction perpendicular to that of travel of the electrons.

(i) Copy and complete the diagram to show the path taken by the electrons. *(02 marks)*

(ii) Explain the motion of the electrons. *(03 marks)*

(c) A simply ionised positive atom passes undeflected through crossed magnetic and electric fields of magnitude 0.3 *T* and 3.6 x 10^4 Vm^{-1} respectively. It then enters a region of uniform magnetic field of flux density 0.5 *T*. If the ion describes a circular path of radius 3 *cm*, find its mass. *(04 marks)*

END