SENIOR SIX

Physics

P510/1

Time: $2\frac{1}{2}$hours

UACE MOCK EXAMINATIONS, 2017

PHYSICS PAPER 1

2 Hours 30 minutes

INSTRUCTIONS

- **Answer not more than five 5 questions and not more than 2 questions from each of sections A, B, and C**
- **Assume where necessary:**

Acceleration due to gravity, g	=	9.81m s^{-2}
Density of water	=	1000 kg m^{-3}
Density of mercury	=	136000 kg m^{-3}
Radius of the sun	=	7.0×10^{8} m
Radius of the earth	=	6.4×10^{6} m
Mass of the earth	=	6.0×10^{24} kg
Universal gravitational constant, G	=	6.7×10^{-11} N m^{2} kg^{-2}
Stefan's constant, σ	=	5.7×10^{-8} m^{-2} K^{-4}
Molar gas constant, R	=	8.31 J mol^{-1} K^{-1}
Electronic charge, e	=	1.6×10^{-19} C
Electron mass	=	9.11×10^{-31} kg

Avogadro's number, N_A = 6.02×10^{23} mol^{-1}
Specific latent heat of vaporization of water = 2.3×10^{3} kJ kg^{-1}
Orbital radius of the earth around the sun = 1.5×10^{11} m
Planck's constant, h = 6.63×10^{-34} J s

SECTION A

1. a) i) Define **limiting friction**. (1 mark)

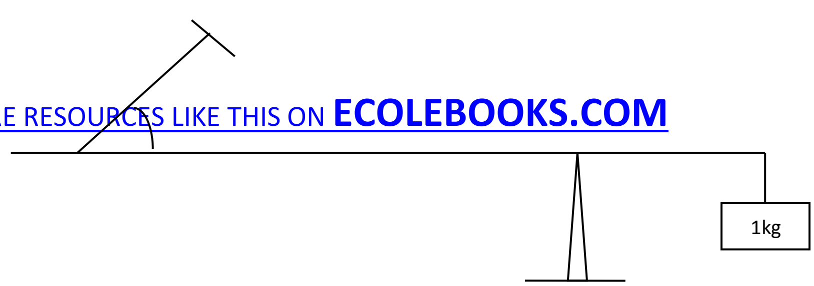
ii) Describe an experiment to determine the coefficient of static friction between two surfaces. (4marks).

iii) A block of mass 3kg at rest is given an initial velocity of 7 m s^{-1} upwards along the line of greatest slope on a rough plane inclined at 30^0 to the horizontal. If the block undergoes a vertical displacement of 1.05 m, find the coefficient of kinetic friction between the two surfaces. (4 marks)

b) i) State the conditions for a rigid body to be in mechanical equilibrium. (2 marks)

ii) A one metre long uniform rod AB of mass 5 kg is pivoted at the 80 cm mark and an elastic spring of force c onstant 196 N m^{-1} supports the rod horizontally at the 5 cm mark when mass of 1kg is suspended from

end B as shown below:



A 0 60° 5 80 B 100cm

Find the extension produced in the spring and the coefficient of friction at the pivot. (6 marks)

c) i) What is meant by centre of gravity of a body. (1 mark)

ii) Explain how a racing car is made more stable. (2 marks).

2 a) i) What is meant by dimensions of a physical quantity. (1mark)

ii) The equation of state for one mole of a real gas is $(P + {}^{a}/_{V^2})(V- b) = RT$.

Find the dimensions and units of the constants a and b. (3marks)

b) i) State Archimedes' principle. (1 mark)

ii) Describe an experiment to determine the relative density of paraffin using Archimedes' principle

(5 marks).

c) (i) What is meant by coefficient of viscosity of a fluid. (1mark).

(ii) Account for the effect of temperature on the viscosity of fluids. (4marks) .

d) (i) Sketch a velocity – time graph for a body falling down in a viscous oil.

ii) Describe the features of the graph.
(5marks).

3. a) State Kepler's laws of planetary motion. (3 marks)

b) i) Define a parking orbit. (1 mark)

ii) Calculate the speed of relay satellites when in their orbits.
(4marks)

c) i) A particle of mass 200 g at a height of 2R above the earth is fired to a distance 10 R from the centre of the earth where R is the radius of the earth. Using the principle of conservation of mechanical energy find the velocity with which the particle is fired. (3 marks)

ii) State what will happen to the satellite if its mechanical energy was reduced. (2 marks)

d) i) Define simple harmonic motion.
(1 mark)

ii) Sketch a graph to show the variation of kinetic and potential energies with displacement of a body performing simple harmonic motion. (2 marks)

e) A particle of mass 150 g is executing simple harmonic motion with amplitude of 3.6cm between two points A and B about point O as the centre of oscillation. The maximum restoring force on the particle has a magnitude of 3.52 N. Calculate;

i) The period of motion.
(2 marks)

ii) The kinetic energy of the particle of a point in the path of the motion a distance 4.5cm from A. (2marks)

4. a) Define the terms: coefficient of surface tension and surface energy. (2 marks)

b) i) Describe an experiment to determine the surface tension of a liquid by Jaeger's method. (6 marks).

ii) Two soap bubbles of diameters 8.0cm and 4.0cm respectively coalesce under isothermal conditions

to form a common interface. If the surface tension of the soap solution is 2.5×10^{-2} Nm^{-1}, calculate

the pressure difference across the interface the resulting soap bubbles. (3 marks)

c) i) State Bernoulli's principle. (1 mark)

ii) Explain the origin of the force on the wing of an aeroplane at takeoff. (4 marks)

iii) Water flows through a horizontal pipe of varying cross section. If the pressure of water is 8 cm Hg

where the velocity of flow is $0.3ms^{-1}$, what is the pressure at another point where the velocity of

flow is $0.8\ m\ s^{-1}$. (4 marks)

SECTION B

5. a) i) Define specific heat capacity of a substance. (1 mark)

ii) Explain why the specific heat capacity of a body in solid state is lower than its specific heat

capacity in liquid state. (2 marks)

b) i) With the aid of a labeled diagram describe the continuous flow experiment to determine

specific heat capacity of water. (6 marks)

ii) State two advantages of the continuous flow method over the method of mixture in the determination of specific heat capacity. (1mark)

c) i) What is meant by internal energy of a gas? (1 mark)

(ii) State the relationship between internal energy, work and heat of a gas. (2 marks)

d) 1cm^3 of water at 100^{0}C expands to 1601cm^3 when changing to steam at 100^{0}C. Calculate the amount of potential energy gained per water molecule at 100^{0}C. (5marks).

e) The density of nitrogen gas at a temperature of 17^{0}C and pressure of 76 cm Hg is 0.64 kg m^{-3}. Calculate the root mean square speed of nitrogen molecules at 37^{0}C. (3 marks)

6. a) Describe an experiment to determine thermal conductivity of a good conductor of heat. (6marks)

b) In double glazing, two glass panes, each 10 mm thick are separated by an air gap of 10 mm. If the outside surfaces are maintained at 25^{0}C and 5^{0}C, calculate;

i) the heat current per 1m^{-2} flowing through the arrangement (2marks)

ii) the air-glass interface temperatures. (2marks)

(Thermal conductivities of glass and air are: 1.0 and 0.02 Wm^{-1}K^{-1} respectively).

c) The intensity of the sun's radiation incident on the earth is about 1.6 kW m^{-2}.

i) Calculate the surface temperature of the sun. (3 mark)

ii) If this radiation falls normally on a lake of area 1.5 km^2 and average depth 18 m, calculate the initial rate of temperature rise of the lake assuming that the lake reflects 30% of the radiation falling on it.(4marks)

d) What is global warming .How does it occur?
(3marks)

7. a) Define molar heat capacity of a gas;

i) at constant pressure C_p (1 mark)

ii) at constant volume C_v
(1 marks)

b) i) Derive an expression relating C_p and C_v as defined above. (4 marks)

ii) Define an adiabatic change and an isothermal change. (2 marks)

iii) Explain what happens to a gas when it expands and no heat enters or leaves the gas.
(2marks).

c) An ideal gas at 27^0C and at a pressure of 1.01×10^5 Pa is compressed reversibly and isothermally until its volume is halved. It is then expanded reversibly and adiabatically to twice its original volume.

i) Draw a P - V graph for the above processes. (2mark)

ii) Calculate the final pressure and temperature of the gas given C_v = ${}^{5R}/_{2}$ (4 marks)

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

ii) A glass bulb of 100 cm^3 is connected to another bulb of 200 cm^3 by a narrow tube of negligible volume. The apparatus contains air at 17^0C and 90.0 kPa pressure. When the smaller bulb is then maintained at 57^0C the new equilibrium pressure in the apparatus is 93.4 kPa. Calculate the temperature of the bigger bulb.
(3marks)

SECTION C

8. a) Define the terms: work function and threshold wavelength. (2marks)

b) Explain the laws of photoelectric emission in terms of the quantum theory.. (4 marks)

c) A point source emits monochromatic light of wave length 4.5 x 10^{-7}m at a rate of 0.2W uniformly in all directions, Light from the source falls normally on a photocathode of area 3.14 x $10^{-}4$ m^2 and threshold frequency 5.0 x 1014 Hz at a distance of 50 cm from the source.

i) How many photons leave the source per second? (2marks)

ii) Calculate the photocurrent assuming 90% of the photons incident the cathode have frequencies below 5.0 x 10^{14}Hz . (3 marks)

iii) Calculate the maximum velocity of the electrons emitted. (3 marks)

d) i) Draw a graph showing the x – ray spectra indicating the main features. (3 marks)

ii) Explain the origin of the main features shown on the graph. (3 marks)

9. a). Describe the mechanism of thermionic emission. (2 marks)

b). With the aid of a diagram describe the action of a Bainbridge mass spectrometer. (6marks)

c). A beam of cathode rays is directed mid way between two parallel plates of length 4.0 cm and separated 1.0 cm apart. The beam is deflected through 10.0 cm on a fluorescent screen placed 20.0 cm beyond the nearest edge of the plates, when a p.d of 200 V is applied across the plates. If this deflection is annulled by a magnetic field of flux density of 1.14 x 10^{-3}T applied normal to the electric field within the plates. find the charge to mass ratio of the cathode rays. (4 marks)

d) i) State and explain the observations in Rutherford's alpha particle scattering experiment. (4marks)

ii) Calculate the wave length of the electrons that have been accelerated from rest through a p.d of 100 V. (4 marks)

10. a) i) Explain the observation of emission line spectra. (3 marks)

ii) An atom is in an excited state of energy -10.6eV. It absorbs a photon of wave length

1.2×10^{-7}m and is excited to a higher energy level. When it goes back to its ground state, a photon of

wave length 0.9×10^{-7}m is emitted. Find the energy of the atom in ground state. (4 marks)

b) i) Define the term mass defect of the nucleus and explain its origin. (2 marks)

ii) A nucleus of Uranium disintegrates by emission of an alpha particle according to the reaction

$${}^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$$

Mass of Uranium nucleus = 238.12492 u

Mass of thorium nucleus = 234.11650 u

Mass of an α particle = 4.00387 u

1 u = 930 MeV

Calculate the kinetic energy of the alpha particle, the nucleus being at rest before disintegration (4 marks)

c) i) Define the terms; activity, half-life and decay constant. (3 marks)

ii ii) A small volume of a solution which contained a radioactive isotope of sodium had an activity of 200 Bq when injected into a patient's bloodstream. After 48 hours the activity of 10.0 cm^3 of blood was found to be 4 disintegrations per minute. If the half life of the sodium isotope is 15 hours, estimate the volume of blood in the patient. Comment on your answer. (4 marks)

iii) Explain the use radioactive carbon -14 as an atomic calendar. (2marks)

END.