UACE Physics paper 1 2005 Time 2½ marks

Instructions the candidates:

Answer **five** questions, including at least **one**, but **not more than two** from each sections **A, Band C**.

Any additional question(s) answered will not be marked.

Non programmable scientific calculators may be used.

Assume where necessary

Acceleration due to gravity, g	$9.81ms^{-2}$
Electron charge, e	$1.6 x10^{-19}C$
Electron mass	$9.11 x 10^{-31}kg$
Mass of the earth	$5.97 x 10^{24}kg$
Plank's constant, h	$6.6 x 10^{-34}Js$
Stefan's-Boltzmann's constant, σ	$5.67 x 10^{-8}Wm^{-2}K^{-1}$
Radius of the earth	6.4 x 106m
Radius of the sun	$7 x 10^{8}m$
Radius of the earth's orbit about the sun	$1.5 x 10^{11}m$
Speed of light in the vacuum, c	$3.0 x 108ms^{-1}$
Thermal conductivity of copper	$390Wm^{-1}K^{-1}$
Thermal conductivity of aluminium	$210Wm^{-1}K^{-1}$
Specific heat capacity of water	$4.200Jkg^{-1}K^{-1}$
Universal gravitational constant	$6.67 x 10^{-11}Nm^{2}Kg^{-2}$
Avogadro's number, N_A	$6.02 x 10^{23}mol^{-1}$
Surface tension of water	$7.0 x 10^{-2}Nm^{-1}$
Density of water	$1000kgm^{-3}$
Gas constant, R	$8.31Jmol^{-1}K^{-1}$
Charge to mass ratio, e/m	$1.8 x 10^{11}Ckg^{-1}$
The constant, $\frac{1}{4\pi\varepsilon_0}$	$9.0 x 10^{9}F^{-1}m$
Faraday's constant, F	$9.65 x 10^{4}Cmol^{-1}$

SECTION A

1. (a) Distinguish between scalar and vector quantities giving two example each. (03marks)
   (b) The equation for volume, V, of a liquid flowing through a pipe in time t, under steady flow is given by $\frac{V}{t} = \frac{\pi r^4 P}{8\eta L}$ where
   r = radius of the pipe
   P = pressure difference between two point of the pipe
   L = length of the pipe
   η = coefficient of viscosity of the liquid
   If the dimensions of η are $ML^{-1}T^{-1}$, show that the above equation is dimensionally consistent.

   (c) (i) define linear momentum. (01mark)

   (ii) State the law of conservation of linear momentum. (01mark)

   (iii) Show the law in (c)(ii) above follows from Newton's law of motion. (03marks)
   (iv) Explain why, when catching a fast moving ball, the hands are drawn back while the ball is being brought to rest. (02marks

   (d) A car of mass 100kg travelling at uniform velocity of $20ms^{-1}$ collides perfectly inelastically with a stationary car of mass 1500kg. Calculate the lass in kinetic energy of the car as a result of the collision. (04marks)

   (e) (i) What is meant by conservation of energy? (01mark)

   (ii) Explain how conservation of energy applies to an object falling from rest in a vacuum. (02marks)

2. (a) Explain the term
   (i) Ductility (01mark)
   (ii) Stiffness (01mark)

   (b) A copper wire and steel wire each of length 1.0m and diameter 1.0mm are joined end to end to form a composite wire 2.0m long. Find the strain in each when the composite stretches by 2.0×10^{-3}m.

   [Young's Modulus for copper and steel are 1.2×10^{11}Pa and 2.0×10^{11}Parespectively] (07marks)

   (c) (i) Define centre of gravity (01mark)

   (ii) Describe an experiment to find the centre of gravity of a flat irregular piece of cardboard. (03marks)

   (d) Explain the laws of solid friction using molecular theory (07marks)

3. (a) What is meant by the following terms?
   (i) Velocity gradient. (01mark)
   (ii) Coefficient of viscosity (01mark)

(b) Derive an expression for terminal velocity of a steel ball-bearing of radius, r, and density, ρ, falling through a liquid of density, σ, and coefficient of viscosity, η. (05marks)

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

(ii) Explain the origin of surface tension. (03marks)

(iii) Describe an experiment to measure surface tension of a liquid by capillary method. (06marks)

(d) Explain, with the aid of a diagram why air-flow over the wings of an aircraft at take-off cause a lift. (03marks)

4. (a) (i) Define angular velocity. (01marks)
(ii) Derive an expression for the force, F, on a particle of mass, m, moving with angular velocity, ω, in a circle of radius, r. (03marks)
(b) A stone of mass 0.5kg is attached to a string of length 0.5m which will break if the tension in it exceeds 20N. The stone is whirled in a vertical circle, the axis of rotation being at a vertical height of 1.0m above ground. The angular speed is gradually increased until the string breaks.
(i) In what position is the string most likely to break? (02marks)
(ii) At what angular speed will the string break? (03marks)
(iii) Find the position where the stone hits the ground when the string breaks. (03marks)

(c) Explain briefly the action of a centrifuge. (03marks)

(d) Describe how the acceleration due to gravity can be measured using helical spring of unknown force constant, and the other relevant apparatus. (05marks)

SECTION B

5. (a)(i) What is meant by term fixed point in thermometry? Give two examples (02marks)
(ii) How is temperature on Celsius scale defined on a platinum resistance thermometer? (02marks)

(b) Explain the extent to which two thermometers based on different properties but calibrated using the same fixed points are likely to agree when used to measure temperature.

(i) near one of the fixed point (02marks)

(ii) mid-way between two fixed points (02marks)

(c) The continuous flow method is used in determination of the specific heat capacity of liquids.

(i) What are the principal advantages of this method compared to the method of mixtures? (03marks)

(ii) In such a method, 50gof water is collected in 1 minute. The voltmeter and ammeter readings are 12.0V and 2.50A respectively, while the inflow and outflow temperatures are 20^0C and 28^0C respectively. When the flow rate is reduced to 25gmin^{-1}, the voltmeter and ammeter read 8.8V and 1.85A respectively while the temperatures remain constant. Calculate the specific heat capacity of water. (05marks)

(d) What are the advantages of a thermocouple over a constant volume thermometer for measuring temperature? (04marks)

6. (a)(i) What is meant by isothermal and adiabatic changes? (02marks)
   (ii) Using the same axes, and starting from the same point, sketch a P-V diagram to illustrate the changes in (a)(i) (02marks)
   (b) An ideal gas is trapped in a cylinder by a movable piston. Initially it occupies a volume of $8 \times 10^{-3}m^3$ and exerts a pressure of 108kPa. The gas undergoes an isothermal expansion until its volume is $27 \times 10^{-3}m^3$. It is then compressed adiabatically to the original volume of the gas.
   (i) Calculate the final pressure of the gas (06marks)
   (ii) Sketch and label the two stages on a p-v diagram. (02marks)
   [The ratio of the principal molar heat capacities of the gas = 5:3]
   (c) (i) Define molar heat capacities at constant pressure. (01mark)
   (ii) Derive the expression $C_p - C_v = R$, for 1mole of a gas (05marks)
   (iii) In which ways does a real gas differ from an ideal gas? (02marks)
7. (a) (i) Define thermal conductivity. (01mark)
   (ii) State two factors which determine the rate of heat transfer through a material (02marks)
   (b)(i) Describe with the aid of a diagram an experiment to measure the thermal conductivity of glass. (08marks)
   (ii) Briefly discuss the advantages of the apparatus in (b)(i). (02marks)
   (c) Metal rods of copper, brass are welded together to form Y shaped figure.
   The cross-section area of each rod is $2cm^2$. The free end of copper rod are maintained at 100^0C, while the free ends of brass and steel rods are maintained at 0^0C. If there is no heat loss from the surfaces of the rods and the length of the rods are 0.46m, 0.13m and 0.12m respectively.
   (i) Calculate the temperature of the junction (05marks)
   (ii) Find the heat current in the copper rod. (02marks)

   [Thermal conductivities of copper, brass and steel are $385Wm^{-1}K^{-1}$, $109\ Wm^{-1}K^{-1}$ and $50.2\ Wm^{-1}K^{-1}$ respectively.]

SECTION C

8. (a)(i) Draw a labelled diagram of an X-ray tube. (02marks)
   (ii) Use the diagram in (a)(i) to describe how X-rays are produced. (03marks)
   (iii) State one industrial and one biological use of X-rays. (01marks)
   (b)(i) Sketch a graph of intensity versus wavelength of X-rays from an X-ray tube and describe its main features. (04marks)
   (ii) Calculate the maximum frequency of X-rays emitted by an X-ray tube operating on voltage of 34.0kV. (03marks)
   (c) In the measurement of electron charge by Millikan's apparatus, a potential difference of 1.6kV is applied between two horizontal plates 14mm apart. With the potential difference switched off, an oil drop is observed to fall with constant velocity $4.0 \times 10^{-4}ms^{-1}$. When the potential difference is switched on, the drop rises with constant velocity $8.0 \times 10^{-5}ms^{-1}$.
   If the mass of the oil drop is $1.0 \times 10^{-14}kg$, find the number of electron charges on the drop.
   [assume air resistance is proportional to velocity of the oil drop and neglect the up thrust due to air] (07marks]

9. (a) (i) State the laws of photo-electric emission. (04marks)
   (ii) Write down Einstein's equation for photo electric emission. (02marks)
   (iii) Ultra –violet light of wavelength 3.3 x 10-8m is incident on a metal. Given the work function of the metal is 3.5eV, calculate the maximum velocity of the liberated electron. (03marks)

   (b) Describe, with aid of a diagram, the structure and mode of operation of a cathode ray oscilloscope (C.R.O) (06marks)

   A C.R.O has its y-sensitivity set to $10Vm^{-1}$. A sinusoidal input voltage is suitably applied to give a steady trace with time base switched on so that the electron beam takes 0.01s to traverse the screen. If the trace seen has a peak-to-peak height of 4.0cm and contains two complete cycles, find the

   (i) r.m.s value of the input voltage. (03marks)
   (ii) frequency of the input signal. (02marks)

10. (a) define binding energy of nuclide (01mark)
   (b) (i) Sketch a graph showing how binding energy per nucleon varies with mas number (01mark)
   (ii) Describe the main features of the graph in (b)(i). (03marks)
   (c) Distinguish between nuclear fission and nuclear fusion and account for the energy released. (03mark)
   (d) (i) with the aid of a labelled diagram describe the working of the Geiger-Muller tube. (05marks)
   (ii) How would you use a Geiger-Muller tube to determine the half-life of a radioactive sample? (04marks)
   (e) A radioactive source produces alpha particles each of energy 60eV. If 20% of the alpha particles enter an ionization chamber a current of 0.2μA flows. Find the activity of the alpha source, if the energy needed to make an ion pair in the chamber is 32MeV. (03marks)

Compiled by Dr. Bbosa Science