UACE Physics paper 1 2002 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	$9.11 \times 10^{-31}kg$
Mass of the earth	$5.97 \times 10^{24}kg$
Plank's constant, h	$6.6 \times 10^{-34}Js$
Stefan's-Boltzmann's constant, σ	$5.67 \times 10^{-8}Wm^{-2}K^{-1}$
Radius of the earth	6.4 x 106m
Radius of the sun	$7 \times 10^{8}m$
Radius of the earth's orbit about the sun	$1.5 \times 10^{11}m$
Speed of light in the vacuum, c	$3.0 \times 108ms^{-1}$
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	$6.67 \times 10^{-11}Nm^{2}Kg^{-2}$
Avogadro's number, N_A	$6.02 \times 10^{23}mol^{-1}$
Surface tension of water	$7.0 \times 10^{-2}Nm^{-1}$
Density of water	$1000kgm^{-3}$
Gas constant, R	$8.31Jmol^{-1}K^{-1}$
Charge to mass ratio, e/m	$1.8 \times 10^{11}Ckg^{-1}$
The constant, $\frac{1}{4\pi\varepsilon_0}$	$9.0 \times 10^{9}F^{-1}m$
Faraday's constant, F	$9.65 \times 10^{4}Cmol^{-1}$

SECTION A

1. (a) (i) what is meant by the dimensions of a physical quantity? (01mark)

   (ii) For stream line flow of non-viscous, incompressible fluid, the pressure, P, at a point is related to height, h, and the velocity, V by the equation $(P-a) = \rho g(h-b) + \frac{1}{2}(v^2-d)$ where a, b, and d, are constants and ρ is the density of the fluid and g is the acceleration due to gravity. Given that the equation is dimensionally consistent, find the dimensions of a, b and d. (03marks)

   (b) Define simple harmonic motion.(01marks)

   (c) Sketch the following graphs for a body performing simple harmonic motion:

   (i) velocity against displacement (01mark)

   (ii) displacement against time (01mark)

   (d) The period of oscillation of a conical pendulum is 2.0s. If the string makes 60^0 to the vertical at the point of suspension, calculate the

   (i) vertical height of the point of suspension above the circle. (03marks)

   (ii) length of the string (01 mark)

   (iii) Velocity of the mass attached to the string (03marks)

   (e) (i) give one example of an oscillatory motion which approximates simple harmonic motion

   (ii) What approximation is made in (e)(i) above? (01mark)

   (f) Explain why the acceleration of a ball bearing falling through a liquid decreases continuously until it become zero. (04marks).

2. (a) (i) State Newton's law of universal gravitation. (01mark)

   (ii) Show that this law is consistent with Kepler's third law. (03marks)

   (iii) Two alternative units for gravitational field strength are Nkg^{-1} and ms^{-1}. Use the method of dimensions to show that the two units are equivalent. (03marks)

   (b) (i) Derive an expression for speed of a body moving uniformly n a circular path. (03marks)

   (ii) Explain why a force is necessary to maintain a body moving with constant speed in a circular path. (02marks)

   (c) A small mass attached to a string suspended from a fixed point moves in a circular path at constant speed in horizontal plane.

   (i) Draw a diagram showing the force acting on the mass. (01mark)

   (ii) Derive an equation showing the angle of inclination of the string depends on the speed of the mass and radius of the circular path. (03marks)

   (d) (i) Define moment of force. (01mark)

   (ii) A wheel of radius 0.6m is pivoted at its centre. A tangential force of 4.0N acts on the wheel so that the wheel rotates with uniform velocity. Find the work done by the force to turn the wheel through 10 revolutions. (03marks)

3. (a) (i) Show that the weight of a fluid displaced by an object is equal to up thrust on the object. (05marks)

   (ii) A piece of metal of mass 2.60×10^{-3}kg and density $8.4 \times 10^3 kgm^{-3}$ is attached to a block of wax of mass 1.0×10^{-2}kg and density $9.2 \times 10^2 kgm^{-3}$. When the system is placed in a liquid, it floats with wax just submerged. Find the density of the fluid. (04marks)

   (b) Explain the

(i) term laminar flow and turbulent flow. (04marks)

(ii) effects of temperature on viscosity of liquids and gases. (03marks)

(c) (i)distinguish between static pressure and dynamic pressure. (02marks)

(ii) A pilot-static tube fitted with a pressure gauge is used to measure the speed of a boat at sea. Given that the speed of the boat does not exceed $10ms^{-1}$ and the density of water is $1000kgm^{-3}$, calculate the minimum pressure on the gauge. (02marks)

4. (a) Define the terms surface tension and surface energy. (01mark)
   (b) (i) Calculate the work done against surface tension in blowing a soap bubble of diameter 15mm, if the surface tension of soap solution is 3.0×10^{-2}Nm. (03marks)
   (ii) A soap bubble of radius r_1 is attached to another bubble of radius r_2. If r_1 is less than r_2. Show that the radius of curvature of the common interface is $\frac{r_1 r_2}{r_2 - r_1}$. (05marks)
   (c) (i) Define coefficient of viscosity of a liquid. (01mark)
   (ii) Describe an experiment to demonstrate streamline and turbulent flow in liquids. (06marks)
   (d) (i) Sketch a graph of potential energy against separation of two molecules of a substance. (01mark)
   (ii) Explain the main features of the graph in (d)(i). (03marks)

SECTION B

5. (a) State the assumption made in the derivation of the expression P = $\frac{1}{3}\rho \overline{c^2}$ for pressure of an
   ideal gas (02marks)
   (b) Use the expression in (a) above to deduce Dalton's law of partial pressures. (03marks)
   (c) Describe an experiment to determine the saturation vapor pressure of a liquid. (06marks)
   (d) (i) What is meant by a reversible isothermal change? (02marks)
   (ii) State the conditions for achieving a reversible isothermal change. (02marks)
   (e) An ideal gas at 27^0C and at a pressure of 1.01×10^5Pa is compressed reversibly and isothermally until its volume is halved. It is then expanded reversibly and adiabatically to twice its original volume. Calculate the final pressure and temperature of the gas if γ=1.4 (05marks)
6. (a) Explain the mechanism of heat conduction in solids. (03marks)
   (b) Describe a method of determining the thermal conductivity of cork in form of a thin sheet. (06marks)
   (c) A window of height 1.0m and width 1.5m contains a double grazed unit consisting of two single glass panes, each of thickness 4.0mm separated by an air gap of 2.0mm. Calculate the rate at which heat is conducted through the window if the temperatures of external surfaces of glass are 20^0C and 30^0Crespectively.
   [Thermal conductivities of glass and air are $0.72Wm^{-1}K^{-1}$ and $0.025\ Wm^{-1}K^{-1}$ respectively] (07marks)
   (d) (i) State Stefan's law. (01mark)
   (ii) The element of a 1.0kW electric fire is 30.0cm long and 1.0cm in diameter. If the temperature of the surroundings is 20^0C, estimate the working temperature of the element. [Stefan's constant, $\sigma = 5.7 \times 10^{-18}Wm^{-1}K^{-1}$] (03marks)

7. (a) (i) Define specific heat capacity of a substance (01mark)

(ii) State how heat losses are minimized in calorimetry (02mark)

(b) (i) What is meant by cooling correction? (01marks)

(ii) Explain how the cooling correction may be estimated in the determination of the heat capacity of poor by the method of mixtures (05marks)

(iii) Explain why a small body cools faster than a larger one of the same material. (04marks)

(c) Describe how you would determine the specific heat capacity of a liquid by the continuous flow method. (07marks)

SECTION C

8. (a) What is meant by

(i) Bohr atom (01mark)

(ii) binding energy of a nucleus (02marks)

(b) The total energy, E, of an electron n an atom may be expressed as

$$E=\frac{-mq^4}{8\varepsilon_0^2 n^2 h^2}$$

(i) Identify the quantities, m, q, n and h in this expression (02marks)

(ii) Explain the physical implication of the fact that E is always negative (02marks)

(iii) Draw an energy level diagram for hydrogen to indicate emission of ultraviolet, visible and infrared spectral lines. (03marks)

(c)(i) Explain briefly the sources and absorption of infrared radiation. (04 marks)

(ii) Describe briefly, the method of detecting infrared radiation (03marks)

(d) The atomic nucleus may be considered to be a sphere of positive charge with a diameter very much less than that of an atom. Discuss the experimental evidence which supports this view. (03marks)

9. (a) (i) What are cathode rays? (01mark)

(ii) An electron gun operating at 3 x 10^3V is used to project electrons into the space between two oppositely charged parallel plates of length 10cm and separation 5cm.

Calculate the deflection of the electrons as they emerge from the region between the charged plates when the potential difference is 1 x 10^3V. (03marks)

(b) (i) Describe a simple experiment to demonstrate photoelectric emission. (04marks)

(ii) Explain why the wave theory of light fails to account for the photoelectric effect. (06marks)

(iv) Describe an experiment to verify Einstein's equation for the photoelectric effect and explain how Plank's constant may be obtained from the experiment. (06marks)

10. (a) What is meant by

(i) half-life of radioactive element (01mark)

(ii) nuclear fission (01mark)

(iii) Nuclear fusion

(b) An atom of ^{222}Ra emits an α-particle of energy 5.3eV. Given that the half-life of ^{222}Ra is 3.8days. Use the decay law, $N= N_0e^{-\lambda t}$ to calculate the:

(i) decay constant (03marks)

(ii) amount of energy released by 3.0 x 10^{-9}kg of ^{222}Ra after 3.8days (05marks)

(c) Describe a simple form of a mass spectrometer and explain how it is used to distinguish between isotopes (07marks)

(d) The nucleus of $^{37}_{17}Cl$ emits an α-particle followed by two β-particles. Show that the final nucleus is an isotope of chlorine (02mark)

Compiled by Dr. Bbosa Science