UACE Physics paper 1 2003 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) Distinguish between fundamental and derived physical quantities. Give two examples of each. (04marks)

   (b) (i) What is meant by scalar and vector quantities? (02marks)

   (ii) A ball is thrown vertically upwards with a velocity $10m^{-1}$ from a point 3.0m above ground. Describe with the aid of a velocity-time sketch graph, the subsequent motion of the ball. (10marks)

   (c) A boat crosses a river 3km wide flowing at $4ms^{-1}$ to reach a point on the opposite bank 5km upstream. The boat's speed in still water is $12ms^{-1}$. Find the direction in which the boat must be headed. (04marks)

2. (a) Define the following terms:

   (i) Angular velocity (01mark)

   (ii) Centripetal acceleration (01mark)

   (b) (i) Explain why a racing car can travel faster on a banked road than on flat track of the same curvature. (04marks)

   (ii) Derive an expression for the speed with which a car can negotiate a bend on a banked track without skidding. (03marks)

   (c) a Show how to estimate the mass of the sun if the period and radius of one of its planets are known. (03marks)

   (d) The gravitational potential, U, at the surface of a planet of mass M and radius R is given by $U=-\frac{GM}{R}$, where G is gravitational constant.

   Derive an expression for the lowest velocity, V, which an object of mass, m, must have at the surface of the planet if it is to escape from the planet. (04marks)

   (e) Communication satellites orbit the earth in synchronous orbits. Calculate the height of communication satellite above the earth. (04marks)

3. (a) State the law of floatation. (01mark)

   (b) With the aid of a diagram, describe how to measure the relative density of a liquid using Archimedes' Principle of moments (06marks)

   (c) A cross sectional area of a ferry at its water-line is $720m^2$.if sixteen cars of average mass 1100kg are placed on board, to what extra depth will the boat sink in the water? (04marks)

   (d) (i) Define longitudinal stress and Young's Modulus of elasticity. (02marks)

   (ii) Describe how to determine Young's Modulus for steel wire. (07marks)

4. (a) A mass of 0.1kg is suspended from a light spring of force constant $24.5Nm^{-1}$. Calculate the potential energy of the mass. (04marks)

   (b) (i) State four characteristics of simple harmonic motion. (04marks)

   (ii) Show that the speed of a body moving with simple harmonic motion of angular velocity, ω, is given by $V = \omega(A^2 - x^2)^{½}$,where A is the amplitude and x is the displacement from equilibrium position. (04marks)

   (iii) Sketch graphs to show the variation with displacement, of kinetic and potential energies of a body moving with simple harmonic motion (02marks)

(c) A mass of 0.1kg suspended from a spring of force constant $24.5Nm^{-1}$ is pulled vertically downwards through a distance 5.0cm and released. Find the

(i) period of acceleration (02marks)

(ii) position of the mass0.3s after release. (04marks)

SECTION B

5. (a) (i) Define molar heat capacity of a gas at constant volume. (01mark)
   (ii) The specific heat capacity of oxygen at constant volume is $719Jkg^{-1}K^{-1}$. If the density of oxygen at s.t.p is $1.429kgm^{-3}$, calculate the specific heat capacity of oxygen at constant pressure. (04marks)
   (b) Indicate the different states of a real gas at different temperatures and pressure versus volume sketch graph.
   (c) (i) In deriving the expression P = $\frac{1}{3}\rho\overline{c^2}$ for the pressure of an ideal gas, two of the assumptions made are not valid for a real gas. State these assumptions. (02marks)
   (ii) The equation of state of one mole of a real gas is $\left(P + \frac{a}{v^2}\right)(v - b) = RT$
   Account for the terms $\frac{a}{v^2}$ and b (02marks)
   (d) Use the expression P = $\frac{1}{3}\rho\overline{c^2}$; for the pressure of an ideal gas to derive Dalton's law of partial pressures (04marks)
   (e) Explain, with the aid of a volume versus temperature sketch graph, what happens to a gas cooled at constant pressure from room temperature to zero Kelvin. (04marks)
6. (a) What is meant by black body? (01mark)
   (b) Describe how an approximate black body can be realized in practice. (02marks)
   (c)(i)Draw sketch graphs to show how variation of relative intensity of black body radiation with wavelength for three different temperatures. (02marks)
   (ii) Describe the features of the sketch in (c)(i) above. (03marks)
   (d)(i) State Stefan's law (01mark)
   (ii) A solid copper sphere of diameter 10 mm and temperature of 150K is placed in an enclosure maintained at a temperature of 290K. Calculate, stating assumptions made, the initial rate of rise of temperature of the sphere.
   [Density of copper = $8.93 \times 10^3 kgm^{-3}$, specific heat capacity of copper = $3.7 \times 10^2 JkgK^{-1}$)
   (07marks)
   (e) With the aid of a labelled diagram, describe how a thermopile can be used to determine infrared radiation. (04marks)
7. (a) (i)What is meant by kinetic theory of gases? (03marks)
   (ii) Define an ideal gas (01mark)
   (iii) State and explain conditions under which real gases behave like ideal gases. (04mark)
   (b) (i) Describe an experiment to show that a liquid boils only when its saturated vapor pressure is equal to external pressure (05marks)
   (ii) Explain how cooking at a pressure of 76cm of mercury and temperature of 100^0C may be achieved on top of high mountains. (o3marks)
   (c) (i) Define root-mean-square speed of molecules of a gas. (01mark)
   (ii) The mass of hydrogen and oxygen atoms are 1.66×10^{-27}kg and 2.66×10^{-26}kg respectively. What is the ratio of the root mean square speed of hydrogen to that of oxygen molecules at the same temperature? (03marks)

SECTION C

8. (a) (i) State Rutherford's model of the atom. (02marks)

(ii) Explain two main failures of Rutherford's model of the atom. (03marks)

(b) (i) Explain how Millikan's experiment for measuring the charge of an electron proves that charge is quantized. (04marks)

(ii) Oil droplets are introduced into the space between two flat horizontal plates, set 5.0mm apart. The plate voltage is then adjusted to exactly 780V so that one of the droplets is held stationary. Then the plate voltage is switched off and the selected droplet is observed to fall a measured distance of 1.5mm in 11.2s. Given the density of oil used is $900kgm^{-3}$ and the viscosity of air is $1.8 \times 10^{-5}Nsm^{-2}$, calculate the charge on the droplet. (06marks)

(c) A beam of positive ions is accelerated through a potential difference of 1 x 103V into a region of uniform magnetic field of flux density 0.2T. While in magnetic field it moves in a circle of radius 2.3cm. Derive an expression for the charge to mass ration of the ions, and calculate the value. (05marks)

9. (a) (i) What is meant by thermionic emission? (01mark)

(ii) Sketch the current-potential difference characteristics of a thermionic diode for two different operating temperature and explain their main features. (05marks)

(i) Describe one application of a diode. (02marks)

(b) (i) What features of an x-ray tube make it suitable for continuous production of X-rays. (03marks)

(ii) Sketch a graph of intensity versus frequency of a radiation produced in an X-ray tube and explain its main feature. (05marks)

(iii) A mono chromatic X-ray beam of wavelength 1.0×10^{-10}cm is incident on a set of planes in a crystal of spacing 2.8×10^{-10}m.What is the maximum order possible with these X-rays? (04marks)

10. (a) What is meant by the following terms:

(i) nuclear number (01mark)

(ii) binding energy (01marks)

(b) Calculate the energy released during the decay of ${}^{220}_{86}Rn$ nucleus into ${}^{216}_{84}P_0$ and α-particle

Mass of ${}^{220}_{86}Rn$ = 219.964176u

Mass of ${}^{216}_{84}Po$ = 215.955794u

Mass of ${}^{4}_{2}He$ = 4.001566u

(1u = 931eV) (04marks)

(c) Describe the Bainbridge mass spectrometer and explain how it can be used to distinguish between isotopes (07marks)

(d) (i) Explain how you would use a decay curve for a radioactive material to determine its half-life. (02marks)

(ii) A radioactive source contain 1.0μg of plutonium of mass number 239. If the source emits 2300 α-particles per second, calculate the half-life of plutonium.

[Assume the decay law $N + N_0e^{-\lambda t}$] (05mark)

Compiled by Dr. Bbosa Science