UACE Physics paper 1 set 3 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) (i)State Newton's laws of motion. (03marks)
   (ii) A molecule of a gas contained in a cube of side L strikes the wall of the cube repeatedly with a velocity u. Show that the average force F on the wall is given by
   F = $\frac{mu^2}{L}$; where m is the mass of the molecule (04marks)
   (b) (i) Define linear momentum and state the law of conservation of linear momentum. (02marks)
   (ii) A body of mass m1 moving with velocity u, collides with another body of mass m2 at rest. If they stick together after collision, find the common velocity with which they move (04marks)
   (c) A bullet of mass 10g is fired horizontally with a velocity of 300ms^{-1} into a block of wood of mass 290g which rests on a rough horizontal floor. After impact, the block and the bullet move together and come to rest when the block has travelled a distance of 15m. Calculate the coefficient of sliding friction between the block and the floor. (07marks)

2. (a) State Kepler's laws of planetary motion. (03marks)
   (b) Use Newton's law of gravity to derive the dimension of the universal gravitational constant (03marks)
   (c) A satellite is resolving at a height, h, above the surface of the earth with period T.
   (i) Show that the acceleration due to gravity, g, on the earth's surface is given by
   g = $\frac{4\pi^2(r_e+h)^3}{T^2r_e^2}$ where r_e is the radius of the earth. (06marks)
   (ii) What is meant by parking orbit? (02marks)
   (d) A satellite revolves in a circular orbit at a height of 600kmabove the earth's surface. Calculate the
   (i) speed of the satellite. (03marks)
   (ii) period of the satellite. (03marks)
3. (a)(i) Define Simple harmonic motion. (01mark)
   (ii) Sketch a displacement-time graph for a body performing simple harmonic motion. (01mark)
   (b) A uniform cylindrical rod of length 16cm and density 920kgm^{-3} floats vertically in a liquid of density 1000kgm^{-3}. The rod is depressed through a distance of 7mm and then released.
   (i) Show that the rod performs simple harmonic motion (06marks)
   (ii) Find the frequency of the resultant oscillations. (04marks)
   (iii) Find the velocity of the rod when is at a distance of 5mm above the equilibrium position (03marks)
   (c) What is meant by potential energy? (01mark)
   (d) Describe the energy changes which occur when a
   (i) ball thrown upwards in air (03marks)
   (ii) loud speaker vibrating (01mark)
4. (a)(i) Define elastic deformation and plastic deformation (02marks)
   (ii) Explain what is meant by work hardening. (02marks)
   (b) (i) Sketch using the same axes, stress-strain curves for ductile material and for rubber (03marks)

(ii) Explain the features of the curve for rubber. (03marks)

(c) A capillary tube is held in a vertical position with one end dipping in a liquid of surface tension γ and density ρ. If the liquid rises to a height, h, derive an expression for h in terms of γ, ρ and radius r of the tube assuming the angle of contact is zero. (04marks)

(d) A mercury drop of radius 2mm falls vertically and on hitting the ground, it splits into two drops each of radius 0.5mm. Calculate the change in surface energy given that the surface tension of mercury is $0.52Nm^{-1}$. (05marks)

(e) State the effect of temperature on surface tension of a liquid. (01mark)

SECTION B

5. (a) (i) State the thermometric property used in a constant-volume gas thermometer (01mark)

(ii) Give two characteristic of a good thermometric property, (02marks)

(b) (i) Describe the steps taken to set up a Celsius scale of temperature for a mercury-in glass thermometer. (04marks)

(ii) State four disadvantages of a mercury in glass thermometer. (04marks)

(c) Describe with the aid of a diagram the operation of an optical pyrometer (06marks)

(d) When oxygen is withdrawn from a tank of volume 50L, the reading of pressured gauge attached to the tank drops from 4.4×10^5 Pa to 7.8×10^5Pa. If the temperature of gas remaining in the tank falls from 30^0C to 10^0C, calculate the mass of oxygen withdrawn.

6. (a)(i) What is meant by boiling point? (01marks)

(ii) Explain why boiling point of a liquid increases with increase in the external pressure. (05marks)

(b) (i) Explain how the pressure of a fixed mass of a gas can be increased at

- Constant temperature (03marks)
- Constant volume (03marks)

(c) Sketch a pressure versus volume curve for a real gas undergoing compression (0marks)

(d) The cylinder of an exhaust pump has a volume of $5cm^3$. If it is connected through a valve to a flask of volume 225 cm^3 containing air at a pressure of 75cmHg, calculate the pressure of air in the flask after two strokes of the pump, assuming that the temperature of the air remain constant.

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

(ii) Explain the mechanism of heat transfer by convention. (03marks)

(b) (i) State Newton's law of cooling (01mark)

(ii) Describe briefly an experiment to verify Newton's law of cooling. (05marks)

(c) A wall is constructed using two types of bricks. The temperatures of the inner and outer surface of the wall are 29^0C and 21^0C respectively. The value of thermal conductivity for the inner brick is $0.4Wm^{-1}K^{-1}$ and that of the outer brick is $0.8Wm^{-1}K^{-1}$.

(i) Explain why in a steady state the rate of thermal energy transfer is the same in both layers. (0marks)

(ii) If each layer is 12 cm thick, find the temperature at the interface between the layers. (04mrks)

(d) Explain the greenhouse effect and how it leads to rise of the earth temperature. (04marks)

SECTION C

8. (a) What is meant by the following
   (i) Radioactivity (01mark)
   (ii) Isotopes (01marks)

(b) (i) Define mass defect (01mark)

(ii) State the conditions for a heavy nucleus to be unstable (01mark)

(iii) Explain your answer in (b)(ii) (02marks)

(c) A sample of $^{226}_{88}Ra$ emits both α-particles and γ-rays. A mass defect of 0.0053u occurs in the decay.

(i) Calculate the energy released in joules. (03 marks)

(ii) If the sample decays by emission of α-particle, each of energy 4.60MeV and γ-rays, find the frequency of the γ-rays emitted. (04marks)

(d) (i) Sketch a graph showing the variation of binding energy per nucleon with mass number, clearly showing the fusion and fissions. (02marks)

(ii) Use the sketch in (d)(i) to explain how energy is released in each of the process of fusion and fission. (03marks)

(e) State two

(i) applications of radioisotopes (01marks)

(ii) health hazards of radioisotopes (01mark)

9. (a) What are X-rays? (01marks)

(b) (i) With the aid of a diagram explain how X-rays are produced in an X-ray tube (05marks)

(ii) State the energy changes that take place in the production of X-rays in an X-ray tube. (02marks)

(c) In an X-ray tube, the electrons strike the target with a velocity of 3.75 x 107ms-1 after travelling a distance of 5.0cm from the cathode. If a current of 10mS flows through the tube, find the

(i) tube voltage (02marks)

(ii) number of electrons striking the target per second. (02marks)

(ii) Number of electrons within the space of 1cm length between the anode and the cathode. (05marks)

(d) Briefly explain one medical application of x-rays (03marks)

10. (a) state Bohr's postulates of an atom (03marks)

(b) Explain the occurrence of the emission and absorption line spectra. (06marks)

(c) Explain the main observations in Rutherford's α-particles scattering experiment. (06marks)

(d) A beam of alpha particles of energy 3.5MeV is incident normal to the gold foil.

(i) Calculate the least distance of approach to the nucleus of the gold atom given its atomic number is 79, (04marks)

(ii) State the significance of the value of the least distance of approach. (01mark)

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