UACE Physics paper 1 2001 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) State the principle of conservation of mechanical energy. (01mark)

   (ii) Show that a stone thrown vertically upwards obeys the principle in (a)(i) above throughout its upward motion. (04marks)

(b)(i) A wind turbine made of a blade of radius, r, is driven by wind of speed, V. If σ is the density of air, derive an expression for minimum power, P, which can be developed by the turbine in terms of σ, r and V. (03marks)

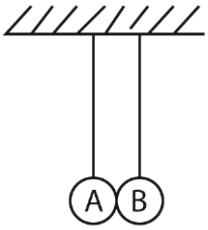
(ii) Explain why the power attained is less than the maximum value in (b)(i) above. (02marks)

(c) State the conditions under which the following will be conserved in collision between two bodies

(i) linear momentum (10mark)

(ii) kinetic energy (01mark)

(d) Two pendulum bobs A and B of equal length L, and masses 3M and M respectively. The pendula are hung with bobs in contact as shown below



The bob A is displaced such that the string makes an angle θ with the vertical and released. If A makes a perfectly inelastic collision with B, fins the height to which B rises. (08marks)

2. (a) Define the following terms

   (i) Stress (01mark)

   (ii) Strain (01mark)

(b) The velocity, V, of sound travelling along a rod made of a material of Young's Modulus, Y, and density, ρ is given by V = $\sqrt{\frac{Y}{\rho}}$.

Show that the formula is dimensionally consistent. (03marks)

(c) State the measurement necessary in the determination of Young's Modulus of a metal wire. (02marks)

(d) Explain why the following precautions are taken during an experiment to determine Young's Modulus of a metal wire.

(i) two long, thin wires of the same material are suspended from a common support. (02marks)

(ii) the readings of the vernier are also taken when the loads are gradually removed in steps. (01marks)

(e) The ends of a uniform wire of length 2.00m are fixed to points A and B which are 2.00m apart in the same horizontal line. When a 5kg mass is attached to the mid-point C of the wire, the equilibrium position of C is 7.5 below the line AB. Given that Young's Modulus for the material of the wire is 2.0x 10^{11}Pa, find

(i) the strain in the wire (03marks)

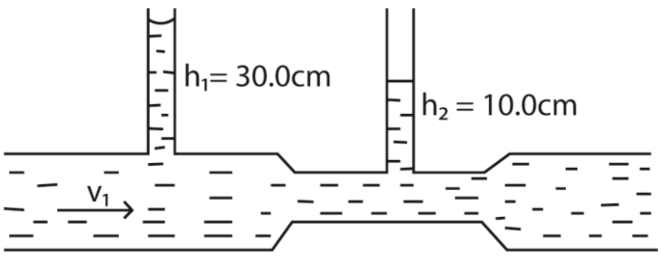
(ii) the stress in the wire, (02marks)

(iii) The energy stored in the wire (04marks)

(iv) State any assumptions made. (01mark)

3. (a) Define surface tension and derive its dimensions (03marks)
   (b) Explain using the molecular theory the occurrence of surface tension. (04 marks)
   (c) Derive an experiment to measure surface tension of a liquid by the capillary tube method. (06marks)
   (d) (i) Show that the excess pressure in a soap bubble is given by P = $\frac{4\gamma}{r}$, (03marks)
   (ii) Calculate the total pressure within a bubble of air of radius 0.1mm in water if the bubble is formed 10cm below the water surface and surface tension of water is 7.27 x 10^{-2}Nm^{-1}. [Atmospheric pressure = 1.01 x 10^5Pa] (05marks)

4. (a) (i) Define coefficient of viscosity and determine its dimensions. (04marks)
   (ii) The resistive force on a steel ball bearing of radius, r, falling with speed, V, in a liquid of viscosity, η is given by F = KηrV, where K is a constant. Show that K is dimensionless. (04marks)
   (b) Write down Bernoulli's equation for fluid flow, defining all symbols used (03marks)
   (c) A venturi meter consists of a horizontal tube with a constriction which replaces part of the piping system as shown below



If the cross-sectional area of the main pipe is 5.81 x 10^{-3}m^2 and that of the constriction is 2.58 x 10^{-3}m^2, find the velocity v_1 of the liquid in the main pipe. (5marks)

(d) Explain the origin of the lift on an aeroplane at take-off. (04marks)

SECTION B

5. (a) Define thermal conductivity of a substance and state its units. (02marks)

   (b) Flux of solar energy incident on the earth's surface is $1.36x\ 10^3Wm^{-2}$.

   Calculate

   (i) The temperature of the surface of the sun (04marks)

   (ii) The total power emitted by the sun (03marks)

   (iii) The rate of loss of mass by the sun (03marks)

   (c)(i) Explain how heat is conducted through a glass rod. (03marks)

   (ii) Why is a metal a better conductor of heat than glass? (02marks)

   (iii) Explain briefly why it is necessary to use a thin specimen of large cross-section area in determining thermal conductivity of a poor conductor of heat. (03marks)

6. (a) (i)Explain what happens when a quantity of heat is applied to a fixed mass of a gas (02marks)

   (ii) Derive the relationship between the principal molar heat capacities C_p and C_v for an deal gas. (05marks)

   (b) (i) What is adiabatic process? (01mark)

   (ii) A bicycle pump contains air at 290K. The piston of the pump is slowly pushed in until the volume of the air enclosed is one fifth of the total volume of the pump. The outlet is sealed off and the piston suddenly pulled out to full extension. If no air escapes, find its temperature immediately after pulling the piston. $\left(Take\ {C_p}/{C_v} = 1.4\right)$ (03marks)

   (c) (i) Distinguish between unsaturated and saturated vapors. (02marks)

   (ii) Draw graphs to show the relationship between pressure and temperature for ideal gas and for saturated water vapour originally at 0^0C. (03marks)

   (d) In an experiment, the pressure of a fixed mass of air at constant temperature is 10.4kPa. When the volume is halved, keeping the temperature constant, the pressure becomes 19.0kPa. Discuss the applicability of the above results in verifying Boyle's law. (04marks)

7. (a) Explain why temperature remains constant during change of phase. (04marks)

   (b) Describe with the aid of labelled diagram, an electrical method for determination of specific latent heat of vaporization of a liquid. (07marks)

   (c) Water vapour and liquid water are confined in an air tight vessel. The temperature of the water is raised until all the water has evaporated.

   Draw a sketch graph to show how the pressure of water vapour changes with temperature and account for its main features. (06marks)

   (d) Calculate the work done against the atmosphere when 1kg of water turns into vapour at atmospheric pressure of 1.01×10^5Pa.

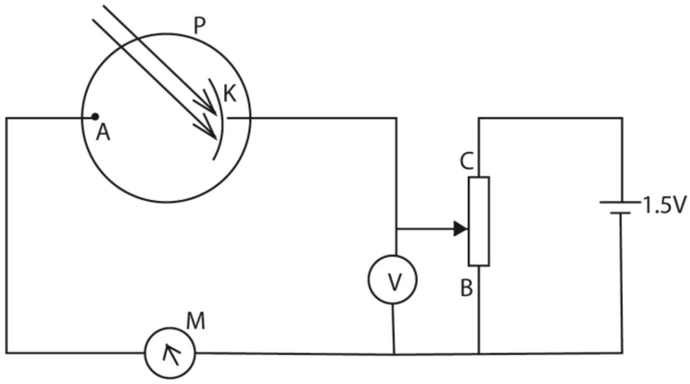
   [Density of water vapour $=0.598kgm^{-3}$](03marks)

SECTION C

8. (a) (i) Write down the Einstein photo-electric equation (01mark)

(ii) Explain how the equation in (a)(i) above accounts for the emission of electrons from metal surfaces illuminated by radiation. (04marks)

(b)



P is a vacuum photocell with anode, A, and cathode, K, made from the same metal of work function 2.0eV. The cathode is illuminated by monochromatic light of constant intensity and wavelength 4.4×10^{-7}m

(i) Describe and explain how the current shown by the micro ammeter, M will vary as the slider of potential divider is moved from B to C. (03marks)

(ii) What will the reading of the high-resistance voltmeter, V, be when photo-electric emission just ceases? (03marks)

(c) With the slider set mid-way between B and C, describe and explain how the reading of M would change if

(i) the intensity of the light was increased, (03marks)

(ii) the wavelength of the light was changed to 5.5×10^{-7}m

9. (a) What is meant by the following

(i) an alpha particle, (01mark)

(ii) radioactivity (01mark)

(b) Show that when an alpha particle collides head –on with an atom of atomic number Z, the closest distance of approach to the nucleus b_o, is given by

$$b_o = \frac{Ze^2}{\pi\varepsilon_0 m v^2}$$

where e is the electronic charge, ε0 is the permittivity of free space, m, mass of the alpha particle and v is the initial velocity of the particle. (06marks)

(c) Describe the structure and action of a cloud chamber. (06marks)

(d) State four uses of radioactive isotopes (02marks)

(e) one kilogram of wood from a ship wreck has activity of 1.2×10^2 counts per second due to ^{14}C, whereas the same amount of wood had an activity of 2.0×10^2counts per second. Find the age of the ship wreck. [Half-life of 14C = 5.7×10^3years] (04 marks)

10. (a) What is meant by emission line spectra?

E_∞ …………………………………………………………	0eV
E_4…………………………………………………………	-0.81eV
E_3…………………………………………………………	-2.77eV
E_2…………………………………………………………	-4.87eV
E_1…………………………………………………………	-27.47eV

(ii) The figure above shows some energy levels of neon. Determine the wavelength of the radiation emitted in an electron transition from E_4 to E_3. In what region of the electromagnetic spectrum does the radiation lie? (04marks)

(b) Outline the principles of generation of continuous line spectra of X-rays in X-ray tube. (05marks)

(c) State Bragg's law of X-ray diffraction. (01mark)

(d) A beam of X-rays of wavelength 1.0 x 10-10m is incident on a set of cubic planes in a sodium chloride crystals. The first order diffraction m is obtained for a grazing angle of 10.2^0.

Find

(i) The spacing between consecutive planes (03marks)
(ii) The density of the sodium chloride (04marks)

Compiled by Dr. Bbosa Science