P510/1
**Physics**
**Paper 1**
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2 ½ hours

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UACE JOINT MOCK EXAMINATIONS 2011
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## *Instructions to Candidates*

Attempt five questions, including at least one, but not more than two question from each of the sections, A, B and C

Non programmable scientific electronic calculators may be used

Assume where necessary:

| | |
|---|---|
| Acceleration due to gravity, g | = $9.81 ms^{-2}$ |
| Electron charge, e | = $1.6 \times 10^{-19}$ C |
| Electron mass | = $9.11 \times 10^{-31}$ kg |
| Mass of the earth | = $5.97 \times 10^{24}$ kg |
| Planck's constant h | = $6.63 \times 10^{-34}$ Js |
| Stefan's Boltzman's constant, σ | = $5.67 \times 10^{-5}$ W $m^{-2}$ $K^{-1}$ |
| Radius of the earth | = $6.4 \times 10^{6}$ m |
| Radius of Earth's orbit about the sun | = $1.5 \times 10^{11}$ m |
| Speed of light in a vacuum, c | = $3.0 \times 10^{8}$ $ms^{-1}$ |
| Thermal conductivity of copper | = 390 $Wm^{-1}$ $K^{-1}$ |
| Thermal conductivity of aluminium | = 210 $Wm^{-1}$ $K^{-1}$ |
| Specific heat capacity of water | = 4,200 J $kg^{-1}$ $K^{-1}$ |
| Universal gravitational constant G | = $6.67 \times 10^{-11}$ $Nm^2$ $kg^{-2}$ |
| Avogadro's number Na | = $6.02 \times 10^{23}$ $mol^{-1}$ |
| Surface tension of water | = $7.0 \times 10^{-2}$ $Nm^{-1}$ |
| Density of water | = 1000kg $m^{-3}$ |
| Gas constant, R | = 8.31 J $mol^{-1}$ $K^{-1}$ |
| Charge to mass ratio, e/m | = $1.8 \times 10^{11}$ $kg^{-1}$ |

The constant $\frac{1}{4\pi_o}$ $= 9.0 \times 10^{9}\ F^{-1}\ m$

**SECTION A:**

1. (a) What is meant by the following
   (i) Strain (1 mark)
   (ii) Stress (1 mark)
   (iii) Young's modulus (1 mark)
   (b) Use the method of dimensions to determine the units of Young's modulus (2mks)
   (c) A wire of length $l_o$ m and cross sectional area A has a force constant k. The wire is stretched to a length $l_o + x$ by a constant force.
   (i) Assuming Hooke's law F = kx. Find an expression for k in terms of $l_o$, A and Young's modulus Y for the wire. (2 marks)
   (ii) Show that the energy stored in a unit volume of the wire is equal to $\frac{1}{2}Y\left(\frac{x}{l_o}\right)^2$ (5 marks)
   (d) A metal wire of diameter $2.0 \times 10^{-4}$ m and length 2m is fixed horizontally between two points 2m apart. Young's modulus for the wire is $2 \times 10^{11}\ Nm^{-2}$
   (i) What force should be applied at the mid point of the wire to depress it by $1.0 \times 10^{-1}$ m? (5 marks)
   (ii) Find the work done in (i) above (3 marks)

2. (a) i) State the law of conservation of linear momentum. (1mk)
   ii) A body explodes and produces two fragments of masses m and M. if the velocities of the fragments are u and v respectively, show that the ratio of the kinetic energies of the fragments is $E_1/E_3 = M/m$. Where $E_1$ is the kinetic energy of m and $E_2$ is the kinetic energy of M. (04mk)

b) show that the centripetal acceleration of an object moving with constant speed, v, in a circle of radius r is $v^2/r$. (04mk)

c) A car of mass 1000 kg moves round a banked track at a constant speed of 108 km/h. Assuming the total reaction at the wheels is normal to the truck and the radius of the curvature of the track is 100 m, calculate the;
   (i) angle of inclination of the track to the horizontal. (04mk)
   (ii) reaction at the wheels (02mk)

d) (i) define uniformly accelerated motion. (1mk)
   (ii) a train starts from rest at a station A and accelerates at 1.25 $ms^{-2}$ until it reaches a speed of 20 $ms^{-1}$. It then travels at this steady speed for a distance for a distance of 1.56 km and then decelerates at 2$ms^{-2}$ to come to rest at station B. find the distance AB. (04mk)

3. (a) define the following terms as applied to simple harmonic motion (SHM)
   i) Amplitude (01mk)
   ii) period (01mk)
   (b) state four characteristics of SHM. (02mk)
   (c) a mass m is suspended from a rigid support by a string of length *l*. the mass is pulled a side so that the string makes a small angle with the vertical and then released.
   i) show that the mass executes SHM with a period, $T^2 = 4\pi^2 l/g$. (05mk)

ii) explain why the mass comes to rest after a short time. (02mk)

(c) (i) State Archimedes's principle. (1 mark)

(ii) A string supports a metal block of 2kg which is completely immersed in a liquid of density $8.80 \times 10^3$ kgm $^{-3}$ If the density of the metal is $9.0 \times 10^3$ kg $^{-3}$, calculate the tension in the string. (4 marks)

4. (a) (i) State Newton's law of gravitation (1 mark)

(ii) Derive an expression for the period T of a planet moving in a circular orbit about the sun in terms of the radius R of the orbit. (4 marks)

(b) A satellite is launched in a circular orbit at a height $3.6 \times 10^4$ km above the surface of the earth, find,

(i) the speed with which the satellite is launched into the orbit. (5 marks)

(ii) the period of the satellite (2 marks)

(c) A steel ball of mass 0.5kg is suspended from a light inelastic string of length 1000mm. The ball is whirled in a horizontal circle of radius 0.5m. Find

(i) the angular speed of the ball (2 marks)

(ii) the angle between the string and the radius of the circle of the angular speed is increased to such a value that the tension in the string is 10N. (2 marks)

## SECTION B:

5. (a) (i) Distinguish between heat capacity and latent heat. (2 marks)

(ii) Explain why latent heat of vaporization is always greater than that of fusion (2 marks)

(b) Describe how you would determine the specific heat capacity of a liquid by the Continuous flow method. (7 marks)

(c) (i) State Newton's law of cooling (1 mark)

(ii) What is meant by a cooling correction? (1 mark)

(d) In an experiment to determine the specific heat capacity of a metal of mass 500g, an electric heater rated 42W was used to heat the metal. The temperature of the metal was recorded at different times as follows

| Time/minutes | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 |
|---|---|---|---|---|---|---|---|
| Temperature/$^o$C | 25.0 | 30.0 | 35.0 | 39.0 | 43.0 | 46.5 | 48.0 |

| | | | | |
|---|---|---|---|---|
| 4.0 | 4.5 | 5.0 | 5.5 | 6.0 |
| 46.5 | 45.5 | 44.0 | 43.0 | 41.7 |

(i) Plot a suitable graph and use it to estimate the cooling correction. (5 marks)

(ii) Determine the specific heat capacity of the metal. (2 marks)

6. (a) Define the following terms
   (i) Saturated vapour pressure (1 mark)
   (ii) Un saturated vapour pressure (1 mark)

(b) Describe an experiment to determine the saturated vapour pressure of a liquid. (6 marks)

(c) (i) State Dalton's law of partial pressures (1 mark)
   (ii) Air saturated with water vapour is confined in a container at a temperature of 27°C and pressure of $1.0 \times 10^5$ $Nm^{-2}$ . At a temperature of 77°C, the pressure is $1.6 \times 10^5$ $Nm^{-2}$ and the air remains saturated. Find the saturation vapour pressure of water at 77°C. (Take saturation vapour pressure of water at 27°C as $3.6 \times 10^3$ $Nm^{-2}$) (5 marks)

(d) Give two differences between a real and an ideal gas. (2 marks)

(e) (i) What is meant by critical temperature of a gas? (1 mark)
   (ii) Draw a labelled P – V diagram to show the behaviour of a real gas under compression for temperatures above and below the critical temperature. (3 marks)

7. (a) (i) Explain what is meant by temperature gradient. (1 mark)
   (ii) Define thermal conductivity and show that it has an SI unit $Wm^{-1} K^{-1}$ (3 marks)

(b) Sketch graphs to illustrate the temperature distribution along a metal bar heated at one end when the bar is
   (i) lagged
   (ii) unlagged (3 marks)
   (iii) Explain the difference between the two graphs (2 marks)

(c) An iron pan containing water boiling steadily at 100°C stands on a hot plate and heat conducted through the base of the pan evaporates 0.090 kg of water per minute. If the base of the pan has an area of $0.04m^2$ and a uniform thickness of 2mm, calculate the surface temperature of the underside of the pan.
(Thermal conductivity of iron = $66Wm^{-1} K^{-1}$, the S.L. h of vaporization of water = $2.2 \times 10^6$ $Jkg^{-1}$) (5 marks)

(d) Describe the conduction and convection mechanisms of heat transfer (6 marks)

**SECTION C:**

8. (a) Explain the following terms as applied to photoelectric emission
   (i) Work function (1 mark)
   (ii) stopping potential (1 mark)

(b) List the main characteristics of photoelectric effect. (4 marks)

(c) (i) A metal of work function 2.50eV is irradiated with light of an unknown frequency. The maximum velocity of the photoelectrons is $1.14 \times 10^{6} ms^{-1}$. Calculate the maximum wavelength of the incident radiation. (4 marks)

(ii) Explain briefly how the kinetic energy of the photoelectrons depend on the frequency of the incident radiation. (3 marks)

(d) In a cathode ray oscilloscope, an electron beam passes between the Y – deflection plate each 5 cm long and 0.5cm apart. The distance between the centre of the Y-plates and the screen is 20cm and the p.d between the anode and the electron gun is 2500V. Determine the deflection in $Vm^{-1}$ of the electron beam on the screen of the CRO. (7 marks)

9. (a) Describe qualitatively Millikan's method for the determination of the electric charge of an electron . (7 marks)

(b) Explain what is meant by quantization of a charge. (3 marks)

(c) A charged oil drop of mass $4.0 \times 10^{-15}$ kg falls at a constant speed in Millikan's oil drop experiment when there is no pd between the plates. This drop is held stationary when an electric field is applied between the two horizontal plates. If the drop carries 6 electric charges each of value $1.6 \times 10^{-19}$ C, Calculate the value of the electric field strength. (4 marks)

(d) (i) Describe briefly the experimental evidence which suggests that X-rays are waves in nature. (3 marks)

(ii) Show that the minimum X-ray wavelength of an X-ray tube operating at a pd of V is given by $\lambda_{min} = hc/eV$ (3 marks)

10. (a) With the aid of a labelled diagram describe the action of a G.m tube. (5 marks)

(b) The graph below shows how the recorded count rate depends on the p.d across the Gm tube

B

(i) Explain why there is an upper limit to the rate at which a G.m tube can detect ∝ – particles (1 mark)

(c) Account for

(i) the sharp rise in the recorded count rate at A. (2 marks)

(ii) the plateau at B (2 marks)

(iii) the uncontrollable rise in the recorded count rate at c. (2 marks)

(d) State what p.d you would choose for the Geiger counter whose response is shown in the graph. Give a reason for your choice. (2 marks)

(e) What is meant by unified atomic mass unit. (1 mark)

(f) $^{224}_{88}Rn$ decays by emission of ∝ particles to produce $^{220}_{86}Ra$

Given that mass of $^{224}_{88}Rn = 224.02200u$

$^{220}_{86}Ra = 220.01140u$

$^{4}_{2}He = 4.00260u$

1u = 932 Mev

(i) Calculate the Kinetic energy of the ∝- particle. (3 marks)

(ii) Find the velocity of the ∝- particle. (2 marks)