UACE Physics paper 1 set 7 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.

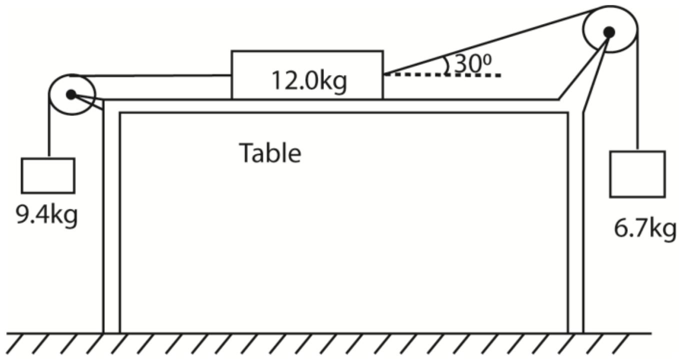
Non programmable scientific calculators may be used.

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) Using the molecular theory, explain the laws of friction between solid surfaces. (06marks)
   (b) With the aid of a labelled diagram, describe how the coefficient of static friction for an interface between a rectangular block of wood and a plane surface can be determined. (06marks)
   (c) The diagram below shows three masses connected by inextensible strings which pass over smooth pulleys. The coefficient of friction between the table and the 12.0kg mass is 0.25.



   If the system is released from rest, determine the
   (i) Acceleration of the 12.0kg mass (05marks)
   (ii) Tension in each string (03marks)
2. (a) Define terminal velocity (01mark)
   (b) Explain laminar flow and turbulent flow (03marks)
   (c) Describe an experiment to measure the coefficient of viscosity of water using Ponselle's formula. (07marks)
   (d) (i) State Bernoulli's principle (01 mark)
   (ii) Explain why a person standing near a railway line is sucked towards the railway line when a fast moving train passes. (03marks)
   (e) A horizontal pipe of cross sectional area $0.4m^2$, tapers to a cross section area of $0.2m^2$. The pressure at the large section of the pipe is $8.0 \times 10^4 Nm^{-2}$ and the velocity of water through the pipe is $11.2ms^{-1}$. If the atmospheric pressure is $1.01 \times 10^5 Nm^{-2}$, find the pressure at the small section of the pipe. (05marks)
3. (a) (i) State the law of conservation of linear momentum (01mark)

   (ii) A body explodes and produces two fragments of mass m and M. is the velocities of the fragments are u and v respectively. Show that the ratio of the kinetic energies of the fragments is

   $\frac{E_1}{E_2} = \frac{M}{m}$ where E_1 is the kinetic energy of m and E_2 is the kinetic energy od M

   (b) Show that the centripetal acceleration of an object moving with constant velocity, v, in a circle of radius, r is$\frac{v^2}{r}$. 904marks)

   (c) A car of mass 1000kg moves round a banked track at constant speed of $108kmh^{-1}$. Assuming the total reaction at the wheels is normal to the track, and the radius of curvature of the truck is 100m, calculate the:

(i) angle of inclination of the track to the horizontal (04marks)

(ii) reaction at the wheels (02marks)

(d) (i) Define uniformly accelerated motion (01mark)

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

4. (a)(i) State Kepler's laws of planetary motion. (03marks)

(ii) Estimate the mass of the sun, if the orbit of the earth around the sun is circular. (04marks)

(b) Explain Brownian motion (03marks)

(c) Explain the energy changes which occur when a pendulum is set into motion. (03marks)

(d) A simple pendulum of length 1m has a bob of mass 100g. It is displaced from mean position A to position B so that the string makes an angle of 45^0 with the vertical. Calculate the

(i) maximum potential energy of the bob. (03marks)

(ii) velocity of the bob when the string makes an angle of 30^0 2ith the vertical. [Neglect air resistance]

SECTION B

5. (a) Define
   (i) Specific heat capacity (01mark)
   (ii) Specific latent heat of vaporization of a liquid. (01 mark)

(b) With the aid of a labelled diagram, describe the electrical method of determining the specific heat capacity of a solid (07marks)

(c) An electrical heater rated 48W, 12V is placed in a well-insulated metal of mass 1.0kg at a temperatures of 18^0C. When power is switched on for 5minutes, the temperature of the metal rises to 34^0C. Find the specific heat capacity of the metal (04marks)

(d) (i) State Newton's law of cooling (01marks)

(ii) Use Newton's law of cooling to show that $\frac{d\theta}{dt} = -k(\theta - \theta_R$

Where $\frac{d\theta}{dt}$is the rate of fall of temperature, and θR is the temperature of the surrounding.

(e) Explain why evaporation causes cooling. (03marks)

6. (a) The pressure, P, of an ideal gas is given by P=$\frac{1}{3}\rho \overline{c^2}$, where ρ is the density of the gas and $\overline{c^2}$ its mean square speed.

(i) Show clearly the steps taken to derive this expression (06marks)
(ii) State the assumptions made in deriving this expression (02marks)

(b) Sketch the pressure versus volume curve for a real gas for temperatures above and below the critical temperature. (03marks)

(c) For 1 mole of a real gas, the equation of state is $\left(P + \frac{a}{V^2}\right)(V - b) = RT$

Explain the significance of the terms $\frac{a}{V^2}$ and b. (02marks)

(d) A balloon of volume 5.5 x $10^{-2}m^3$ is filled with helium to a pressure of 1.10 x 10^5Nm^{-2} at a temperature of 20^0C. Calculate the

(i) the number of helium atoms in the balloon (03marks)

(ii) net force acting on the square meter of material of the balloon if the atmospheric temperature is 1.01 x 10^5Nm^{-2} (04marks)

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

(ii) Describe an experiment to determine the thermal conductivity of copper. (06marks)

(b) (i) What is a black body? (01 marks)

(ii) Describe how infrared radiation can be detected using a bolometer. (03marks)

(iii) Give one characteristic property of infrared radiation. (01mark)

(c) (i) A spherical black body of radius 2.0cm at -73^0C is suspended in an evacuated enclosure whose walls are maintained at 27^0C. If the rate of exchange of thermal energy is equal to $1.85Js^{-1}$, find the value of Stefan's constant, (05marks)

(ii) Calculate the wavelength at which the radiation emitted by the enclosure ha maximum intensity (03mark)

SECTION C

8. (a) Explain briefly how positive rays are produced (03marks)

(b) An electron of charge, e, and mass, m, is emitted from a hot cathode and then accelerated by an electric field towards the anode. If the potential difference between the cathode and the anode is V, show that the speed of the electron, u, is given by

u = $\sqrt{\left(\frac{2eV}{m}\right)}$ (03marks)

(c) An electron starts from rest and moves in an electric field intensity of 2.4 x 10^3Vm^{-1}.

Find the

(i) force on the electron (02 marks)
(ii) acceleration of the electron. (02marks)
(iii) velocity acquired in moving through a p.d of 90V (02marks)

(d) A beam of electrons each of mass, m, and charge, e, is directed horizontally with speed, u, into an electric field between two horizontal metal plates separated by a distance, d.

(i) If the p.d between the plates is V, show that the deflection y of the beam is given by

$$y = \frac{1}{2m}\left(\frac{eV}{du^2}\right)x^2$$

where, x, is the horizontal distance travelled. (06marks)

(ii) Explain the path of the electron beam as it emerges out of the electric field. (02marks)

9. (a) The table below shows the energy levels of a hydrogen atom.

Principal quantum number, n	Energy, eV
6	-0.38
5	-0.54
4	-0.85
3	-1,51
2	-3.39
1	-13.60

(i) Why are the energies for the different levels negative? (01mark)
(ii) Calculate the wavelength of the line arising from a transition from the third to the second level. (03marks)
(iii) Calculate the ionization energy in joules of hydrogen atom. (02marks)

(b) Explain the physical processes in an X-ray tube that account for

(i) cut off wavelength (03marks)

(ii) characteristic lines (04marks)

(c) Calculate the maximum frequency of radiation emitted by an X-ray tube using an accelerating voltage of 33.0kV (03marks)

(d) Derive Bragg's law of X-ray diffraction in crystals. (04marks)

10. (a) A beam of α-particles is directed normally to a thin metal foil

Explain why

(i) Most of the α-particles passed straight through the foil (02marks)
(ii) Few α-particles are deflected through angles more than 900. (02marks)

(b) Calculate the least distance of approach of a 3.5MeV α-particles to the nucleus of a gold atom. (Atomic number of gold= 79) (04marks)

(c) (i) Define space charge as applied to thermionic diodes. (01mark)

(ii) Draw anode current-diode voltage curves of a thermionic diode for two different filament currents and explain their main features. (06marks)

(d) (i)What is a decay constant?

(ii) A sample from fresh wood of a certain species of tree has activity of 16.0 counts per minute per gram. However, the activity of 5g of dead wood of the same species of tree is 10 counts per minute. Calculate the age of the deadwood. (Assume half-life of 5730years) (04marks)