Centre Number	Candidate Number	Name

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

PHYSICS **9702/04**

Paper 4

October/November 2005

1 hour

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen in the spaces provided on the Question Paper.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
You may use a soft pencil for any diagrams, graphs or rough working.
You may lose marks if you do not show your working or if you do not use appropriate units.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
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Total	

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SPA (SJF3506/DG) S81935/2

UNIVERSITY *of* CAMBRIDGE
International Examinations

[Turn over

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
elementary charge,	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
the Planck constant,	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
molar gas constant,	$R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall,	$g = 9.81\ \mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
gravitational potential,	$\phi = -\frac{Gm}{r}$
simple harmonic motion,	$a = -\omega^2 x$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$ $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\epsilon_0 r}$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel,	$C = C_1 + C_2 + \ldots$
energy of charged capacitor,	$W = \frac{1}{2}QV$
alternating current/voltage,	$x = x_0 \sin \omega t$
hydrostatic pressure,	$p = \rho g h$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$
critical density of matter in the Universe,	$\rho_0 = \frac{3H_0^{\,2}}{8\pi G}$
equation of continuity,	$Av = \text{constant}$
Bernoulli equation (simplified),	$p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2$
Stokes' law,	$F = Ar\eta v$
Reynolds' number,	$R_e = \frac{\rho v r}{\eta}$
drag force in turbulent flow,	$F = Br^2 \rho v^2$

Answer **all** the questions in the spaces provided.

1 The Earth may be considered to be a sphere of radius 6.4×10^6 m with its mass of 6.0×10^{24} kg concentrated at its centre.
A satellite of mass 650 kg is to be launched from the Equator and put into geostationary orbit.

(a) Show that the radius of the geostationary orbit is 4.2×10^7 m.

[3]

(b) Determine the increase in gravitational potential energy of the satellite during its launch from the Earth's surface to the geostationary orbit.

energy = ……………………………….. J [4]

(c) Suggest one advantage of launching satellites from the Equator in the direction of rotation of the Earth.

....

....[1]

2 The air in a car tyre has a constant volume of $3.1 \times 10^{-2}\,m^3$. The pressure of this air is $2.9 \times 10^5\,Pa$ at a temperature of 17 °C. The air may be considered to be an ideal gas.

(a) State what is meant by an *ideal* gas.

....

....

.... [2]

(b) Calculate the amount of air, in mol, in the tyre.

amount = ……………………………. mol [2]

(c) The pressure in the tyre is to be increased using a pump. On each stroke of the pump, 0.012 mol of air is forced into the tyre.
Calculate the number of strokes of the pump required to increase the pressure to $3.4 \times 10^5\,Pa$ at a temperature of 27 °C.

number = ……………………………. [3]

3 **(a)** State the first law of thermodynamics in terms of the increase in internal energy ΔU, the heating q of the system and the work w done on the system.

....

.... [1]

(b) The volume occupied by 1.00 mol of liquid water at 100 °C is 1.87×10^{-5} m^3. When the water is vaporised at an atmospheric pressure of 1.03×10^5 Pa, the water vapour has a volume of 2.96×10^{-2} m^3.
The latent heat required to vaporise 1.00 mol of water at 100 °C and 1.03×10^5 Pa is 4.05×10^4 J.
Determine, for this change of state,

(i) the work w done on the system,

w = ... J [2]

(ii) the heating q of the system,

q = ... J [1]

(iii) the increase in internal energy ΔU of the system.

ΔU = ... J [1]

(c) Using your answer to **(b)(iii)**, estimate the binding energy per molecule in liquid water.

energy = ………………………………. J [2]

4 The centre of the cone of a loudspeaker is oscillating with simple harmonic motion of frequency 1400 Hz and amplitude 0.080 mm.

(a) Calculate, to two significant figures,

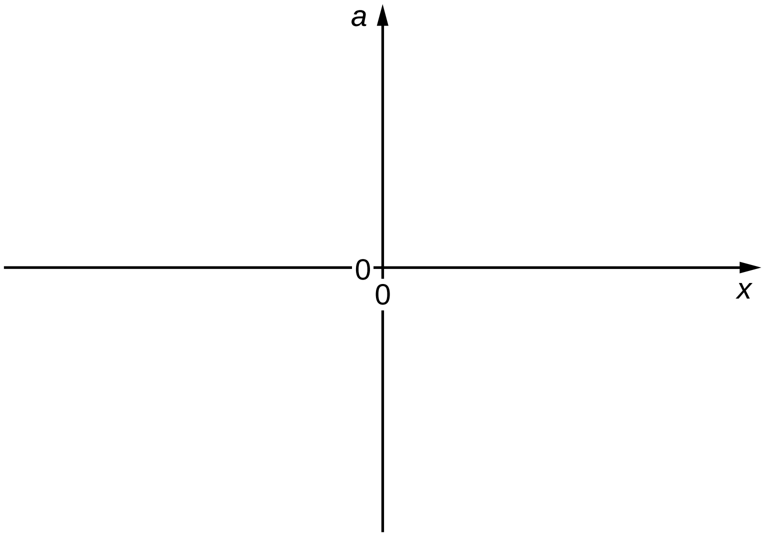
(i) the angular frequency ω of the oscillations,

ω = ………………………………. rad s^{-1} [2]

(ii) the maximum acceleration, in m s^{-2}, of the centre of the cone.

acceleration = ……………………………….. m s^{-2} [2]

(b) On the axes of Fig. 4.1, sketch a graph to show the variation with displacement x of the acceleration a of the centre of the cone.



[2]

Fig. 4.1

(c) **(i)** State the value of the displacement *x* at which the speed of the centre of the cone is a maximum.

x = …………………………… mm [1]

(ii) Calculate, in $m\,s^{-1}$, this maximum speed.

speed = …………………………… $m\,s^{-1}$ [2]

5 **(a)** An electron is accelerated from rest in a vacuum through a potential difference of 1.2×10^4 V.
Show that the final speed of the electron is 6.5×10^7 m s^{-1}.

[2]

(b) The accelerated electron now enters a region of uniform magnetic field acting into the plane of the paper, as illustrated in Fig. 5.1.

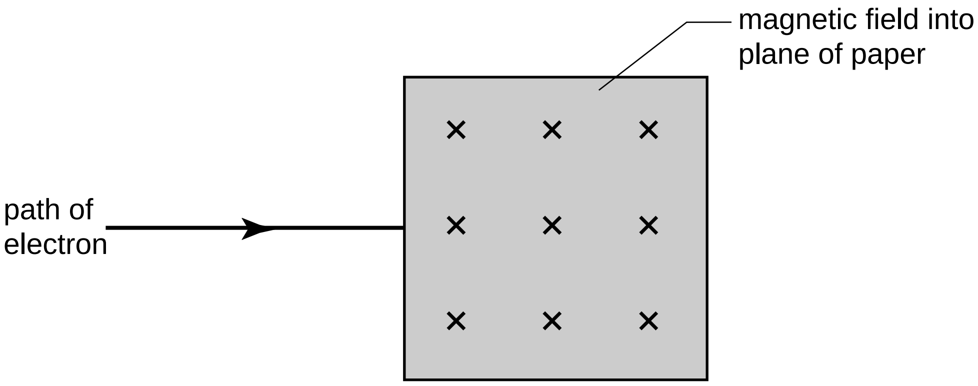


Fig. 5.1

(i) Describe the path of the electron as it passes through, and beyond, the region of the magnetic field. You may draw on Fig. 5.1 if you wish.

path within field: ....

....

path beyond field: ....

.... [3]

(ii) State and explain the effect on the magnitude of the deflection of the electron in the magnetic field if, separately,

1. the potential difference accelerating the electron is reduced,

....

....

.... [2]

2. the magnetic field strength is increased.

....

....

.... [2]

6 (a) Define *magnetic flux density*.

....

....

....

.... [3]

(b) A flat coil consists of N turns of wire and has area A. The coil is placed so that its plane is at an angle θ to a uniform magnetic field of flux density B, as shown in Fig. 6.1.

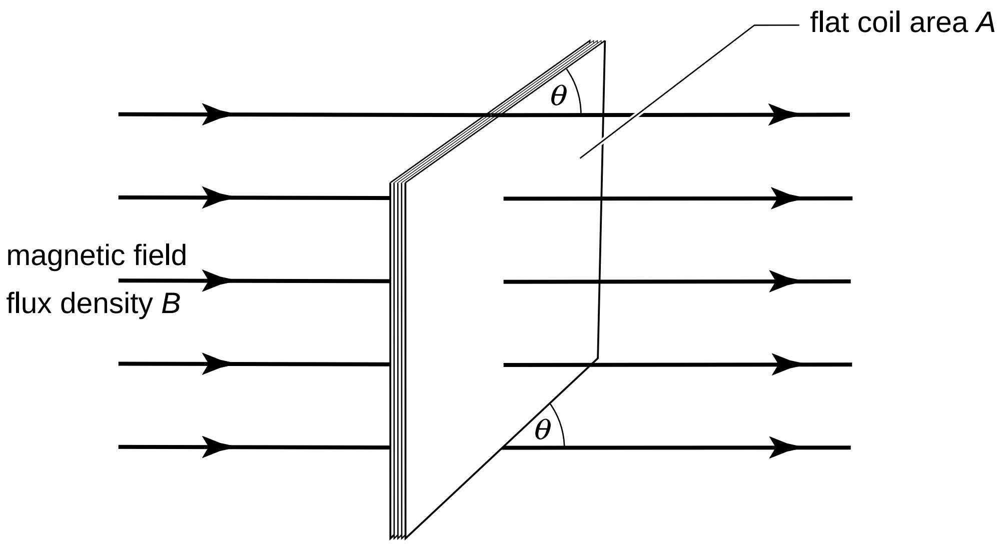


Fig. 6.1

Using the symbols A, B, N and θ and making reference to the magnetic flux in the coil, derive an expression for the magnetic flux linkage through the coil.

[2]

(c) **(i)** State Faraday's law of electromagnetic induction.

....

....

.... [2]

(ii) The magnetic flux density B in the coil is now made to vary with time t as shown in Fig. 6.2.

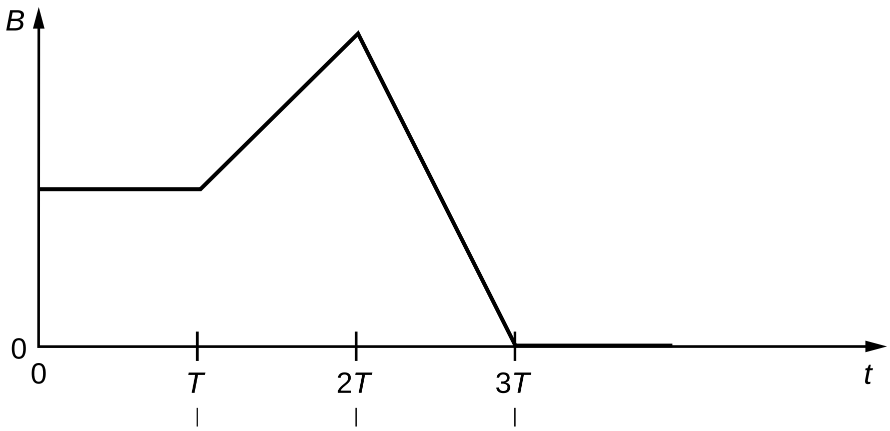


Fig. 6.2

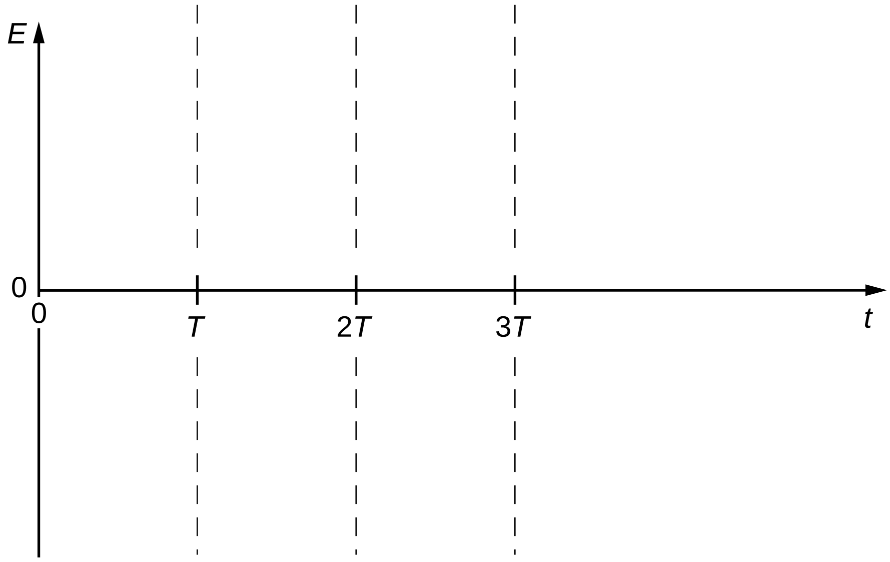


Fig. 6.3

On Fig. 6.3, sketch the variation with time t of the e.m.f. E induced in the coil. [3]

7 Fig. 7.1 illustrates the variation with nucleon number *A* of the binding energy per nucleon *E* of nuclei.

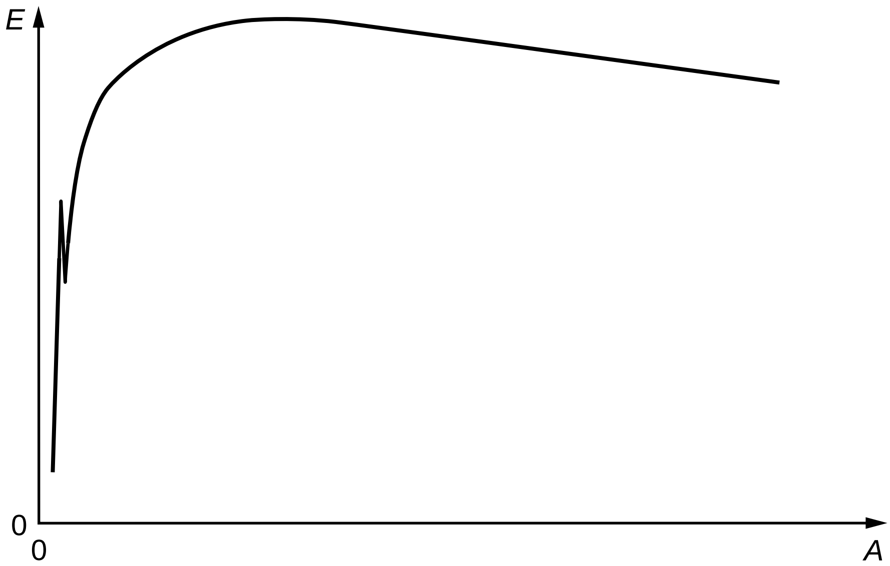


Fig. 7.1

(a) **(i)** Explain what is meant by the *binding energy* of a nucleus.

....

....

.... [2]

(ii) On Fig. 7.1, mark with the letter S the region of the graph representing nuclei having the greatest stability. [1]

(b) Uranium-235 may undergo fission when bombarded by a neutron to produce Xenon-142 and Strontium-90 as shown below.

$$^{235}_{92}\text{U} + ^{1}_{0}\text{n} \rightarrow ^{142}_{54}\text{Xe} + ^{90}_{38}\text{Sr} + \text{neutrons}$$

(i) Determine the number of neutrons produced in this fission reaction.

number = ………………………….. [1]

(ii) Data for binding energies per nucleon are given in Fig. 7.2.

isotope	binding energy per nucleon / MeV
Uranium-235	7.59
Xenon-142	8.37
Strontium-90	8.72

Fig. 7.2

Calculate

1. the energy, in MeV, released in this fission reaction,

energy = ………………………… MeV [3]

2. the mass equivalent of this energy.

mass = ………………………….. kg [3]

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