Centre Number	Candidate Number	Name

CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

PHYSICS **9702/04**

Paper 4

May/June 2003

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.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
The number of marks is given in brackets [ ] at the end of each question or part question.
You may lose marks if you do not show your working or if you do not use appropriate units.

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1	
2	
3	
4	
5	
6	
Total	

If you have been given a label, look at the details. If any details are incorrect or missing, please fill in your correct details in the space given at the top of this page.

Stick your personal label here, if provided.

This document consists of **15** printed pages and **1** blank page.

SJF2603/CG S46432/2

UNIVERSITY of CAMBRIDGE
Local Examinations Syndicate

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,	$\phi = -\dfrac{Gm}{r}$
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,	$V = \dfrac{Q}{4\pi\epsilon_0 r}$
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,	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$
critical density of matter in the Universe,	$\rho_0 = \dfrac{3H_0^2}{8\pi G}$
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,	$R_e = \dfrac{\rho v r}{\eta}$
drag force in turbulent flow,	$F = Br^2\rho v^2$

[Turn over

For Examiner's Use

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

1 **(a)** Define gravitational potential.

....

.... [2]

(b) Explain why values of gravitational potential near to an isolated mass are all negative.

....

....

.... [3]

(c) The Earth may be assumed to be an isolated sphere of radius 6.4×10^3 km with its mass of 6.0×10^{24} kg concentrated at its centre. An object is projected vertically from the surface of the Earth so that it reaches an altitude of 1.3×10^4 km.

Calculate, for this object,

(i) the change in gravitational potential,

change in potential = ... $\mathrm{J\,kg^{-1}}$

(ii) the speed of projection from the Earth's surface, assuming air resistance is negligible.

speed = ... $\mathrm{m\,s^{-1}}$
[5]

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(d) Suggest why the equation

$$v^2 = u^2 + 2as$$

is not appropriate for the calculation in **(c)(ii)**.

....

.... [1]

2 **(a)** On Fig. 2.1, place a tick (✓) against those changes where the internal energy of the body is increasing. [2]

water freezing at constant temperature	....
a stone falling under gravity in a vacuum	....
water evaporating at constant temperature	....
stretching a wire at constant temperature	....

Fig. 2.1

(b) A jeweller wishes to harden a sample of pure gold by mixing it with some silver so that the mixture contains 5.0% silver by weight. The jeweller melts some pure gold and then adds the correct weight of silver. The initial temperature of the silver is 27 °C. Use the data of Fig. 2.2 to calculate the initial temperature of the pure gold so that the final mixture is at the melting point of pure gold.

	gold	silver
melting point / K	1340	1240
specific heat capacity (solid or liquid) / $J\,kg^{-1}\,K^{-1}$	129	235
specific latent heat of fusion / $kJ\,kg^{-1}$	628	105

Fig. 2.2

temperature = ... K [5]

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(c) Suggest a suitable thermometer for the measurement of the initial temperature of the gold in **(b)**.

.... [1]

3 An aluminium sheet is suspended from an oscillator by means of a spring, as illustrated in Fig. 3.1.

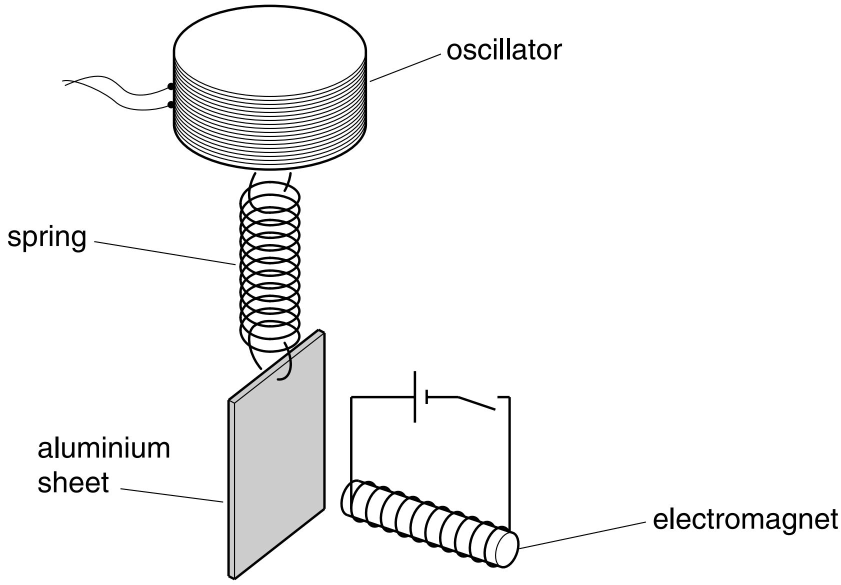

Fig. 3.1

An electromagnet is placed a short distance from the centre of the aluminium sheet.

The electromagnet is switched off and the frequency *f* of oscillation of the oscillator is gradually increased from a low value. The variation with frequency *f* of the amplitude *a* of vibration of the sheet is shown in Fig. 3.2.

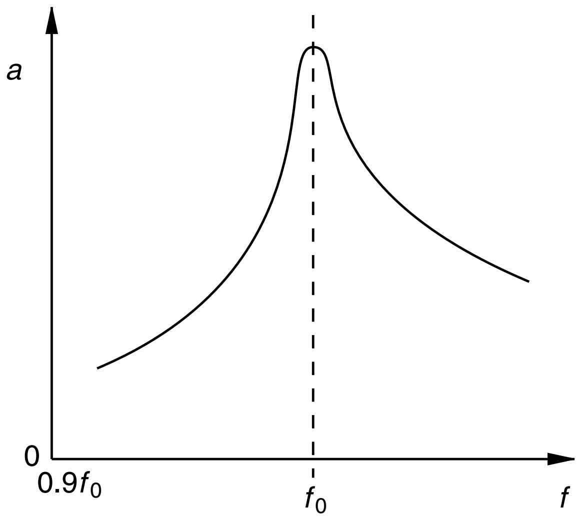

Fig. 3.2

A peak on the graph appears at frequency f_0.

(a) Explain why there is a peak at frequency f_0.

....

....

.... [2]

(b) The electromagnet is now switched on and the frequency of the oscillator is again gradually increased from a low value. On Fig. 3.2, draw a line to show the variation with frequency *f* of the amplitude *a* of vibration of the sheet. [3]

(c) The frequency of the oscillator is now maintained at a constant value. The amplitude of vibration is found to decrease when the current in the electromagnet is switched on.

Use the laws of electromagnetic induction to explain this observation.

....

....

....

....

....

.... [4]

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4 In a particular experiment, a high voltage is created by charging an isolated metal sphere, as illustrated in Fig. 4.1.

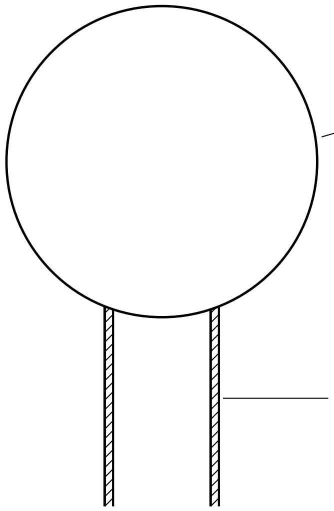

Fig. 4.1

The sphere has diameter 42 cm and any charge on its surface may be considered as if it were concentrated at its centre.

The air surrounding the sphere loses its insulating properties, causing a spark, when the electric field exceeds 20 kV cm^{-1}.

(a) By reference to an atom in the air, suggest the mechanism by which the electric field causes the air to become conducting.

....

....

....

.... [3]

(b) Calculate, for the charged sphere when a spark is about to occur,

(i) the charge on the sphere,

charge = ………………………………. C [3]

(ii) its potential.

potential = ………………………………. V [2]

(c) Under certain conditions, a spark sometimes occurs before the potential reaches that calculated in **(b)(ii)**. Suggest a reason for this.

....

.... [1]

[Turn over

For Examiner's Use

5 An α-particle and a β-particle are both travelling along the same path at a speed of $1.5 \times 10^6\,\mathrm{m\,s^{-1}}$.

They then enter a region of uniform magnetic field as shown in Fig. 5.1.

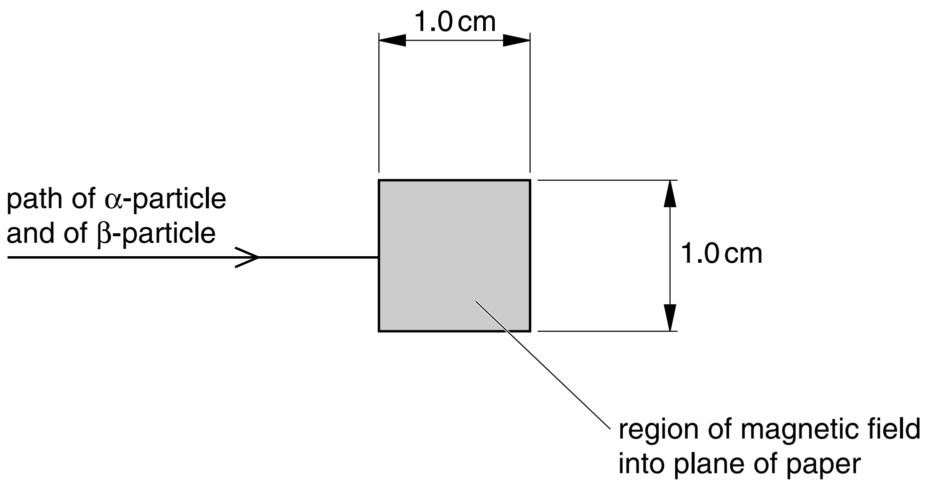

Fig. 5.1

The magnetic field is normal to the path of the particles and is into the plane of the paper.

(a) Show that, for a particle of mass *m* and charge *q* travelling at speed *v* normal to a magnetic field of flux density *B*, the radius *r* of its path in the field is given by

$$r = \frac{mv}{Bq}.$$

[3]

(b) Calculate the ratio

$$\frac{\text{radius of path of the } \alpha\text{-particle}}{\text{radius of path of the } \beta\text{-particle}}.$$

ratio = …………………………………. [3]

(c) The magnetic field has flux density 1.2 mT. Calculate the radius of the path of

(i) the α-particle,

radius = …………………………….. m

(ii) the β-particle.

radius = …………………………….. m
[3]

(d) The magnetic field extends over a region having a square cross-section of side 1.0 cm (see Fig. 5.1). Both particles emerge from the region of the field.

On Fig. 5.1,

(i) mark with the letter **A** the position where the emergent α-particle may be detected,

(ii) mark with the letter **B** the position where the emergent β-particle may be detected.
[3]

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6 Strontium-90 decays with the emission of a β-particle to form Yttrium-90. The reaction is represented by the equation

$$^{90}_{38}\text{Sr} \rightarrow\ ^{90}_{39}\text{Y} +\ ^{0}_{-1}\text{e} + 0.55\ \text{MeV}.$$

The decay constant is 0.025 year $^{-1}$.

(a) Suggest, with a reason, which nucleus, $^{90}_{38}$Sr or $^{90}_{39}$Y, has the greater binding energy.

....

....

.... [2]

(b) Explain what is meant by the decay constant.

....

....

.... [2]

(c) At the time of purchase of a Strontium-90 source, the activity is 3.7×10^{6} Bq.

(i) Calculate, for this sample of strontium,

1. the initial number of atoms,

number = ... [3]

2. the initial mass.

mass = ... kg [2]

(ii) Determine the activity A of the sample 5.0 years after purchase, expressing the answer as a fraction of the initial activity A_0. That is, calculate the ratio $\frac{A}{A_0}$.

ratio = ……………………………….. [2]

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