THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

PHYSICS B (ADVANCING PHYSICS) 2864/01

Field and Particle Pictures

Candidates answer on the Question Paper

OCR Supplied Materials:
- Data, Formulae and Relationships Booklet

Other Materials Required:
- Electronic calculator

Monday 18 January 2010
Afternoon

Duration: 1 hour 15 minutes

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number			

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.
- Show clearly the working in all calculations, and give answers to only a justifiable number of significant figures.

INFORMATION FOR CANDIDATES

- You are advised to spend about 20 minutes on Section A and 55 minutes on Section B.
- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **70**.
- Four marks are available for the quality of written communication in Section B.
- The values of standard physical constants are given in the Data, Formulae and Relationships Booklet. Any additional data required are given in the appropriate question.
- This document consists of **16** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Section	**Max.**	**Mark**
A	**20**	
B	**50**	
TOTAL	**70**	

Answer **all** the questions.

Section A

1 Here is a list of units.

A **C** **J C^{-1}** **T**

Choose the correct unit for

(a) electric potential ....

(b) magnetic flux density. ....

[2]

2 The typical dose equivalent for a single dental X-ray is 5×10^{-5} Sv.
A dose equivalent of 1 Sv gives a person a 3% probability of developing cancer.

Calculate the probability of a person developing cancer from two dental X-rays per year for 40 years.

probability = ...**[2]**

3 The equation shows a possible neutron-induced fission for a nucleus of uranium-238.

$${}^{238}_{92}\text{U} + {}^{1}_{0}\text{n} \longrightarrow {}^{100}_{42}\text{Mo} + {}^{126}_{50}\text{Sn} + \text{neutrons}$$

How many neutrons are emitted?

number of neutrons = ...**[1]**

4 The graphs of Fig. 4.1 show how the electrical potential *V* around an object depends on the distance *d* from its centre.

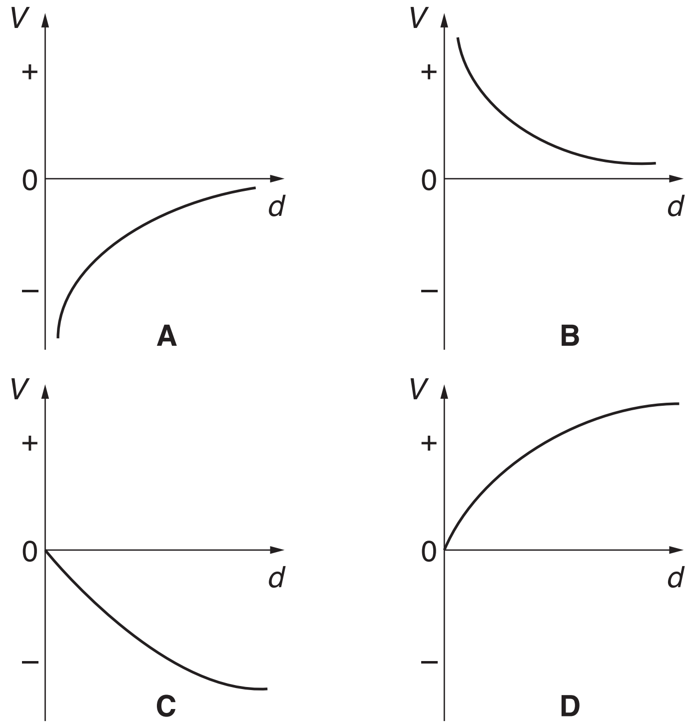

Fig. 4.1

(a) Which graph best shows the variation of potential with distance from a negatively charged particle, such as an electron?

answer ....**[1]**

(b) Calculate the potential at a distance of 1.2×10^{-9} m from the centre of an electron.

$e = -1.6 \times 10^{-19}$ C

$k = 9.0 \times 10^{9}$ N m^{2} C^{-2}

potential = ... V **[2]**

5 Fig. 5.1 shows the directions of the current I and flux density B for a wire.

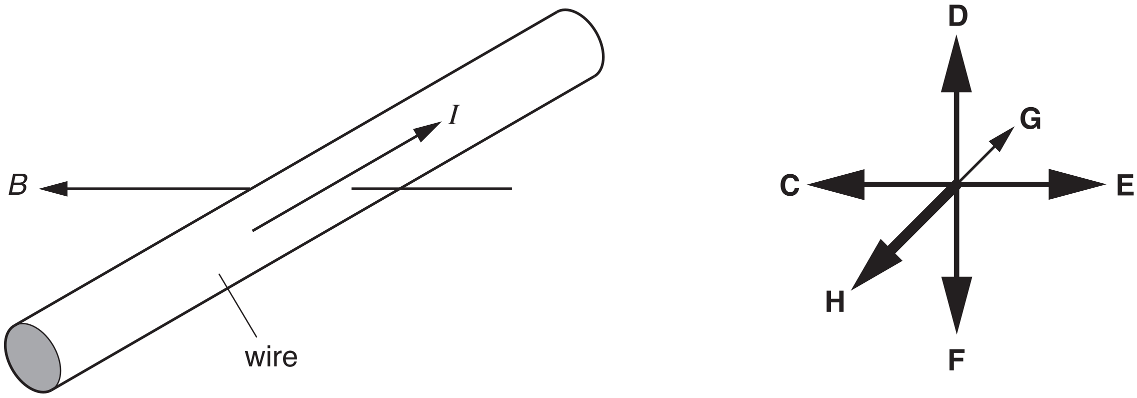

Fig. 5.1

The current interacts with the flux density to exert a force on the wire.

The directions of the current and flux density are at right angles to each other.

(a) Along which direction (**DF**, **CE** or **GH**) is the force on the wire? answer ....**[1]**

(b) The piece of wire is 25 cm long and the flux density is 340 mT.

Calculate the force on the wire when the current in it is 680 μA.

force = ... N **[2]**

6 Strontium-90 is a radioisotope with a half-life of 8.8×10^{8} s.

(a) Show that the decay constant of strontium-90 is about $1 \times 10^{-9}\,s^{-1}$.

[1]

(b) A sample of pure strontium-90 has an activity of 5.6×10^{3} Bq.

Calculate the mass of the sample.

$1\,u = 1.7 \times 10^{-27}$ kg

mass = ... kg **[2]**

7 Under the right circumstances, a single high energy photon can convert into a proton and an anti-proton, each of mass 1.7×10^{-27} kg.

(a) Complete the nuclear equation to show this process.

$$_{\dots\dots\dots}^{0}\gamma \rightarrow \, _{\dots\dots\dots}^{1}\mathrm{p} + \, _{\dots\dots\dots}^{1}\bar{\mathrm{p}}$$

[1]

(b) Calculate the minimum energy, in GeV, for a photon to be able to do this.

$c = 3.0 \times 10^{8}\,\mathrm{m\,s^{-1}}$

$1\,\mathrm{eV} = 1.6 \times 10^{-19}\,\mathrm{J}$

photon energy = ... GeV **[3]**

8 Fig. 8.1 shows the electric field between a metal sphere at –340V held above a metal plate at 0V.

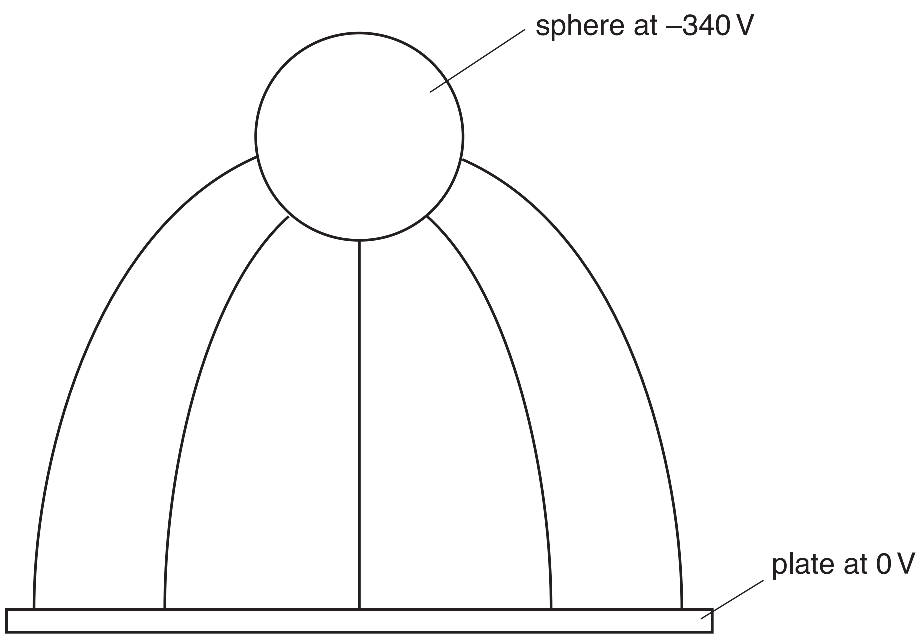

Fig. 8.1

On Fig. 8.1, sketch the equipotential surface for –170V in the region between the sphere and the plate. **[2]**

[Section A Total: 20]

Section B

In this section, four marks are available for the quality of written communication.

9 This question is about transformers.

Fig. 9.1 shows the construction of a typical transformer.

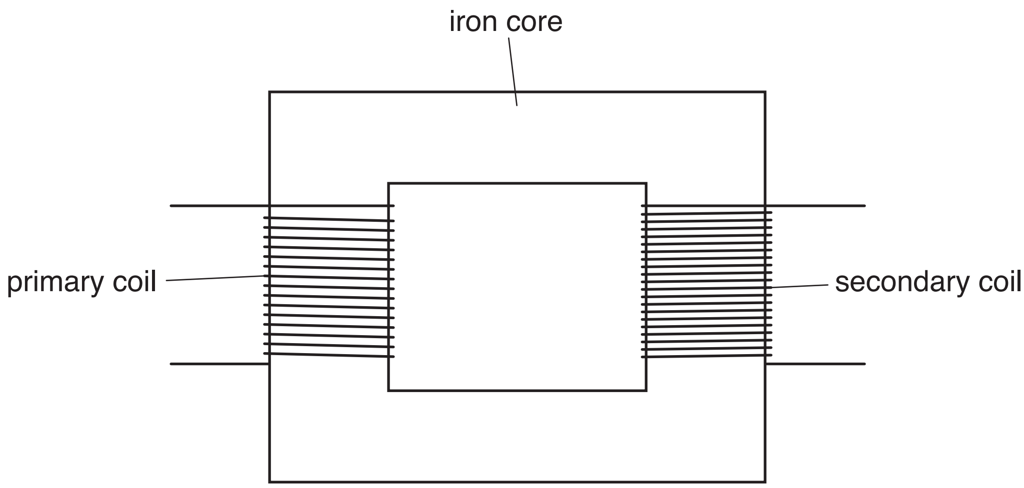

Fig. 9.1

(a) Explain why an alternating current in the primary coil induces an emf in the secondary coil.

[3]

Fig. 9.2 shows how the current in the primary coil varies with time.

There is no current in the secondary coil.

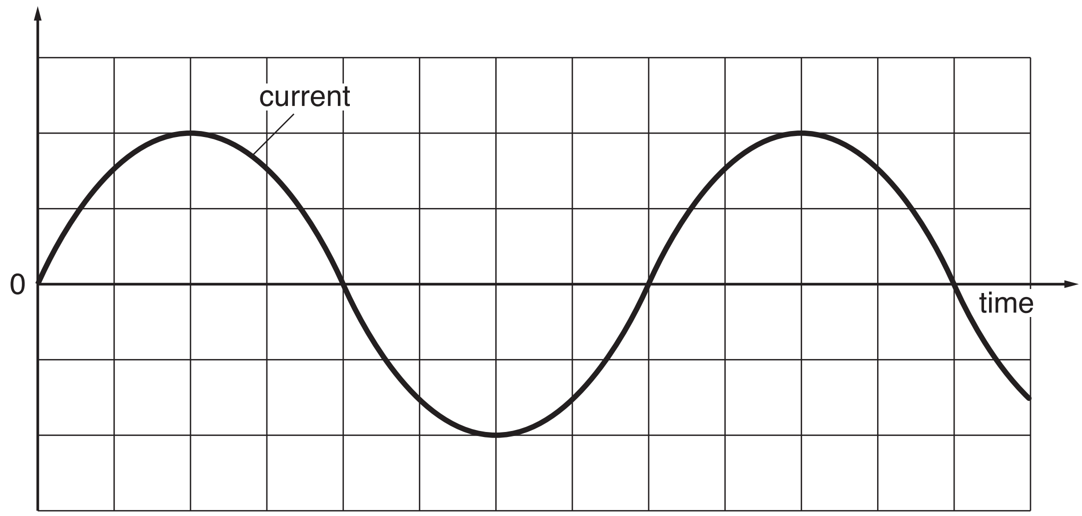

Fig. 9.2

(b) On Fig. 9.2, sketch a graph to show how the flux in the secondary coil varies with time. Label the graph **flux**. **[1]**

(c) On Fig. 9.2, sketch a graph to show how the emf induced in the secondary coil varies with time. Label the graph **emf**. **[1]**

(d) The emf induced in the secondary coil has a peak emf of 300 V and a frequency of 60 Hz.

(i) Show that the maximum flux linkage of the secondary coil is about 1 Wb.

[3]

(ii) The maximum flux density in the transformer core is 1.2 T.

The secondary coil has 400 turns.

Calculate the cross-sectional area of the core.

area = ... m^2 **[2]**

[Total: 10]

10 This question is about forces in electric fields.

Fig. 10.1 shows two conducting parallel plates connected to a power supply.

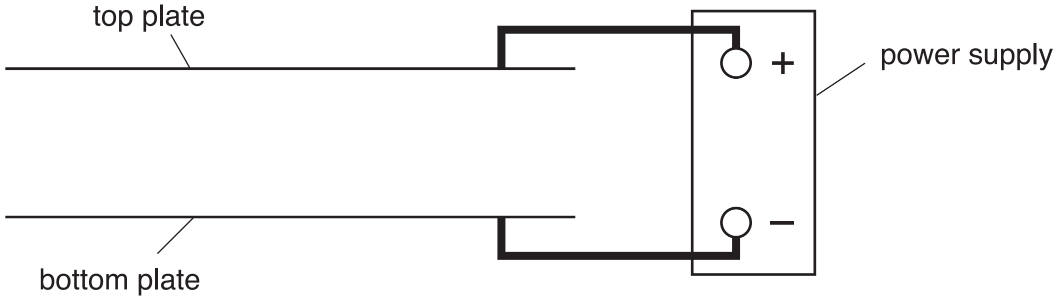

Fig. 10.1

(a) On Fig. 10.1, sketch five lines to represent the electric field between the plates. **[2]**

(b) A small metal sphere is placed between the plates as shown in Fig. 10.2.

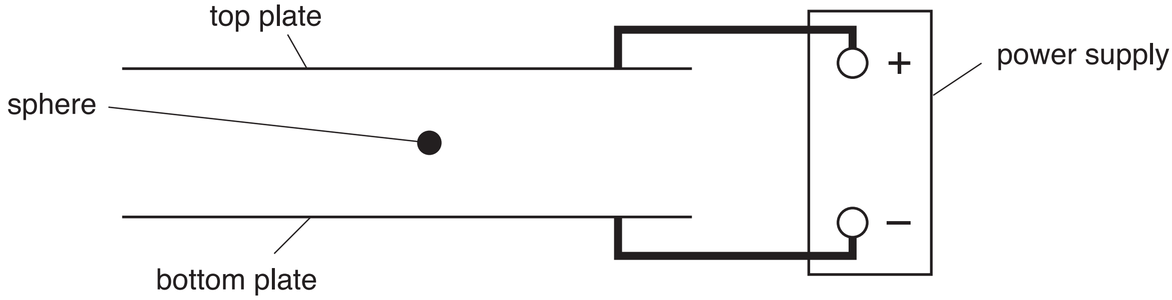

Fig. 10.2

Both plates are horizontal and the sphere is charged.

(i) The sphere does not move when the electric field is present.

What sign of charge does the sphere have? Give reasons for your answer.

[3]

(ii) The magnitude of the charge on the sphere is 3.2×10^{-14} C.

How many electrons had to be removed or added to give the sphere this charge?

$e = 1.6 \times 10^{-19}$ C

number of electrons = ...**[1]**

(iii) The mass of the sphere is 6.2×10^{-9} kg. The separation of the plates is 14 mm.

1 Show that, for the sphere not to move, the electric field strength must be about $2 \times 10^{6}\,\mathrm{V\,m^{-1}}$.

$g = 9.8\,\mathrm{N\,kg^{-1}}$

[3]

2 Calculate the potential difference across the plates required for the sphere not to move.

potential difference = ... V **[2]**

(iv) The magnitude of the charge on the sphere can be changed by exposing the air between the plates to radiation from a beta source.

Explain how this can alter the charge on the sphere.

[2]

[Total: 13]

11 This question is about the motion of charged particles in magnetic fields.

Fig. 11.1 shows the path of a beam of ions in a vacuum as they pass though a magnetic field.

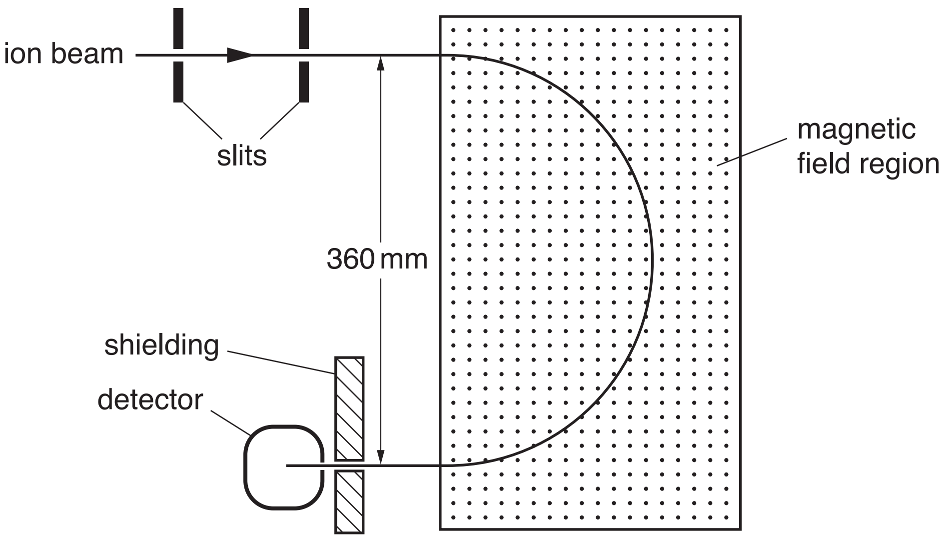

Fig. 11.1

(a) The beam consists of singly ionized chlorine-35 atoms, all with the same speed.

They are accelerated by an electric field as they pass through a pair of slits.

The ions enter the first slit with a speed of $3.0 \times 10^{2}\,\mathrm{m\,s^{-1}}$ and are accelerated to a speed of $4.0 \times 10^{5}\,\mathrm{m\,s^{-1}}$ by the time they leave the second slit.

(i) Show that each ion gains about 5×10^{-15} J of kinetic energy as it passes between the slits.

mass of a chlorine-35 ion = 6.0×10^{-26} kg

[2]

(ii) Calculate the required potential difference between the slits.

$e = 1.6 \times 10^{-19}$ C

potential difference = ... V **[2]**

(b) After passing through the second slit, the ions enter a region of uniform magnetic field at right angles to the plane of the diagram. As each ion passes through the magnetic field it follows a circular path of radius 0.18 m.

(i) Explain why the path is a part of a circle.

[2]

(ii) Each chlorine-35 ion has a speed of $4.0 \times 10^5\,\mathrm{m\,s^{-1}}$ in the magnetic field and a mass of $6.0 \times 10^{-26}\,\mathrm{kg}$.

Show that the centripetal force on the ion is about 5×10^{-14} N.

[2]

(iii) By considering the magnetic force on a chlorine-35 ion, calculate a value for the magnetic flux density.

flux density = ...**[2]**

(c) On one occasion the beam of chlorine-35 ions is contaminated with a small amount of chlorine-37 ions.

Explain why none of the chlorine-37 ions arrive at the detector.

[2]

[Total: 12]

12 This equation is about the elastic scattering of alpha particles from a nucleus.

Fig. 12.1 shows the path **A** followed by an alpha particle as it is scattered by a nucleus of uranium-238.

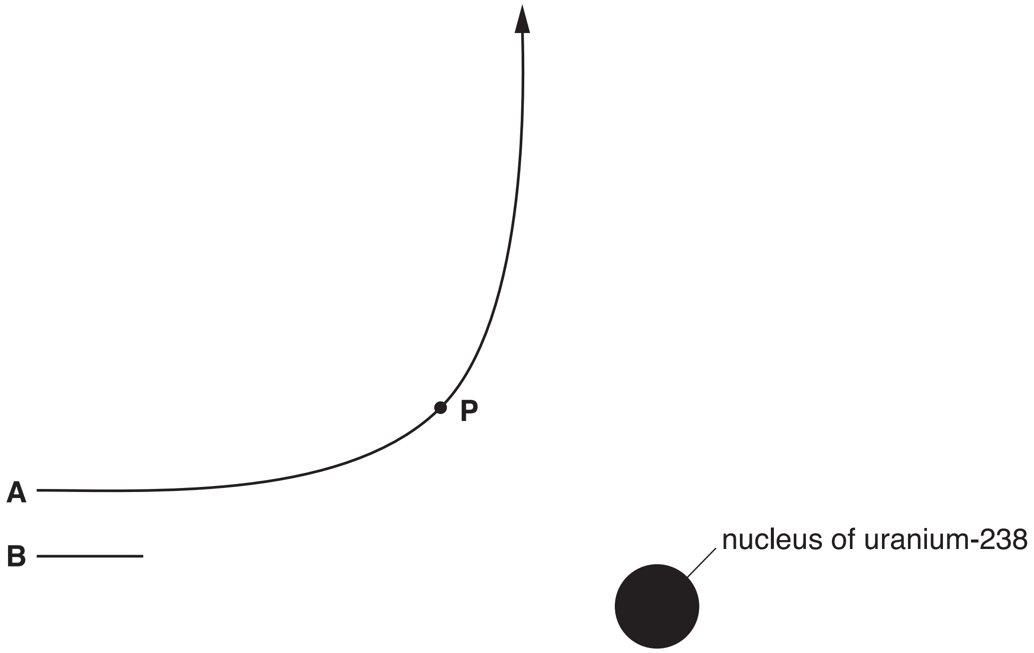

Fig. 12.1

(a) At point **P** the alpha particle on path **A** is a distance of 4.2×10^{-14} m from the centre of the nucleus. A uranium nucleus contains 92 protons.

(i) Calculate the force on the alpha particle at point **P**.

$e = 1.6 \times 10^{-19}$ C

$k = 9.0 \times 10^{9}$ N m^{2} C^{-2}

force = ... N **[3]**

(ii) On Fig. 12.1, draw an arrow to show the direction of the force on the alpha particle when it is at point **P**. **[1]**

(b) Fig. 12.1 shows part of the path **B** followed by another alpha particle with the same initial energy but aimed closer to the nucleus.

(i) On Fig. 12.1, sketch the rest of the path **B**. **[3]**

(ii) The alpha particles following paths **A** and **B** are deflected by different amounts. Explain why.

[2]

(c) The alpha particle following path **A** is scattered through 90°.

When a thin foil of uranium is bombarded with a beam of monoenergetic alpha particles, one alpha particle in every 100 million is scattered by more than 90°.

Explain the effect on this fraction of decreasing the energy of the alpha particles in the beam.

[2]

[Total: 11]

Quality of Written Communication [4]

[Section B Total: 50]

END OF QUESTION PAPER

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