Magnetic Fields & Moving Charges
Question paper 4

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Magnetic Fields
Sub Topic	Magnetic Fields & Moving Charges
Paper Type	Theory
Booklet	Question paper 4

Time Allowed: **80 minutes**

Score: **/66**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)** A straight conductor carrying a current *I* is at an angle *θ* to a uniform magnetic field of flux density *B*, as shown in Fig. 6.1.
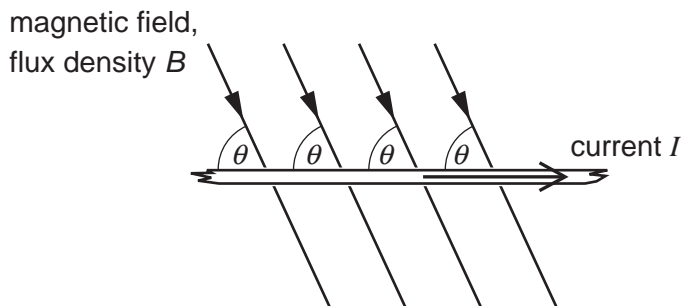

Fig. 6.1

The conductor and the magnetic field are both in the plane of the paper. State

(i) an expression for the force per unit length acting on the conductor due to the magnetic field,

force per unit length =...[1]

(ii) the direction of the force on the conductor.

....[1]

(b) A coil of wire consisting of two loops is suspended from a fixed point as shown in Fig. 6.2.
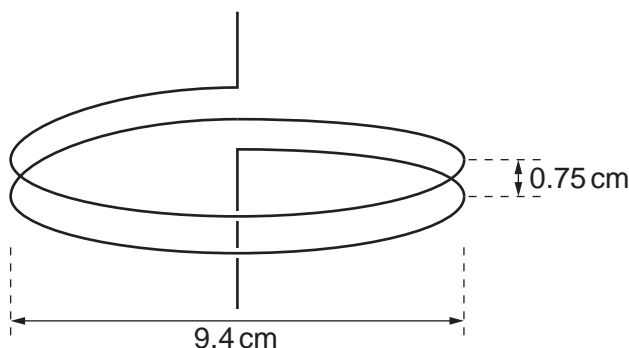

Fig. 6.2

Each loop of wire has diameter 9.4 cm and the separation of the loops is 0.75 cm.
The coil is connected into a circuit such that the lower end of the coil is free to move.

(i) Explain why, when a current is switched on in the coil, the separation of the loops of the coil decreases.

....

....

....

....

....[4]

(ii) Each loop of the coil may be considered as being a long straight wire.
In SI units, the magnetic flux density B at a distance x from a long straight wire carrying a current I is given by the expression

$$B = 2.0 \times 10^{-7} \frac{I}{x}.$$

When the current in the coil is switched on, a mass of 0.26 g is hung from the free end of the coil in order to return the loops of the coil to their original separation.
Calculate the current in the coil.

current = ...A [4]

2 Two long, straight, current-carrying conductors, PQ and XY, are held a constant distance apart, as shown in Fig. 6.1.
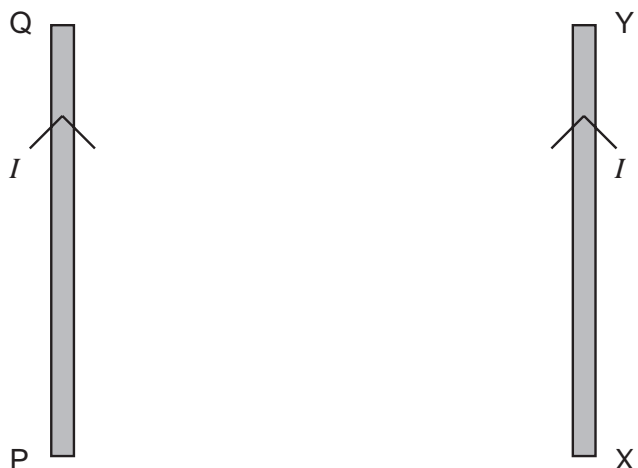

Fig. 6.1

The conductors each carry the same magnitude current in the same direction.

A plan view from above the conductors is shown in Fig. 6.2.

Fig. 6.2

(a) On Fig. 6.2 draw arrows, one in each case, to show the direction of

    (i) the magnetic field at Q due to the current in wire XY (label this arrow B),   [1]

    (ii) the force at Q as a result of the magnetic field due to the current in wire XY (label this arrow F).   [1]

(b) (i) State Newton's third law of motion.

....

....

.... [1]

(ii) Use this law and your answer in **(a)(ii)** to state the direction of the force on wire XY.

....

.... [1]

(c) The magnetic flux density *B* at a distance *d* from a long straight wire carrying a current *I* is given by

$$B = 2.0 \times 10^{-7} \times \frac{I}{d} \; .$$

Use this expression to explain why, under normal circumstances, wires carrying alternating current are not seen to vibrate. Make reasonable estimates of the magnitudes of the quantities involved.

....

....

....

....

.... [4]

3   A proton is moving with constant velocity *v*. It enters a uniform magnetic field that is normal to the initial direction of motion of the proton, as shown in Fig. 8.1.
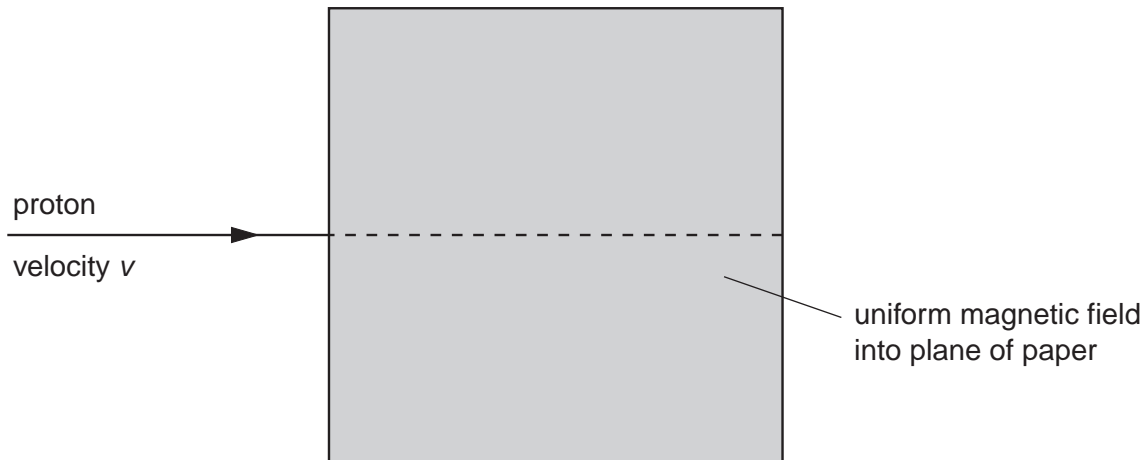
proton

velocity *v*

uniform magnetic field
into plane of paper

Fig. 8.1

A uniform electric field is applied in the same region as the magnetic field so that the proton passes undeviated through the fields.

(a)   On Fig. 8.1, draw an arrow labelled E to show the direction of the electric field.   [1]

(b)   The proton is replaced by other particles. The electric and magnetic fields remain unchanged.

State and explain the deviation, if any, of the following particles in the region of the fields.

(i)   an α-particle with initial velocity *v*

....

....

....

.... [3]

(ii)   an electron with initial velocity 2*v*

....

....

....

.... [3]

4   **(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.
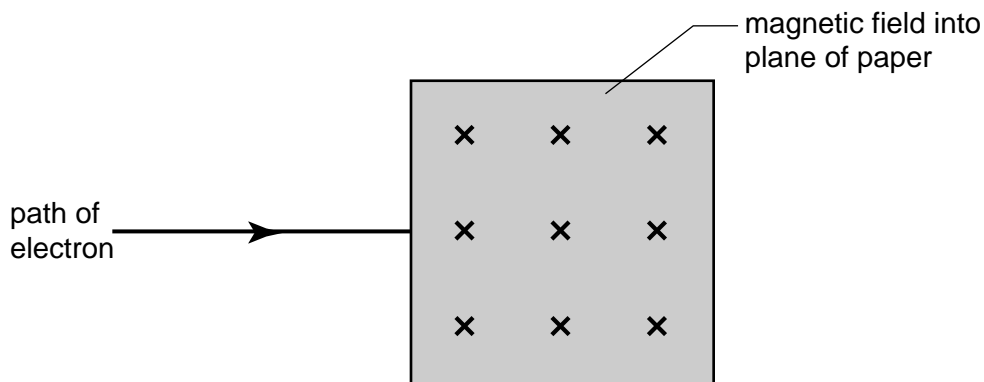

Fig. 5.1

(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]

5 A charged particle passes through a region of uniform magnetic field of flux density 0.74 T, as shown in Fig. 5.1.
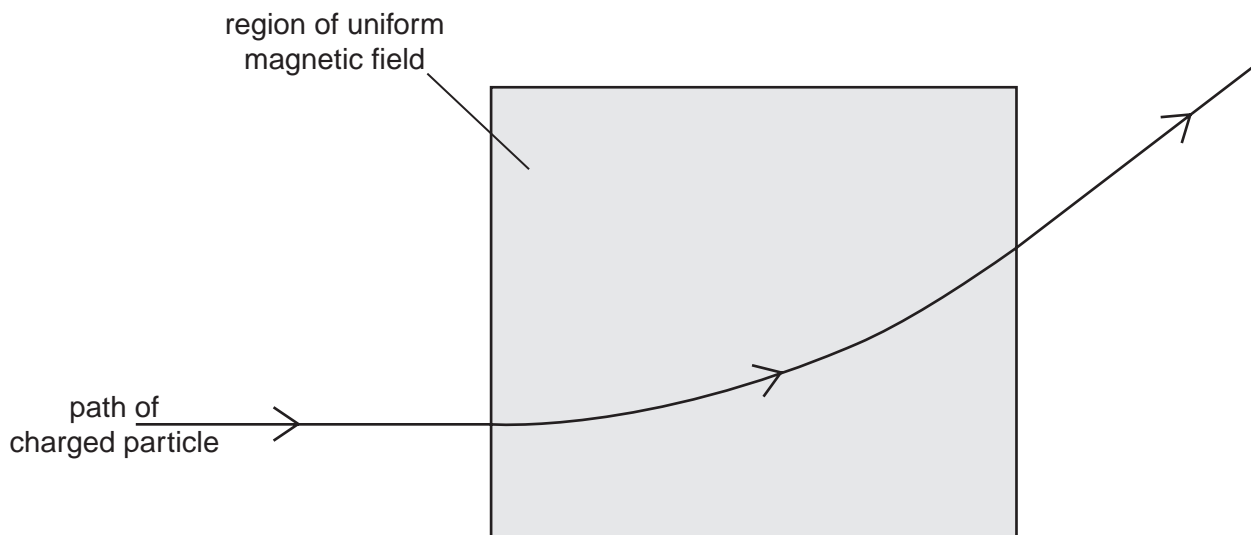

Fig. 5.1

The radius *r* of the path of the particle in the magnetic field is 23 cm.

(a) The particle is positively charged. State the direction of the magnetic field.

....[1]

(b) (i) Show that the specific charge of the particle (the ratio $\frac{q}{m}$ of its charge to its mass) is given by the expression

$$\frac{q}{m} = \frac{v}{rB},$$

where *v* is the speed of the particle and *B* is the flux density of the field.

[2]

(ii) The speed v of the particle is 8.2 x 10^6 m s^{-1}. Calculate the specific charge of the particle.

specific charge = ... C kg^{-1} [2]

(c) (i) The particle in **(b)** has charge 1.6 x 10^{-19} C. Using your answer to **(b)(ii)**, determine the mass of the particle in terms of the unified atomic mass constant u.

mass = ... u [2]

(ii) The particle is the nucleus of an atom. Suggest the composition of this nucleus.

....

....[1]

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

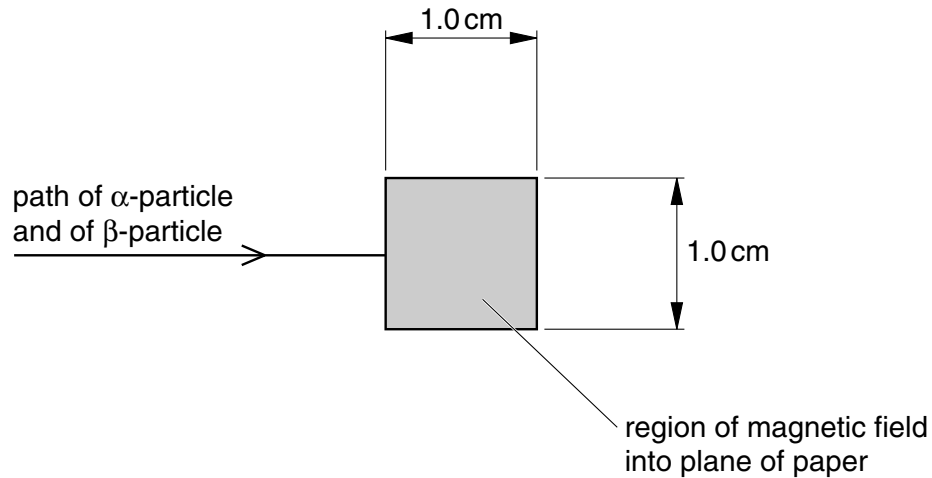They then enter a region of uniform magnetic field as shown in Fig. 5.1.

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]

7 **(a)** A charged particle may experience a force in an electric field and in a magnetic field.

State two differences between the forces experienced in the two types of field.

1. ....

....

2. ....

....[4]

(b) A proton, travelling in a vacuum at a speed of 4.5×10^6 m s^{-1}, enters a region of uniform magnetic field of flux density 0.12 T. The path of the proton in the field is a circular arc, as illustrated in Fig. 6.1.
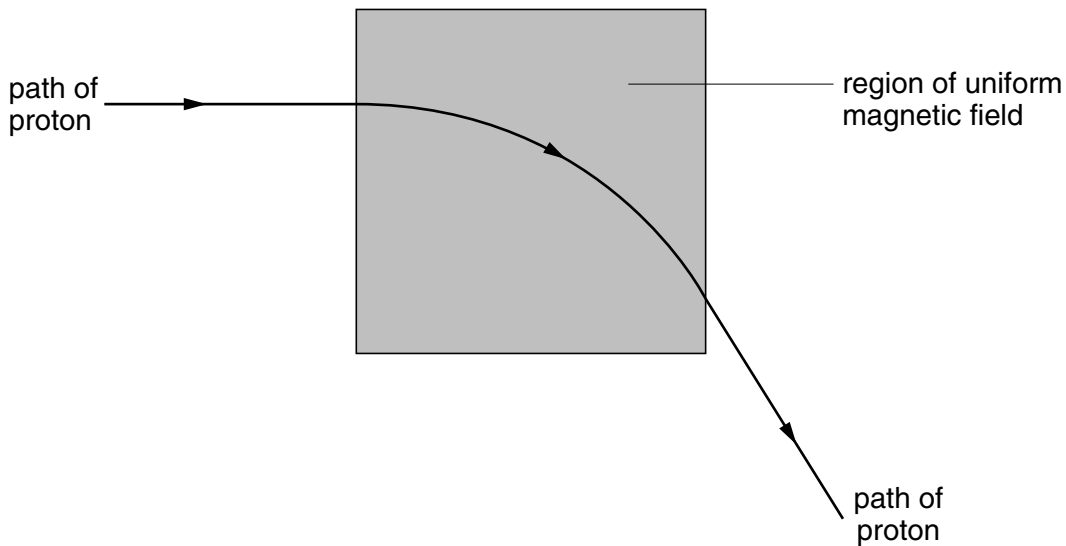

Fig. 6.1

(i) State the direction of the magnetic field.

....

(ii) Calculate the radius of the path of the proton in the magnetic field.

radius = ... m
[4]

(c) A uniform electric field is now created in the same region as the magnetic field in Fig. 6.1, so that the proton passes undeviated through the region of the two fields.

    (i) On Fig. 6.1 mark, with an arrow labelled E, the direction of the electric field.

    (ii) Calculate the magnitude of the electric field strength.

field strength = ... $V\,m^{-1}$

[3]

(d) Suggest why gravitational forces on the proton have not been considered in the calculations in **(b)** and **(c)**.

....

....[1]