Magnetic Fields & Moving Charges

Question paper 1

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Magnetic Fields
Sub Topic	Magnetic Fields & Moving Charges
Paper Type	Theory
Booklet	Question paper 1

Time Allowed: **78 minutes**

Score: **/65**

Percentage: **/100**

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

1 (a) State three conditions that must be satisfied in order that two waves may interfere.

1. ....

2. ....

3. .... [3]

(b) The apparatus illustrated in Fig. 4.1 is used to demonstrate two-source interference using light.

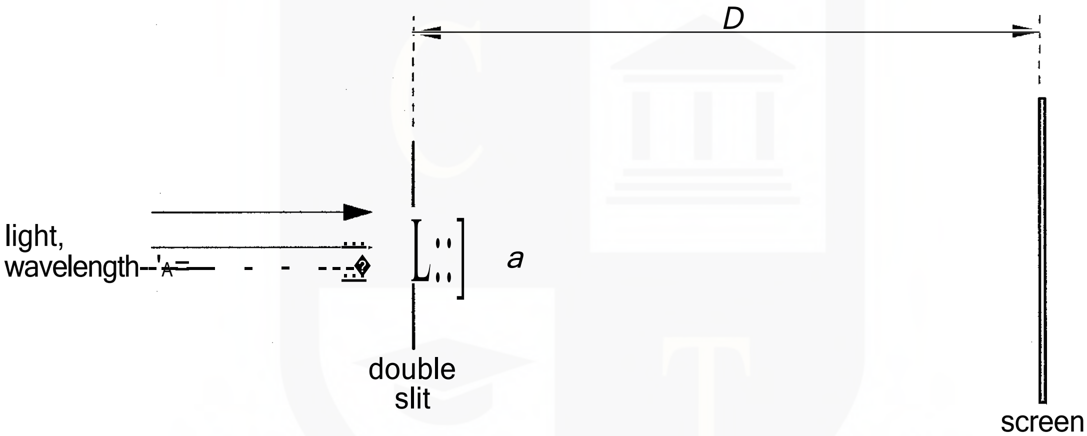

Fig. 4.1 (not to scale)

The separation of the two slits in the double slit arrangement is *a* and the interference fringes are viewed on a screen at a distance *D* from the double slit. When light of wavelength A is incident on the double slit, the separation of the bright fringes on the screen is *x*.

(i) 1. Suggest a suitable value for the separation ***a*** of the slits in the double slit.

....

2. Write down an expression relating A, ***a***, D and ***x***

....

[2]

(ii) Describe the effect, if any, on the separation and on the maximum brightness of the fringes when the following changes are made.

1. The distance *D* is increased to *2D,* keeping *a* and *l* constant.

   separation: ....

   maximum brightness: ....

2. The wavelength l is increased to 1.Sl, keeping *a* and D constant.

   separation: ....

   maximum brightness: ....

3. The intensity of the light incident on the double slit is increased, keeping l, *a* and *D* constant.

   separation: ....

   maximum brightness: ....

[7]

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2 **(a)** State the type of field, or fields, that may cause a force to be exerted on a particle that

(i) uncharged and moving, is

.... [1]

(ii) charged and stationary,

.... [1]

(iii) charged and moving at right-angles to the field.

.... [2]

(b) A particle X has mass 3.32×10^{-26} kg and charge $+1.60 \times 10^{-19}$ C.

The particle is travelling in a vacuum with speed $7.60 \times 10^{4}\,\mathrm{m\,s^{-1}}$. It enters a region of uniform magnetic field that is normal to the direction of travel of the particle. The particle travels in a semicircle of diameter 12.2 cm, as shown in Fig. 6.1.

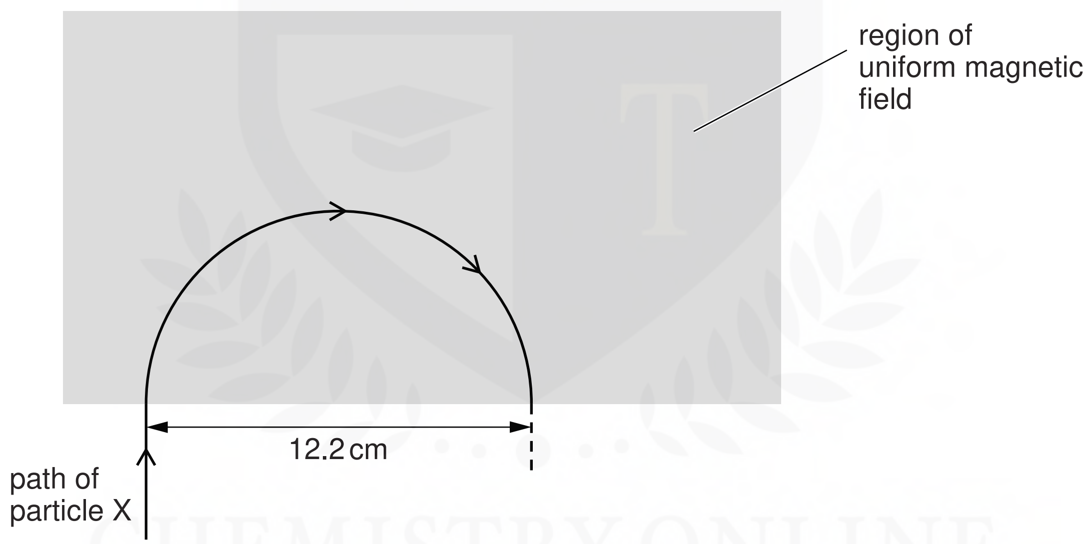

Fig. 6.1

For the uniform magnetic field,

(i) state its direction,

....

.... [1]

(ii) calculate the magnetic flux density.

magnetic flux density = ... T [3]

(c) A second particle Y has mass less than that of particle X in **(b)** and the same charge.

It enters the region of uniform magnetic field in **(b)** with the same speed and along the same initial path as particle X.

On Fig. 6.1, draw the path of particle Y in the region of the magnetic field. [1]

3 A stiff straight copper wire XY is held fixed in a uniform magnetic field of flux density 2.6×10^{-3} T, as shown in Fig. 6.1.

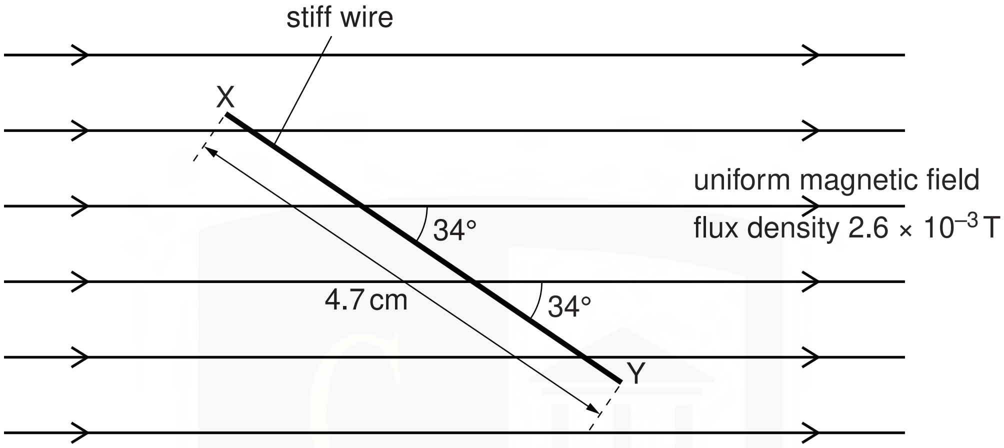

Fig. 6.1

The wire XY has length 4.7 cm and makes an angle of 34° with the magnetic field.

(a) Calculate the force on the wire due to a constant current of 5.4 A in the wire.

force = ... N [2]

(b) The current in the wire is now changed to an alternating current of r.m.s. value 1.7 A.

Determine the total variation in the force on the wire due to the alternating current.

variation in force = ... N [3]

4 **(a)** On the axes of Fig. 2.1, sketch the variation with distance from a point mass of the gravitational field strength due to the mass.

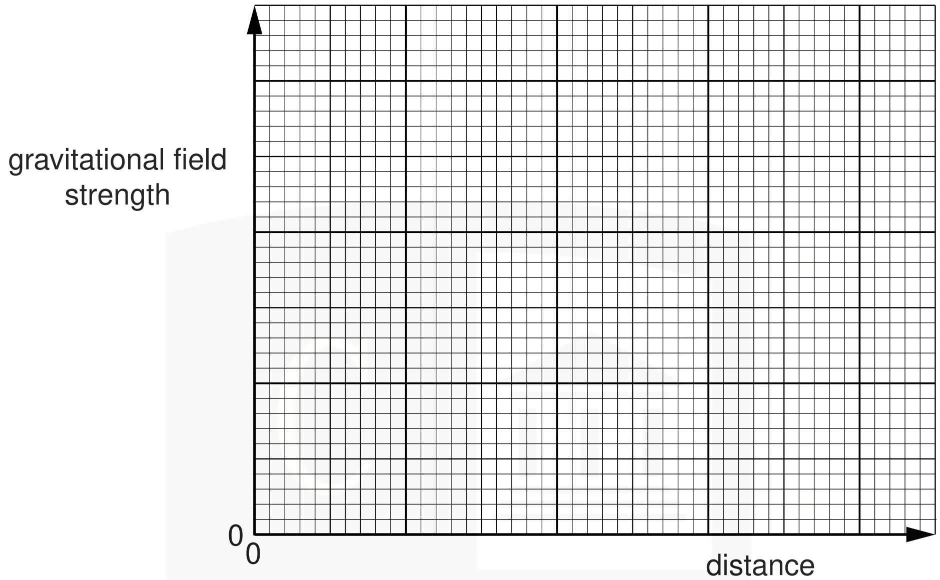

Fig. 2.1

[2]

(b) On the axes of Fig. 2.2, sketch the variation with speed of the magnitude of the force on a charged particle moving at right-angles to a uniform magnetic field.

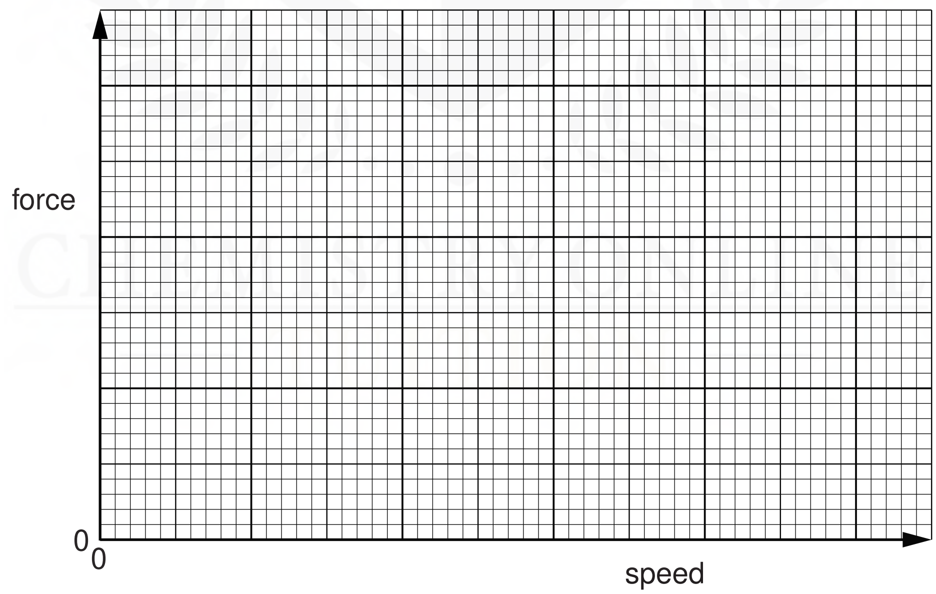

Fig. 2.2

[2]

(c) On the axes of Fig. 2.3, sketch the variation with time of the power dissipated in a resistor by a sinusoidal alternating current during two cycles of the current.

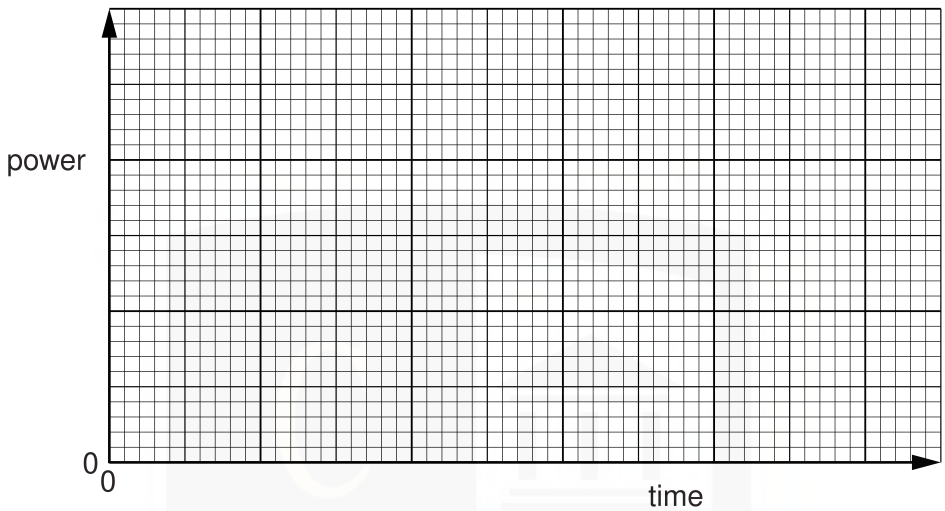

Fig. 2.3

[3]

5 **(a)** State what is meant by ***quantisation*** of charge.

....

.... [1]

(b) Charged parallel plates, as shown in Fig. 7.1, produce a uniform electric field between the plates.

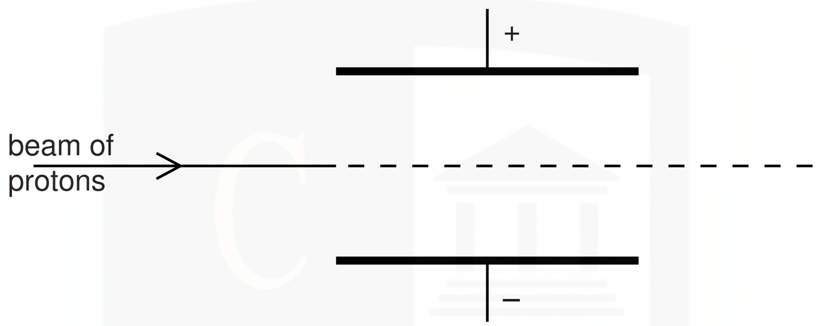

Fig. 7.1

The electric field outside the region between the plates is zero.
A uniform magnetic field is applied in the region between the plates so that a beam of protons passes undeviated between the plates.

(i) State and explain the direction of the magnetic field between the plates.

....

....

.... [2]

(ii) The magnetic flux density between the plates is now increased.

On Fig. 7.1, sketch the path of the protons between the plates. [2]

6 **(a)** Explain the use of a uniform electric field and a uniform magnetic field for the selection of the velocity of a charged particle. You may draw a diagram if you wish.

....

....

....

.... [3]

(b) Ions, all of the same isotope, are travelling in a vacuum with a speed of $9.6 \times 10^{4}\,\mathrm{m\,s^{-1}}$.
The ions are incident normally on a uniform magnetic field of flux density 640 mT. The ions follow semicircular paths A and B before reaching a detector, as shown in Fig. 6.1.

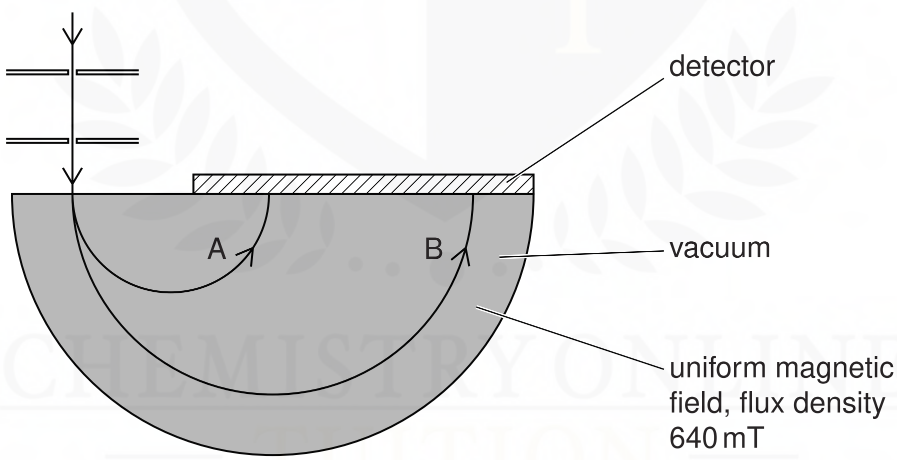

Fig. 6.1

Data for the diameters of the paths are shown in Fig. 6.2.

path	diameter / cm
A	6.2
B	12.4

Fig. 6.2

The ions in path B each have charge $+1.6 \times 10^{-19}\,\mathrm{C}$.

(i) Determine the mass, in u, of the ions in path B.

mass = ... u [4]

(ii) Suggest and explain quantitatively a reason for the difference in radii of the paths A and B of the ions.

....

....

....

.... [3]

7 A charged particle of mass $\boldsymbol{m}$ and charge $-\boldsymbol{q}$ is travelling through a vacuum at constant speed $\boldsymbol{v}$.
It enters a uniform magnetic field of flux density $\boldsymbol{B}$. The initial angle between the direction of motion of the particle and the direction of the magnetic field is 90°.

(a) Explain why the path of the particle in the magnetic field is the arc of a circle.

....

....

....

....[3]

(b) The radius of the arc in **(a)** is $\boldsymbol{r}$.

Show that the ratio $\dfrac{q}{m}$ for the particle is given by the expression

$$\frac{q}{m} = \frac{v}{Br}.$$

[1]

(c) The initial speed $\boldsymbol{v}$ of the particle is $2.0 \times 10^{7}\,\mathrm{m\,s^{-1}}$. The magnetic flux density $\boldsymbol{B}$ is $2.5 \times 10^{-3}\,\mathrm{T}$.
The radius $\boldsymbol{r}$ of the arc in the magnetic field is 4.5 cm.

(i) Use these data to calculate the ratio $\dfrac{q}{m}$.

ratio = ... $\mathrm{C\,kg^{-1}}$ [2]

(ii) The path of the negatively-charged particle before it enters the magnetic field is shown in Fig. 6.1.

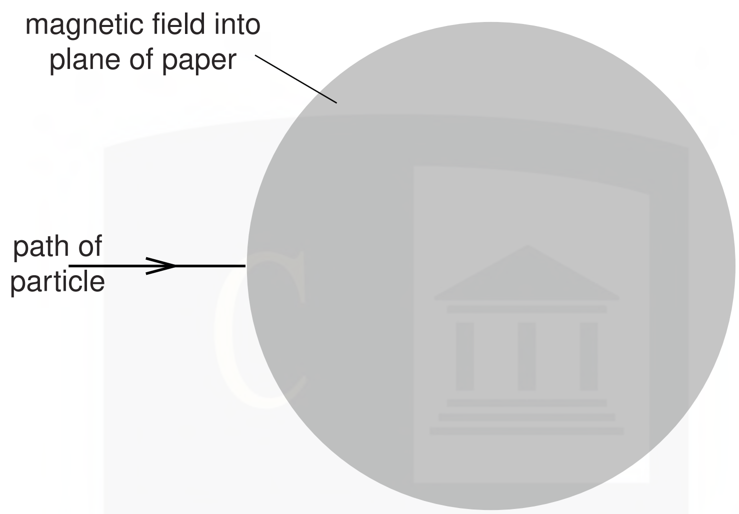

Fig. 6.1

The direction of the magnetic field is into the plane of the paper.

On Fig. 6.1, sketch the path of the particle in the magnetic field and as it emerges from the field. [2]

8 A particle has mass ***m*** and charge +***q*** and is travelling with speed ***v*** through a vacuum. The initial direction of travel is parallel to the plane of two charged horizontal metal plates, as shown in Fig. 6.1.

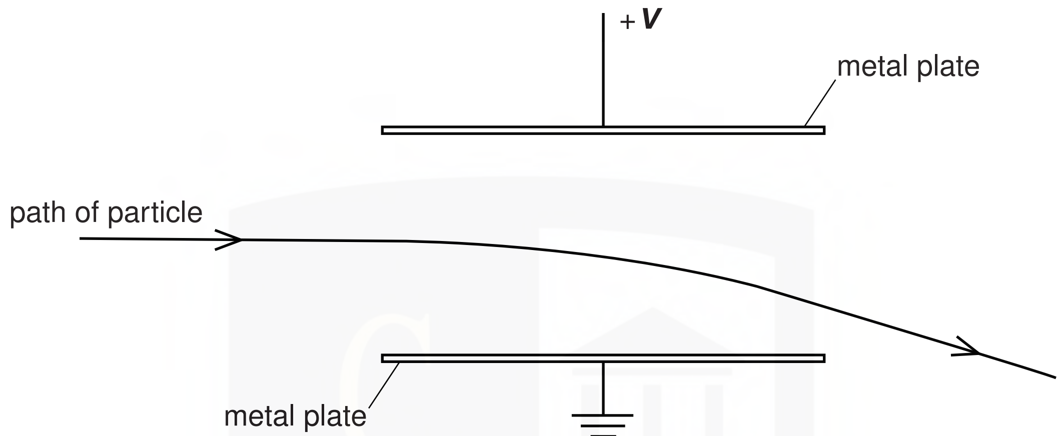

Fig. 6.1

The uniform electric field between the plates has magnitude $2.8 \times 10^4\,\mathrm{V\,m^{-1}}$ and is zero outside the plates.
The particle passes between the plates and emerges beyond them, as illustrated in Fig. 6.1.

(a) Explain why the path of the particle in the electric field is not an arc of a circle.

....

....

....[1]

(b) A uniform magnetic field is now formed in the region between the metal plates. The magnetic field strength is adjusted so that the positively charged particle passes undeviated between the plates, as shown in Fig. 6.2.

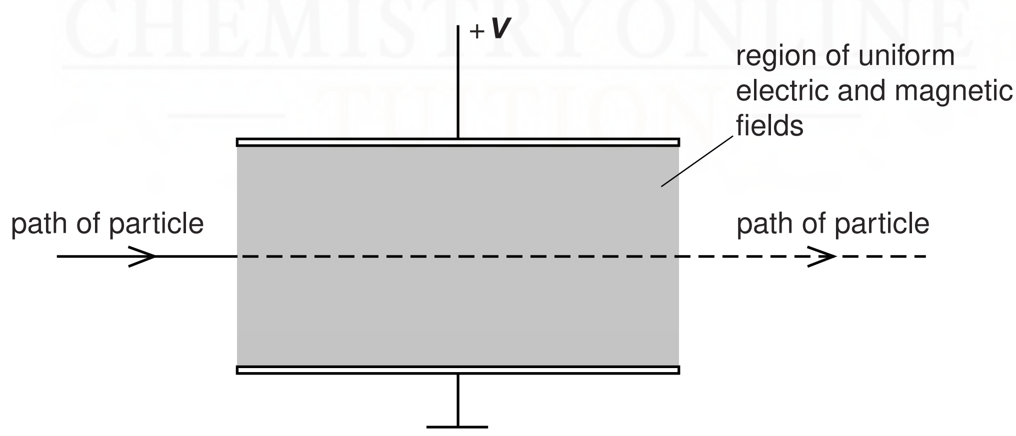

Fig. 6.2

(i) State and explain the direction of the magnetic field.

....

....

.... [2]

(ii) The particle has speed $4.7 \times 10^5\,\mathrm{m\,s^{-1}}$.
Calculate the magnitude of the magnetic flux density.
Explain your working.

magnetic flux density = ... T [3]

(c) The particle in **(b)** has mass $\boldsymbol{m}$, charge $+\boldsymbol{q}$ and speed $\boldsymbol{v}$.
Without any further calculation, state the effect, if any, on the path of a particle that has

(i) mass $\boldsymbol{m}$, charge $-\boldsymbol{q}$ and speed $\boldsymbol{v}$,

.... [1]

(ii) mass $\boldsymbol{m}$, charge $+\boldsymbol{q}$ and speed $2\boldsymbol{v}$,

.... [1]

(iii) mass $2\boldsymbol{m}$, charge $+\boldsymbol{q}$ and speed $\boldsymbol{v}$.

.... [1]

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