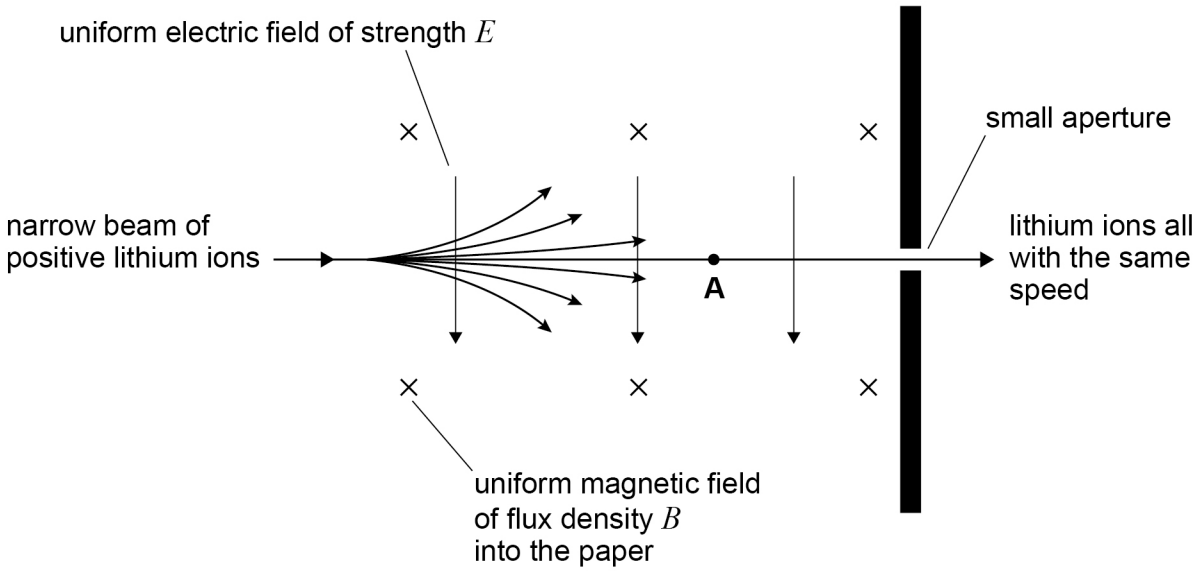
Do not write outside the box

0 3 Mass spectrometers are used to measure the masses of ions.

Figure 3 shows one part of a mass spectrometer.

Figure 3



A narrow beam consists of positive lithium ions travelling at different speeds.
The beam enters a region where there is an electric field and a magnetic field.
The directions of the uniform electric field of strength E and the uniform magnetic field of flux density B are shown on **Figure 3**.

Most ions are deflected from their original path.
Lithium ions that travel at one particular speed are not deflected, and pass through the small aperture.

0 3 . 1 The positive lithium ion **A** in **Figure 3** moves at a speed v.

Draw **two** labelled arrows on **Figure 3** to show the directions of the electric force F_{E} and the magnetic force F_{M} acting on **A**.

[1 mark]

Do not write outside the box

0 3 . 2 Lithium ions travelling at $1.5 \times 10^5\ \text{m s}^{-1}$ pass through the small aperture.

Calculate E.

$B = 0.12\ \text{T}$

[2 marks]

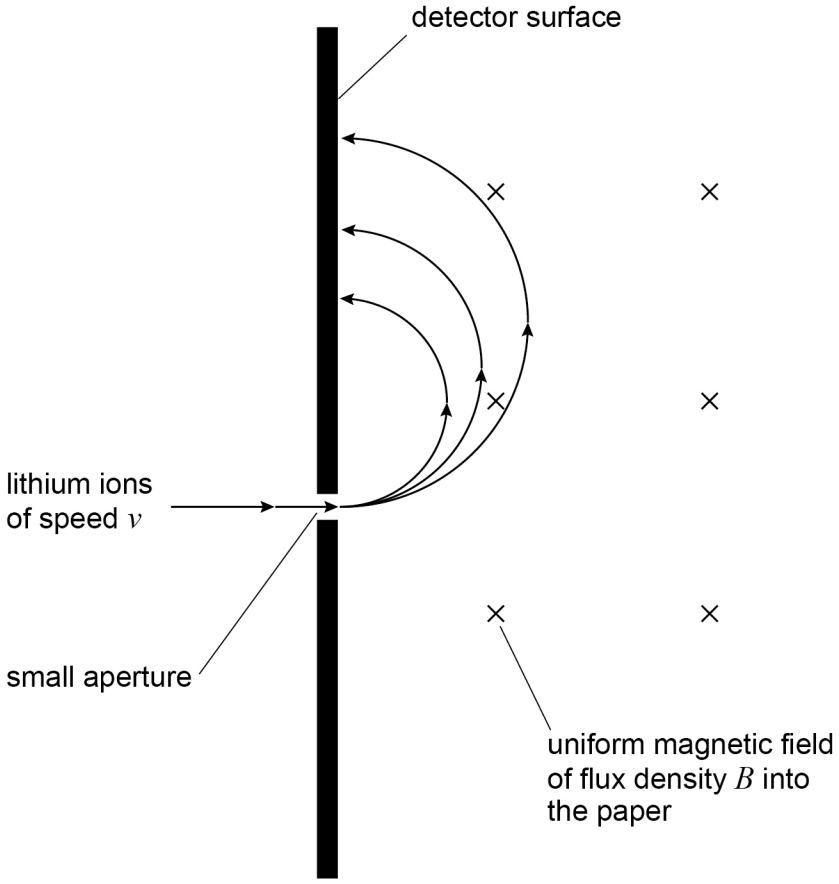
$E =$ _____ V m^{-1}

Question 3 continues on the next page

Do not write outside the box

0 3 . 3 Ions that pass through the small aperture enter a second uniform magnetic field of flux density B.
Ions of different mass are separated because they follow different paths as shown in **Figure 4**.

Figure 4



Do not write outside the box

Ions of mass m and charge q travelling at speed v follow a circular path in the uniform magnetic field.

Show that the radius r of the circular path is given by

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

[1 mark]

0 3 . 4 The ions of different mass are deflected and strike the detector surface at different distances from the small aperture as shown in **Figure 4**.

A singly-charged lithium ion ($^{6}_{3}\mathrm{Li}^{+}$) passes through the small aperture.

Calculate the distance between the small aperture and the point where this ion strikes the detector surface.

$v = 1.5 \times 10^{5}\ \mathrm{m\ s^{-1}}$

$B = 0.12\ \mathrm{T}$

mass of $^{6}_{3}\mathrm{Li}^{+}$ ion $= 1.0 \times 10^{-26}\ \mathrm{kg}$

[2 marks]

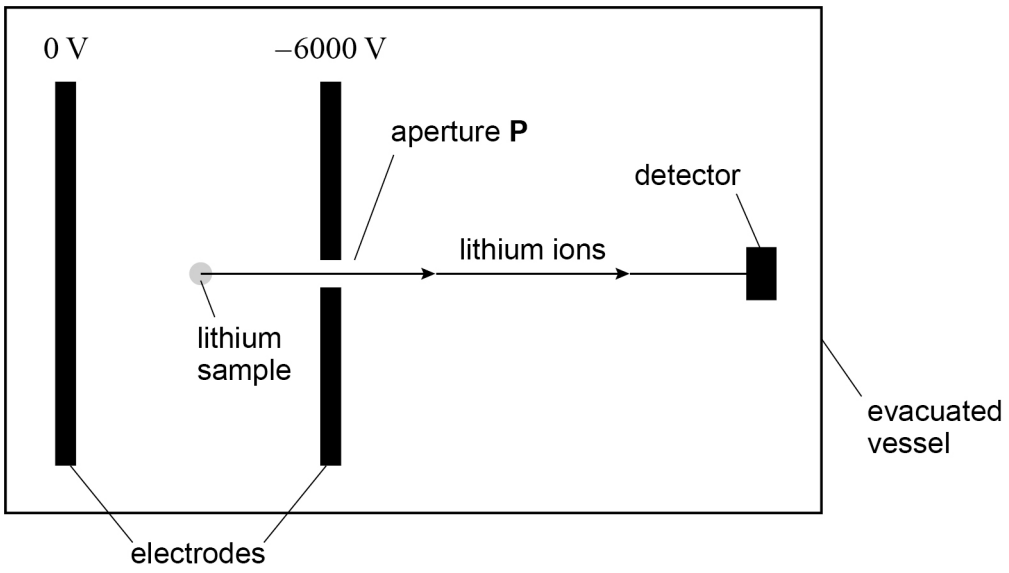
distance = _____ m

Question 3 continues on the next page

Do not write outside the box

0 3 . 5 **Figure 5** shows a different type of mass spectrometer working with lithium ions.

Figure 5



A stationary $^{7}_{3}\mathrm{Li}^{+}$ ion in the lithium sample is at the mid-point between the parallel electrodes. The $^{7}_{3}\mathrm{Li}^{+}$ ion accelerates towards aperture **P**.

Determine the speed of the ion when it emerges through aperture **P**.

mass of $^{7}_{3}\mathrm{Li}^{+}$ ion $= 1.2 \times 10^{-26}$ kg

[3 marks]

speed = _____ $\mathrm{m\ s^{-1}}$

Do not write outside the box

0 3 . 6 $^{6}_{3}Li^{+}$ and $^{7}_{3}Li^{+}$ ions are produced in the sample simultaneously and travel a distance L from aperture **P** to the detector.
For each type of ion, the time interval between production and detection is measured.

Discuss how the masses of the ions can be deduced from the measurement of these time intervals.

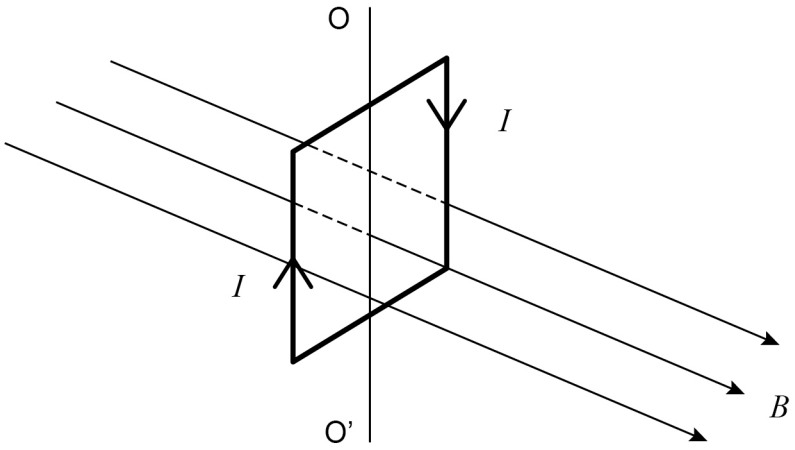
[2 marks]

11

Turn over for the next question

Do not write outside the box

2 3 The diagram shows a current I in a vertical square coil.
The coil can rotate about an axis OO'.
The plane of the coil is at right angles to a uniform horizontal magnetic field of flux density B.



Which statement is correct?

[1 mark]

A The forces on the vertical sides of the coil are equal in magnitude and opposite in direction. ⬭

B A non-zero couple acts on the coil. ⬭

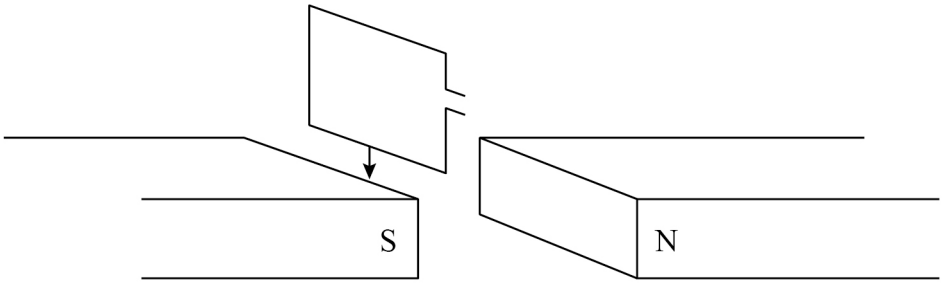
C No forces act on the horizontal sides of the coil. ⬭

D The forces on all sides of the coil act toward the centre of the coil. ⬭

Turn over for the next question

Do not write outside the box

2 4 The diagram shows a small rectangular coil falling between two magnetic poles.

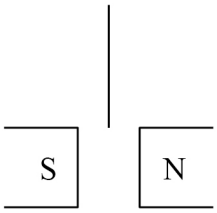


The coil is shown at four instants as it passes through the magnetic field.

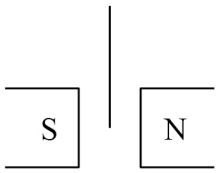
At which instant will the induced emf be a maximum?

[1 mark]

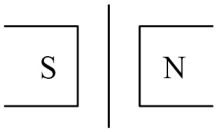
A



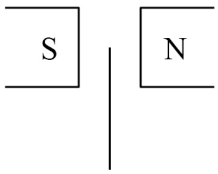
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

Do not write outside the box

2 5 An alternating emf is induced in a coil rotating in a magnetic field.

What is the phase difference between the magnetic flux linkage through the coil and the emf?

[1 mark]

A 0 ⬭

B $\frac{\pi}{3}\text{rad}$ ⬭

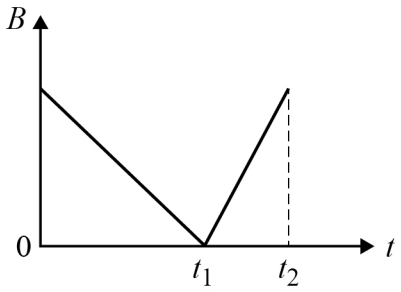
C $\frac{\pi}{2}\text{rad}$ ⬭

D $\pi\ \text{rad}$ ⬭

Turn over for the next question

Do not write outside the box

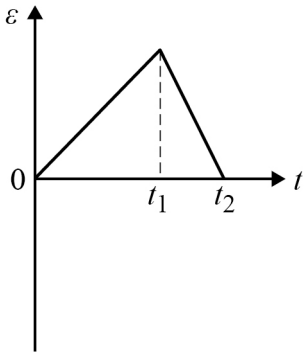
2 6 The diagram shows the variation with time t of the magnetic flux density B of the field linking a coil.



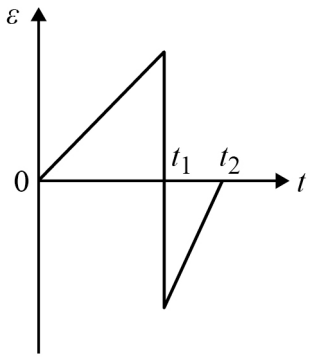
Which graph shows the variation of induced emf ε in the coil during this time interval?

[1 mark]

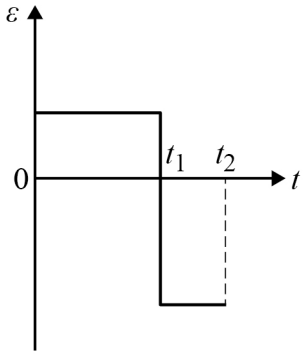
A



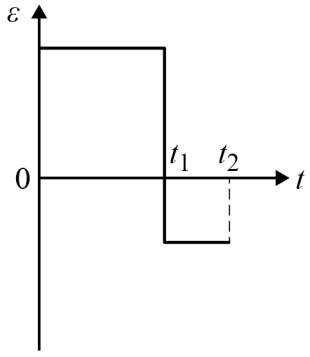
B



C



D



A ⬭

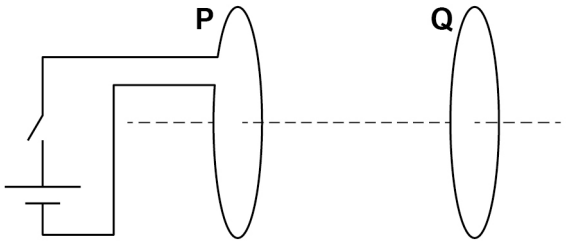
B ⬭

C ⬭

D ⬭

Do not write outside the box

2 7 A coil **P** is connected to a cell and a switch.
A closed coil **Q** is parallel to **P** and is arranged on the same axis.



Which describes the force acting on **Q** after the switch is closed?

[1 mark]

A steady and directed to the left ⬭

B steady and directed to the right ⬭

C short-lived and directed to the left ⬭

D short-lived and directed to the right ⬭

2 8 A point source emits gamma radiation. The intensity I of the radiation is measured at different distances d from the source.

Which graph will show a straight line through the origin?

[1 mark]

A I plotted against d ⬭

B I plotted against d^2 ⬭

C I plotted against d^{-1} ⬭

D I plotted against d^{-2} ⬭

Turn over for the next question