OCR

A Level

A Level Physics

Electromagnetism 1 (Answers)

Name:

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Total Marks: /30

1. A parallel-plate capacitor is made using two perfectly overlapping 5 m $\times$ 5 m plates separated by a vacuum.

Total for Question 1: 12

(a) Sketch the magnetic field lines associated with the following:

i. A solenoid. Indicate the direction in which charge carriers are moving. [2]

Solution: If the true current is indicated as coming in on the left, then the magnetic field should also come out on the left. Uniform within the solenoid. Like a bar magnet outside.

ii. The Earth. [1]

Solution:

Solution: From N to S.

iii. Two 'north' poles adjacent to each other. [1]

Solution:

Solution: No field in the central region. Lines should be diverging from the magnet's ends.

(b) Which one of the following is correct? [1]
1 T=1 NAm^{-1}
1 T=1 $Nm^{-1}A^{-1}$
1 T=1 $N^{-1}m^{-1}A^{-1}$

Solution: 2

(c) Outline an experiment you could perform to determine the magnetic flux density between two magnets using, amongst other things, a current carrying wire and a digital balance. Detail precisely the experimental setup, the measurements taken and the analysis. [4]

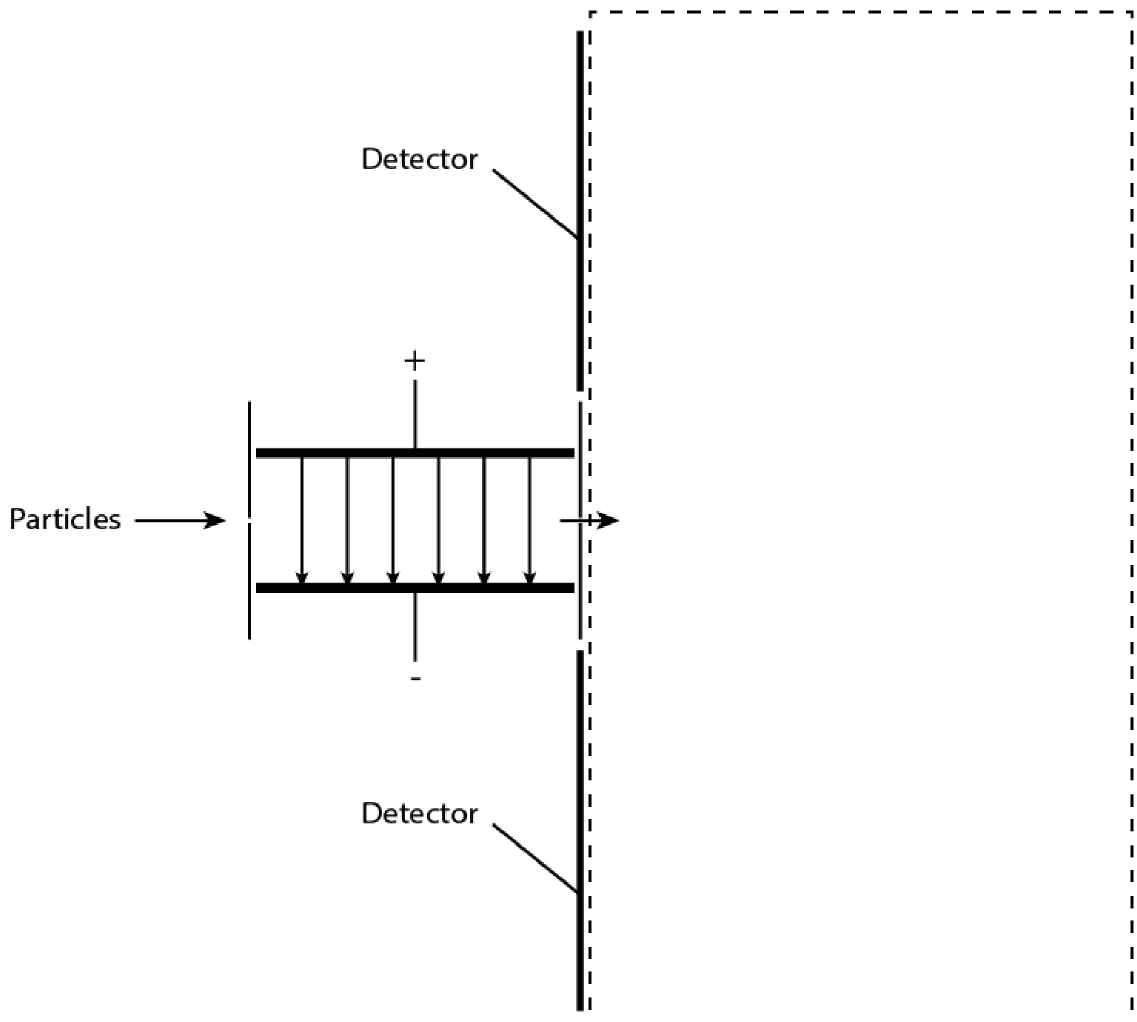
Solution:
Setup: magnets placed atop the balance, with the wire between the two (perpendicular to the direction of the field); the wire is connected to an ammeter and a power supply.
Procedure: the balance is zeroed when there is no current; when there is a current, the wire will feel an upwards force and the magnets a downward force (N3L).
Measurements: the length L of the wire in the field; the reading on the balance for different currents.
Analysis: $F = g\Delta m = BIL \rightarrow$ a plot of F against I will have a gradient of BL, allowing B to be calculated.

(d) A 4.0 cm length of copper wire, carrying a current of 3.0 A, is placed obliquely inside a uniform field of flux density $B = 0.4$ T. It experiences a force of 10 mN. Calculate the angle between the wire and the field. [3]

Solution: 12°

2. A velocity selector, illustrated in the plot below, uses both electric and magnetic fields to select charged particles with a specific velocity. The electric field is present in the region between the two plates, across which the potential difference is 1 kV and the separation is 2 cm. The magnetic field, with a flux density of $B = 0.5$ T, is present both in the velocity selector and in the region indicated by the dashed line.

Total for Question 2: 18



(a) Indicate on the diagram the direction of the magnetic field. [1]

Solution: Into the page.

(b) By balancing the forces associated with the electric field and the magnetic field, calculate the velocity of the particles that escape through the right hand hole. [4]

Solution: 10^5 ms^{-1}

After leaving the selector, the particles are being subjected only to the forces associated with the magnetic field.

(c) What effect will this have on the particles' motion? Justify your answer. [2]

Solution: They will begin to move in circular paths: their motion is perpendicular to the field so the magnetic force acts centripetally.

This scenario is exploited in mass spectrometers, which are used to measure the masses and relative abundances of different atomic species in a sample.

(d) Why is it important that all particles are travelling with the same speed when they enter the mass spectrometer. [1]

Solution: The radius of curvature is given by $r = mv/BQ$.
Since we need $r \propto m$, we need v to be the same.

(e) Sketch, on the diagram above, the paths taken by the following particles: [2]

i. A negatively charged particle with a high mass.
ii. A negatively charged particle with a low mass.
iii. A positively charged particle with a high mass.
iv. A positively charged particle with a low mass.

Solution: Negative particles are deflected 'downwards'; positive 'upwards'.
Higher mass particles are deflected less acutely i.e. their arcs have larger radii.

(f) Calculate the radius of curvature of the following paths:

i. A singly ionised sodium atom (atomic mass = 23). [2]

Solution: 0.048 m

ii. A singly ionised potassium atom (atomic mass = 39). [2]

Solution: 0.081 m

(g) Calculate their separation when they reach the detector. [2]

Solution: 0.066 m

(h) If the potassium atom had been given a positive charge of $+1e$, would your answer to the previous part change? If so, quantify the change. [2]

> **Solution:** Yes.
> It would be deflected upwards, so the separation would be $2r_{Na} + 2r_K = 0.13$ m.