Name: _____

Magnetism 1

Date:

Time:

Total marks available:

Total marks achieved: _____

Questions

Q1. A charged, non-magnetic particle is moving in a magnetic field.

Which of the following would **not** affect the magnetic force acting on the particle

- ☒ **A** the magnitude of the charge on the particle
- ☒ **B** the strength of the magnetic field
- ☒ **C** the velocity component parallel to the magnetic field direction
- ☒ **D** the velocity component perpendicular to the magnetic field direction

(Total for Question = 1 mark)

Q2.

A current of 1.50 A flows in a straight wire of length 0.450 m. The wire is placed in a uniform magnetic field of flux density 2.00×10^{-3} T which acts perpendicular to the wire.
Under these conditions the magnetic force balances the weight of the wire.

Calculate the mass of the wire.

- ☒ **A** 1.32×10^{-2} kg
- ☒ **B** 1.35×10^{-3} kg
- ☒ **C** 1.38×10^{-4} kg
- ☒ **D** 1.35×10^{-4} kg

(Total for question = 1 mark)

Q3.

A unit for magnetic flux is the

- ☒ **A** Wb
- ☒ **B** Wb m^2
- ☒ **C** T
- ☒ **D** T m^{-2}

(Total for question = 1 mark)

Q4.

An alpha particle and a beta particle both move into the same uniform magnetic field which is perpendicular to their direction of motion. The beta particle travels at 15 times the speed of the alpha particle.

The ratio of the force on the beta particle to the force on the alpha particle is

☒ **A** 3.7

☒ **B** 7.5

☒ **C** 30

☒ **D** 60

(Total for question = 1 mark)

Q5.

A length of current-carrying wire is placed at right angles to a uniform magnetic field of flux density B. When the current in the wire is I the force acting on the wire is F.

What is the force when the flux density is increased to $2B$ and the current reduced to $0.25I$?

☒ **A** $8F$

☒ **B** $2F$

☒ **C** $F/2$

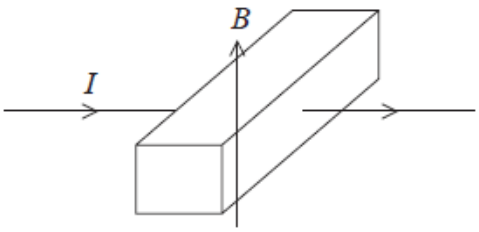
☒ **D** $F/4$

(Total for question = 1 mark)

Q6.

Some liquids conduct electricity. This property can be used to pump these liquids through pipes.

A short section of a rectangular pipe containing a liquid is shown in the diagram. The pipe is placed in a magnetic field of flux density B and a current I is passed through the liquid as shown.



Add an arrow to the diagram above to show the direction in which the liquid will move.

(1)

(Total for question = 1 mark)

Q7.

An alpha particle moves at right angles to a uniform magnetic field and experiences a force *F*. A beta particle moves at right angles to a magnetic field of half the magnetic flux density but at ten times the velocity of the alpha particle.
The magnitude of the force on the beta particle will be

Calculate the mass of the wire.

- **A** 0.25 *F*
- **B** 0.40 *F*
- **C** 2.5 *F*
- **D** 5.0 *F*

(Total for question = 1 mark)

Q8.

A conductor of length 50 mm carries a current of 3.0 A at 30º to a magnetic field of magnetic flux density 0.40 T.

The magnitude of the magnetic force acting on the conductor is

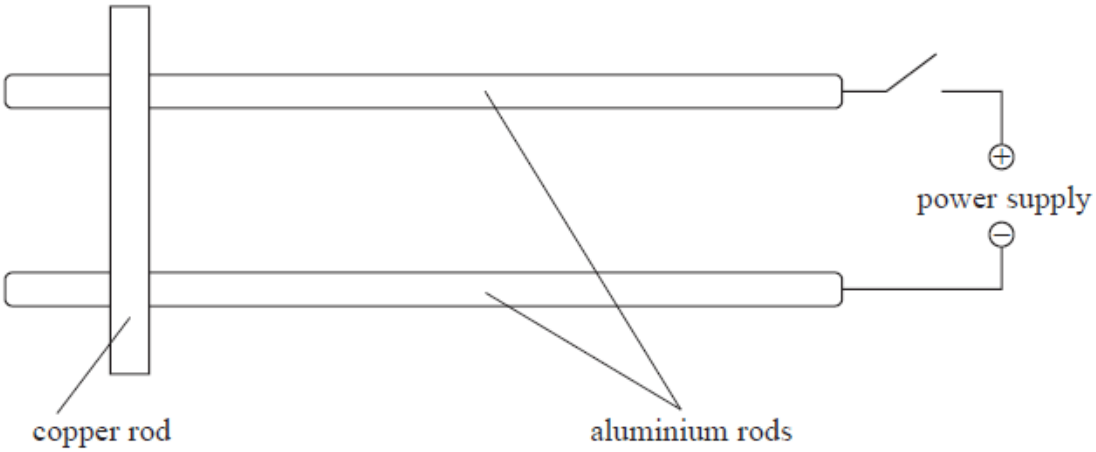
- **A** 0.030 N
- **B** 0.050 N
- **C** 30 N

☒ **D** 52 N

(Total for question = 1 mark)

Q9.

The apparatus shown in the diagram can be used to demonstrate that a force acts on a current-carrying conductor when the conductor is in a magnetic field.



The apparatus is placed in a magnetic field. When the switch is closed, the copper rod rolls along the aluminium rods.

(a) Add to the diagram to indicate the direction of the current in the copper rod.

(1)

(b) State the direction of the magnetic field that will make the copper rod move to the right.

(2)

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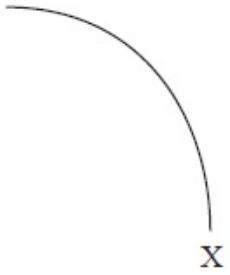
(Total for question = 3 marks)

Q10. Scientists studying anti-matter recently observed the creation of a nucleus of anti-helium 4, which consists of two anti-protons and two anti-neutrons.

The diagram represents the path of a proton through a magnetic field starting at point X.



Add to the diagram the path of an anti-helium 4 nucleus also starting at point X and initially travelling at the same velocity as the proton.

Explain any differences between the paths.

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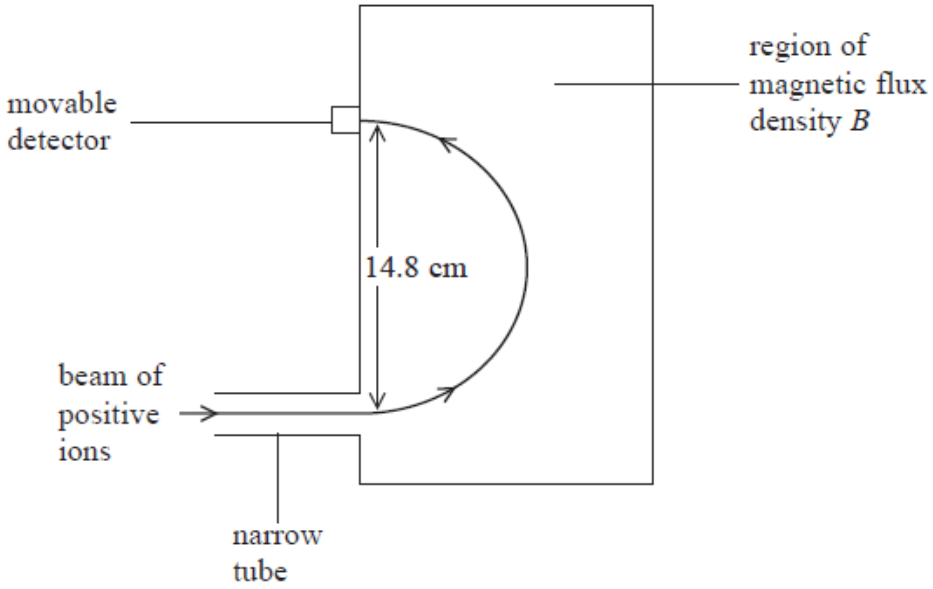
(Total for Question = 5 marks)

Q11.

A mass spectrometer is an instrument that is used to measure the masses of molecules.

Molecules of a gas are ionised and travel through a vacuum in a narrow tube. The ions enter a region of uniform magnetic flux density B where they are deflected in a semicircular path as shown.



(a) State why it is necessary for the molecules to be ionised.

(1)

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(b) State the direction of the magnetic field.

(1)

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(c) The ions have a charge of $+e$ and a speed of 1.20×10^5 m s^{-1}. When B has a value of 0.673 T, the ions are detected at a point where the diameter of the arc is 14.8 cm.

Calculate the mass of an ion.

(3)

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Mass of an ion = ...

(d) Ions with a smaller mass but the same charge and speed are also present in the beam.
On the diagram sketch the path of these ions.

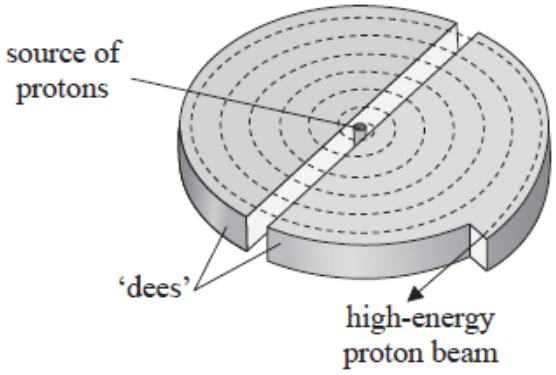
(1)

(Total for question = 6 marks)

Q12.

Proton beam therapy is being introduced in the UK as a new cancer treatment.

A beam of protons is accelerated by a cyclotron to an energy of 23 MeV and is then focused onto a tumour.



* Explain how the cyclotron produces the high-energy proton beam.

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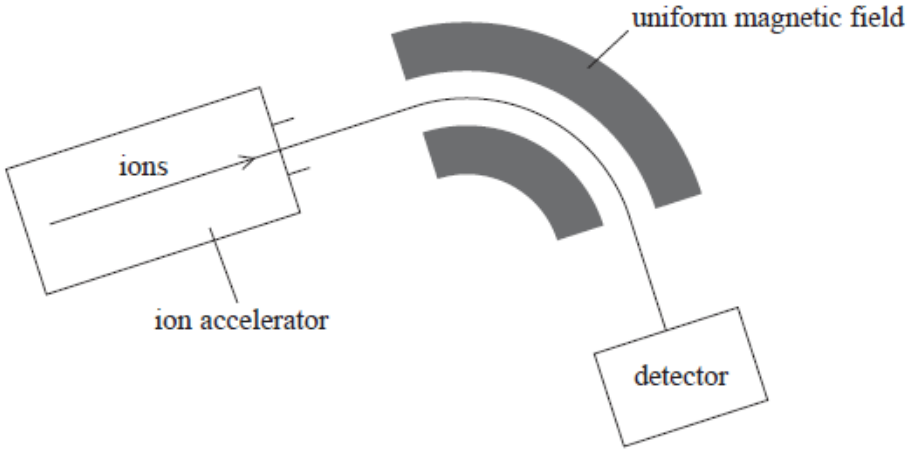
(Total for question = 6 marks)

Q13.

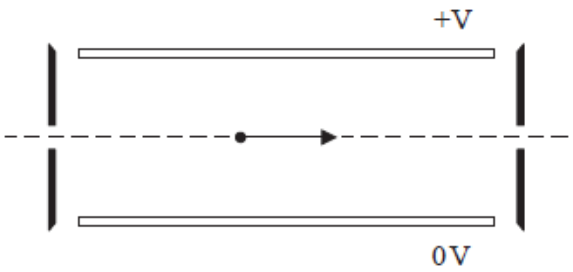
Mass spectrometry is a technique used to separate ions based on their charge to mass ratio.

The atoms in a sample are ionised and then accelerated and formed into a fine beam.
This beam is passed into a region of uniform magnetic field and the ions are deflected by different amounts according to their mass.



Analysis of mass spectrometer data shows that chlorine exists in nature as two isotopes, chlorine-35 and chlorine-37.

In most mass spectrometers the ions are passed through a velocity selector, after being accelerated, to produce a beam of ions of a particular velocity.
The velocity selector consists of a pair of parallel plates, across which a potential difference (p.d.) is applied to create an electric field.



In one mass spectrometer the plates are 2.5 cm apart and a p.d. of 135 V is applied.

A magnetic field is also applied to produce a force on the ions in the opposite direction to the force from the electric field. For one particular speed the ions travel in a straight line and emerge from the selector.

(i) Add to the diagram to indicate the directions of the electric field and the magnetic field.

(2)

(ii) The magnetic flux density applied to the velocity selector is 24.5 mT.

Deduce whether this magnetic flux density is suitable to produce a beam of chlorine-35 ions of speed 2.2×10^5 m s^{-1}.

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(Total for question = 6 marks)

Q14.

The photograph is an image of the paths of particles obtained from an early particle detector, the cloud chamber.

Modern particle detectors such as the ones at CERN still work on the basic principle that charged particles cause ionisation of the material through which they pass. These ionisations can be tracked and recorded. Magnetic fields are used to deflect the particles so that their properties can be investigated.

(a) State what is meant by ionisation in this context.

(1)

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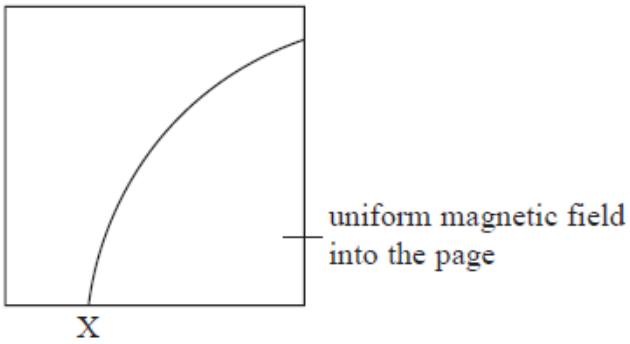
(b) The diagram below shows the ionisation path of a particle when it is in the region of a uniform magnetic field. The particle enters the field at X.



State how we know that the particle is negatively charged.

(1)

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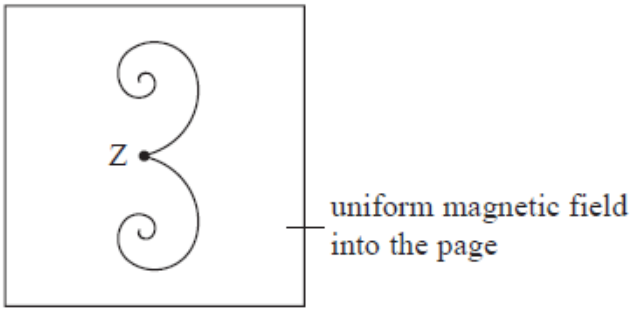
(c) The diagram below shows an event occurring in the same magnetic field.



Point Z is where a high energy photon interaction occurs which causes two particles to be formed.

Describe, with reasons, what can be deduced about the photon and the two particles that are formed in this interaction.

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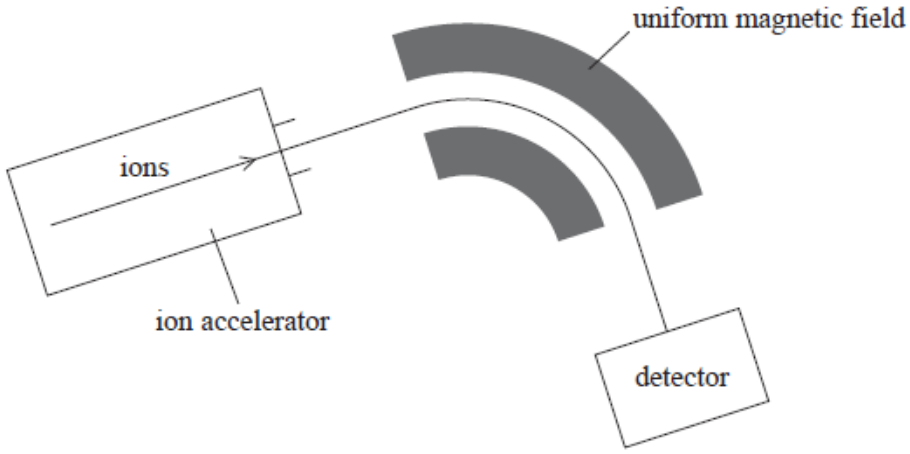
(Total for question = 7 marks)

Q15.

Mass spectrometry is a technique used to separate ions based on their charge to mass ratio.

The atoms in a sample are ionised and then accelerated and formed into a fine beam.
This beam is passed into a region of uniform magnetic field and the ions are deflected by different amounts according to their mass.



Analysis of mass spectrometer data shows that chlorine exists in nature as two isotopes, chlorine-35 and chlorine-37.

After passing through the velocity selector the ion beam enters a region of uniform magnetic flux density 0.35 T with the ions travelling at right angles to the field direction.

(i) Explain why the ions travel in a circular path.

(2)

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(ii) Calculate the radius of the circular path.

(2)

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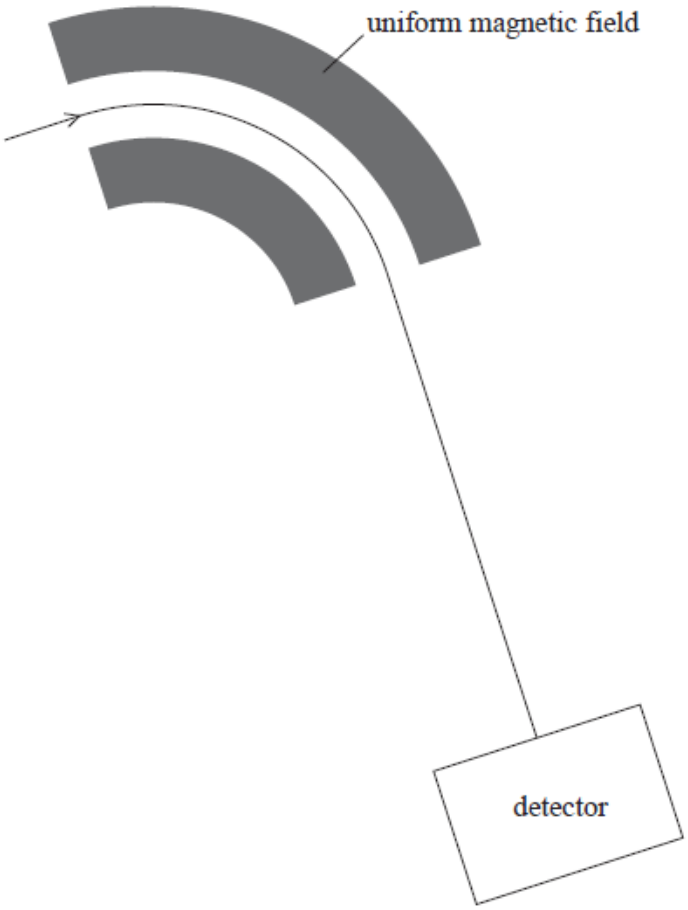
Radius = ...

(iii) The diagram shows the path of the chlorine-35 ions in the field. Chlorine-37 ions enter the magnetic field with the same velocity.



1. Add another line to the diagram to show the path of these chlorine-37 ions.

(1)

2. Explain any differences in the paths.

(2)

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(Total for question = 7 marks)

Q16. The magnetic force *F* that acts on a current-carrying conductor in a magnetic field is given by the equation

$F = BIl$.

(a) State the condition under which this equation applies.

(1)

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(b) The unit for magnetic flux density B is the tesla.

Express the tesla in base units.

(2)

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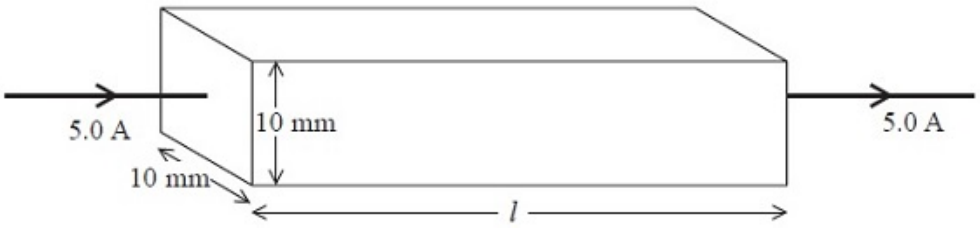
(c) The diagram shows a rectangular bar of aluminium which has a current of 5.0 A through it.



The bar is placed in a magnetic field so that its weight is supported by the magnetic field.

Calculate the minimum value of the magnetic flux density B needed for this to occur.

density of aluminium = 2.7×10^3 kg m^{-3}

(3)

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Minimum B = ...

(d) State the direction of the magnetic field.

(1)

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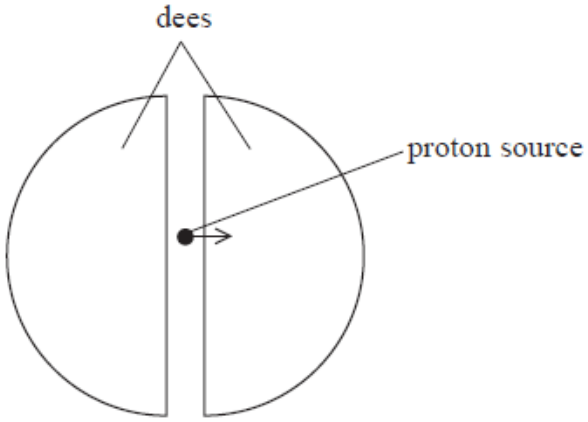
(Total for Question = 7 marks)

Q17.

A cyclotron is a particle accelerator which can be used to accelerate protons. The cyclotron consists of two semicircular electrodes called 'dees'. An alternating potential difference is applied across the gap between the dees. A uniform magnetic field is applied at right angles to the plane of the dees.



(i) Complete the diagram to show the path of the protons.

(1)

(ii) State the direction of the magnetic field needed in order to produce the path you have sketched.

(1)

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(iii) Explain how the kinetic energy of the protons is increased as they follow the path you have shown.

(3)

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(iv) Show that the magnetic flux density B of the applied magnetic field is given by

$$B = \frac{2\pi f m}{e}$$

where f is the frequency of the alternating potential difference, m is the mass of the proton and e is the charge on the proton.

(3)

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(v) In a particular cyclotron B is 1.2 mT.
Calculate the frequency f of the alternating potential difference.

(2)

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f = ...