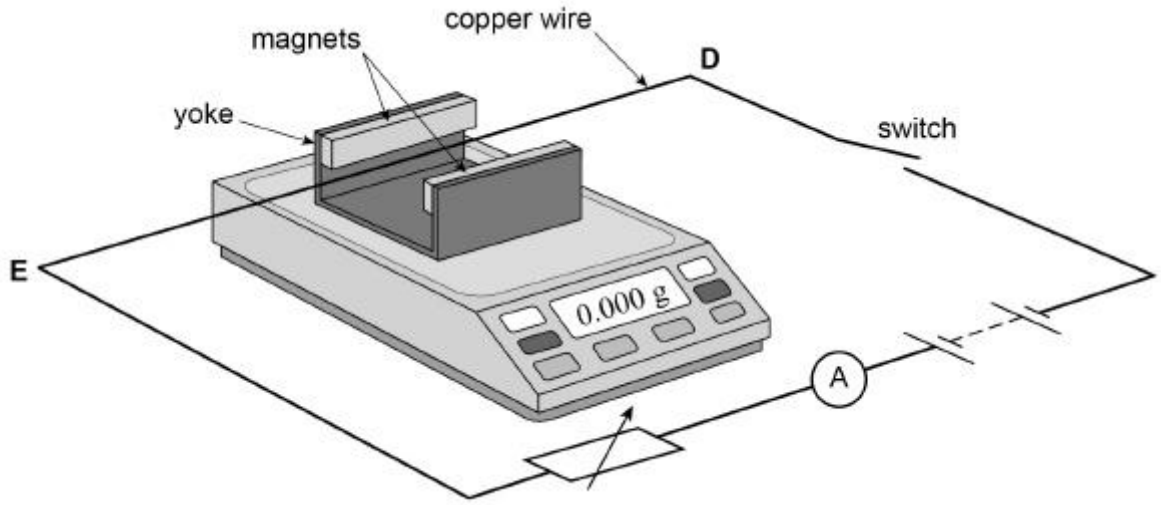
Name of the Student:_____
Max. Marks : 24 Marks **Time : 24 Minutes**

Q1.

Figure 1 shows two magnets, supported on a yoke, placed on an electronic balance.

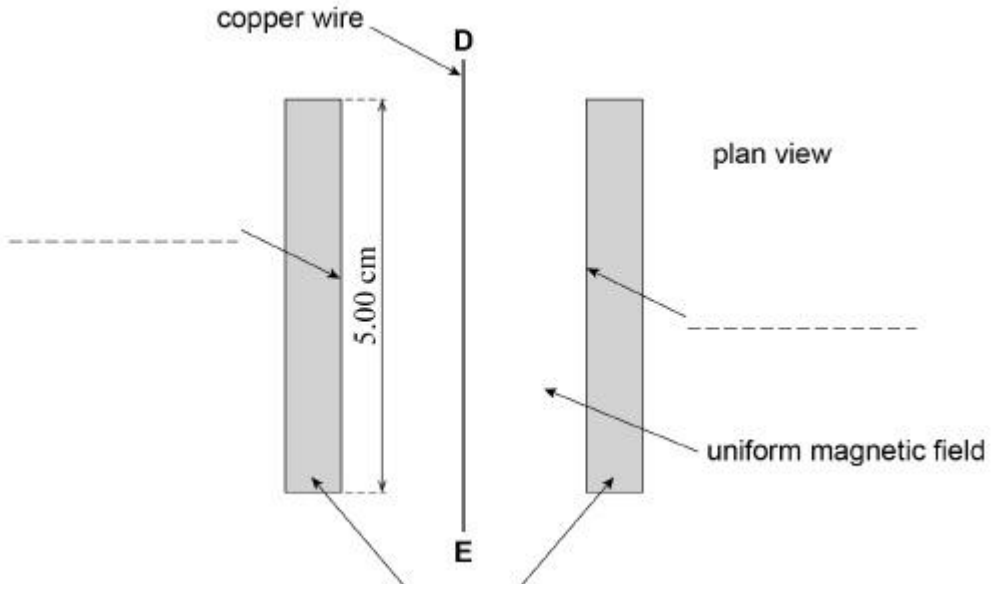
Figure 1



The magnets produce a uniform horizontal magnetic field in the region between them. A copper wire **DE** is connected in the circuit shown in **Figure 1** and is clamped horizontally at right angles to the magnetic field.

Figure 2 shows a simplified plan view of the copper wire and magnets.

Figure 2



When the apparatus is assembled with the switch open, the reading on the electronic balance is set to 0.000 g. This reading changes to a positive value when the switch is closed.

(a) Which of the following correctly describes the direction of the force acting on the wire **DE** due to the magnetic field when the switch is closed?

Tick (✔) the correct box.

towards the left magnet in **Figure 2** ☐

towards the right magnet in **Figure 2** ☐

vertically up ☐

vertically down ☐

(1)

(b) Label the poles of the magnets by putting **N** or **S** on each of the two dashed lines in **Figure 2**.

(1)

(c) Define the tesla.

_____

_____

_____

(1)

(d) The magnets are 5.00 cm long. When the current in the wire is 3.43 A the reading on the electronic balance is 0.620 g.

Assume the field is uniform and is zero beyond the length of the magnets.

Calculate the magnetic flux density between the magnets.

magnetic flux density = _____ T

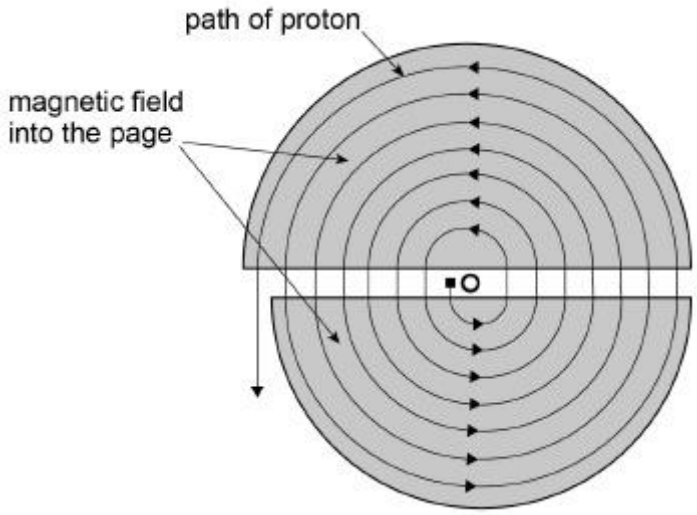
(2)

(Total 5 marks)

Q2.

A cyclotron has two D-shaped regions where the magnetic flux density is constant.
The D-shaped regions are separated by a small gap.
An alternating electric field between the D-shaped regions accelerates charged particles. The magnetic field causes the charged particles to follow a circular path.

The diagram shows the path followed by a proton that starts from **O**.



(a) Explain why it is **not** possible for the magnetic field to alter the speed of a proton while it is in one of the D-shaped regions.

_____

_____

_____

_____

_____

(1)

(b) Derive an expression to show that the time taken by a proton to travel round one semi-circular path is independent of the radius of the path.

(3)

(c) The maximum radius of the path followed by the proton is 0.55 m and the magnetic flux density of the uniform field is 0.44 T.

Ignore any relativistic effects.

Calculate the maximum speed of a proton when it leaves the cyclotron.

maximum speed = _____ m s^{-1}

(2)

(Total 6 marks)

Q3.

Read the following passage and answer the questions that follow.

A mass spectrometer is an instrument for measuring the masses of isotopes. The main working parts of the instrument are shown in **Figure 1**.

Figure 1

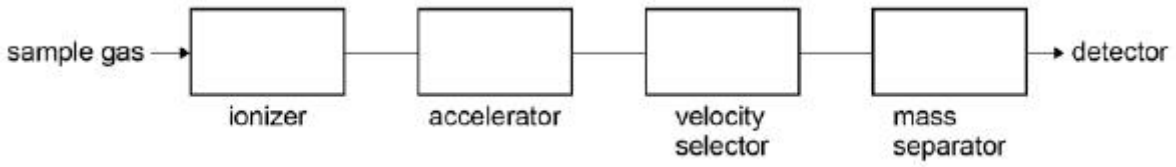
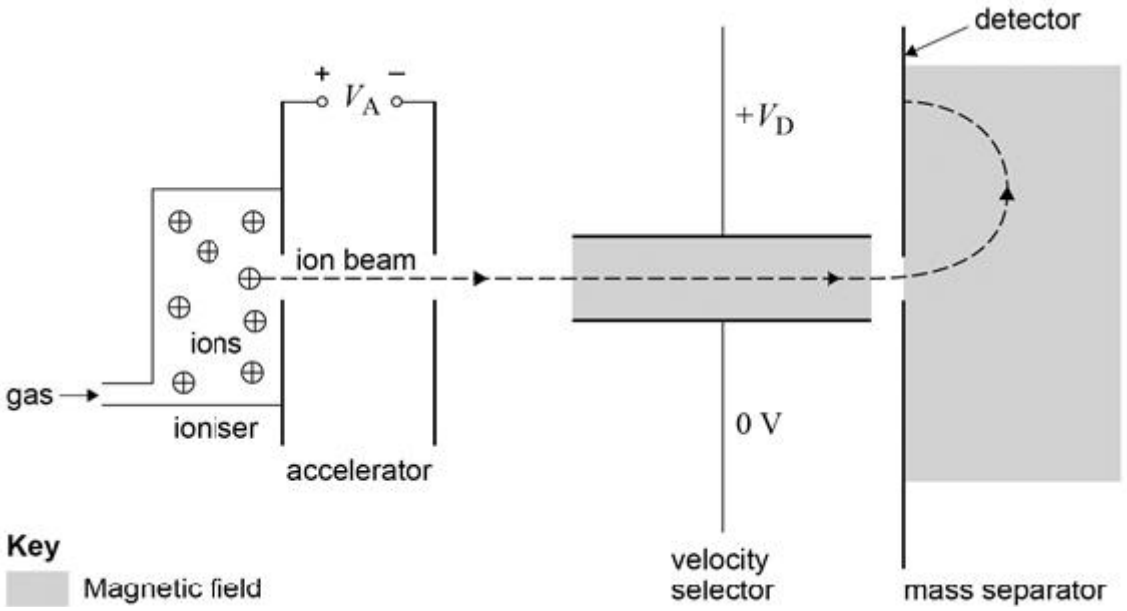


Figure 2 shows the components in more detail. Positive ions are created in the ionizer. Some of these ions enter the accelerator where they are accelerated by a potential difference V_A. The ions emerge from the accelerator with different speeds and enter the velocity selector.

The velocity selector contains a region where there is a uniform magnetic field at right angles to an electric field. This electric field is formed between two parallel plates held at a potential difference V_D. This combination of fields only allows ions of a particular velocity to enter the mass separator. Here ions of different mass are separated by a uniform magnetic field. Finally the ions are detected.

Figure 2



(a) Explain what is meant by ionisation.

_____

_____

(1)

(b) Discuss the energy transfers that take place in the accelerator as the ion passes through it. Assume the ions are in a perfect vacuum.

_____

_____

_____

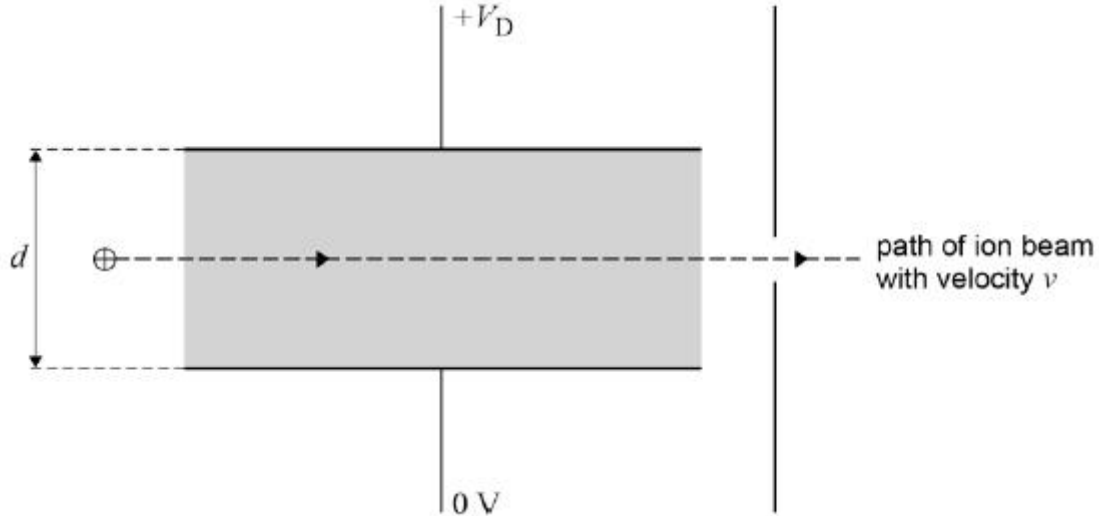
_____

_____

(3)

(c) **Figure 3** shows the path taken by an ion that moves through the velocity selector at a velocity v.

Figure 3



Discuss how the path changes when an ion enters the velocity selector with a velocity greater than v.

(3)

(d) Draw, on **Figure 3**, the path of the ion that is suggested by your answer to part **(c)**.

(1)

(e) Ions created in the ioniser may have the same charge but a different number of nucleons.

Discuss how the path of an ion in the mass separator is affected when it has more nucleons.

(2)

(f) Some ions are created with the same mass but a double charge. The path of the ions shown in **Figure 2** is that of a singly charged ion.

Compare, with justification, the path of a doubly charged ion through the mass spectrometer with that of a singly charged ion of the same mass.

_____

_____

_____

(3)
(Total 13 marks)