18 Mass spectrometry is used to determine the masses of different isotopes of an element.
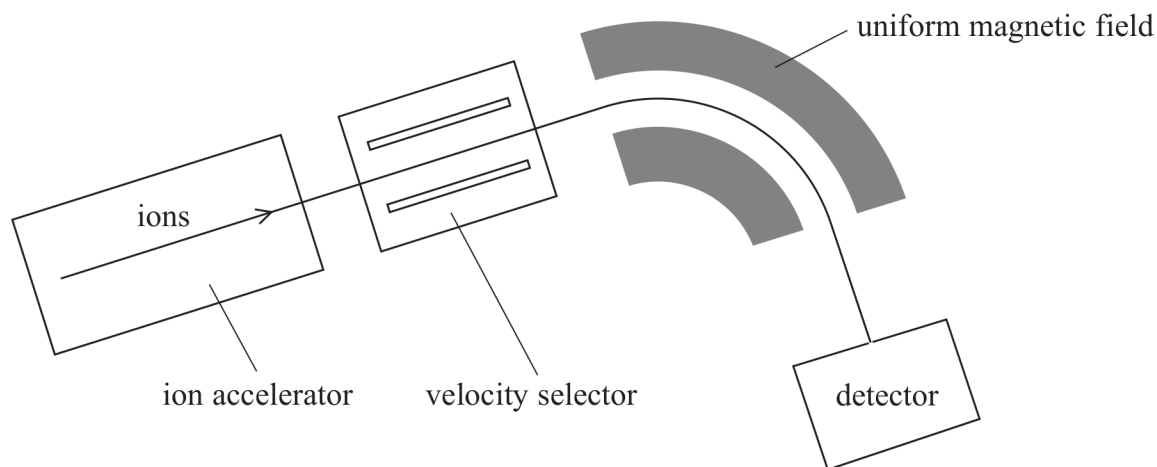
Atoms of the isotopes are ionised and accelerated. They pass through a velocity selector and into a region with a uniform magnetic field, as shown.

(a) An ion accelerator uses an electron beam to ionise atoms of oxygen gas. The positive ions are then accelerated across a high potential difference between an anode and a cathode, as shown in the diagram below. The cathode has a hole in it so that the accelerated ions may pass in a fine beam to the velocity selector.
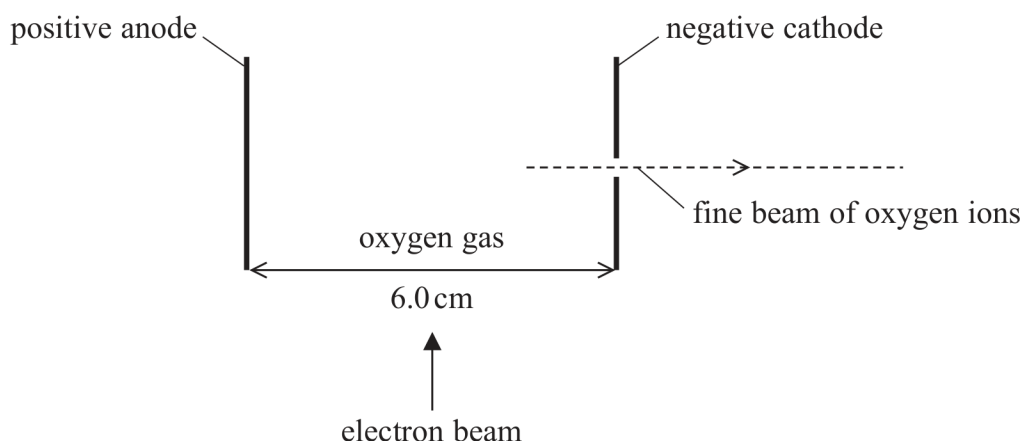
(i) The electric field strength between the anode and cathode is $7.5 \times 10^5 \, V \, m^{-1}$.

Calculate the potential difference between the anode and cathode.

(2)

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Potential difference = ...

(ii) A stationary oxygen ion is formed half-way between the anode and cathode with a charge of $+1.6 \times 10^{-19}$ C.

Show that the velocity of the ion as it passes through the hole in the cathode is about 5×10^{5} m s^{-1}.

mass of oxygen ion $= 2.7 \times 10^{-26}$ kg

(4)

(b) Oxygen ions enter the velocity selector with a range of velocities. The velocity selector allows ions with a specific velocity to travel in a straight line, as shown. Plate P is positive and plate Q is negative.
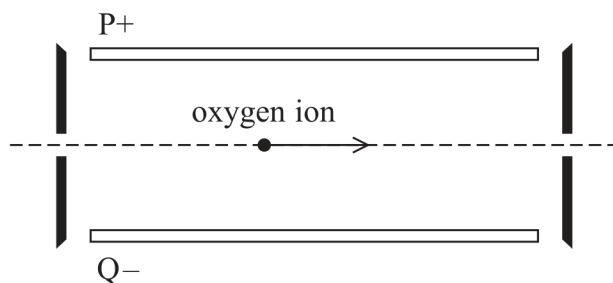
(i) A uniform electric field between the plates acts on an oxygen ion. A uniform magnetic field acts so that the magnetic force on the oxygen ion is in the opposite direction to the electric force.

Explain the direction of the magnetic field.

(2)

(ii) The velocity selector is used to produce a beam of oxygen ions travelling in a straight line with a speed of $5.0 \times 10^5 \, \text{m s}^{-1}$.

Calculate the magnetic flux density of the magnetic field that is required.

electric field strength between plates $= 10\,500 \, \text{N C}^{-1}$

(3)

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Magnetic flux density = ...

(c) After passing through the velocity selector, a beam of oxygen ions with the same velocity enters a region of uniform magnetic flux density. Different isotopes of oxygen can be present in the beam.

Explain why the detector will only detect one particular isotope.

(3)

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(Total for Question 18 = 14 marks)