Section B

Answer **one** question from this Section in the spaces provided.

8 A mass spectrometer separates charge particles based on mass-to-charge ratio so that the composition of the charge particles can be identified.

The schematic diagram of a type of mass spectrometer is shown in Fig. 8.1. There are three sections to this mass spectrometer – the accelerator, the velocity selector and the mass separator.

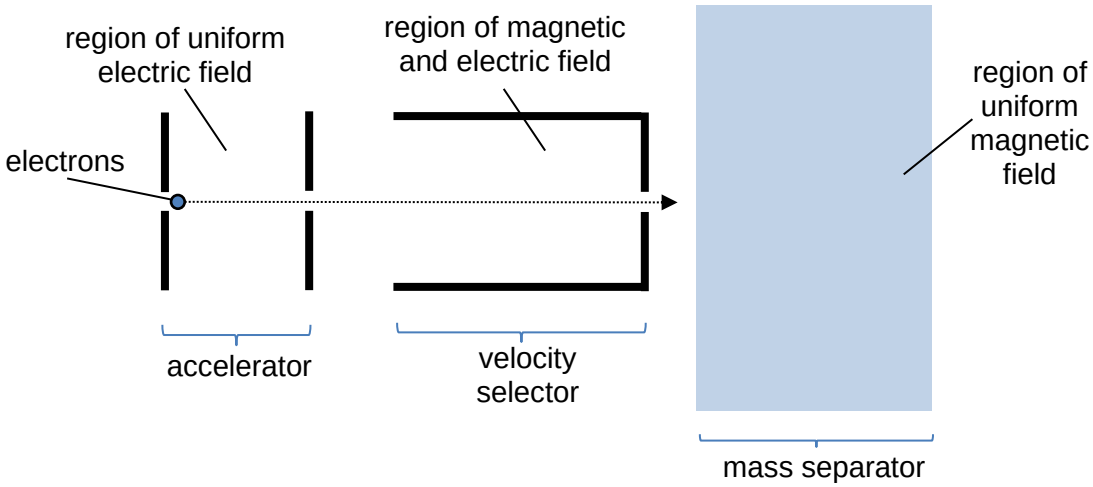

Fig. 8.1

Electrons are ejected into the mass spectrometer to demonstrate the working principle of the mass spectrometer.

(a) **(i)** Electrons enter the mass spectrometer at the accelerator near to the negatively charged plate so that they accelerate towards the positively charged plate as shown in Fig. 8.2.

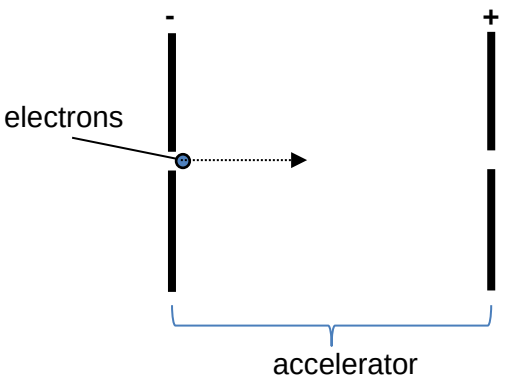

Fig. 8.2

The kinetic energy of the electrons increases by 2.50×10^{-16} J between leaving the negatively charged plate and reaching the positively charged plate.

Calculate the accelerating potential difference (p.d.).

accelerating p.d. = ……..……..V [2]

(ii) Suggest a reason why the electrons reaching the positively charged plate have a range of speeds.

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…… [1]

(b) At the velocity selector, the electrons enter a region in between two horizontal parallel charged plates placed 16 mm apart with a potential difference of 1500 V across them.

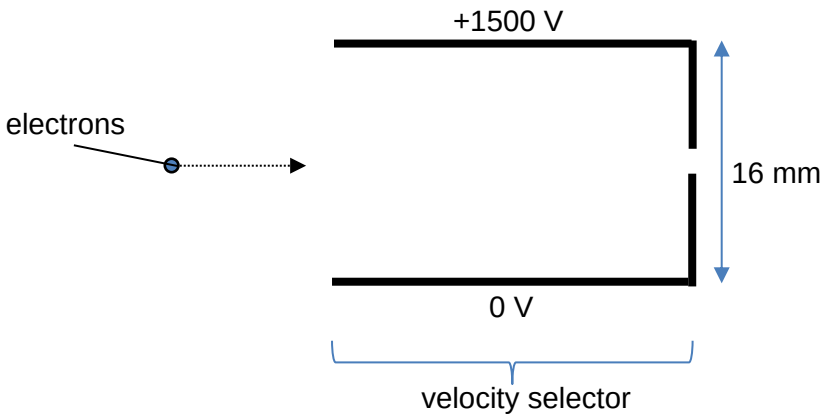

Fig. 8.3

Describe and explain the path of the electrons due to only the uniform electric field set up in between the parallel charged plates.

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…… [3]

(c) A uniform magnetic field is subsequently applied to the region in between the parallel charged plates such that only electrons with specific velocity pass through the velocity selector undeflected.

(i) State the direction of the magnetic field.

…… [1]

(ii) Calculate the magnetic flux density in the velocity selector if the electrons that are undeflected have a speed of 3.25×10^6 m s^{-1} after passing through the fields.

magnetic flux density = ……..…….. T [3]

(d) At the mass separator, the electrons then enter a region of uniform magnetic field set up by a large solenoid.

The solenoid has 120 turns for every 15 cm of the solenoid. The current in the solenoid is 3.5 A.

(i) Calculate the magnitude of the magnetic flux density *B* at the centre of the solenoid due to the current of 3.5 A.

B = ……..…….. T [2]

(ii) Inside the dashed region on Fig. 8.4, sketch the magnetic field pattern due to the current in the solenoid.

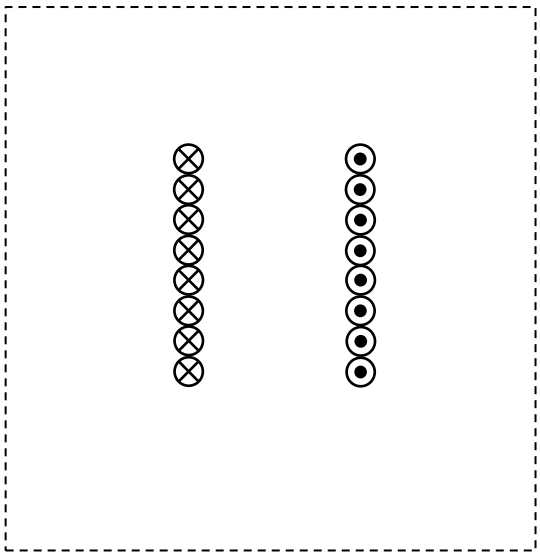

Fig. 8.4 [3]

(iii) The electrons enter the region of the uniform magnetic field perpendicularly.

Explain why the path of the electrons in the magnetic field is circular.

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..…….. [3]

(iv) In usual application, charged particles of different masses enter the mass separator instead of just electrons.

Suggest how the uniform magnetic field can separate the charge particles by mass.

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…… [2]

[Total: 20]