Student:_____

Max. **Marks : 22 Marks**

Time : 22 Minutes

Q1.

A defibrillator is an electrical device designed to deliver a brief electrical signal to restore a normal rhythm to the heart. Electrodes are attached to the chest of a patient and a charged capacitor is discharged through the chest cavity.

In one defibrillator a 56 μF capacitor is charged by a potential difference of 2500 V.
During the discharge of the capacitor the resistance between the electrodes is 45 Ω.

Show that the time taken for 99% of the discharge to take place is about 12 ms and hence calculate the average current delivered by the defibrillator during this period.

(6)

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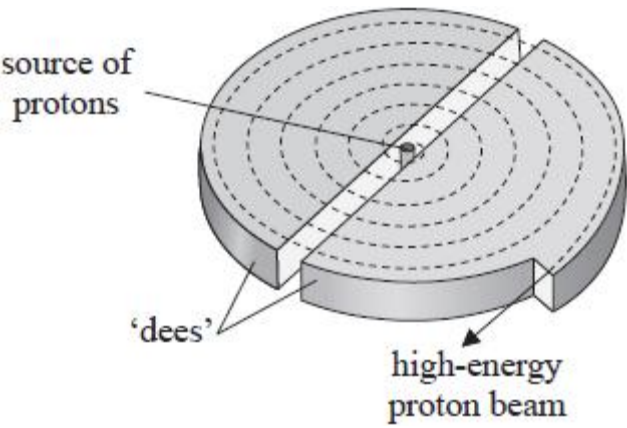...
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Average current = ...

(Total for question = 6 marks)

Q2.

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.

(6)

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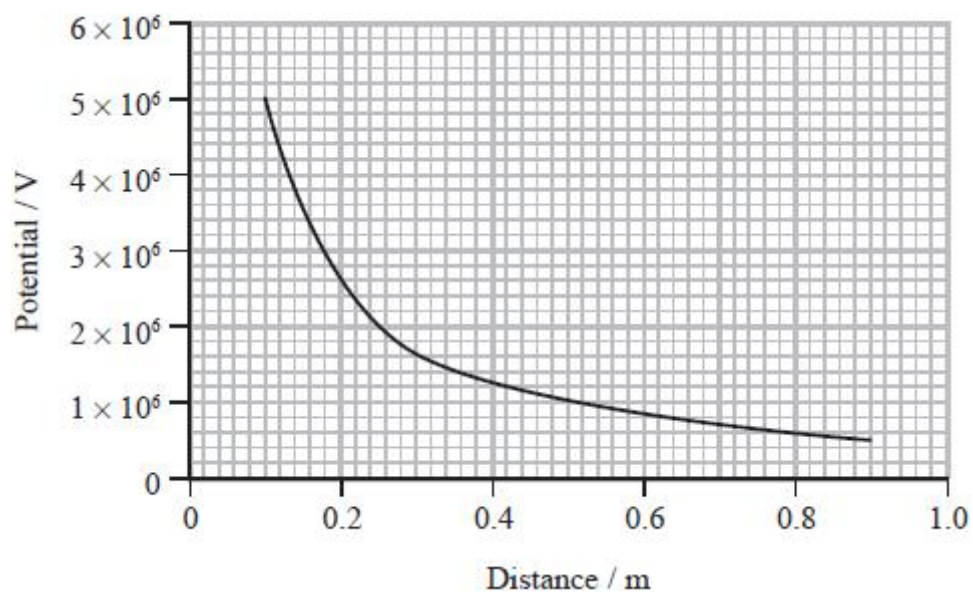
(Total for question = 6 marks)

Q3.

The graph shows how potential varies with distance from the centre of a charged sphere.

Air molecules will be ionised if the electric field strength exceeds 3×10^6 V m^{-1}.

Deduce whether air molecules will be ionised at a distance of 30 cm from the centre of this sphere.

(4)

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(Total for question = 4 marks)

Q4.

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.

ions

ion accelerator

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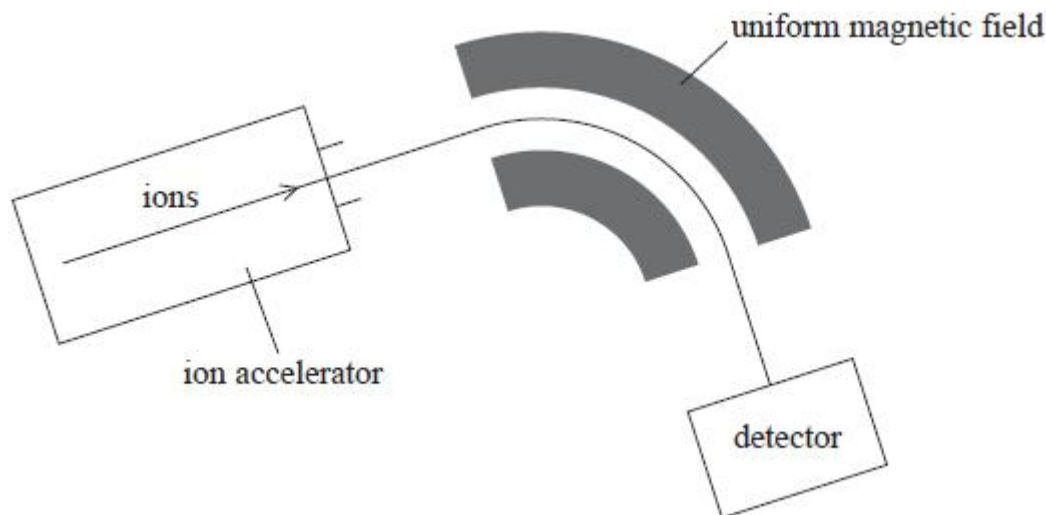
Analysis of mass spectrometer data shows that chlorine exists in nature as two isotopes, chlorine-35 and chlorine-37.

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.

+V

0V
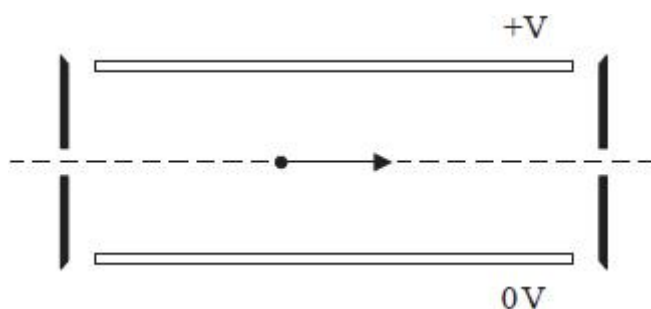
In one mass spectrometer the plates are 2.5 cm apart and a p.d. of 135 V is applied.

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}.

(4)

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(Total for question = 6 marks)