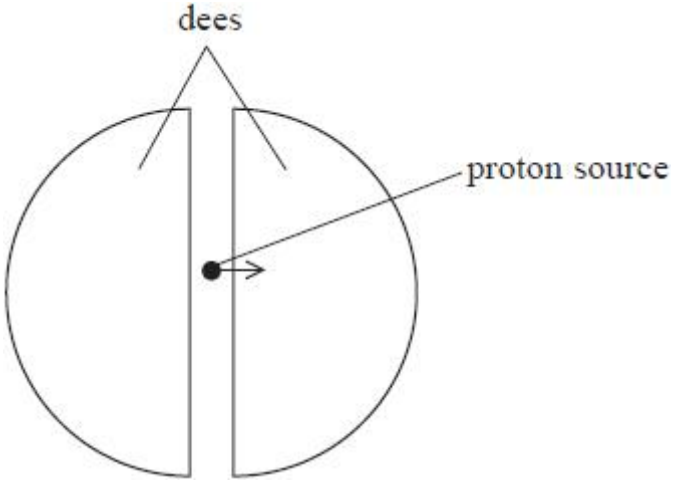
Student:_____
Max. Marks : 23 Marks **Time : 23 Minutes**

Q1.

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

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

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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 = ...

(Total for question = 10 marks)

Q2.

A muon (μ) is a lepton with a mass of 106 MeV/c^2.

Muons are produced from the decay of pions in the upper atmosphere.

An example of this decay is given by the equation

$$\pi^- \rightarrow \mu^- + \bar{\nu}_\mu$$

(i) Explain how this decay obeys the laws of conservation of charge, baryon number and lepton number.

(3)

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(ii) The masses of these three particles, in MeV/c^2, are given below.

π^-	μ^-	$\bar{\nu}_\mu$
140	106	≈0

Explain why the total kinetic energy of the products of this decay is approximately 34 MeV. Assume the π^- is stationary.

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(2)

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(iii) State which two conservation laws could be used to calculate the kinetic energy of the μ– and the $\bar{\nu}_{\mu}$ just after the decay of the π^-.

(2)

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* (iv) The muons are produced at a height of 10 km in the atmosphere. The velocity of the muons is 0.99 *c*. The average lifetime for muons is normally 2.2 μs and yet muons produced in the upper atmosphere are found in significant numbers at sea level.

Discuss this apparent anomaly.

(6)

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(Total for question = 13 marks)

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