Name of the Student:_____
Max. Marks : 17 Marks **Time : 17 Minutes**

Q1.

Figure 1 shows the plan view of a cyclotron in which protons are emitted in between the dees. The protons are deflected into a circular path by the application of a magnetic field. **Figure 2** shows a view from in front of the cyclotron.

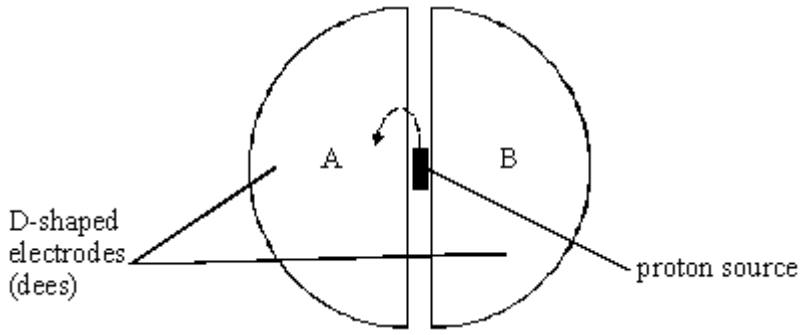

Figure 1

Figure 2

(a) (i) Mark on **Figure 2** the direction of the magnetic field in the region of the dees such that it will deflect the proton beam in the direction shown in **Figure 1**.

(2)

(ii) Show that the velocity of the proton, v, at some instant is given by:

$$v = \frac{Ber}{m}$$

where m is the proton mass, r the radius of its circular path, B the magnetic flux density acting on the proton and $+e$ the proton charge.

(2)

(iii) Write down an equation for the time *T* for a proton to make a complete circular path in this magnetic field.

(2)

(iv) Explain how your equation leads to the conclusion that T is independent of the speed with which the proton is moving.

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(1)

(b) In addition to this magnetic field there is an electric field provided between the dees. This accelerates the proton towards whichever dee is negatively charged. An alternating potential difference causes each dee to become alternately negative and then positive. This causes the proton to accelerate each time it crosses the gap between the dees.

(i) Describe and explain the effect the acceleration has on the path in which the proton moves.

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(2)

(ii) In terms of *T*, write down the frequency with which the p.d. must alternate to match the period of motion of the proton.

(1)

(c) (i) Calculate the velocity of a proton of energy 0.12 keV.

the proton mass, $m = 1.7 \times 10^{-27}$ kg
the magnitude of the electronic charge, $e = 1.6 \times 10^{-19}$ C

(3)

(ii) Calculate the de Broglie wavelength of the 0.12 keV proton.

the Planck constant, $h = 6.6 \times 10^{-34}$ J s

(3)

(iii) Name the region of the electromagnetic spectrum which has an equivalent wavelength to that of the proton.

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(1)

(Total 17 marks)