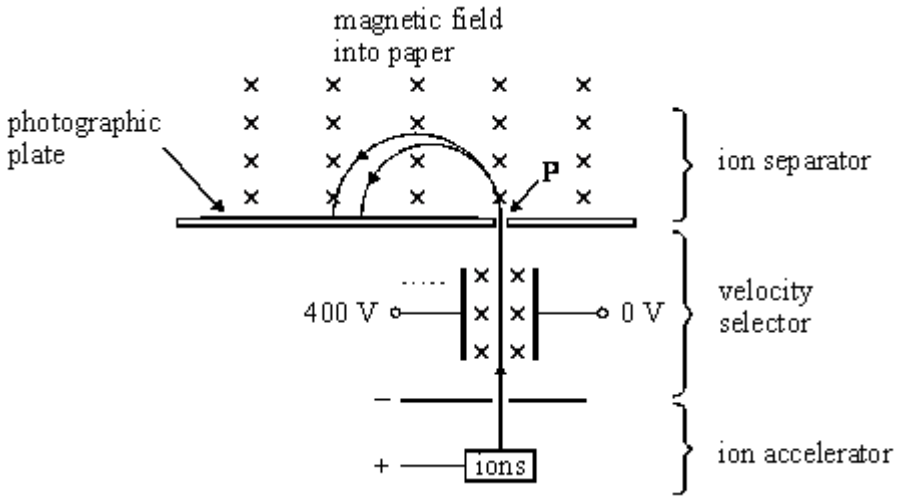
Name of the Student:_____
Max. Marks : 22 Marks **Time : 22 Minutes**

Q1.

The diagram below shows a diagram of a mass spectrometer.



(a) The magnetic field strength in the velocity selector is 0.14 T and the electric field strength is 20 000 V m^{-1}.

(i) Define the unit for magnetic flux density, the tesla.

_____

_____

(2)

(ii) Show that the velocity selected is independent of the charge on an ion.

(2)

(iii) Show that the velocity selected is about 140 km s^{-1}.

(1)

(b) A sample of nickel is analysed in the spectrometer. The two most abundant isotopes of nickel

are $^{58}_{28}$Ni and $^{60}_{28}$Ni. Each ion carries a single charge of $+1.6 \times 10^{-19}$ C.

mass of a proton or neutron = 1.7×10^{-27} kg

The $^{58}_{28}$Ni ion strikes the photographic plate 0.28 m from the point **P** at which the ion beam enters the ion separator.

Calculate:

(i) the magnetic flux density of the field in the ion separator;

(3)

(ii) the separation of the positions where the two isotopes hit the photographic plate.

(2)
(Total 10 marks)

Q2.

(a) Explain why a particle is accelerating even when it is moving with a uniform speed in a circular path.

_____

_____

_____

(2)

(b) **Figure 1** shows a schematic diagram of a proton synchrotron. This is a device for accelerating protons to high speeds in a horizontal circular path.

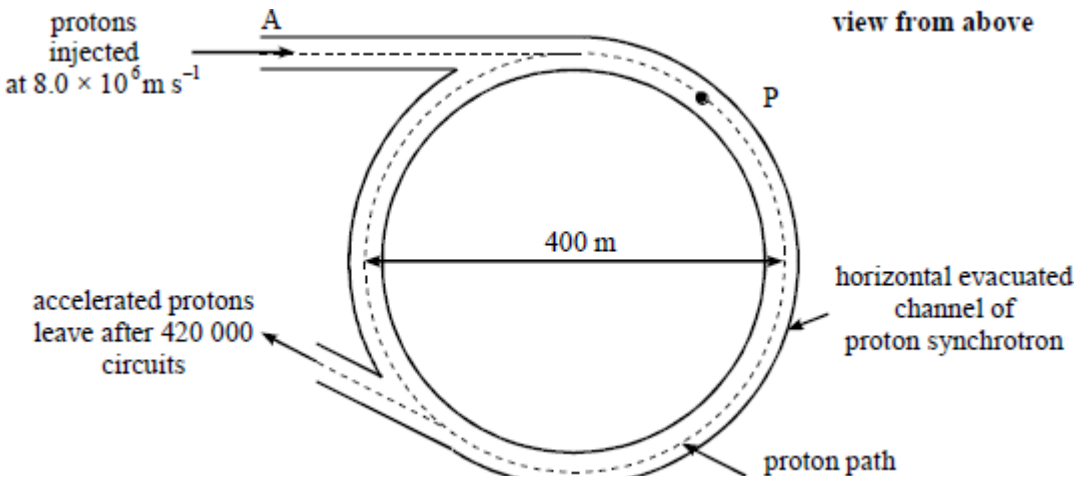


Figure 1

In the synchrotron the protons of mass 1.7×10^{-27} kg are injected at point **A** at a speed of 8.0×10^6 m s^{-1}. The diameter of the path taken by the protons is 400 m.

(i) Show on **Figure 1** the direction of the force required to make a proton move in the circular path when the proton is at the position marked **P**.

(1)

(ii) Calculate the force that has to be provided to produce the circular path when the speed of a proton is 8.0×10^6 m s^{-1}.

(2)

(iii) Sketch on **Figure 2** a graph to show how this force will have to change as the speed of the proton increases over the range shown on the *x*-axis. Insert an appropriate scale on the force axis.

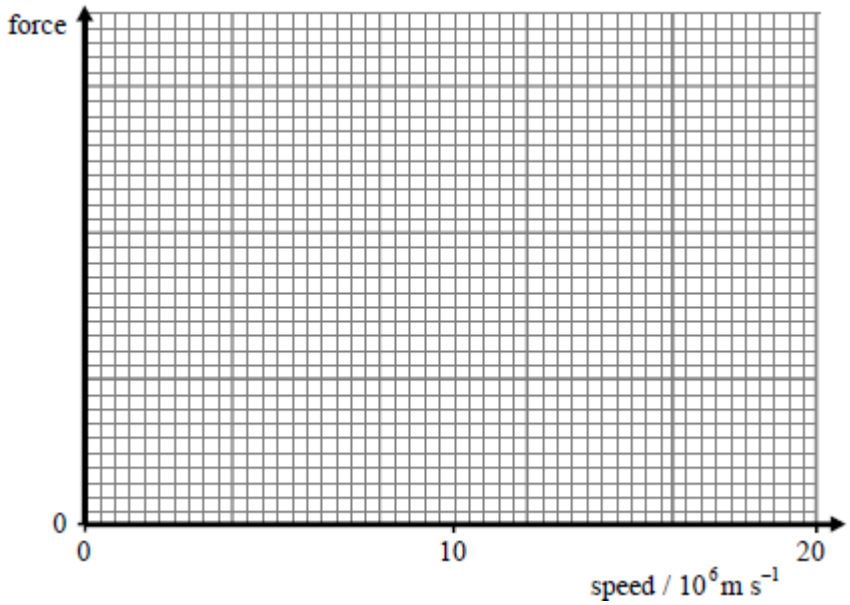


Figure 2

(c) Before reaching their final energy the protons in the synchrotron in part (b) travel around the accelerator 420 000 times in 2.0 s.

acceleration of free fall, g = 9.8 m s^{-2}

(i) Calculate the total distance travelled by a proton in the 2.0 s time interval.

(2)

(ii) Unless a vertical force is applied the protons wold fall as they move through the horizontal channel.

Calculate the distance a proton would fall in two seconds.

(2)

(iii) Determine the force necessary to prevent the vertical movement.

(1)
(Total 12 marks)