5 A cloud chamber consists of a rectangular box saturated with alcohol vapour. When a charged particle enters the cloud chamber, it interacts with the vapour and leaves a trail, indicating its path in the chamber.

A student designed a cloud chamber with a detector for the charged particles placed at one side of the chamber. A sample which emits identical charged particles is placed at a small opening through one side of the chamber. The charged particles are all emitted with the same speed. A uniform vertical magnetic field of flux density *B* is directed perpendicularly through the entire chamber.

Fig. 5.1 shows the top view of the chamber and the dotted line represents the path of a charged particle entering the chamber and moving on a horizontal plane in the chamber.

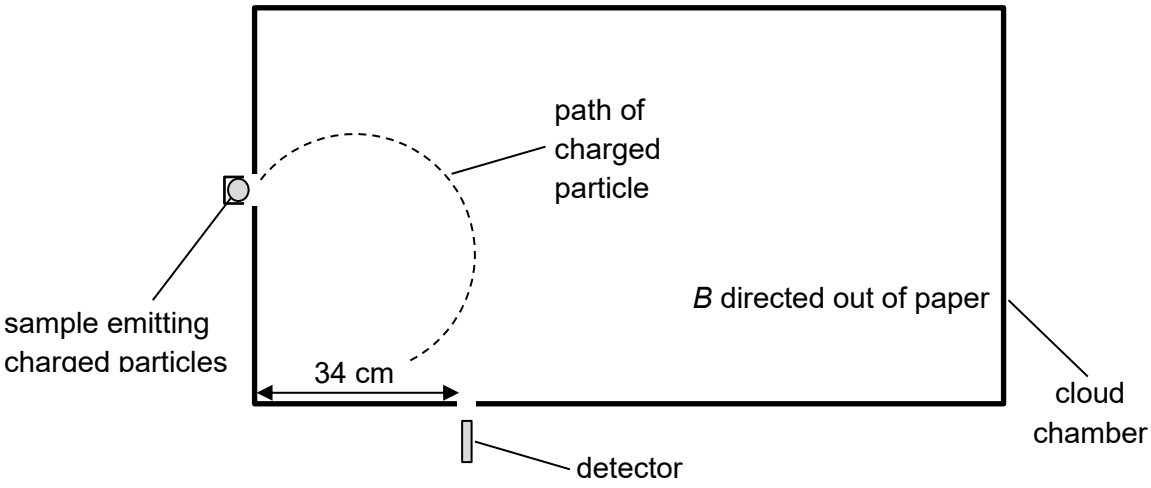

Fig. 5.1 (top view)

(a) (i) Define magnetic flux density.

.....

.....

..... [2]

(ii) State if the charged particle is positively or negatively charged.

..... [1]

(b) The design of the cloud chamber is refined so that particles only enter perpendicularly, as shown in Fig. 5.2.

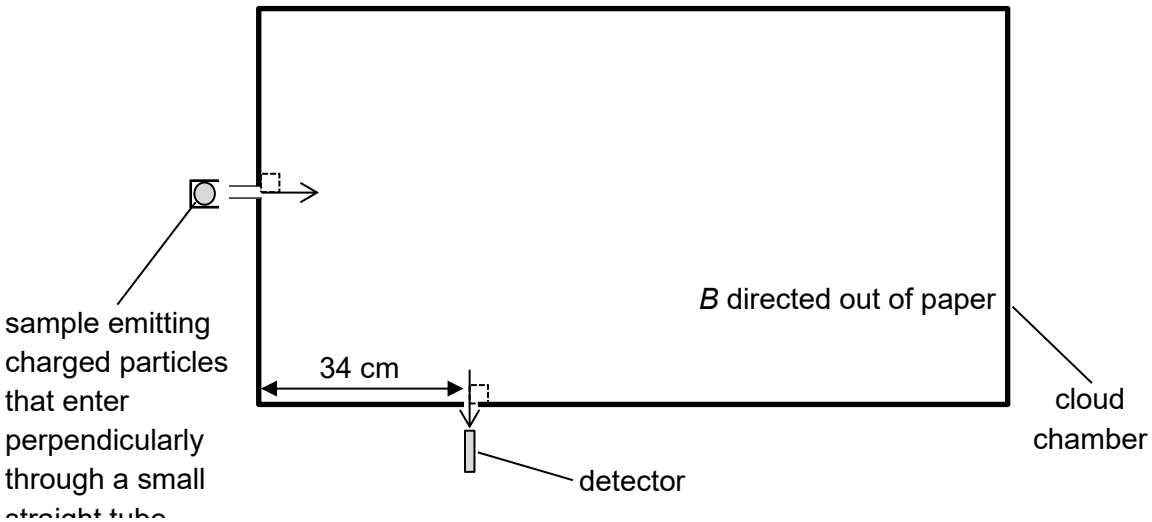

Fig. 5.2 (top view)

The magnitude of B is adjusted so that the particles with the same speed as in Fig. 5.1 will exit perpendicularly through a small opening on another side where the detector is placed. The detector is placed 34 cm from the corner of the chamber.

(i) Derive an expression for B in terms of mass m, speed v and charge q of a charged particle and the radius r of its circular path in the chamber.

[2]

(ii) Deduce whether the magnitude of B has increased or decreased.

.....

..... [1]

(iii) Given the magnitude of B is 7.6×10^{-3} T, and each particle has a charge of magnitude 3.2×10^{-19} C and mass 6.6×10^{-27} kg, determine the speed of the charged particle that reaches the detector.

speed = ... m s^{-1} [2]

(c) The design of the cloud chamber is further amended so that particles which enter perpendicularly will move though the chamber undeflected. This is achieved by simultaneously applying a uniform electric field across the chamber.

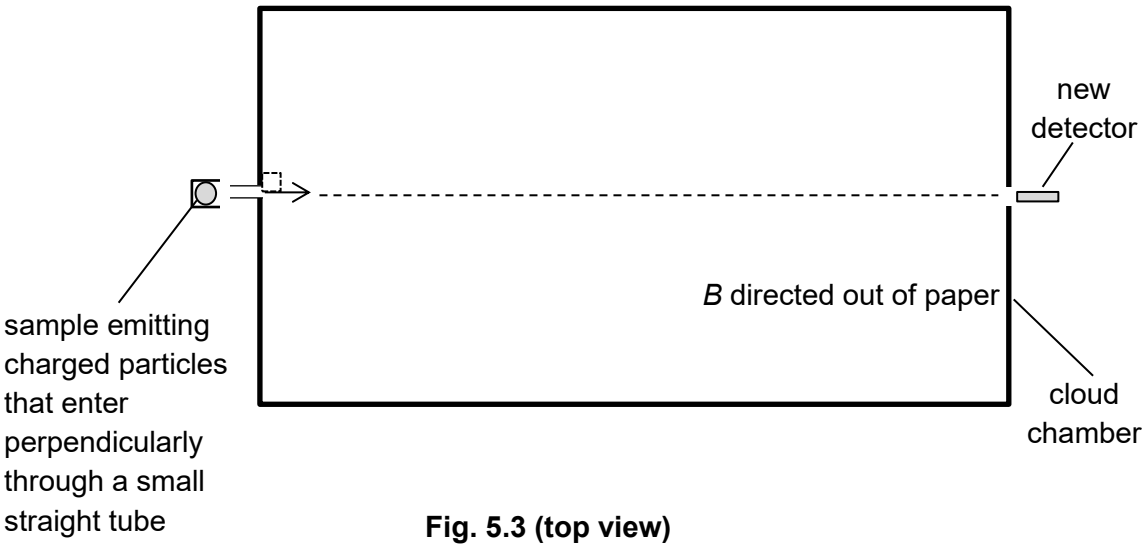

Fig. 5.3 (top view)

(i) State and explain the direction of the electric field.

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.....

..... [2]

(ii) The sample is now placed in the centre of the cloud chamber. Fig. 5.4 shows the direction of speed *v* of one of the emitted charged particles.

With the electric and magnetic fields still applied in the same directions in the cloud chamber as in **(c)(i)**, draw arrows to represent the electric force and the magnetic force acting on the particle at this instant. Label the forces.

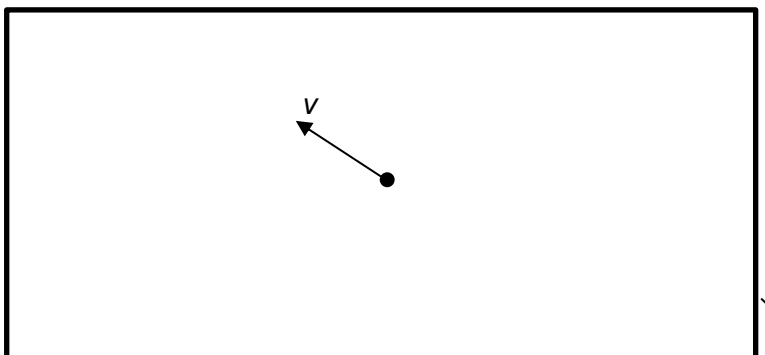

Fig. 5.4 (top view)

[2]