9 **(a)** Two point charges A and B are placed in a vacuum 10.0 cm apart, as illustrated in Fig. 9.1. A point P lies on the line joining the charges, at a distance x from charge A. The variation of electric field strength E with distance x is shown in Fig. 9.2.

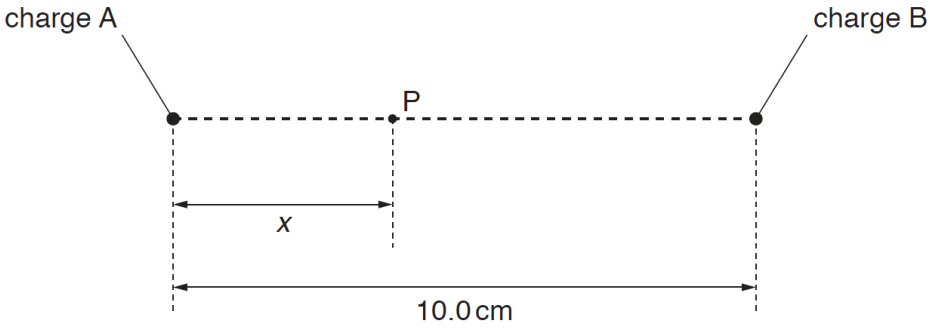

Fig. 9.1

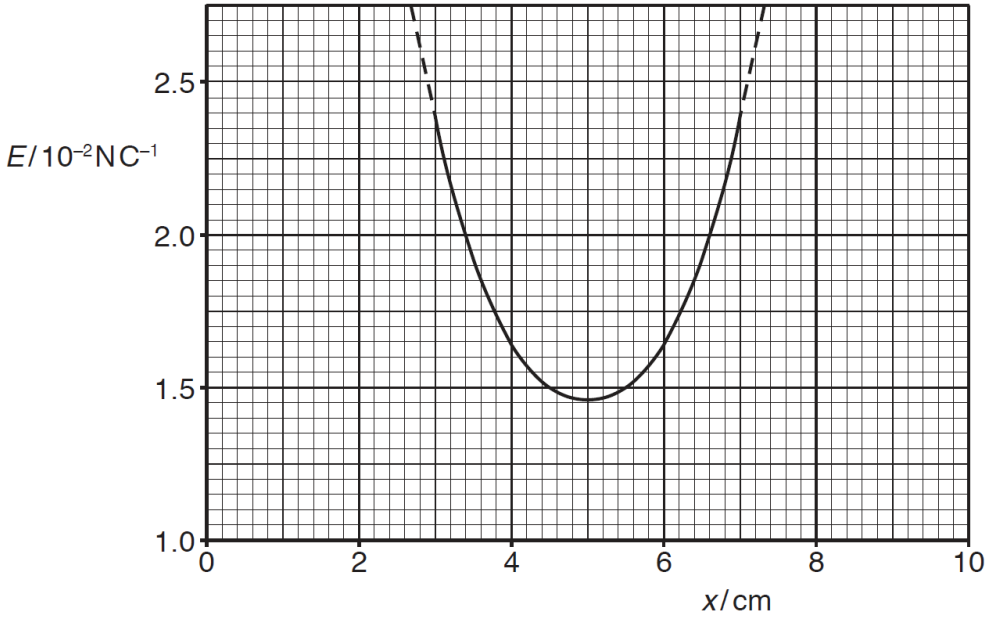

Fig. 9.2

State and explain whether the charges A and B:

(i) have the same, or opposite, signs.

.....

.....

..... [2]

(ii) State and explain whether the charges A and B have the same, or different, magnitudes.

.....

.....

..... [2]

[Turn over

(b) An electron is situated at point P.

Without calculation, state and explain the variation in the magnitude of the acceleration of the electron as it moves from the position where x = 3.0 cm to the position where x = 7.0 cm.

……

……

……

……

……

…… [4]

(c) Determine the acceleration of the electron at x = 7.0 cm.

acceleration = …… m s^{-2} [3]

(d) A particle of charge +q and mass m is travelling with a constant speed of 1.6 × 10^5 m s^{-1} in a vacuum. The particle enters a uniform magnetic field of flux density 9.7 × 10^{-2} T, as shown in Fig. 9.3.

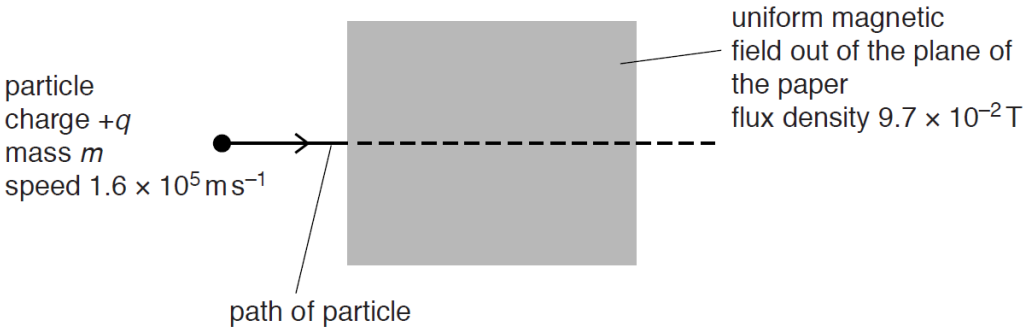

Fig. 9.3

The magnetic field direction is perpendicular to the initial velocity of the particle and perpendicular to, and out of, the plane of the paper.

A uniform electric field is applied in the same region as the magnetic field so that the particle passes undeviated through the fields.

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

……

……

…….. [2]

(ii) The electric field is now removed so that the positively charged particle follows a curved path in the magnetic field. This path is an arc of a circle of radius 4.0 cm.

Calculate, for the particle, the ratio $\frac{q}{m}$.

ratio = ...C kg^{-1} [2]

(iii) Determine the time taken for the particle to complete one full circle.

time taken = …… s [2]

(e) With the electric field still switched off, a proton enters the same uniform magnetic field, but at an angle of 30° to the magnetic field lines as shown in Fig. 9.4.

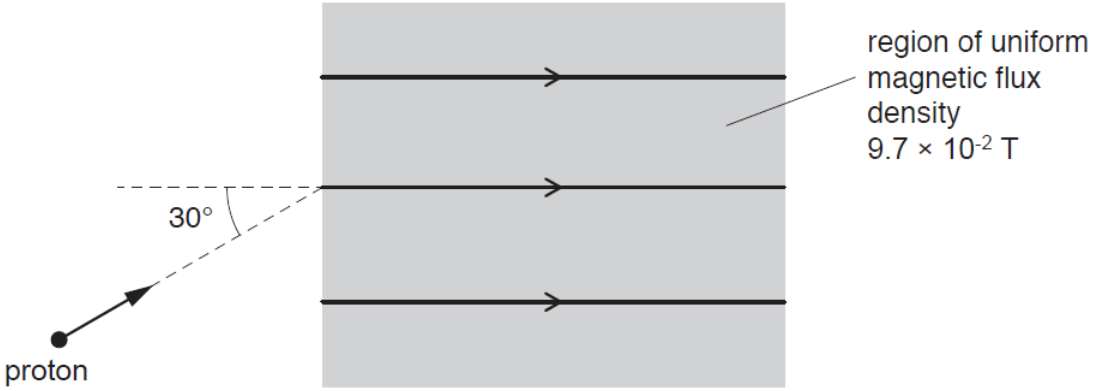

Fig. 9.4.

(i) Describe the resultant path of the proton in the magnetic field.

.....

..... [1]

(ii) Calculate the speed of the proton if it experiences a magnetic force of 4.7×10^{-15} N.

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

[Total: 20]