[May/June 2004]

1 **(a)** State the significance of the Millikan experiment.

....

.... [1]

(b) In the Millikan experiment, oil droplets were found to have the following charges.

1.56×10^{-19} C
4.88×10^{-19} C
1.64×10^{-19} C
3.14×10^{-19} C
4.76×10^{-19} C

Use these data to determine a value for the elementary charge. Explain your working.

....

....

elementary charge = ... C [2]

For Examiner's Use

[May/June 2006]

2 A proton is moving with constant velocity *v*. It enters a uniform magnetic field that is normal to the initial direction of motion of the proton, as shown in Fig. 8.1.

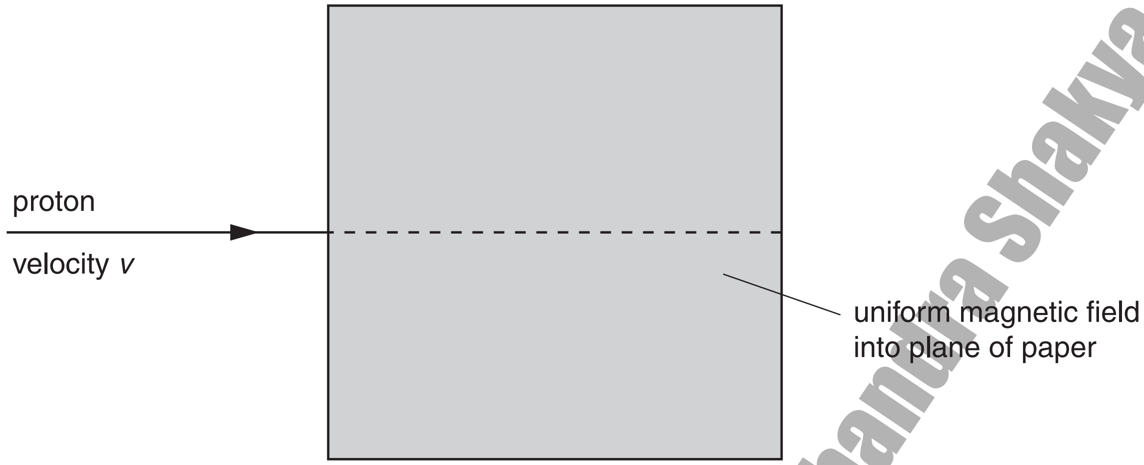

Fig. 8.1

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

(a) On Fig. 8.1, draw an arrow labelled E to show the direction of the electric field. [1]

(b) The proton is replaced by other particles. The electric and magnetic fields remain unchanged.

State and explain the deviation, if any, of the following particles in the region of the fields.

(i) an α-particle with initial velocity *v*

....

....

....

.... [3]

(ii) an electron with initial velocity 2*v*

....

....

....

.... [3]

[May/June 2008]

3 The Millikan oil-drop experiment enabled the charge on the electron to be determined.

(a) State a fundamental property of charge that was suggested by this experiment.

....

.... [1]

(b) Two parallel metal plates P and Q are situated in a vacuum. The plates are horizontal and separated by a distance of 5.4 mm, as illustrated in Fig. 7.1.

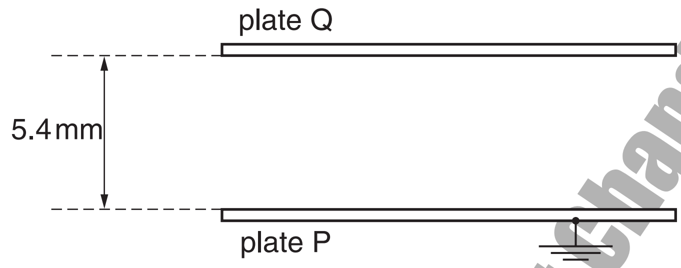

Fig. 7.1

The lower plate P is earthed. The potential difference between the plates can be varied. An oil droplet of mass 7.7×10^{-15} kg is observed to remain stationary between the plates when plate Q is at a potential of +850 V.

(i) Suggest why plates P and Q must be parallel and horizontal.

....

....

.... [2]

(ii) Calculate the charge, with its sign, on the oil droplet.

charge = ... C [3]

(c) The procedure in **(b)** was repeated for three further oil droplets. The magnitude of the charge on each of the droplets was found to be 3.2×10^{-19} C, 6.4×10^{-19} C and 3.2×10^{-19} C.
Explain what value these data and your answer in **(b)(ii)** would suggest for the charge on the electron.

....

....

.... [1]

[November/December 2008]

4 **(a)** Describe what is meant by a *magnetic field.*

....

....

....

....

.... [3]

(b) A small mass is placed in a field of force that is either electric or magnetic or gravitational.
State the nature of the field of force when the mass is

(i) charged and the force is opposite to the direction of the field,

.... [1]

(ii) uncharged and the force is in the direction of the field,

.... [1]

(iii) charged and there is a force only when the mass is moving,

.... [1]

(iv) charged and there is no force on the mass when it is stationary or moving in a particular direction.

.... [1]

[May/June 2007]

5 Two charged points A and B are separated by a distance of 6.0 cm, as shown in Fig. 3.1.

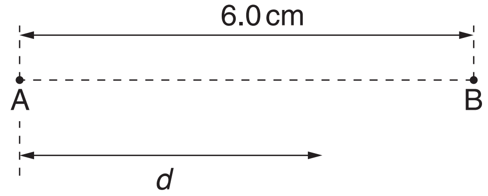

Fig. 3.1

The variation with distance *d* from A of the electric field strength *E* along the line AB is shown in Fig. 3.2.

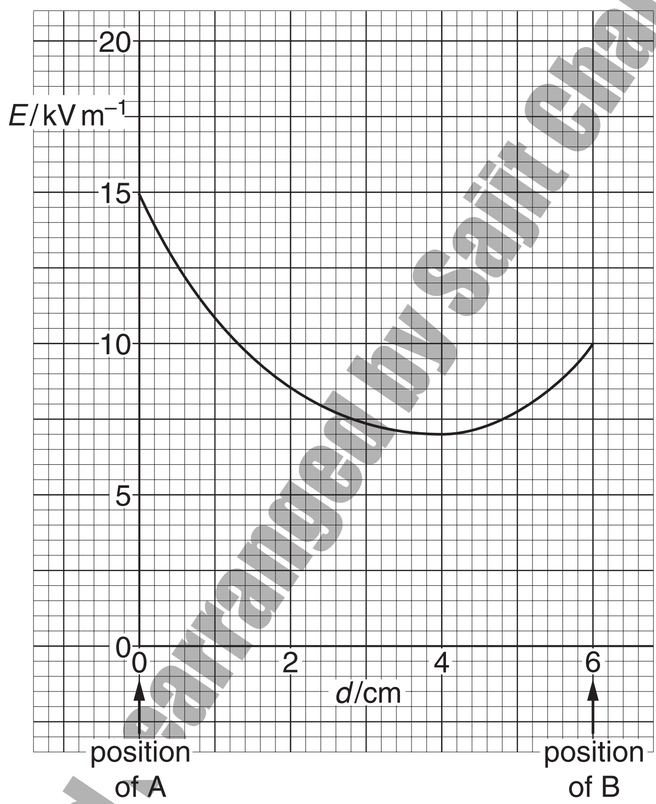

Fig. 3.2

An electron is emitted with negligible speed from A and travels along AB.

(a) State the relation between electric field strength *E* and potential *V*.

....

.... [2]

(b) The area below the line of the graph of Fig. 3.2 represents the potential difference between A and B.

Use Fig. 3.2 to determine the potential difference between A and B.

potential difference = ... V [4]

(c) Use your answer to **(b)** to calculate the speed of the electron as it reaches point B.

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

(d) **(i)** Use Fig. 3.2 to determine the value of *d* at which the electron has maximum acceleration.

d = ... cm [1]

(ii) Without any further calculation, describe the variation with distance *d* of the acceleration of the electron.

....

....

.... [2]

[May/June 2005]

6 An isolated conducting sphere of radius r is given a charge $+Q$. This charge may be assumed to act as a point charge situated at the centre of the sphere, as shown in Fig. 5.1.

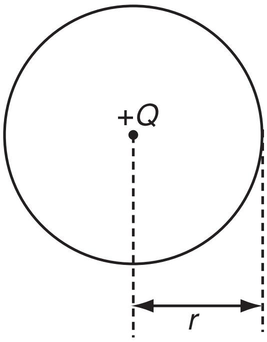

Fig. 5.1

Fig. 5.2. shows the variation with distance x from the centre of the sphere of the potential V due to the charge $+Q$.

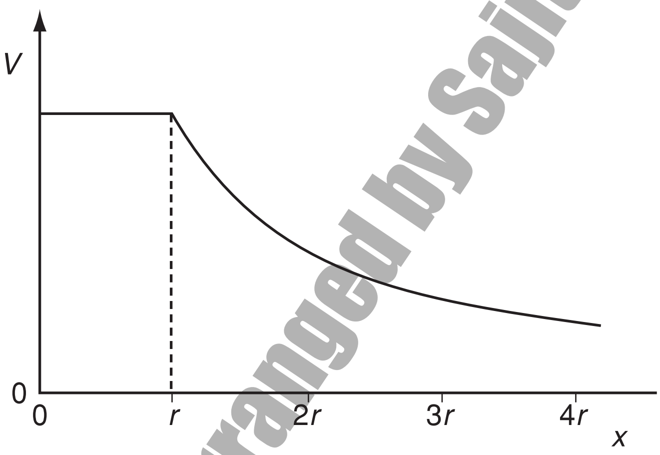

Fig. 5.2

(a) State the relation between electric field and potential.

....[1]

(b) Using the relation in **(a)**, on Fig. 5.3 sketch a graph to show the variation with distance *x* of the electric field *E* due to the charge +*Q*.

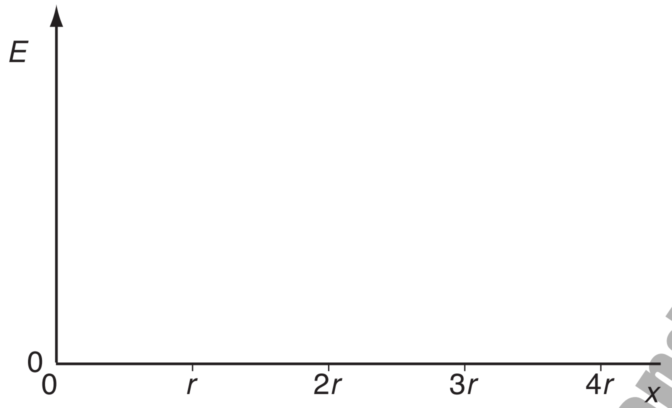

Fig. 5.3

[3]

[May/June 2008]

For Examiner's Use

7 **(a)** Define *electric potential* at a point.

....

....

.... [2]

(b) Two isolated point charges A and B are separated by a distance of 30.0 cm, as shown in Fig. 4.1.

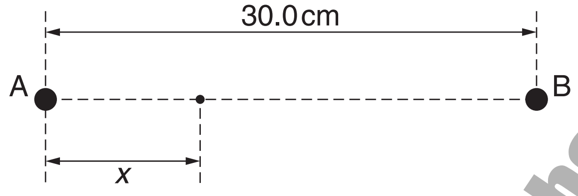

Fig. 4.1

The charge at A is + 3.6×10^{-9} C.
The variation with distance x from A along AB of the potential V is shown in Fig. 4.2.

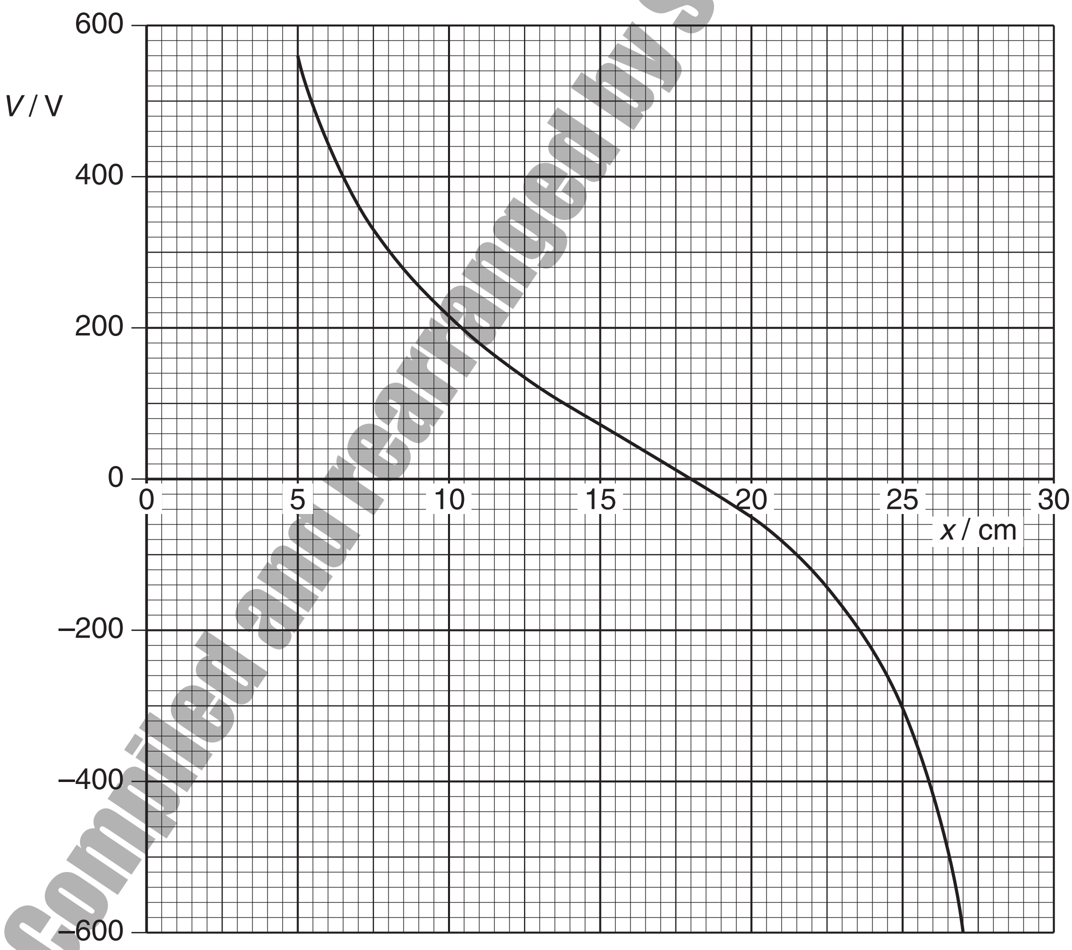

Fig. 4.2

(i) State the value of x at which the potential is zero.

x = ... cm [1]

(ii) Use your answer in **(i)** to determine the charge at B.

charge = ... C [3]

(c) A small test charge is now moved along the line AB in **(b)** from x = 5.0 cm to x = 27 cm. State and explain the value of x at which the force on the test charge will be maximum.

....

....

....

....[3]

8 Two point charges A and B each have a charge of $+6.4 \times 10^{-19}$ C. They are separated in a vacuum by a distance of 12.0 μm, as shown in Fig. 4.1.

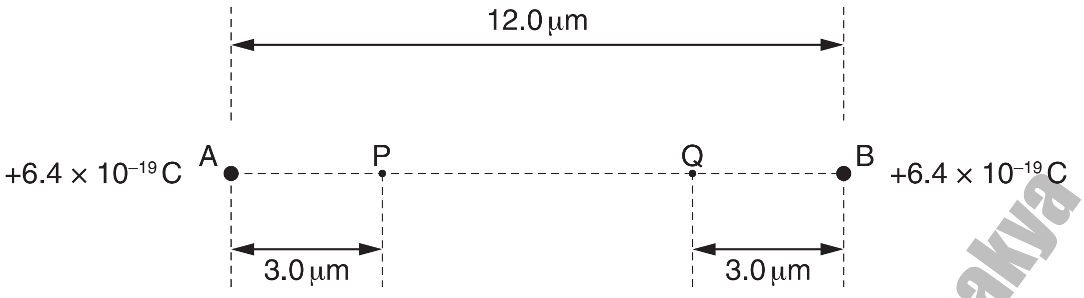

Fig. 4.1

Points P and Q are situated on the line AB. Point P is 3.0 μm from charge A and point Q is 3.0 μm from charge B.

(a) Calculate the force of repulsion between the charges A and B.

force = ... N [3]

(b) Explain why, without any calculation, when a small test charge is moved from point P to point Q, the net work done is zero.

....

....

.... [2]

(c) Calculate the work done by an electron in moving from the midpoint of line AB to point P.

work done = ... J [4]

9 Negatively-charged particles are moving through a vacuum in a parallel beam. The particles have speed v.
The particles enter a region of uniform magnetic field of flux density 930 μT. Initially, the particles are travelling at right-angles to the magnetic field. The path of a single particle is shown in Fig. 7.1.

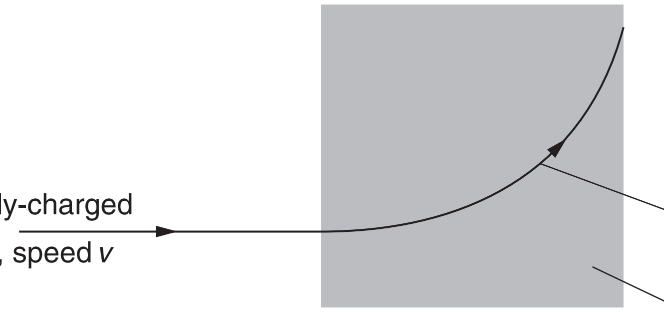

Fig. 7.1

The negatively-charged particles follow a curved path of radius 7.9 cm in the magnetic field.

A uniform electric field is then applied in the same region as the magnetic field. For an electric field strength of 12 kV m^{-1}, the particles are undeviated as they pass through the region of the fields.

(a) On Fig. 7.1, mark with an arrow the direction of the electric field. [1]

(b) Calculate, for the negatively-charged particles,

(i) the speed v,

v = ... m s^{-1} [3]

(ii) the ratio $\frac{\text{charge}}{\text{mass}}$.

ratio = ... C kg^{-1} [3]

For Examiner's Use

7 Electrons are moving through a vacuum in a narrow beam. The electrons have speed *v*.
The electrons enter a region of uniform magnetic field of flux density *B*. Initially, the electrons are travelling at a right-angle to the magnetic field.
The path of a single electron is shown in Fig. 7.1.

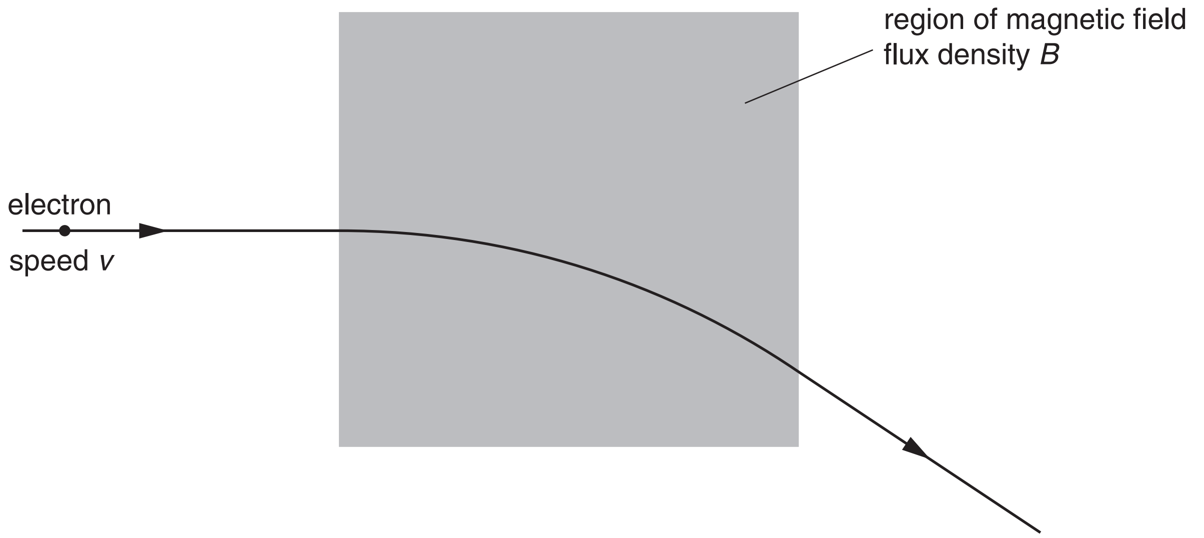

Fig. 7.1

The electrons follow a curved path in the magnetic field.

A uniform electric field of field strength *E* is now applied in the same region as the magnetic field.
The electrons pass undeviated through the region of the two fields.
Gravitational effects may be neglected.

(a) Derive a relation between *v*, *E* and *B* for the electrons not to be deflected. Explain your working.

....

....

....

....

.... [3]

(b) An α-particle has speed *v* and approaches the region of the two fields along the same path as the electron. Describe and explain the path of the α-particle as it passes through the region of the two fields.

....

....

.... [2]

5 **(a)** State what is meant by a *magnetic field*.

....

....

.... [2]

(b) A charged particle of mass m and charge $+q$ is travelling with velocity v in a vacuum. It enters a region of uniform magnetic field of flux density B, as shown in Fig. 5.1.

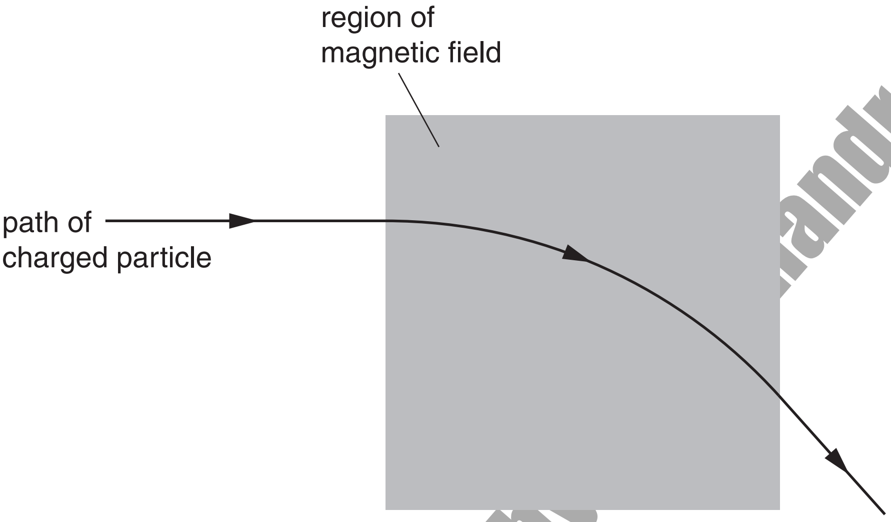

Fig. 5.1

The magnetic field is normal to the direction of motion of the particle. The path of the particle in the field is the arc of a circle of radius r.

(i) Explain why the path of the particle in the field is the arc of a circle.

....

....

....

.... [2]

(ii) Show that the radius r is given by the expression

$$r = \frac{mv}{Bq}.$$

[2]

(c) A thin metal foil is placed in the magnetic field in **(b)**.
A second charged particle enters the region of the magnetic field. It loses kinetic energy as it passes through the foil. The particle follows the path shown in Fig. 5.2.

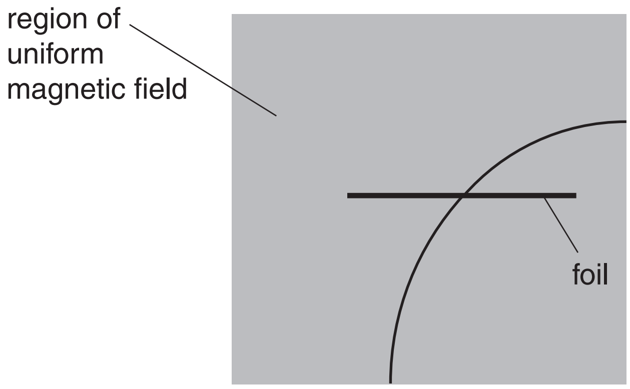

Fig. 5.2

(i) On Fig. 5.2, mark with an arrow the direction of travel of the particle. [1]

(ii) The path of the particle has different radii on each side of the foil.
The radii are 7.4 cm and 5.7 cm.
Determine the ratio

$$\frac{\text{final momentum of particle}}{\text{initial momentum of particle}}$$

for the particle as it passes through the foil.

ratio = ... [2]