Electric Fields

For Examiner's Use

1 Two horizontal metal plates are situated 1.2 cm apart, as illustrated in Fig. 6.1.

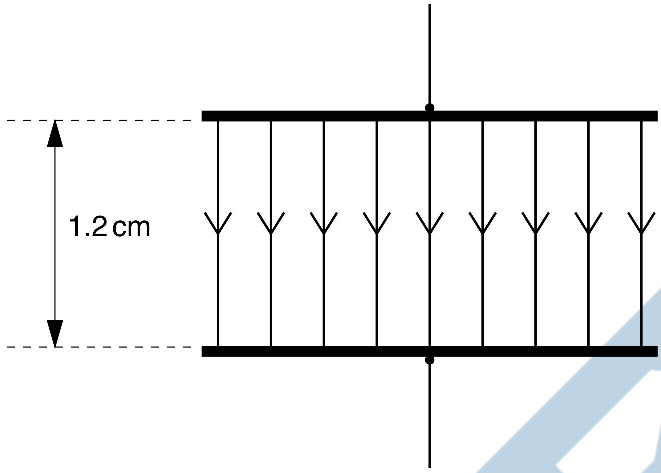

Fig. 6.1

The electric field between the plates is found to be $3.0 \times 10^4\,N\,C^{-1}$ in the downward direction.

(a) **(i)** On Fig. 6.1, mark with a + the plate which is at the more positive potential.

(ii) Calculate the potential difference between the plates.

potential difference = ... V [3]

(b) Determine the acceleration of an electron between the plates, assuming there is a vacuum between them.

acceleration = ... $m\,s^{-2}$ [3]

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2 Two parallel metal plates P and Q are situated 8.0 cm apart in air, as shown in Fig. 6.1.

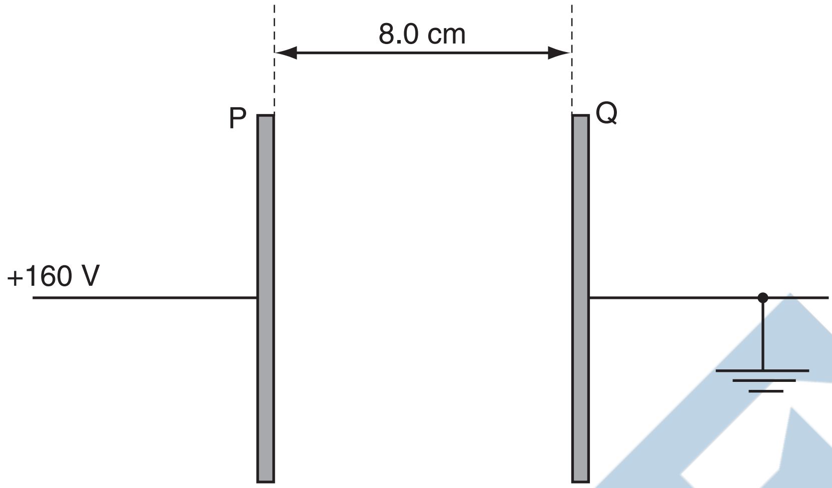

Fig. 6.1

Plate Q is earthed and plate P is maintained at a potential of +160 V.

(a) **(i)** On Fig. 6.1, draw lines to represent the electric field in the region between the plates. [2]

(ii) Show that the magnitude of the electric field between the plates is $2.0 \times 10^3\,\mathrm{V\,m^{-1}}$.

[1]

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(b) A dust particle is suspended in the air between the plates. The particle has charges of $+1.2 \times 10^{-15}$ C and -1.2×10^{-15} C near its ends. The charges may be considered to be point charges separated by a distance of 2.5 mm, as shown in Fig. 6.2.

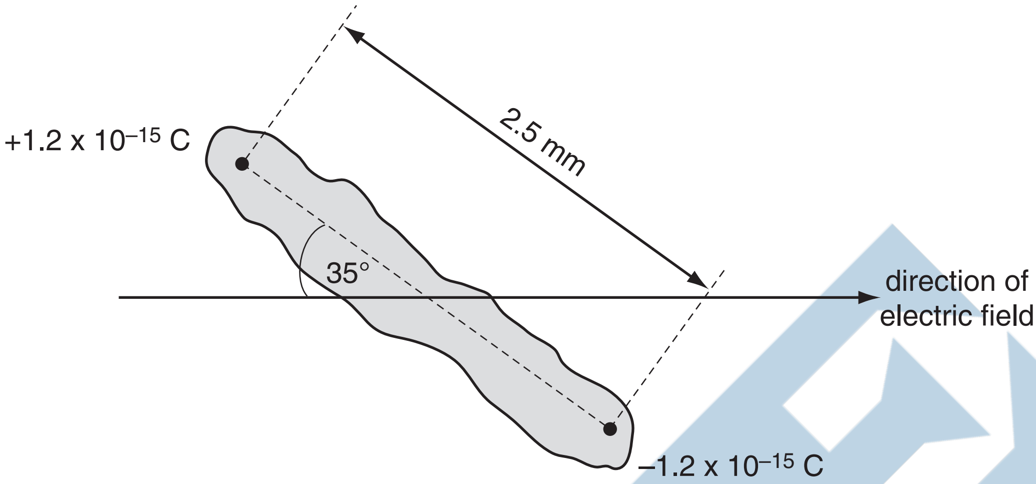

Fig. 6.2

The particle makes an angle of 35° with the direction of the electric field.

(i) On Fig. 6.2, draw arrows to show the direction of the force on each charge due to the electric field. [1]

(ii) Calculate the magnitude of the force on each charge due to the electric field.

force = ... N [2]

(iii) Determine the magnitude of the couple acting on the particle.

couple = ... N m [2]

(iv) Suggest the subsequent motion of the particle in the electric field.

....

....

....[2]

For Examiner's Use

3 **(a)** Define *electric field strength*.

....

....[1]

(b) Two flat parallel metal plates, each of length 12.0 cm, are separated by a distance of 1.5 cm, as shown in Fig. 2.1.

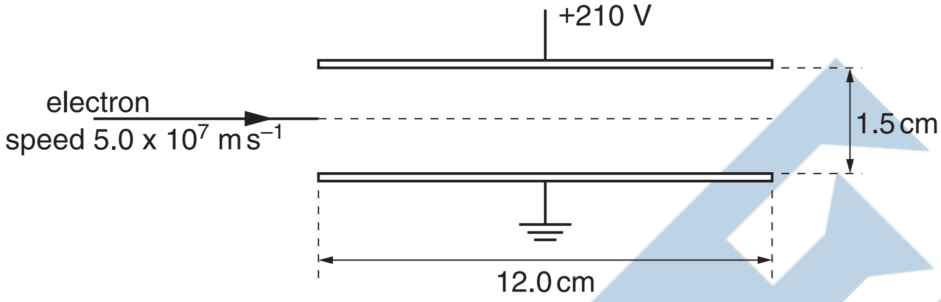

Fig. 2.1

The space between the plates is a vacuum.
The potential difference between the plates is 210 V. The electric field may be assumed to be uniform in the region between the plates and zero outside this region.
Calculate the magnitude of the electric field strength between the plates.

field strength = ... N C^{-1} [1]

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(b) The electron accelerates horizontally across the space between the plates. Determine

(i) the horizontal acceleration of the electron,

acceleration = ... $m\,s^{-2}$ [2]

(ii) the time to travel the horizontal distance of 2.50 cm between the plates.

time = ... s [2]

(c) Explain why gravitational effects on the electron need not be taken into consideration in your calculation in **(b)**.

....

....

.... [2]

4 Two vertical parallel metal plates are situated 2.50 cm apart in a vacuum. The potential difference between the plates is 350 V, as shown in Fig. 6.1.

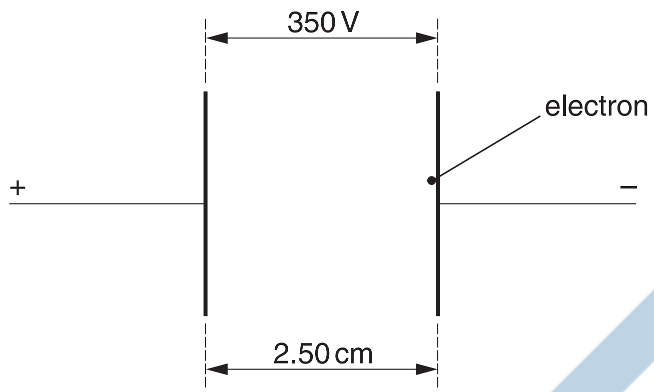

Fig. 6.1

An electron is initially at rest close to the negative plate and in the uniform electric field between the plates.

(a) **(i)** Calculate the magnitude of the electric field between the plates.

electric field strength = ... $N C^{-1}$ [2]

(ii) Show that the force on the electron due to the electric field is 2.24×10^{-15} N.

[2]

(b) The electron accelerates horizontally across the space between the plates. Determine

(i) the horizontal acceleration of the electron,

acceleration = ... $m\,s^{-2}$ [2]

(ii) the time to travel the horizontal distance of 2.50 cm between the plates.

time = ... s [2]

(c) Explain why gravitational effects on the electron need not be taken into consideration in your calculation in **(b)**.

....

....

.... [2]

5 An electron travelling horizontally in a vacuum enters the region between two horizontal metal plates, as shown in Fig. 6.1.

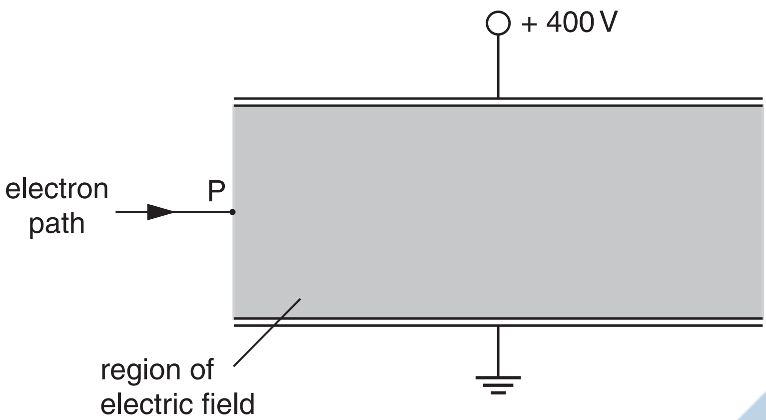

Fig. 6.1

The lower plate is earthed and the upper plate is at a potential of + 400 V. The separation of the plates is 0.80 cm.

The electric field between the plates may be assumed to be uniform and outside the plates to be zero.

(a) On Fig. 6.1,

(i) draw an arrow at P to show the direction of the force on the electron due to the electric field between the plates,

(ii) sketch the path of the electron as it passes between the plates and beyond them. [3]

(b) Determine the electric field strength *E* between the plates.

E = ... V m^{-1} [2]

(c) Calculate, for the electron between the plates, the magnitude of

(i) the force on the electron,

force = ... N

(ii) its acceleration.

acceleration = ... m s^{-2} [4]

(d) State and explain the effect, if any, of this electric field on the horizontal component of the motion of the electron.

....

....

....[2]

For Examiner's Use

6 Two horizontal metal plates X and Y are at a distance 0.75 cm apart. A positively charged particle of mass 9.6×10^{-15} kg is situated in a vacuum between the plates, as illustrated in Fig. 6.1.

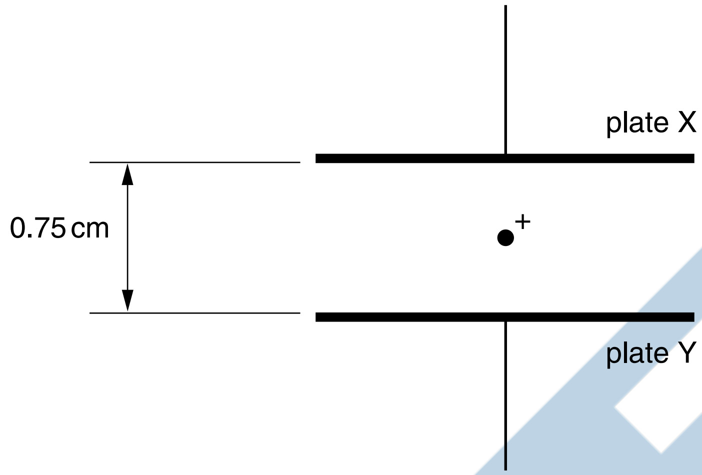

Fig. 6.1

The potential difference between the plates is adjusted until the particle remains stationary.

(a) State, with a reason, which plate, X or Y, is positively charged.

....

....

.... [2]

(b) The potential difference required for the particle to be stationary between the plates is found to be 630 V. Calculate

(i) the electric field strength between the plates,

field strength = ... N C^{-1} [2]

(ii) the charge on the particle.

charge = ……………………………... C [3]

7 Two parallel plates P and Q are separated by a distance of 7.6 mm in a vacuum. There is a potential difference of 250 V between the plates, as illustrated in Fig. 4.1.

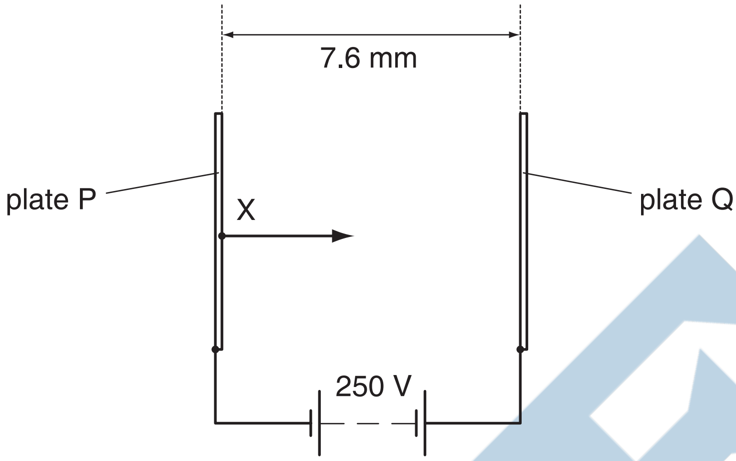

Fig. 4.1

Electrons are produced at X on plate P. These electrons accelerate from rest and travel to plate Q.
The electric field between the plates may be assumed to be uniform.

(a) (i) Determine the force on an electron due to the electric field.

force = ……………………….. N [3]

(ii) Show that the change in kinetic energy of an electron as it moves from plate P to plate Q is 4.0×10^{-17} J.

[2]

For Examiner's Use

(iii) Determine the speed of an electron as it reaches plate Q.

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

(b) The positions of the plates are adjusted so that the electric field between them is not uniform. The potential difference remains unchanged.
State and explain the effect, if any, of this adjustment on the speed of an electron as it reaches plate Q.

....

....

....

.... [3]

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

....

.... [1]

(b) The electric field between an earthed metal plate and two charged metal spheres is illustrated in Fig. 5.1.

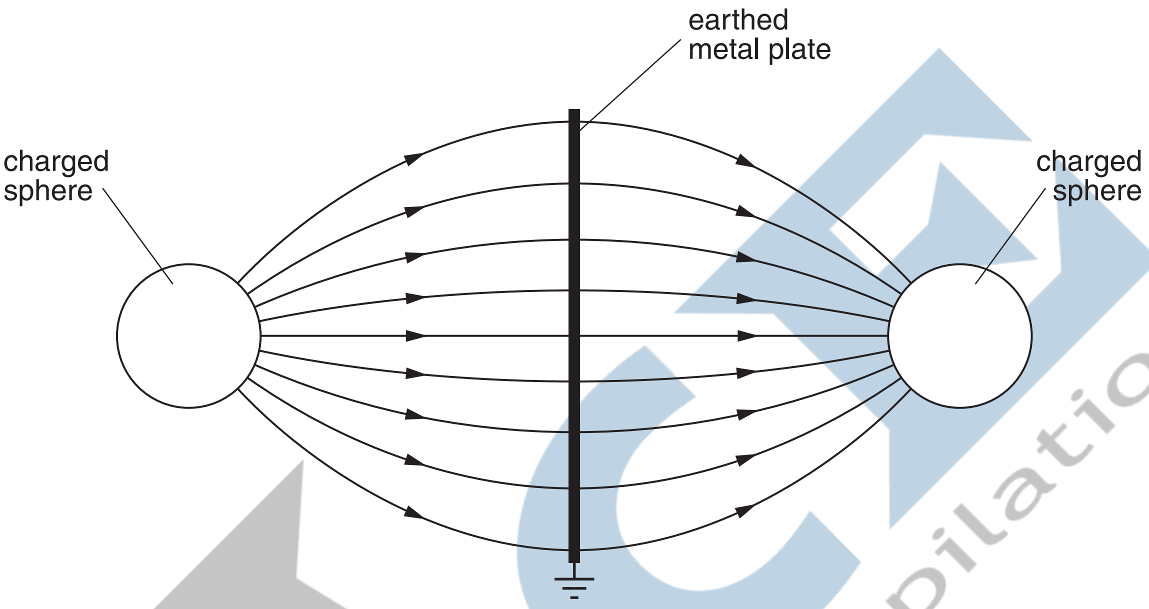

Fig. 5.1

(i) On Fig. 5.1, label each sphere with (+) or (–) to show its charge. [1]

(ii) On Fig. 5.1, mark a region where the magnitude of the electric field is

1. constant (label this region C), [1]

2. decreasing (label this region D). [1]

(c) A molecule has its centre P of positive charge situated a distance of 2.8×10^{-10} m from its centre N of negative charge, as illustrated in Fig. 5.2.

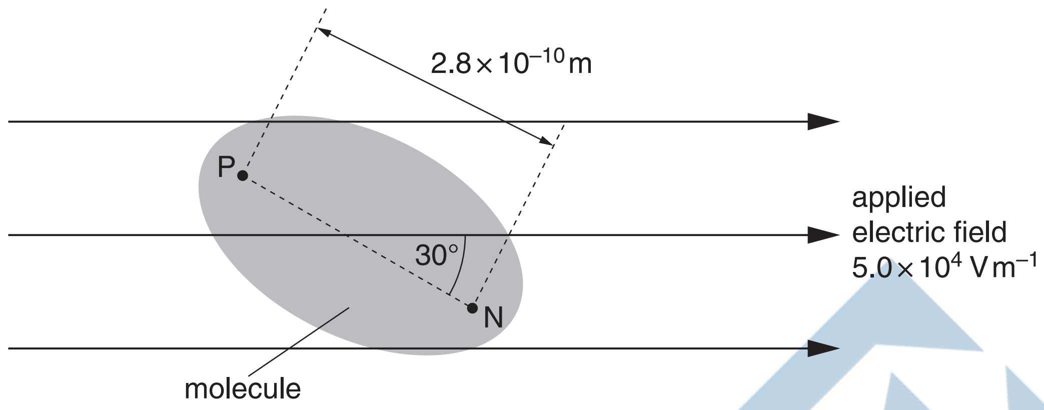

Fig. 5.2

The molecule is situated in a uniform electric field of field strength 5.0×10^{4} V m^{-1}. The axis NP of the molecule is at an angle of 30° to this uniform applied electric field. The magnitude of the charge at P and at N is 1.6×10^{-19} C.

(i) On Fig. 5.2, draw an arrow at P and an arrow at N to show the directions of the forces due to the applied electric field at each of these points. [1]

(ii) Calculate the torque on the molecule produced by the forces in **(i)**.

torque = ... N m [2]

7 Two oppositely-charged parallel metal plates are situated in a vacuum, as shown in Fig. 7.1.

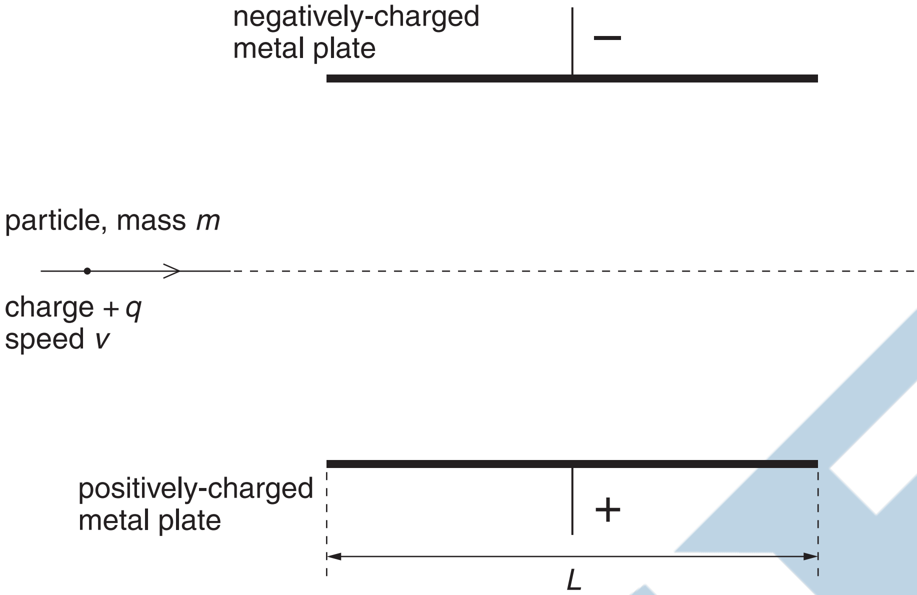

Fig. 7.1

The plates have length L.
The uniform electric field between the plates has magnitude E. The electric field outside the plates is zero.

A positively-charged particle has mass m and charge $+q$. Before the particle reaches the region between the plates, it is travelling with speed v parallel to the plates.
The particle passes between the plates and into the region beyond them.

(a) **(i)** On Fig. 7.1, draw the path of the particle between the plates and beyond them. [2]

(ii) For the particle in the region between the plates, state expressions, in terms of E, m, q, v and L, as appropriate, for

1. the force F on the particle,

.... [1]

2. the time t for the particle to cross the region between the plates.

.... [1]

For Examiner's Use

(b) **(i)** State the law of conservation of linear momentum.

....

....

.... [2]

(ii) Use your answers in **(a)(ii)** to state an expression for the change in momentum of the particle.

.... [1]

(iii) Suggest and explain whether the law of conservation of linear momentum applies to the particle moving between the plates.

....

....

.... [2]