1 **(a)** An electric field always exists around a charged particle.

Explain what is meant by an *electric field*.

....

.... **[1]**

(b) State **one** difference and **one** similarity between the electric field of a point charge and the gravitational field of a point mass.

difference ....

....

similarity ....

.... **[2]**

(c) Fig. 1.1 shows the uniform electric field between two vertical parallel plates **A** and **B**.

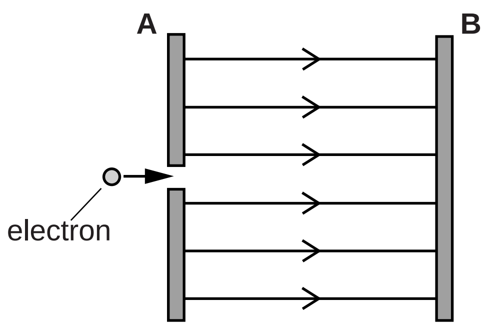

Fig. 1.1

The potential difference between the plates is 6V. An electron of kinetic energy 4eV is fired in a direction parallel to the electric field through a tiny hole in plate **A**.

Describe and explain the subsequent motion of the electron in the space between **A** and **B**. The weight of the electron has negligible effect on its motion between the plates.

....

....

....

....

....

....

.... **[3]**

(d) Two different minerals acquire opposite charges when they are crushed into tiny particles. These oppositely charged mineral particles fall from a conveyor belt through the uniform electric field between two vertical parallel plates, as shown in Fig. 1.2.

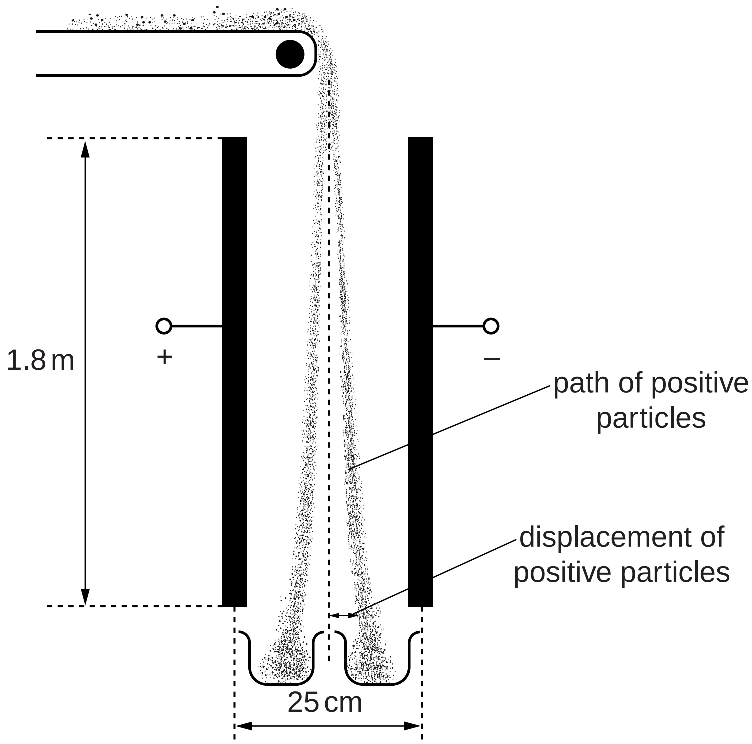

Fig. 1.2

The potential difference across the plates is 60 kV. The separation between the plates is 25 cm and each plate has length 1.8 m. The mineral particles fall through the air between the plates with a terminal velocity of $1.2\,\mathrm{m\,s^{-1}}$. Each mineral particle has a charge of magnitude 1.5×10^{-13} C and a mass of 8.0×10^{-7} kg.

(i) Calculate the horizontal electric force experienced by a positively charged mineral particle as it falls between the plates.

force = ... N **[2]**

(ii) Calculate the horizontal displacement of a positively charged mineral particle after a 1.8 m fall through the electric field of the plates. Ignore any horizontal drag forces due to air.

displacement = ... m **[3]**

2 **(a)** Fig. 1.1 shows a negatively charged metal sphere close to a positively charged metal plate.

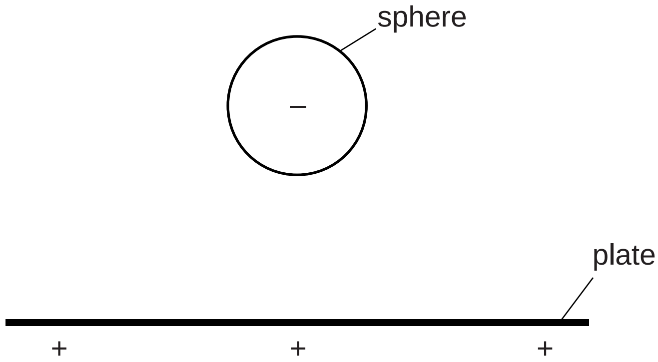

Fig. 1.1

On Fig. 1.1, draw a minimum of five field lines to show the electric field pattern between the plate and the sphere. **[2]**

(b) Fig. 1.2 shows two positively charged particles **A** and **B**.

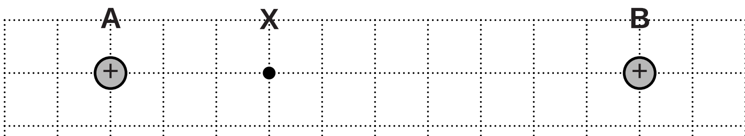

Fig. 1.2

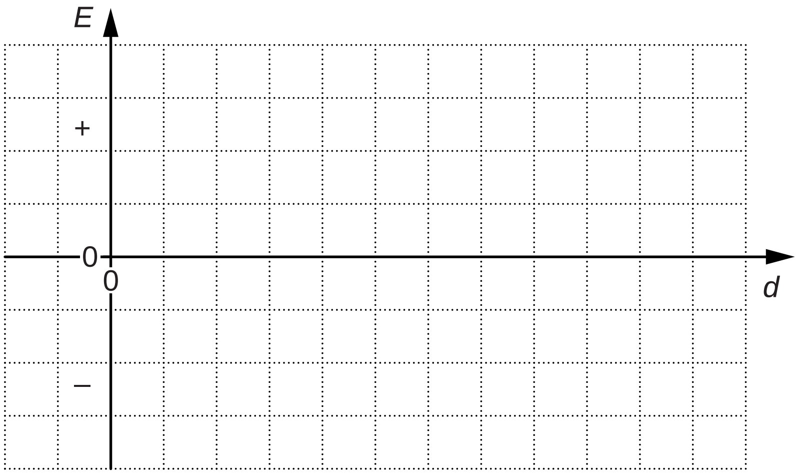

Fig. 1.3

At point **X**, the magnitude of the **resultant** electric field strength due to the particles **A** and **B** is zero.

(i) State, with a reason, which of the two particles has a charge of greater magnitude.

....

....

.... **[1]**

(ii) On Fig. 1.3 sketch the variation of the resultant electric field strength E with distance d from the particle **A**. **[3]**

(c) Fig. 1.4 shows a stationary positively charged particle.

Fig. 1.4

This particle creates both electric and gravitational fields in the space around it. Explain why the **ratio** of the electric field strength E to the gravitational field strength g at any point around this charge is independent of its distance from the particle.

....

....

....

.... **[1]**

[Total: 7]

3 Fig. 2.1 shows two identical negatively charged conducting spheres.

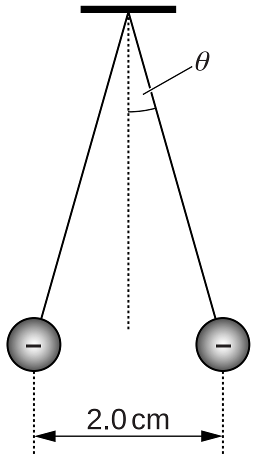

Fig. 2.1

The spheres are tiny and each is suspended from a nylon thread. Each sphere has mass 6.5×10^{-5} kg and charge -2.8×10^{-9} C. The separation between the centres of the spheres is 2.0 cm.

(a) Calculate the number of excess electrons on the surface of each sphere.

number = ... **[1]**

(b) Calculate the repulsive electrical force acting on each sphere.

force = ...N **[2]**

(c) **(i)** Each sphere is in equilibrium and experiences three forces. One of the forces acting on each sphere is the electrical force. State the other **two** forces acting on each sphere.

....

.... **[1]**

(ii) Use your knowledge of vectors to determine the angle θ made by each thread with the vertical.

θ = ...° **[3]**

[Total: 7]

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

....

.... **[1]**

(b) Fig. 3.1 shows two horizontal, parallel metal plates **A** and **B**.

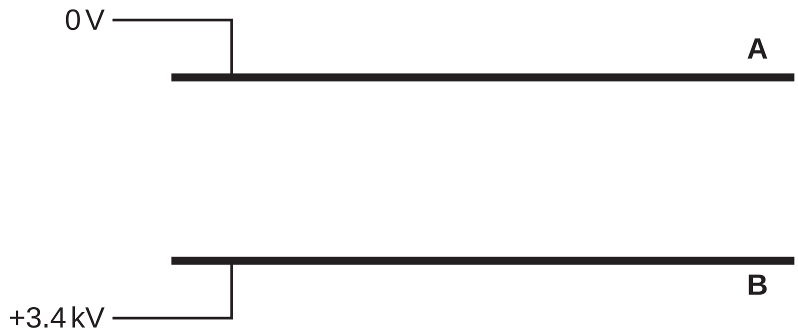

Fig. 3.1

The potential difference across the plates is 3.4 kV and the arrangement provides a uniform electric field between the plates.

On Fig. 3.1 draw at least six lines to represent the electric field between the plates. **[2]**

(c) A beam of electrons enters between the plates at right angles to the electric field. The horizontal velocity of the electrons is $4.0 \times 10^{7}\,\mathrm{m\,s^{-1}}$. The path of the electrons is shown on Fig. 3.2. The horizontal length of each plate is 0.080 m and the separation of the plates is 0.050 cm. **P** is a point 0.040 m from where the beam enters the plates.

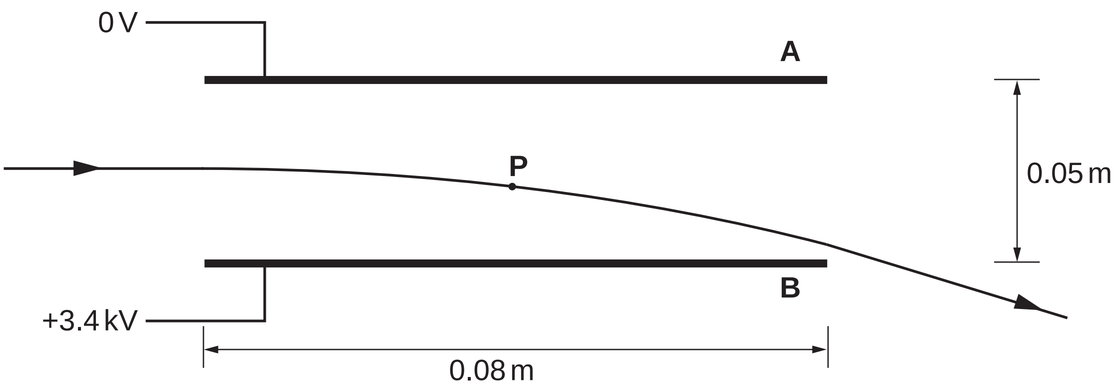

Fig. 3.2

(i) Draw an arrow on Fig. 3.2 to show the direction of the acceleration of an electron at **P**. **[1]**

(ii) Show that the acceleration of an electron between the plates is about $1 \times 10^{16}\,\mathrm{m\,s^{-2}}$.

[2]

(iii) Calculate the time taken for an electron on entering the plates to reach **P**.

time = ... s **[1]**

(iv) Show that the vertical velocity of the electron at **P** is $1.2 \times 10^{7}\,\mathrm{m\,s^{-1}}$.

[1]

(v) Calculate the magnitude of the resultant velocity of the electron at **P**.

magnitude of the velocity = ... $\mathrm{m\,s^{-1}}$ **[2]**

(vi) Calculate the kinetic energy of the electron at **P**.

kinetic energy = ... J **[2]**

(vii) On Fig. 3.3 sketch the variation of kinetic energy E_k of the electron with the horizontal distance x it travels through the electric field and beyond. No calculations are required.

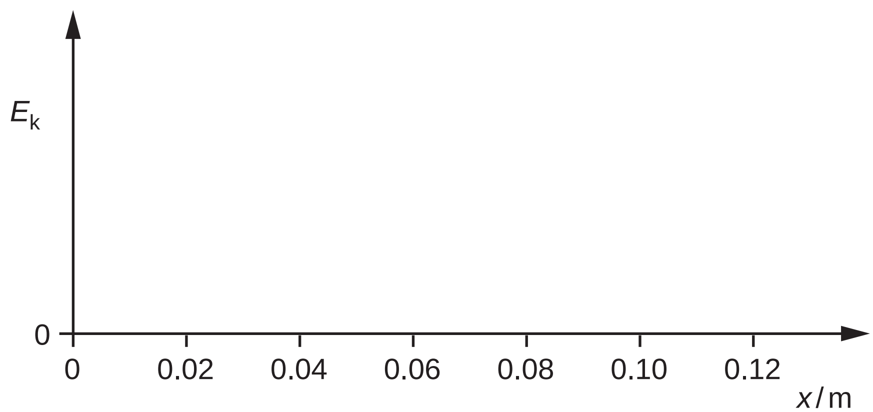

Fig. 3.3

[3]

[Total: 15]

5 A small, charged metal sphere **A** is hung from an insulating string. The charge on **A** is +5.0 nC. Fig. 4.1 shows the effect on **A** when a charged sphere **B** on an insulated rod is positioned close to it. The string makes an angle θ with the vertical.

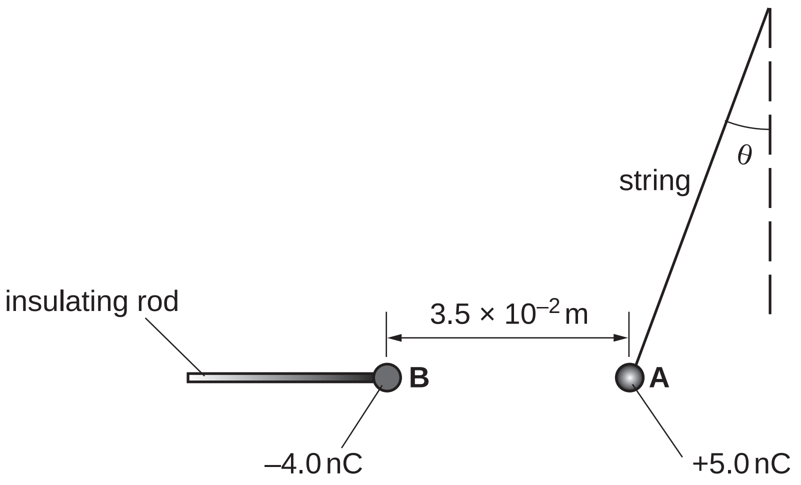

Fig. 4.1

The charge on **B** is −4.0 nC. The separation between the centres of the two spheres is 3.5×10^{-2} m.

(a) Determine the magnitude and direction of the electric field strength at the **midpoint** between the two charged spheres.

electric field strength = ... $N\,C^{-1}$

direction = ...

[4]

(b) Show that the electric force on **A** is 1.5×10^{-4} N.

[2]

(c) The mass of sphere **A** is 4.5×10^{-5} kg. Use the method of resolving vectors or a vector triangle to determine the angle θ made by the string with the vertical.

θ = ...° **[3]**

[Total: 9]