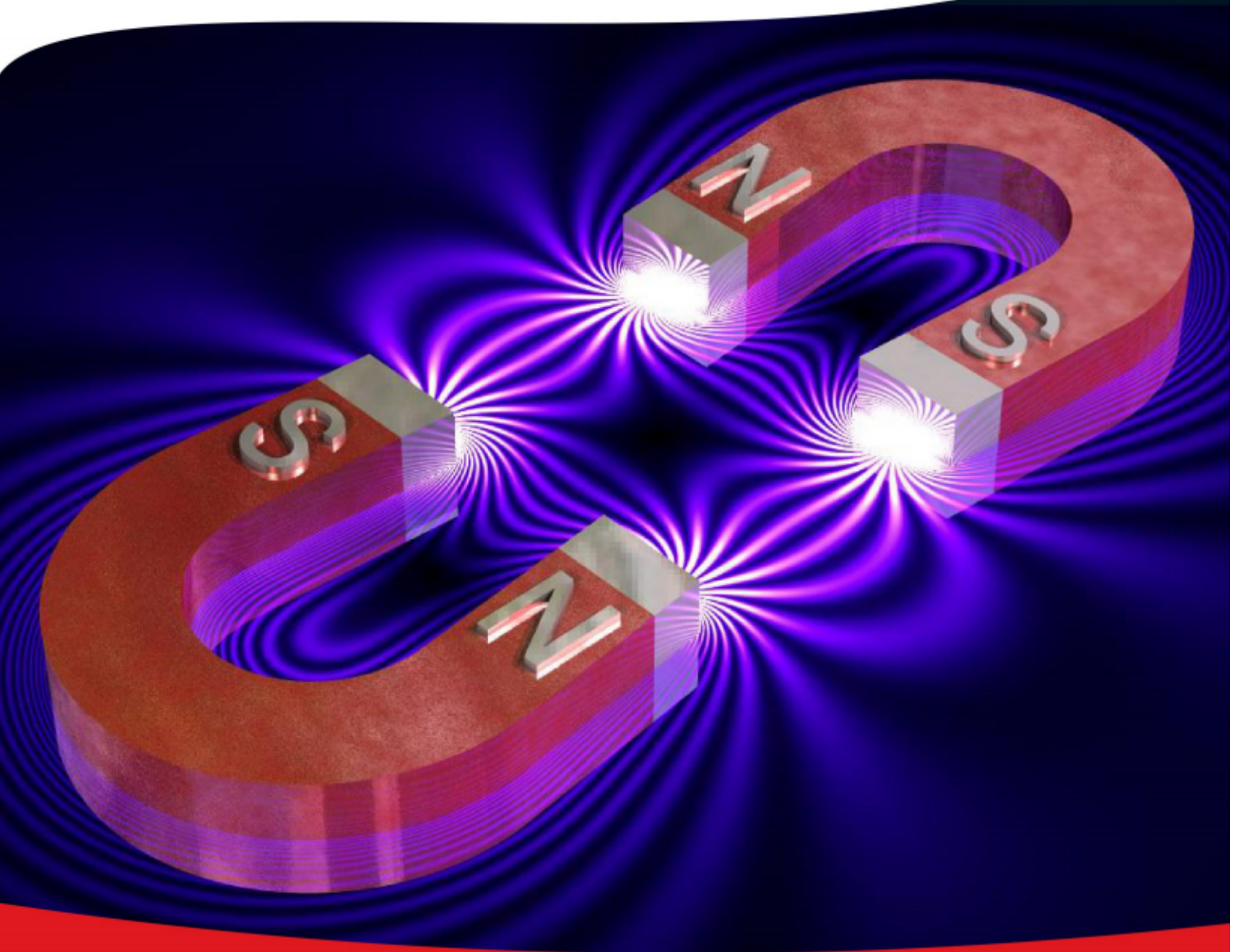
Cambridge International AS & A Level

PHYSICS (9702) P2

TOPIC WISE QUESTIONS + ANSWERS | COMPLETE SYLLABUS



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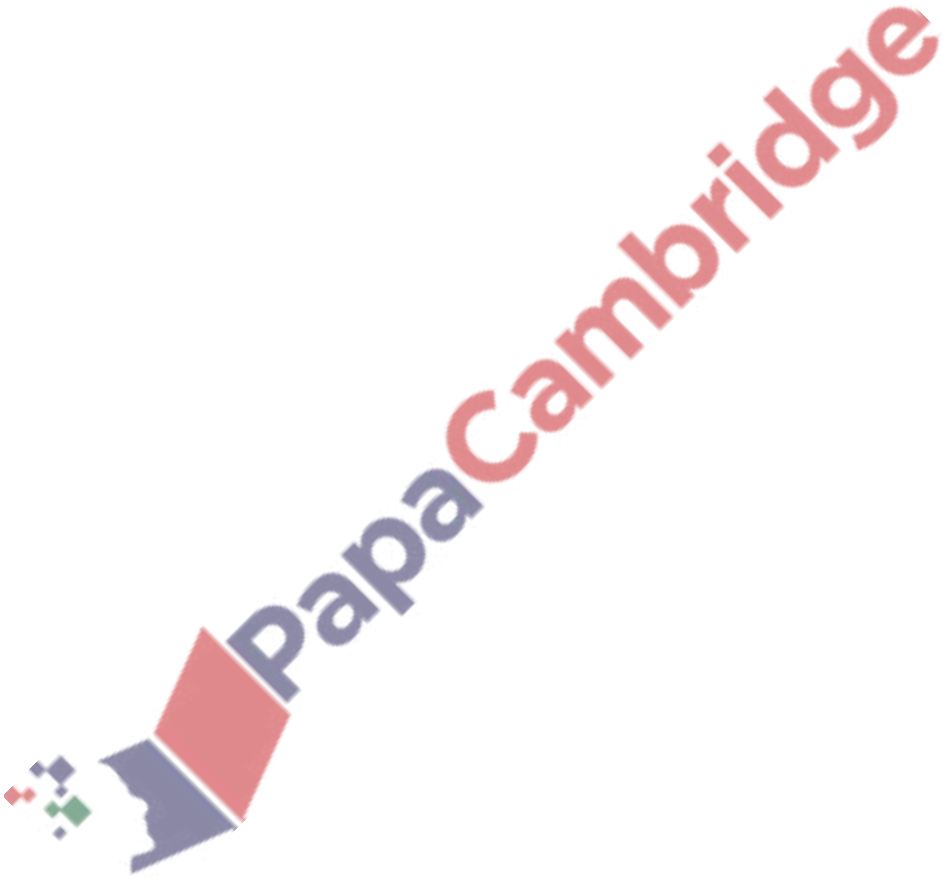
Chapter 10

Electric fields



10.1 Concept of an electric field

186. 9702_m17_qp_22 Q: 5

An electron is travelling in a straight line through a vacuum with a constant speed of $1.5 \times 10^{7}\,\text{m s}^{-1}$. The electron enters a uniform electric field at point A, as shown in Fig. 5.1.

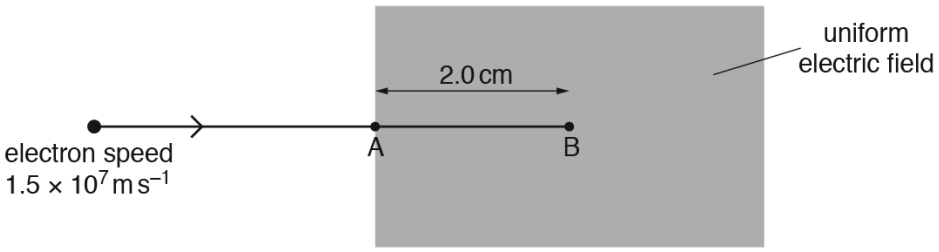


Fig. 5.1

The electron continues to move in the same direction until it is brought to rest by the electric field at point B. Distance AB is 2.0 cm.

(a) State the direction of the electric field.

.....[1]

(b) Calculate the magnitude of the deceleration of the electron in the field.

deceleration = ...m s^{-2} [2]

(c) Calculate the electric field strength.

electric field strength = ...V m^{-1} [3]

(d) The electron is at point A at time $t = 0$.

On Fig. 5.2, sketch the variation with time t of the velocity v of the electron until it reaches point B. Numerical values of v and t do not need to be shown.

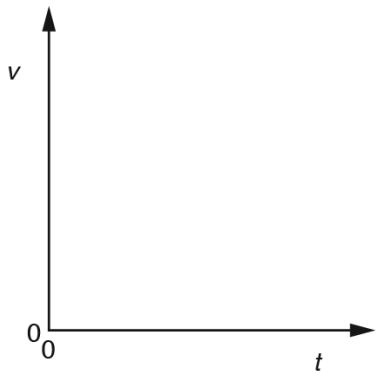


Fig. 5.2

[1]

[Total: 7]

187. 9702_s17_qp_23 Q: 3

(a) Define *electric field strength.*

.....

.....[1]

(b) An electron is accelerated from point A to point B by a uniform electric field, as illustrated in Fig. 3.1.

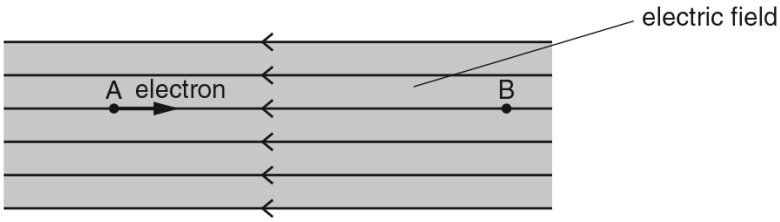


Fig. 3.1

The distance between A and B is 12 mm. The velocity of the electron at A is 2.5 km s^{-1} and at B is 18 Mm s^{-1}.

Calculate

(i) the acceleration of the electron,

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

(ii) the change in kinetic energy of the electron,

change in kinetic energy = ...J [3]

(iii) the electric field strength.

electric field strength = ... $V\,m^{-1}$ [3]

(c) An α-particle moves from A to B in the electric field in **(b)**.

Describe and explain how the change in the kinetic energy of the α-particle compares with that of the electron. Numerical values are not required.

.....

.....

.....

.....

.....[3]

[Total: 12]

10.2 Uniform electric fields

188. 9702_m19_qp_22 Q: 4

(a) Define *electric field strength*.

.....

.....[1]

(b) Two very small metal spheres X and Y are connected by an insulating rod of length 72 mm. A side view of this arrangement is shown in Fig. 4.1.

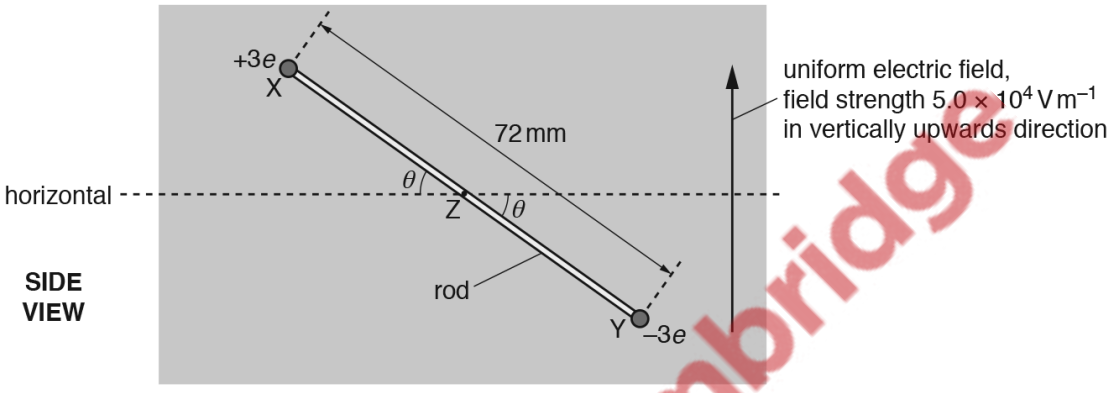


Fig. 4.1 (not to scale)

Sphere X has a charge of $+3e$ and sphere Y has a charge of $-3e$, where e is the elementary charge. The rod is held at its mid point Z at an angle θ to the horizontal. The rod and spheres have negligible mass and are in a uniform electric field. The electric field strength is $5.0 \times 10^4\,\text{V m}^{-1}$. The direction of this field is vertically upwards.

(i) The electric field is produced by applying a potential difference of 4.0 kV between two charged parallel metal plates.

1. Calculate the separation between the plates.

separation = ... m [2]

2. Describe the arrangement of the two plates. Include in your answer a statement of the sign of the charge on each plate. You may draw on Fig. 4.1.

.....

.....

.....

.....[2]

(ii) Determine the magnitude and direction of the force on sphere Y.

magnitude = ... N

direction .....

[2]

(iii) The electric forces acting on the two spheres form a couple. This couple acts on the rod with a torque of 6.2×10^{-16} N m.

Calculate the angle θ of the rod to the horizontal.

θ = ... ° [2]

[Total: 9]

189. 9702_s19_qp_21 Q: 4

(a) A spherical oil drop has a radius of 1.2×10^{-6} m. The density of the oil is 940 kg m^{-3}.

(i) Show that the mass of the oil drop is 6.8×10^{-15} kg.

[2]

(ii) The oil drop is charged. Explain why it is impossible for the magnitude of the charge to be 8.0×10^{-20} C.

.....

.....[1]

(b) The charged oil drop in **(a)** is in a vacuum between two horizontal metal plates, as illustrated in Fig. 4.1.

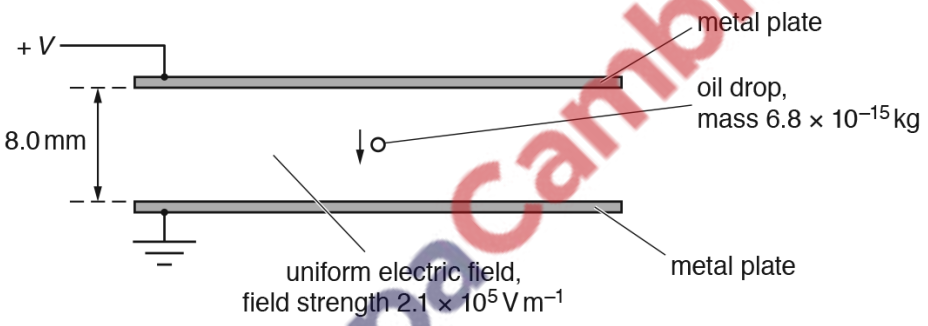


Fig. 4.1

The plates are separated by a distance of 8.0 mm. The electric field between the plates is uniform and has a field strength of 2.1×10^5 V m^{-1}.

The oil drop moves vertically downwards with a constant speed.

(i) Calculate the potential difference V between the plates.

V = ... V [2]

(ii) Explain how the motion of the oil drop shows that it is in equilibrium.

.....

.....[1]

(iii) Determine the charge on the oil drop.

charge = ... C

sign of charge .....

[3]

(c) The magnitude of the potential difference between the plates in **(b)** is decreased.

(i) Explain why the oil drop accelerates downwards.

.....

.....

.....

.....[2]

(ii) Describe the change to the pattern of the field lines (lines of force) representing the uniform electric field as the potential difference decreases.

.....

.....[1]

(d) Two types of force, X and Y, can act on an oil drop when it is in air, but cannot act on an oil drop when it is in a vacuum. Force X can act on an oil drop when it is stationary or when it is moving. Force Y can only act on an oil drop when it is moving.

State the name of:

(i) force X

.....[1]

(ii) force Y.

.....[1]

[Total: 14]

190. 9702_s19_qp_23 Q: 4

Two vertical metal plates in a vacuum are separated by a distance of 0.12 m.
Fig. 4.1 shows a side view of this arrangement.

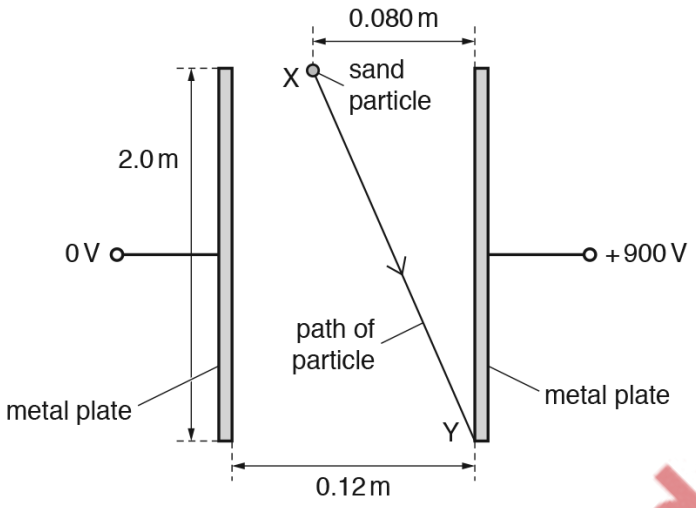


Fig. 4.1 (not to scale)

Each plate has a length of 2.0 m. The potential difference between the plates is 900 V. The electric field between the plates is uniform.

A negatively charged sand particle is released from rest at point X, which is a horizontal distance of 0.080 m from the top of the positively charged plate. The particle then travels in a straight line and collides with the positively charged plate at its lowest point Y, as illustrated in Fig. 4.1.

(a) Describe the pattern of the field lines (lines of force) between the plates.

.....

.....

.....[2]

(b) State the names of the **two** forces acting on the particle as it moves from X to Y.

.....[1]

(c) By considering the vertical motion of the sand particle, show that the time taken for the particle to move from X to Y is 0.64 s.

[2]

(d) Calculate the horizontal component of the acceleration of the particle.

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

(e) **(i)** Calculate the magnitude of the electric field strength.

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

(ii) The sand particle has mass m and charge q. Use your answers in **(d)** and **(e)(i)** to determine the ratio $\frac{q}{m}$.

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

(f) Another particle has a smaller magnitude of the ratio $\frac{q}{m}$ than the sand particle. This particle is also released from point X.

For the movement of this particle, state the effect, if any, of the decreased magnitude of the ratio on:

(i) the vertical component of the acceleration

.....[1]

(ii) the horizontal component of the acceleration.

.....[1]

[Total: 13]

191. 9702_w19_qp_21 Q: 2

A small charged glass bead of weight 5.4×10^{-5} N is initially at rest at point A in a vacuum. The bead then falls through a uniform horizontal electric field as it moves in a straight line to point B, as illustrated in Fig. 2.1.

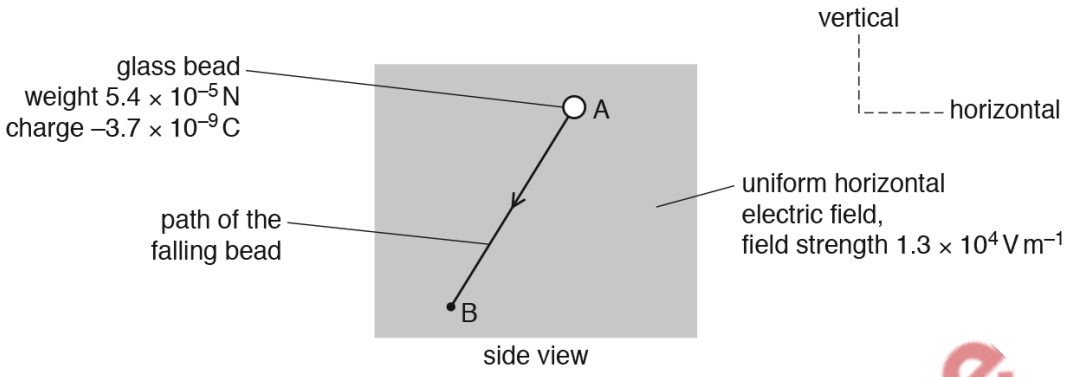


Fig. 2.1 (not to scale)

The electric field strength is 1.3×10^{4} V m^{-1}. The charge on the bead is -3.7×10^{-9} C.

(a) Describe how two metal plates could be used to produce the electric field. Numerical values are not required.

.....

.....

..... [2]

(b) Determine the magnitude of the electric force acting on the bead.

electric force = ... N [2]

(c) Use your answer in **(b)** and the weight of the bead to show that the resultant force acting on it is 7.2×10^{-5} N.

[1]

(d) Explain why the resultant force on the bead of 7.2×10^{-5} N is constant as the bead moves along path AB.

.....

.....

.....

..... [2]

(e) **(i)** Calculate the magnitude of the acceleration of the bead along the path AB.

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

(ii) The path AB has length 0.58 m.

Use your answer in **(i)** to determine the speed of the bead at point B.

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

[Total: 11]

192. 9702_w19_qp_23 Q: 3

(a) State the property of an object that experiences a force when the object is placed in:

(i) a gravitational field

..... [1]

(ii) an electric field.

..... [1]

(b) A potential difference of 1.2×10^3 V is applied between a pair of horizontal metal plates in a vacuum, as shown in Fig. 3.1.

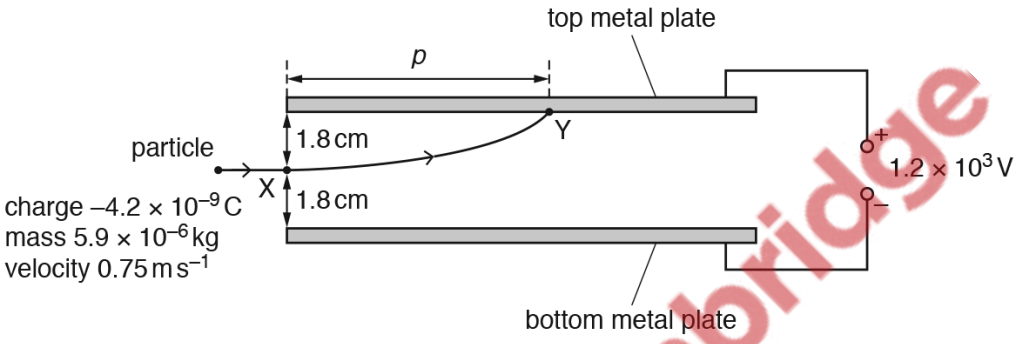


Fig. 3.1 (not to scale)

The separation of the plates is 3.6 cm. The electric field between the plates is uniform.

A particle of mass 5.9×10^{-6} kg and charge -4.2×10^{-9} C enters the field at point X with a horizontal velocity of 0.75 m s^{-1} along a line midway between the two plates.
The particle is deflected by the field and hits the top plate at point Y.

(i) Calculate the magnitude of the electric force acting on the particle in the field.

electric force = ... N [3]

(ii) By considering the resultant vertical force acting on the particle, show that the acceleration of the particle in the electric and gravitational fields is $14\,m\,s^{-2}$.

[4]

(iii) Determine:

1. the time taken for the particle to move from X to Y

time taken = ... s [2]

2. the distance p of point Y from the left-hand edge of the top plate.

p = ... m [1]

[Total: 12]

193. 9702_w17_qp_21 Q: 6

(a) Define *electric field strength*.

.....

.....[1]

(b) Two parallel metal plates in a vacuum are separated by a distance of 15 mm, as shown in Fig. 6.1.

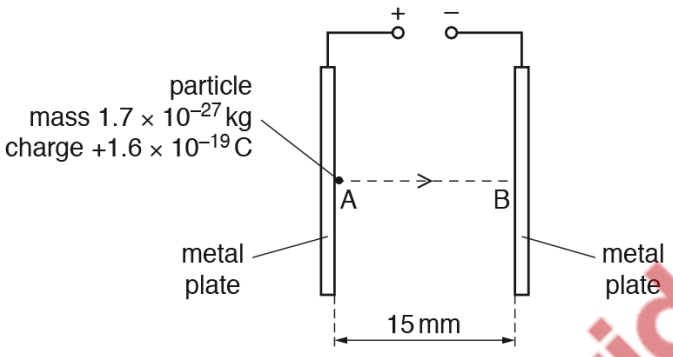


Fig. 6.1

A uniform electric field is produced between the plates by applying a potential difference between them.

A particle of mass 1.7×10^{-27} kg and charge $+1.6 \times 10^{-19}$ C is initially at rest at point A on one plate. The particle is moved by the electric field to point B on the other plate. The particle reaches point B with kinetic energy 2.4×10^{-16} J.

(i) Calculate the speed of the particle at point B.

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

(ii) State the work done by the electric field to move the particle from A to B.

work done = ... J [1]

(iii) Use your answer in **(ii)** to determine the force on the particle.

force = ... N [2]

(iv) Determine the potential difference between the plates.

potential difference = ... V [3]

(v) On Fig. 6.2, sketch a graph to show the variation of the kinetic energy of the particle with the distance x from point A along the line AB.
Numerical values for the kinetic energy are not required.

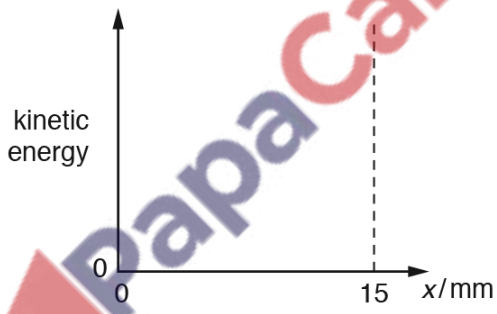


Fig. 6.2

[1]

[Total: 10]

194. 9702_w17_qp_23 Q: 5

(a) Define *electric field strength*.

.....

.....[1]

(b) Two parallel metal plates in a vacuum are separated by 0.045 m. A potential difference V is applied between the plates, as shown in Fig. 5.1.

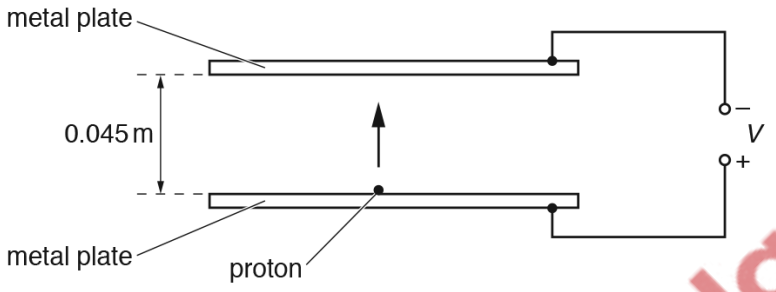


Fig. 5.1

A proton is initially at rest on the surface of the positive plate. The proton in the uniform electric field takes a time of 1.5×10^{-7} s to reach the negative plate.

(i) Show that the acceleration of the proton is $4.0 \times 10^{12}\,\text{m s}^{-2}$.

[2]

(ii) Calculate the electric force on the proton.

force = ... N [1]

(iii) Use your answer in **(ii)** to determine

1. the electric field strength,

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

2. the potential difference V between the plates.

V = ... V [2]

(c) An α particle is now accelerated between the two metal plates in **(b)** by the electric field.

Calculate the ratio

$$\frac{\text{acceleration of } \alpha \text{ particle}}{\text{acceleration of proton}}.$$

ratio = ...[2]

[Total: 10]

195. 9702_s16_qp_22 Q: 6

Two parallel vertical metal plates are connected to a power supply, as shown in Fig. 6.1.

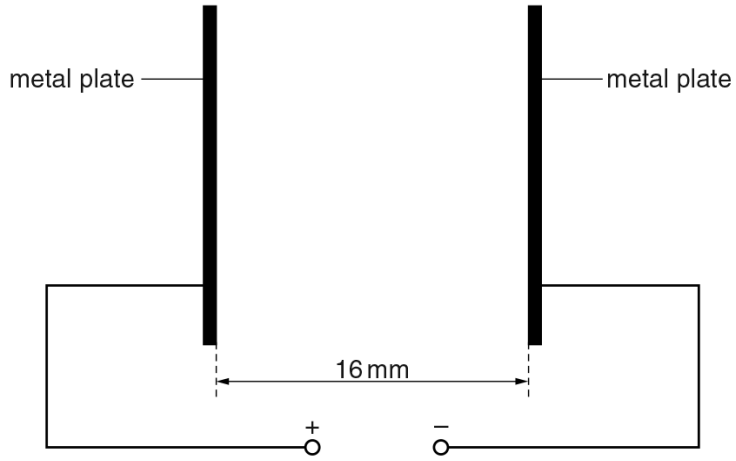


Fig. 6.1

The separation of the plates is 16 mm.

(a) On Fig. 6.1, draw at least six field lines to represent the electric field between the plates. [1]

(b) An α-particle travels in a vacuum between the two plates.

The electric field does work on the α-particle. The gain in kinetic energy of the α-particle is 15 keV.

Calculate the electric field strength between the plates.

electric field strength = ... $V\,m^{-1}$ [4]

[Total: 5]

196. 9702_w16_qp_21 Q: 2

(a) Define *electric field strength*.

.....

.....[1]

(b) A potential difference of 2.5 kV is applied across a pair of horizontal metal plates in a vacuum, as shown in Fig. 2.1.

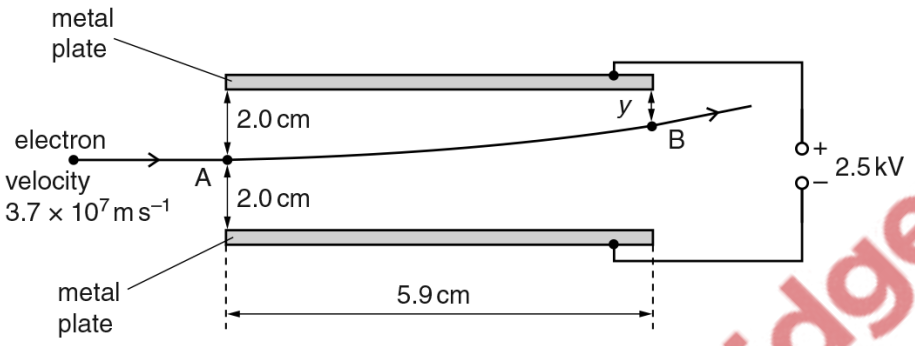


Fig. 2.1 (not to scale)

Each plate has a length of 5.9 cm. The separation of the plates is 4.0 cm. The arrangement produces a uniform electric field between the plates.
Assume the field does not extend beyond the edges of the plates.

An electron enters the field at point A with horizontal velocity $3.7 \times 10^7\,m\,s^{-1}$ along a line mid-way between the plates. The electron leaves the field at point B.

(i) Calculate the time taken for the electron to move from A to B.

time taken = ... s [1]

(ii) Calculate the magnitude of the electric field strength.

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

(iii) Show that the acceleration of the electron in the field is $1.1 \times 10^{16}\,m\,s^{-2}$.

[2]

(iv) Use the acceleration given in **(iii)** and your answer in **(i)** to determine the vertical distance y between point B and the upper plate.

y = ... cm [3]

(v) Explain why the calculation in **(iv)** does not need to include the gravitational effects on the electron.

.....

.....[1]

(vi) The electron enters the field at time $t = 0$.

On Fig. 2.2, sketch graphs to show the variation with time t of

1. the horizontal component v_X of the velocity of the electron,

2. the vertical component v_Y of the velocity of the electron.

Numerical values are not required.

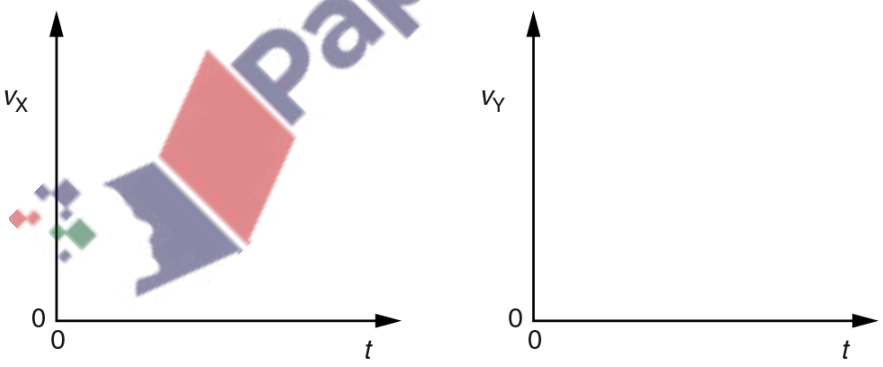


Fig. 2.2

[2]

[Total: 12]

197. 9702_w16_qp_23 Q: 2

(a) Define *electric field strength*.

.....

.....[1]

(b) A potential difference of 2.5 kV is applied across a pair of horizontal metal plates in a vacuum, as shown in Fig. 2.1.

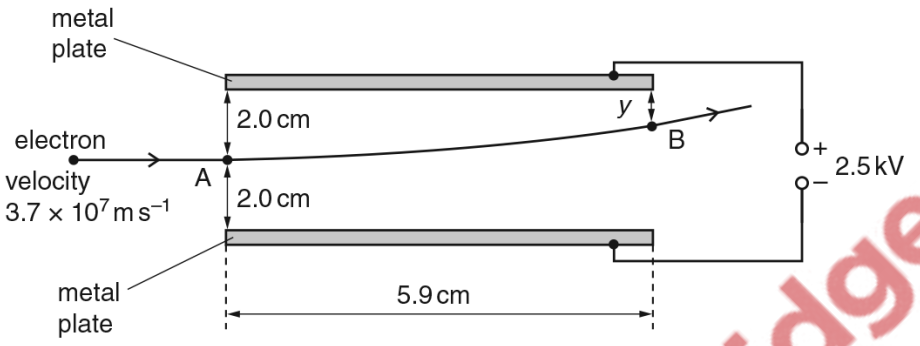


Fig. 2.1 (not to scale)

Each plate has a length of 5.9 cm. The separation of the plates is 4.0 cm. The arrangement produces a uniform electric field between the plates.
Assume the field does not extend beyond the edges of the plates.

An electron enters the field at point A with horizontal velocity $3.7 \times 10^7\,\text{m s}^{-1}$ along a line mid-way between the plates. The electron leaves the field at point B.

(i) Calculate the time taken for the electron to move from A to B.

time taken = ... s [1]

(ii) Calculate the magnitude of the electric field strength.

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

(iii) Show that the acceleration of the electron in the field is $1.1 \times 10^{16}\,\text{m s}^{-2}$.

[2]

(iv) Use the acceleration given in **(iii)** and your answer in **(i)** to determine the vertical distance y between point B and the upper plate.

y = ... cm [3]

(v) Explain why the calculation in **(iv)** does not need to include the gravitational effects on the electron.

.....

.....[1]

(vi) The electron enters the field at time $t = 0$.

On Fig. 2.2, sketch graphs to show the variation with time t of

1. the horizontal component v_X of the velocity of the electron,

2. the vertical component v_Y of the velocity of the electron.

Numerical values are not required.

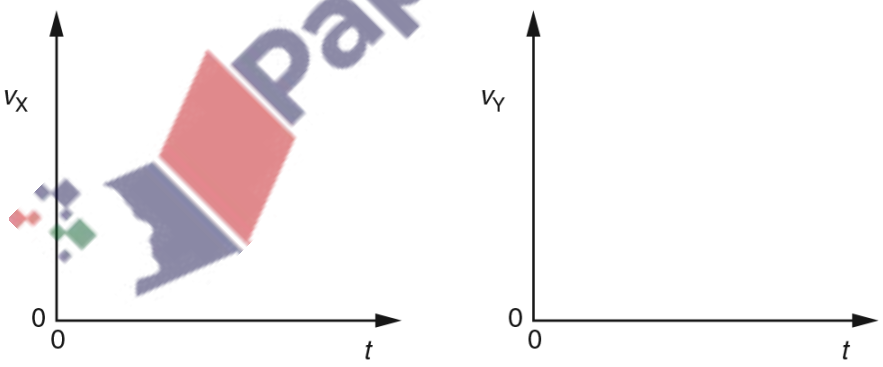


Fig. 2.2

[2]

[Total: 12]

198. 9702_s15_qp_21 Q: 7

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

.....

.....[1]

(b) A uniform electric field is produced between two vertical metal plates AB and CD, as shown in Fig. 7.1.

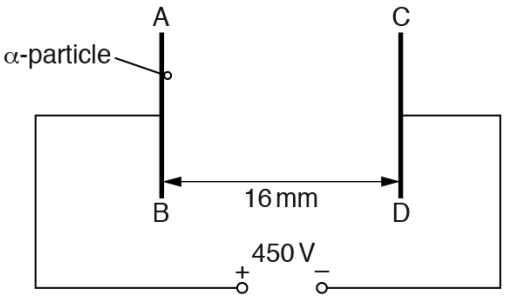


Fig. 7.1

The potential difference between the plates is 450 V and the separation of the plates is 16 mm.

An α-particle is accelerated from plate AB to plate CD.

(i) On Fig. 7.1, draw lines to represent the electric field between the plates. [2]

(ii) Calculate the electric field strength between the plates.

electric field strength = ... $V\,m^{-1}$ [2]

(iii) Calculate the work done by the electric field on the α-particle as it moves from AB to CD.

work done = ... J [3]

(iv) A β-particle moves from AB to CD. Calculate the ratio

$$\frac{\text{work done by the electric field on the } \alpha\text{-particle}}{\text{work done by the electric field on the } \beta\text{-particle.}}$$

Show your working.

ratio = ... [1]