



**A Level Physics Exam Packs**

**Electric fields**

Name:

Form:

Question	Mark

- 3 (a) Fig. 3.1 shows two charged horizontal plates.

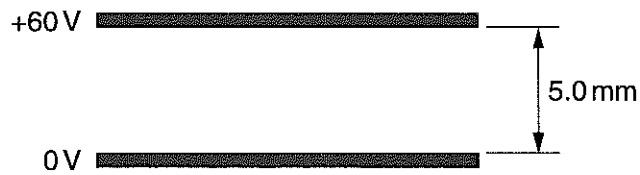


Fig. 3.1

The potential difference across the plates is 60V. The separation of the plates is 5.0 mm.

- (i) On Fig. 3.1 draw the electric field pattern between the plates. [2]
- (ii) Calculate the electric field strength between the plates.

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

- (b) Positive ions are accelerated from rest in the horizontal direction through a potential difference of 400V. The charged plates in (a) are then used to deflect the ions in the vertical direction. Fig. 3.2 shows the path of these ions.

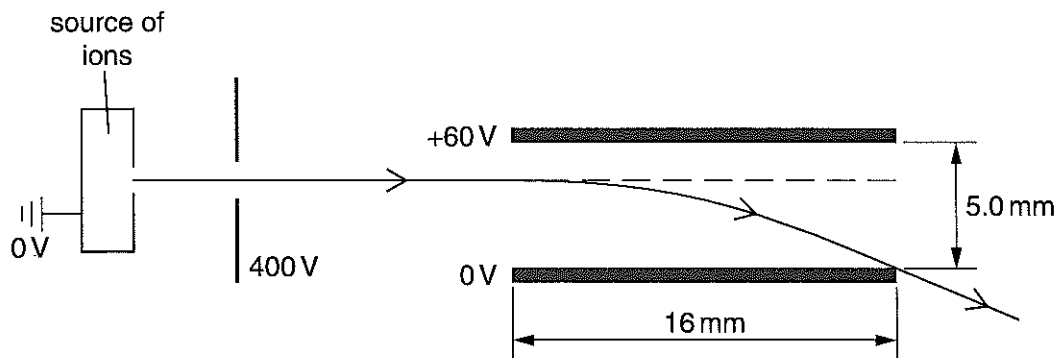


Fig. 3.2

Each ion has a mass of  $6.6 \times 10^{-27}$  kg and a charge of  $3.2 \times 10^{-19}$  C.

- (i) Show that the horizontal velocity of an ion after the acceleration by the 400V potential difference is  $2.0 \times 10^5$  ms<sup>-1</sup>.

[2]

- (ii) The ions enter at right angles to the uniform electric field between the plates. Calculate the vertical acceleration of an ion due to this electric field.

acceleration = ..... ms<sup>-2</sup> [2]

- (iii) The length of each of the charged plates is 16 mm.

- 1 Show that an ion takes about  $8.0 \times 10^{-8}$  s to travel through the plates.

[1]

- 2 Calculate the vertical deflection of an ion as it travels through the plates.

deflection = ..... m [2]

- (c) A uniform magnetic field is applied in the region between the plates in Fig. 3.2. The magnetic field is perpendicular to both the path of the ions and the electric field between the plates.

Calculate the magnitude of the magnetic flux density of field needed to make the ions travel horizontally through the plates.

magnetic flux density = ..... T [3]

- (d) Ions of the same charge but greater mass are accelerated by the potential difference of 400V described in (b). Describe and explain the effect on the deflection of the ions after they have travelled between the plates using the same electric and magnetic fields of (c).

.....  
.....  
.....  
..... [2]

[Total: 15]

Question	Expected Answers	Marks	Additional Guidance
3 a (i)	uniformly spaced, vertical parallel lines must begin and end on the plates with a minimum of three lines	B1	ignore any edge effects
	arrow in the correct direction down	B1	
(ii)	$E = V / d$ $E = 60 / 5 \times 10^{-3}$ $= 12000 \text{ (V m}^{-1}\text{)}$	A1	
b (i)	Use of energy $qV$ and kinetic energy $= \frac{1}{2}mv^2$	M1	
	$v = [(2qV)/m]^{1/2}$		
	$v = [(2 \times 3.2 \times 10^{-19} \times 400)/6.6 \times 10^{-27}]^{1/2}$	M1	
	$v = 1.97 \times 10^5 \text{ (m s}^{-1}\text{)}$	A0	
(ii)	$a = F / m$ $a = Eq / m$  $a = (12000 \times 3.2 \times 10^{-19}) / 6.6 \times 10^{-27}$  $= 5.82 \times 10^{11} \text{ (m s}^{-2}\text{)}$	C1	Both required for the mark
(iii)	1 $t = (16 \times 10^{-3}) / 2 \times 10^5$	M1	Answer will depend on number of sf used by candidate.
	$= 8 \times 10^{-8} \text{ (s)}$	A0	
	2 $s = \frac{1}{2} a \times t^2 = \frac{1}{2} [5.82 \times 10^{11} \times (8 \times 10^{-8})^2]$	C1	Using $u = 2 \times 10^5$ scores 0/2
	$= 1.86 \times 10^{-3} \text{ (m)}$	A1	Allow slight variation in answers that follow from the candidates working



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

.....  
 ..... [1]

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

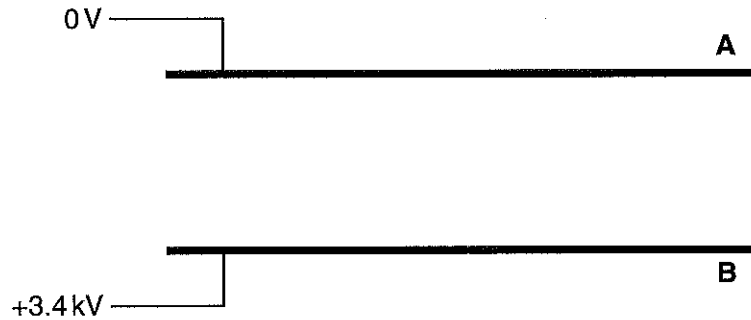


Fig. 3.1

The potential difference across the plates is 3.4kV 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  $4.0 \times 10^7 \text{ m s}^{-1}$ . The path of the electrons is shown on Fig. 3.2. The horizontal length of each plate is 0.080m and the separation of the plates is 0.050m. P is a point 0.040m from where the beam enters the plates.

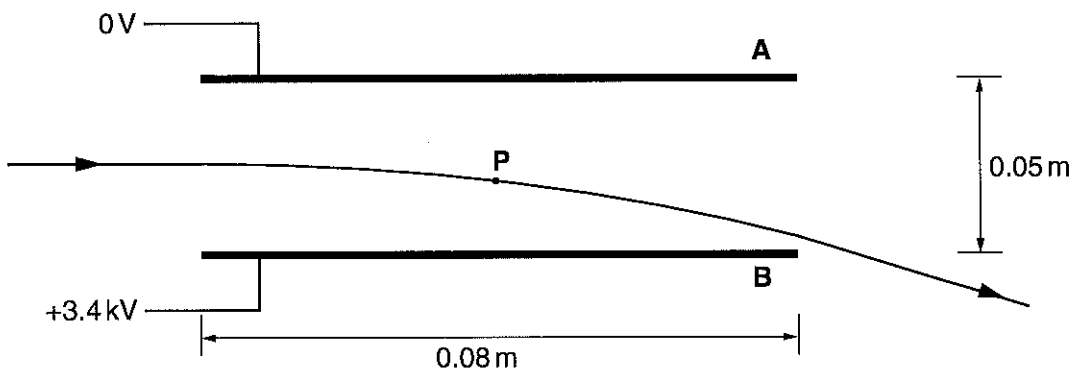


Fig. 3.2

- (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  $1 \times 10^{16} \text{ms}^{-2}$ .

[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  $1.2 \times 10^7 \text{ms}^{-1}$ .

[1]

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

magnitude of the velocity = .....  $\text{ms}^{-1}$  [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.

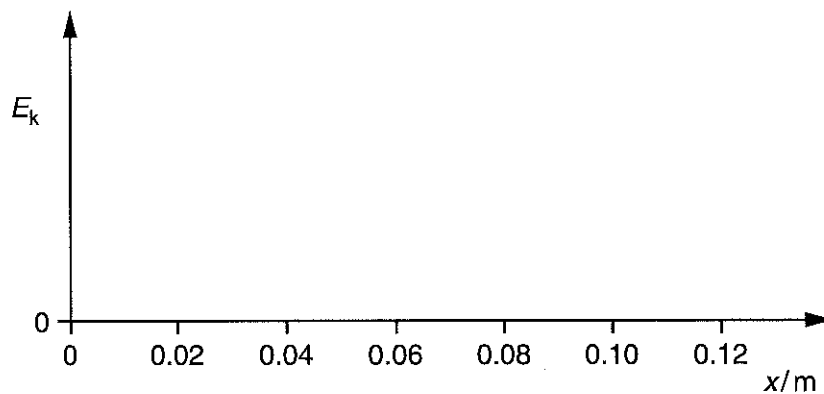


Fig. 3.3

[3]

[Total: 15]

Turn over



Question		Expected Answers	Marks	Additional guidance
3	(a)	(Electric field strength is the) force <u>per</u> (unit positive) charge	B1	<b>Allow:</b> $E = F/Q$ , $F$ is the force on a (positive) charge $Q$
	(b)	Parallel and equally spaced lines at right angles to plates  Correct <u>upward</u> direction of field shown on at least one field line	B1  B1	
	(c) (i)	An arrow vertically downwards at P	B1	
	(ii)	$E = \frac{3400}{0.050}$ or $E = 6.8 \times 10^4$ (V m <sup>-1</sup> ) $a = \frac{EQ}{m}$ $a = \frac{6.8 \times 10^4 \times 1.6 \times 10^{-19}}{9.11 \times 10^{-31}}$ or $a = \frac{1.09 \times 10^{-14}}{9.11 \times 10^{-31}}$ acceleration = $1.19 \times 10^{16}$ (m s <sup>-2</sup> ) or $1.2 \times 10^{16}$ (m s <sup>-2</sup> )	C1  C1  A0	<b>Vital:</b> Candidates using separation of 0.050 cm must be awarded full credit for the analysis shown below $E = \frac{3400}{0.050 \times 10^{-2}}$ or $E = 6.8 \times 10^5$ (V m <sup>-1</sup> ) C1 $a = \frac{EQ}{m}$ $a = \frac{6.8 \times 10^6 \times 1.6 \times 10^{-19}}{9.11 \times 10^{-31}}$ C1 acceleration = $1.19 \times 10^{18}$ (m s <sup>-2</sup> ) A0
	(iii)	$t = \frac{0.04}{4.0 \times 10^7}$ time = $1.0 \times 10^{-9}$ (s)	B1	<b>Allow:</b> $1 \times 10^{-9}$ (s) or $10^{-9}$ (s)
	(iv)	initial vertical velocity = 0, final vertical velocity = $at$ vertical velocity = $1.2 \times 10^{16} \times 1.0 \times 10^{-9}$ <b>(Allow:</b> $1 \times 10^{16} \times 1.0 \times 10^{-9}$ ) vertical velocity = $1.2 \times 10^7$ (m s <sup>-1</sup> )	M1  A0	<b>Vital:</b> Candidates using separation of 0.050 cm must be awarded full credit for the analysis shown below vertical velocity = $1.2 \times 10^{18} \times 1.0 \times 10^{-9}$ M1 vertical velocity = $1.2 \times 10^9$ (m s <sup>-1</sup> ) A0

G485

Mark Scheme

June 2011

Question	Expected Answers	Marks	Additional guidance
(v)	$v^2 = (4.0 \times 10^7)^2 + (1.2 \times 10^7)^2$ velocity = $4.2 \times 10^7$ (m s <sup>-1</sup> ) Or $v^2 = (4.0 \times 10^7)^2 + (1 \times 10^7)^2$ velocity = $4.1 \times 10^7$ (m s <sup>-1</sup> )	C1 A1  C1 A1	Possible ecf from (iv)
(vi)	$KE = \frac{1}{2}mv^2$ $KE = 0.5 \times 9.11 \times 10^{-31} \times (4.2 \times 10^7)^2$ kinetic energy = $8.04 \times 10^{-16}$ (J) or $8.0 \times 10^{-16}$ (J)	C1 A1	Possible ecf from (v) <b>Allow:</b> 1 sf answer if the answer comes out as $8.0 \times 10^{-16}$ (J)
(vii)	Graph starts at non-zero value for $E_k$  Between 0 and 0.08 (m) the graph has increasing gradient  Horizontal line after 0.080 (m)	B1  B1  B1	<b>Note:</b> The $E_k$ value for the horizontal line > $E_k$ value at $x = 0$
	<b>Total</b>	<b>15</b>	

- 4 A small, charged metal sphere **A** is hung from an insulating string. The charge on **A** is  $+5.0\text{ nC}$ . 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  $\theta$  with the vertical.

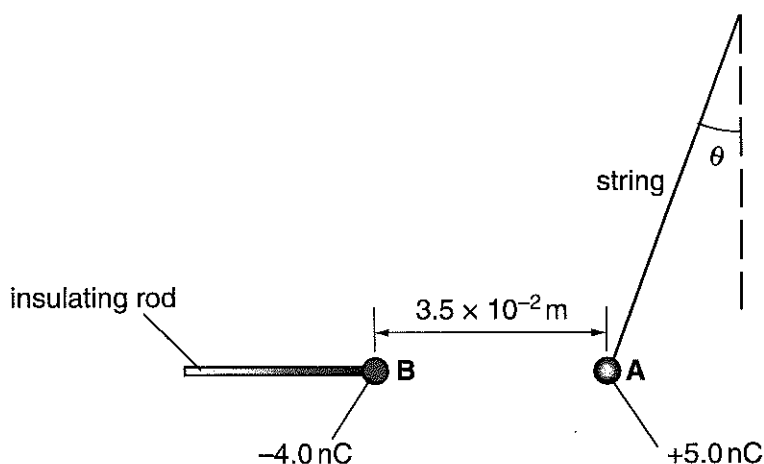


Fig. 4.1

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

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

electric field strength = .....  $\text{NC}^{-1}$

direction = .....

[4]

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

[2]

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

$\theta = \dots\dots\dots^\circ$  [3]

[Total: 9]

Question	Expected Answers	Marks	Additional guidance
4 (a)	$E = \frac{Q}{4\pi\epsilon_0 r^2}$ $\frac{(-)4.0 \times 10^{-9}}{4\pi\epsilon_0 \times (1.75 \times 10^{-2})^2} \text{ and } \frac{5.0 \times 10^{-9}}{4\pi\epsilon_0 \times (1.75 \times 10^{-2})^2}$ $E_B = 1.17 \times 10^5 \text{ (N C}^{-1}\text{)} \text{ and } E_A = 1.47 \times 10^5 \text{ (N C}^{-1}\text{)}$ field strength = $(1.17 + 1.47) \times 10^5 \text{ (N C}^{-1}\text{)}$ field strength = $2.64 \times 10^5 \text{ (N C}^{-1}\text{)}$ or $2.6 \times 10^5 \text{ (N C}^{-1}\text{)}$  direction = to the left / towards B	C1  C1  A1  B1	ignore signs   Allow: 2 marks for $2.9(4) \times 10^4 \text{ (N C}^{-1}\text{)}$ when the fields are subtracted Allow: 2 marks for $6.6 \times 10^4 \text{ (N C}^{-1}\text{)}$ for using $3.5 \times 10^{-2} \text{ m}$
(b)	$F = \frac{Qq}{4\pi\epsilon_0 r^2}$ $\text{force} = \frac{4.0 \times 10^{-9} \times 5.0 \times 10^{-9}}{4\pi \times 8.85 \times 10^{-12} \times (3.5 \times 10^{-2})^2}$ force = $1.47 \times 10^{-4} \text{ (N)}$	C1  C1 A0	ignore signs Allow: $\epsilon_0$ in the equation
(c)	(weight =) $4.5 \times 10^{-5} \times 9.81$ or (weight =) $4.4(1) \times 10^{-4} \text{ (N)}$ $\tan \theta = \frac{1.5 \times 10^{-4}}{4.41 \times 10^{-4}}$ angle = $18.8 \text{ (}^\circ\text{)}$ or $19 \text{ (}^\circ\text{)}$  (Allow: Full credit when angle is determined using a scale diagram)	C1 C1 A1	Allow: weight = $4.5 \times 10^{-5} \times g$  Note: Using force = $1.47 \times 10^{-4} \text{ (N)}$ gives an angle of $18.4^\circ$ ; hence allow $18^\circ$ Allow: 2 marks for $\theta = 71^\circ$ ; this is the complementary angle Allow: 1 mark for ' $\tan \theta = \frac{1.5 \times 10^{-4}}{4.5 \times 10^{-5}}$ , $\theta = 73^\circ$ ' when mass is used instead of weight.
<b>Total</b>	<b>9</b>		

Answer **all** the questions.

- 1 Fig. 1.1 shows a close up of the two electrodes of a spark plug.

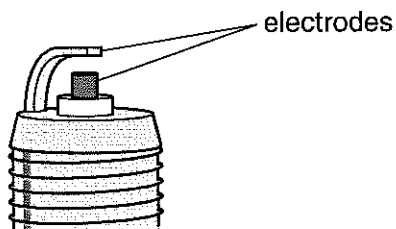


Fig. 1.1

The electrodes may be considered as two parallel plates. The electric field strength between the electrodes is almost uniform.

- (a) Define *electric field strength*.

.....  
 ..... [1]

- (b) The separation between the electrodes is 1.3 mm. An electric spark is produced when the electric field strength is  $3.0 \times 10^6 \text{ V m}^{-1}$ .

- (i) Estimate the potential difference  $V$  between the electrodes when the spark is produced.

$V = \dots\dots\dots \text{ V}$  [2]

3

(ii) The electric spark lasts for  $4.0 \times 10^{-2}$  s and produces an average current of  $2.7 \times 10^{-9}$  A.

1 Calculate the charge transferred between the electrodes.

charge = .....C [2]

2 Calculate the number of electrons transferred between the electrodes.

number = ..... [1]

(iii) Estimate the total energy transferred by the electrons in (ii).

energy = ..... J [2]

[Total: 8]

Question		Answers	Marks	Guidance
1	(a)	electric field strength = force per unit (positive) charge	B1	<b>Allow:</b> force/charge <b>Not:</b> $F/Q$
	(b) (i)	$E = V/d$ $3.0 \times 10^6 = V / 1.3 \times 10^{-3}$ $V = 3900 \text{ (V)}$	C1 A1	<b>Note:</b> This mark is for correct substitution <b>Allow:</b> 1 mark if answer is $3.9 \times 10^6 \text{ (V)}$ , $n \neq 3$ – POT error
	(ii)1	$Q = It$ $Q = 2.7 \times 10^{-9} \times 4.0 \times 10^{-2}$ charge = $1.1 \times 10^{-10} \text{ (C)}$ or $1.08 \times 10^{-10} \text{ (C)}$	C1 A1	<b>Note:</b> This mark is for correct substitution
	(ii)2	number = $1.08 \times 10^{-10} / 1.6 \times 10^{-19}$ number = $6.8 \times 10^8$ or $6.75 \times 10^8$	B1	Possible ecf from (b)(ii)1
	(iii)	energy = $VQ$ energy = $3900 \times 1.08 \times 10^{-10}$ energy = $4.2 \times 10^{-7} \text{ (J)}$	C1 A1	<b>Note:</b> No credit for using $\frac{1}{2} QV$ Possible ecf from (b)(ii)1
<b>Total</b>			<b>8</b>	



- 4 An alpha particle is fired at high speed directly towards a stationary nucleus of a gold atom. At its distance of closest approach to the gold nucleus, the alpha particle stops and the gold nucleus has a small velocity, see Fig. 4.1. The alpha particle and the gold nucleus both have positive charges.

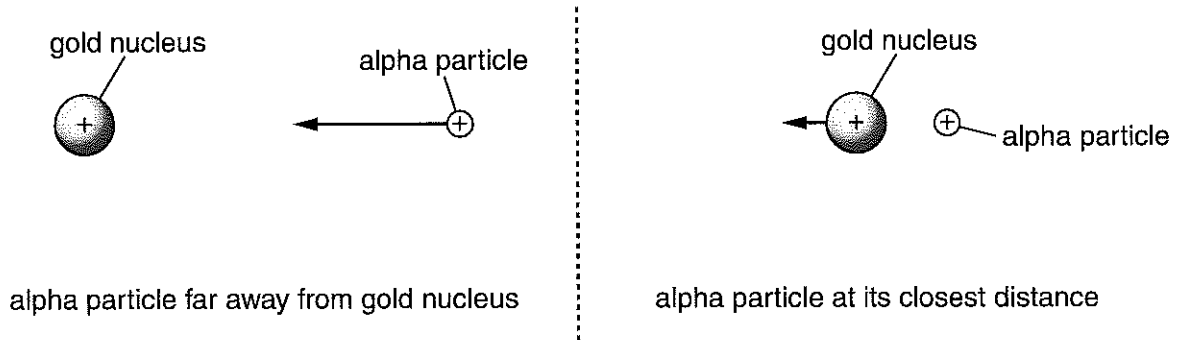


Fig. 4.1

- (a) Explain why, at this distance of closest approach, the gold nucleus has a velocity and the alpha particle does not.

.....

.....

.....

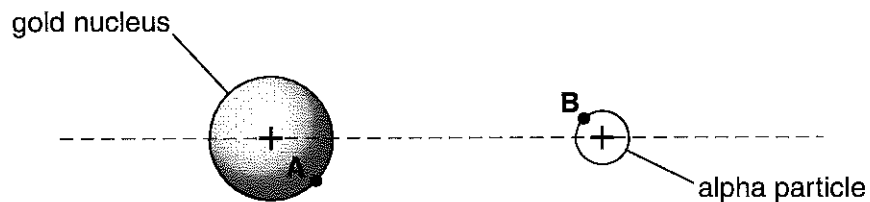
.....

.....

.....

[2]

- (b) Fig. 4.2, shows the alpha particle at its closest distance to the gold nucleus. Draw one electric field line from point A and one from point B. For each field line, show the direction of the field.



[2]

Fig. 4.2

- (c) Show that the electrical force experienced by the alpha particle at its closest distance of  $6.0 \times 10^{-14} \text{ m}$  to the gold nucleus is about 10 N. The gold nucleus has 79 protons and the alpha particle has 2 protons.

[3]

- (d) On Fig. 4.3, sketch a graph to show the variation of the electrical force  $F$  on the alpha particle with distance  $r$  from the centre of the gold nucleus. The value of  $F$  at the distance of closest approach has been marked on the graph.

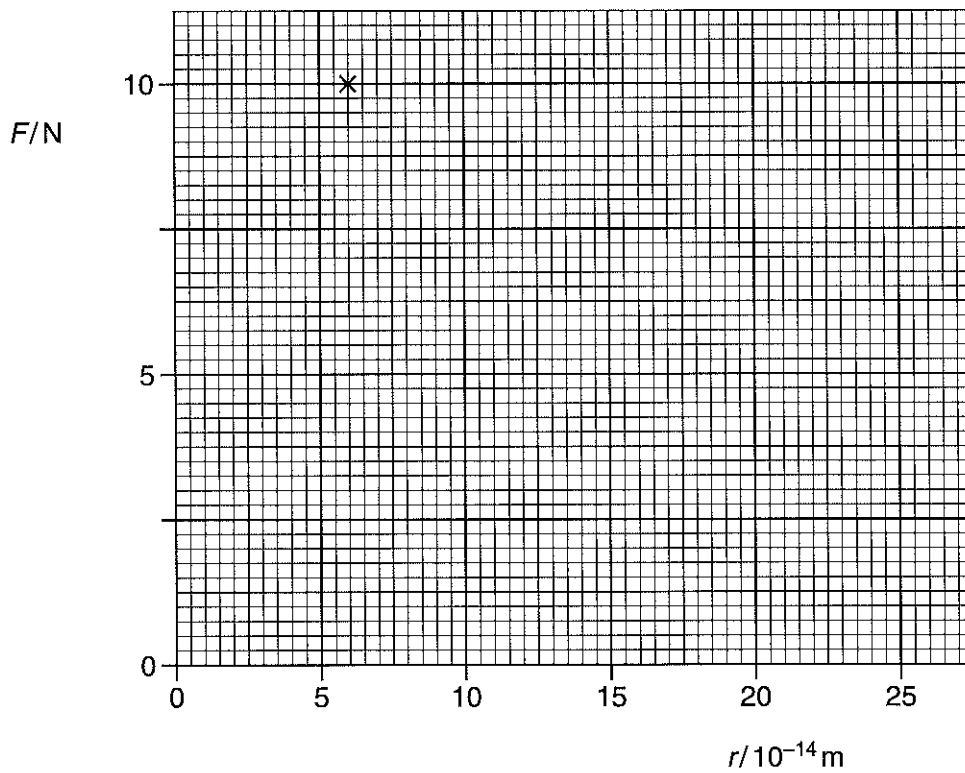


Fig. 4.3

[2]

[Total: 9]

Question	Answer	Marks	Guidance
4 (a)	Any <u>two</u> from: 1. There is a repulsive (electrical) force (between the gold nucleus and the alpha particle) 2. Momentum is conserved (because there are no external forces) / initial momentum of alpha particle = final momentum of gold nucleus (because there are no external forces) 3. KE of alpha particle transformed into (electrical) PE	B1×2	<b>Allow:</b> (The gold nucleus and alpha particle experience) forces in opposite directions
(b)	Correct directions of field shown on lines from <b>A</b> and <b>B</b>  Correct curved field lines from <b>A</b> and <b>B</b>	B1  B1	
(c)	$F = \frac{Qq}{4\pi\epsilon_0 r^2}$ $Q = 79e$ and $q = 2e$ $\text{force} = \frac{79 \times 2 \times (1.60 \times 10^{-19})^2}{4\pi \times 8.85 \times 10^{-12} \times (6.0 \times 10^{-14})^2}$ force = 10.1 (N)	C1  C1  C1  A0	<b>All values must be substituted for this mark</b>
(d)	Correctly shaped curve with $F$ decreasing as $r$ increases  Value of $F$ is between 2 to 3 (N) at $r = 12 \times 10^{-14}$ m	M1  A1	<b>Note:</b> $F \propto 1/r^2$ , hence $F$ should be about 2.5 (N)
	<b>Total</b>	<b>9</b>	

2 (a) Define *electric field strength* at a point in space.

.....  
 ..... [1]

(b) Fig. 2.1 shows an evenly spaced grid.

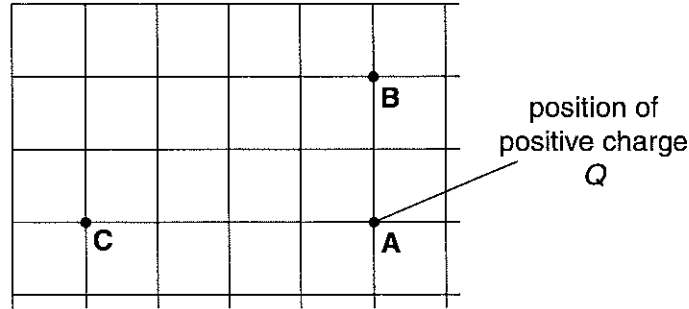


Fig. 2.1

**A**, **B** and **C** are points on the grid. A positive charge  $Q$  is placed on the grid at point **A**. The magnitude of the electric field strength at point **B** due to the charge  $Q$  is  $8.0 \times 10^5 \text{ NC}^{-1}$ .

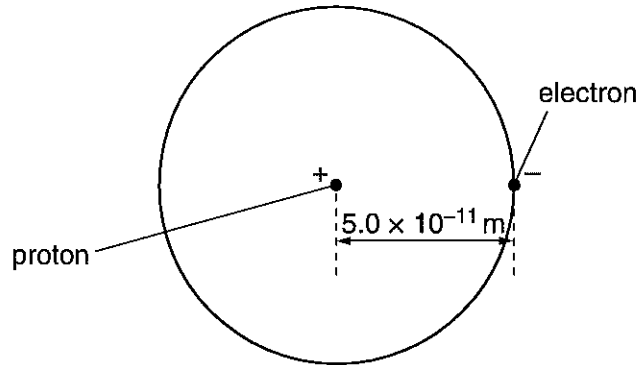
(i) Apart from the magnitudes of the electric field strength, state another difference between the electric field at points **B** and **C**.

.....  
 ..... [1]

(ii) Determine the magnitude of the electric field strength at point **C**.

electric field strength = .....  $\text{NC}^{-1}$  [2]

(c) The simplest atom is that of hydrogen with one proton and one electron, see Fig. 2.2.



**Fig. 2.2**

The mean separation between the proton and the electron is shown in Fig. 2.2.

(i) Calculate the magnitude of the electrical force  $F_E$  acting on the electron.

$$F_E = \dots\dots\dots \text{N} \quad [3]$$

(ii) The gravitational force  $F_G$  acting on the electron due to the proton is very small compared with the electrical force  $F_E$  it experiences.

Calculate the ratio  $\frac{F_E}{F_G}$ .

$$\text{ratio} = \dots\dots\dots [2]$$

- (iii) A simplified model of the hydrogen atom suggests that the de Broglie wavelength of the electron is four times the mean separation between the proton and the electron shown in Fig. 2.2.

Estimate

- 1 the momentum  $p$  of the electron

$$p = \dots\dots\dots \text{kgms}^{-1} \quad [3]$$

- 2 the kinetic energy  $E_k$  of the electron.

$$E_k = \dots\dots\dots \text{J} \quad [3]$$

**[Total: 15]**

Question		Answer	Marks	Guidance
2	(a)	force per unit (positive) charge	B1	<b>Allow:</b> $E = \frac{F}{Q}$ , where $F$ = force on (a positive) charge $Q$
	(b) (i)	The direction is different (AW)	B1	
	(ii)	$E \propto 1/r^2$ or distance is doubled $\therefore E$ decreases by a factor of 4 electric field strength = $2.0 \times 10^5$ (N C <sup>-1</sup> )	C1 A1	<b>Not:</b> $E = \frac{Q}{4\pi\epsilon_0 r^2}$ on its own <b>Allow 1 sf answer</b>
	(c) (i)	$F = \frac{Qq}{4\pi\epsilon_0 r^2}$ $F_E = \frac{1.6 \times 10^{-19} \times 1.6 \times 10^{-19}}{4\pi\epsilon_0 \times (5.0 \times 10^{-11})^2}$ $F_E = 9.2 \times 10^8$ (N)	C1 C1 A1	<b>Allow: 1 mark if <math>Q = q = 1</math> giving an answer of <math>3.6 \times 10^{30}</math> (N)</b>
	(ii)	$F_G = \frac{6.67 \times 10^{-11} \times 1.67 \times 10^{-27} \times 9.11 \times 10^{-31}}{(5.0 \times 10^{-11})^2}$ $F_G = 4.06 \times 10^{47}$ (N) ratio = $9.2 \times 10^8 / 4.06 \times 10^{47}$ ratio = $2.3 \times 10^{39}$	C1 A1	<b>Note:</b> Deduct 1 mark if mass of two electrons or two protons is used, then ecf  Possible ecf from (c)(i)
	(iii)1	wavelength = $2.0 \times 10^{-10}$ (m) $\lambda = h / mv$ $p = \frac{6.63 \times 10^{-34}}{2.0 \times 10^{-10}}$ $p = 3.3 \times 10^{-24}$ (kg m s <sup>-1</sup> )	C1 C1 A1	Possible ecf for incorrect wavelength <b>Note:</b> Answer to 3 sf is $3.32 \times 10^{-24}$ (kg m s <sup>-1</sup> ) <b>Allow: 1 sf answer</b>

Question	Answer	Marks	Guidance
	<p>(iii)2</p> $v = \frac{3.32 \times 10^{-24}}{9.11 \times 10^{-31}} (= 3.64 \times 10^6 \text{ m s}^{-1})$ $E_k = \frac{1}{2} \times 9.11 \times 10^{-31} \times (3.64 \times 10^6)^2$ $E_k = 6.0 \times 10^{-18} \text{ (J)}$ <p>or</p> $E_k = \frac{1}{2} p^2/m$ $E_k = \frac{1}{2} \times (3.32 \times 10^{-24})^2 / 9.11 \times 10^{-31}$ $E_k = 6.0 \times 10^{-18} \text{ (J)}$	<p>C1</p> <p>C1</p> <p>A1</p> <p>C1</p> <p>C1</p> <p>A1</p>	<p>Possible ecf from (iii)1</p> <p><b>Note:</b> Deduct 1 mark if mass of proton is used, then ecf</p> <p><b>Note:</b> Answer to 3 sf is <math>6.05 \times 10^{-18}</math> (J) <b>Allow:</b> 1 sf answer</p> <p><b>Note:</b> Deduct 1 mark if mass of proton is used, then ecf</p>
	<b>Total</b>	<b>15</b>	



- 2 Fig. 2.1 shows two identical negatively charged conducting spheres.

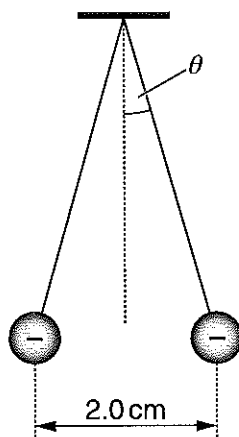


Fig. 2.1

The spheres are tiny and each is suspended from a nylon thread. Each sphere has mass  $6.5 \times 10^{-5} \text{ kg}$  and charge  $-2.8 \times 10^{-9} \text{ C}$ . 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  $\theta$  made by each thread with the vertical.

$\theta = \dots\dots\dots^\circ$  [3]

[Total: 7]

Question	Answer	Marks	Guidance
2 (a)	number = $\frac{2.8 \times 10^{-9}}{1.6 \times 10^{-19}}$ number = $1.75 \times 10^{10}$ or $1.8 \times 10^{10}$	B1	Ignore a negative sign
(b)	$F = \frac{Qq}{4\pi\epsilon_0 r^2}$ $F = \frac{2.8 \times 10^{-9} \times 2.8 \times 10^{-9}}{4\pi \times 8.85 \times 10^{-12} \times (2.0 \times 10^{-2})^2}$ force = $1.76 \times 10^{-4}$ (N) or $1.8 \times 10^{-4}$ (N)	C1 A1	<b>Note:</b> No credit for using charge equal to $e$
(c) (i)	Tension <u>and</u> weight	B1	<b>Allow:</b> force provided by the <u>string</u> / force in the <u>string</u> instead of tension <b>Not:</b> 'gravity' for weight <b>Allow:</b> force due to gravity <b>Allow:</b> gravitational (force)
(ii)	(weight =) $6.5 \times 10^{-5} \times g$ $\tan\theta = 1.76 \times 10^{-4} / 6.38 \times 10^{-4}$ $\theta = 15^\circ$ Or Scale drawing of triangle of force $\theta$ in the range $13^\circ$ to $18^\circ$ $\theta$ in the range $14^\circ$ to $16^\circ$	C1 C1 A1  C1 A1 A1	Deduct 1 mark for the use of $10$ ( $\text{m s}^{-2}$ ) followed by ecf <b>Note</b> that getting to this stage scores both C1 marks Possible ecf from (b) <b>Note:</b> No marks if mass is used instead of the weight
<b>Total</b>		<b>7</b>	

Answer all the questions.

- 1 (a) Fig. 1.1 shows a negatively charged metal sphere close to a positively charged metal plate.

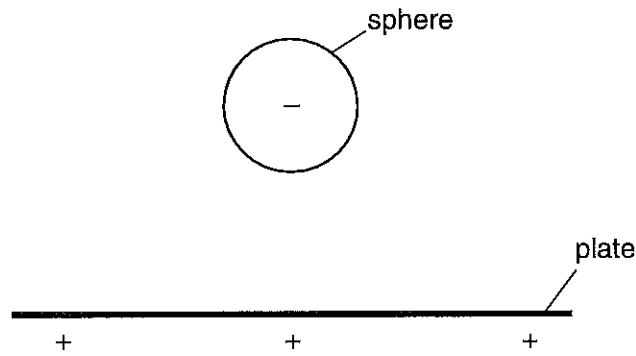


Fig. 1.1

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.

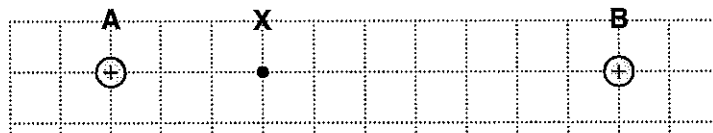


Fig. 1.2

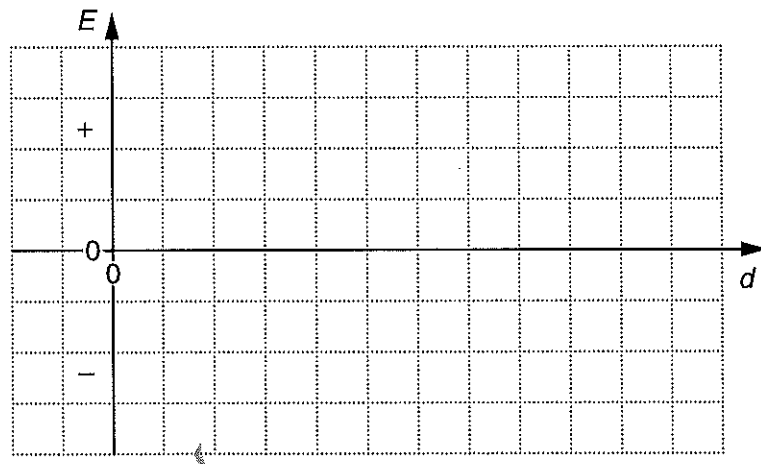


Fig. 1.3

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]

Question		Answers	Marks	Guidance
1	(a)	Correct direction of the electric field.	B1	
		A minimum of 5 field lines shown. Correct shape of field lines.	B1	Expect a minimum of 3 field lines to be normal (by eye) to the plate - ignore the angles made by the field lines at the sphere. Also there must not be any field lines within the sphere.
	(b) (i)	$(E \propto Q/r^2$ and the magnitude of $E$ is the same due to each charge <b>A</b> and <b>B</b> at <b>X</b> . Therefore) <b>B</b> has a greater charge because <b>X</b> is further away from <b>B</b> .	B1	
	(ii)	Curve showing $E = 0$ at position of <b>X</b> .	B1	Allow any graph, including a straight line. Tolerance for $E = 0$ : $\pm \frac{1}{2}$ large square about <b>X</b> .
		Curve showing $E$ is positive between <b>A</b> and <b>X</b> and negative between <b>X</b> and <b>B</b> (or vice versa).	M1	Note: The curve must be continuous and pass through position of <b>X</b> . Ignore any curve to the right of <b>B</b> and to the left of <b>A</b> .
		The magnitude of $E$ is small close to <b>A</b> and large close to <b>B</b> .	A1	Note: This mark can only be scored if the previous M1 has been awarded.
	(c)	Both $E$ and $g$ vary with $1/\text{distance}^2$ .  (Hence the ratio is independent of the distance.)	B1	Allow: $E = \frac{Q}{4\pi\epsilon_0 r^2}$ and $g = \frac{GM}{r^2}$ or $E \propto \frac{1}{r^2}$ and $g \propto \frac{1}{r^2}$ Allow 'both are inverse square laws'.
<b>Total</b>			<b>7</b>	

Answer **all** the questions.

- 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 .....

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

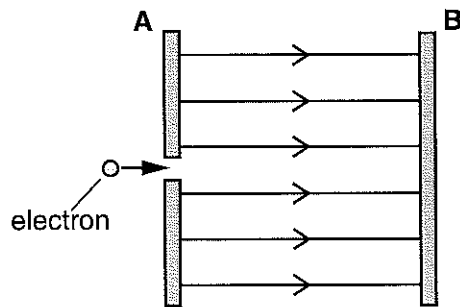


Fig. 1.1

The potential difference between the plates is 6V. An electron of kinetic energy 4 eV 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.

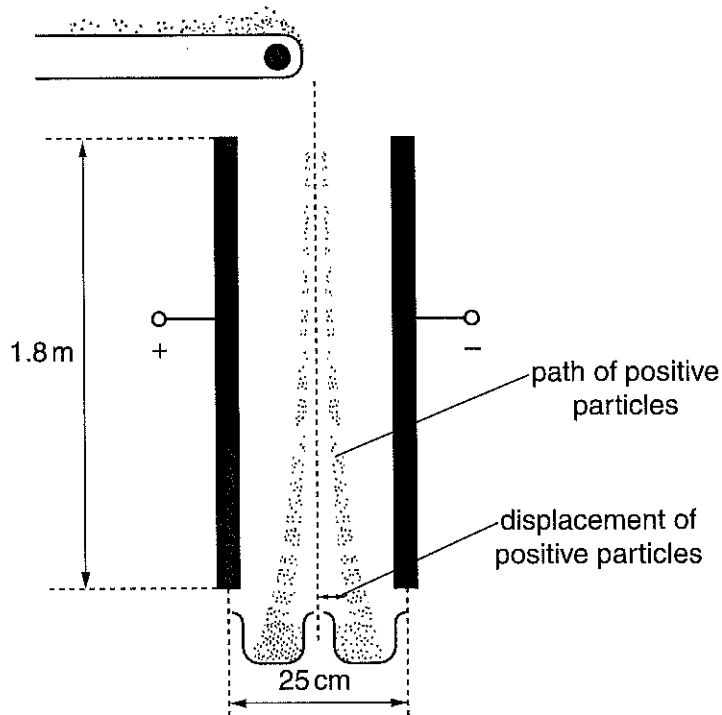


Fig. 1.2

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  $1.2 \text{ m s}^{-1}$ . Each mineral particle has a charge of magnitude  $1.5 \times 10^{-13} \text{ C}$  and a mass of  $8.0 \times 10^{-7} \text{ kg}$ .

- (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 1.8m fall through the electric field of the plates. Ignore any horizontal drag forces due to air.

displacement = ..... m [3]



Question	Answer	Marks	Guidance
	(ii) $t = 1.8/1.2 (= 1.5 \text{ s})$ or $a = \frac{3.6 \times 10^{-8}}{8.0 \times 10^{-7}} (= 4.5 \times 10^{-2} \text{ m s}^{-2})$ $(s = ut + \frac{1}{2}at^2 \text{ and } u = 0)$ $s = \frac{1}{2} \times 4.5 \times 10^{-2} \times 1.5^2$ displacement = $5.1 \times 10^{-2} \text{ (m)}$	C1  C1  A1	Possible ecf from (d)(i)  <b>Note:</b> No ecf within calculation if $t \neq 1.8/1.2$  <b>Note:</b> Answer to 3 sf is $5.06 \times 10^{-2} \text{ (m)}$
	<b>Total</b>	<b>11</b>	