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

Workdone per unit positive charge to move it from infinity to a point within the electric field.

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

**(b)** Two positively charged metal spheres A and B are situated in a vacuum, as shown in Fig. 5.1.

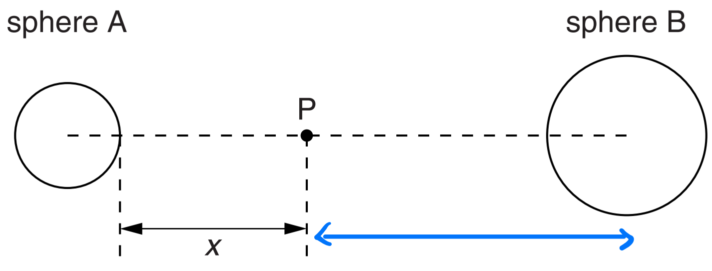



**Fig. 5.1**

A point P lies on the line joining the centres of the two spheres and is a distance $x$ from the surface of sphere A.

The variation with $x$ of the electric potential $V$ due to the two charged spheres is shown in Fig. 5.2.

$E \rightarrow F$

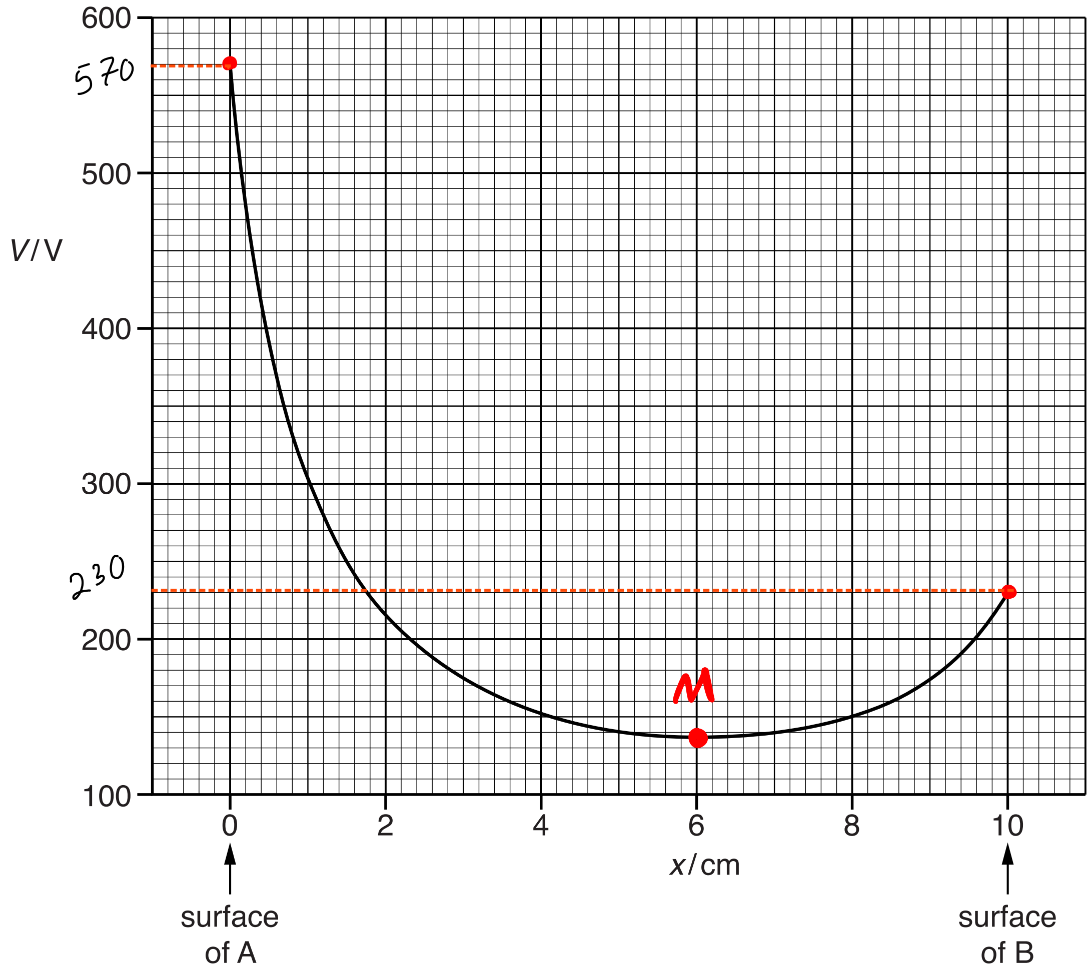



**Fig. 5.2**

**(i)** State how the magnitude of the electric field strength at any point P may be determined from the graph of Fig. 5.2.

By Finding out the gradient of the graph.

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

**(ii)** Without any calculation, describe the force acting on a positively charged particle placed at point P for values of $x$ from $x = 0$ to $x = 10$ cm.

Force is directly proportional to Electric Field Strength

Force is maximum at x = 0. It decreases to Zero at x = 6 cm. It

increases again but in opposite direction. from x = 6 cm to x = 10 cm.

.......................................................................................................................[3]

**(c)** The positively charged particle in **(b)(ii)** has charge $q$ and mass $m$ given by the expression

$$\frac{q}{m} = 4.8 \times 10^{7}\,\mathrm{C\,kg^{-1}}.$$

Initially, the particle is at rest on the surface of sphere A where $x = 0$. It then moves freely along the line joining the centres of the spheres until it reaches the surface of sphere B.

**(i)** On Fig. 5.2, mark with the letter M the point where the charged particle has its maximum speed. [1]

**(ii)** **1.** Use Fig. 5.2 to determine the potential difference between the spheres.

$570 - 230$

potential difference = ............340............ V [1]

**2.** Use your answer in **(ii) part 1** to calculate the speed of the particle as it reaches the surface of sphere B.
Explain your working.

Loss of E.P.E = Gain in K.E

$$\Delta V \times q = \frac{1}{2} \times m \times \left(V^2 - u^2\right)$$

$$340 \times \frac{q}{m} \times 2 = v^2 - u^2$$

speed = ............$1.8 \times 10^5$............ m s$^{-1}$ [3]

$$340 \times 4 \cdot 8 \times 10^7 \times 2 = V^2 - 0^2$$

$$V^2 = 3.264 \times 10^{10}$$

$$V = 1.8 \times 10^5$$

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

It is the Workdone per unit positive charge in moving it from infinity to a point within the electric field. [2]

**(b)** A charged particle is accelerated from rest in a vacuum through a potential difference *V*. Show that the final speed *v* of the particle is given by the expression

$$v = \sqrt{\left(\frac{2Vq}{m}\right)}$$

where $\frac{q}{m}$ is the ratio of the charge to the mass (the specific charge) of the particle.

Loss of E.P.E = Gain in K.E

$$V \times q = \frac{1}{2}m\left(v^2 - u^2\right)$$

$$V \times q = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2Vq}{m}}$$

[2]

**(c)** A particle with specific charge $+9.58 \times 10^7\,\mathrm{C\,kg^{-1}}$ is moving in a vacuum towards a fixed metal sphere, as illustrated in Fig. 4.1.


**Fig. 4.1**

$\infty$

The initial speed of the particle is $2.5 \times 10^5\,\mathrm{m\,s^{-1}}$ when it is a long distance from the sphere.
The sphere is positively charged and has a potential of +470 V.

Use the expression in **(b)** to determine whether the particle will reach the surface of the sphere.

$$v = \sqrt{\frac{2Vq}{m}}$$

$$V = \sqrt{2 \times 470 \times 9 \cdot 58 \times 10^7}$$

$$V = 3.0 \times 10^5 ms^{-1}$$

As particle is travelling slower, $(2 \times 10^5 ms^{-1})$

IT WILL NOT REACH THE SURFACE!

[3]




For Examiner's Use

**5** Two small solid metal spheres A and B have equal radii and are in a vacuum. Their centres are 15 cm apart.
Sphere A has charge +3.0 pC and sphere B has charge +12 pC. The arrangement is illustrated in Fig. 5.1.

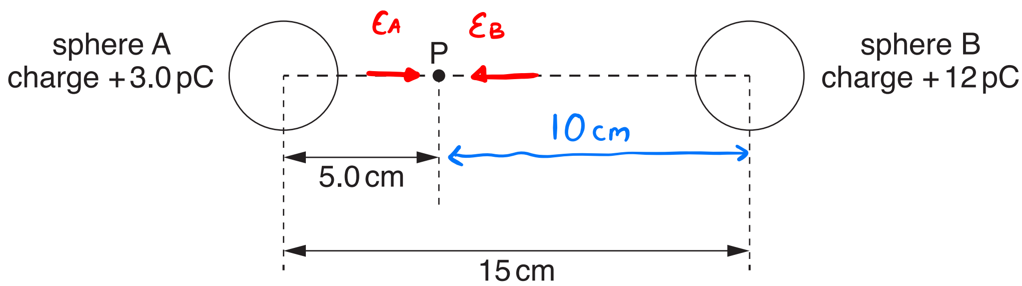



**Fig. 5.1**

Point P lies on the line joining the centres of the spheres and is a distance of 5.0 cm from the centre of sphere A.

**(a)** Suggest why the electric field strength in both spheres is zero.

Metal Spheres are treated as point charges therefore their charge can be considered to be both at surface as well as the center.

[2]

**(b)** Show that the electric field strength is zero at point P. Explain your working.

$$E = EA - EB$$ → Field Lines are opposite to one another.

$$= \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_A}{r_A^2} - \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_B}{r_B^2}$$

$$= \frac{1}{4\pi\varepsilon_0} \left\{ \frac{3 \times 10^{-12}}{(0.05)^2} - \frac{12 \times 10^{-12}}{(0.10)^2} \right\}$$

$$E = 0$$

[3]

**(c)** Calculate the electric potential at point P.

$$V = V_A + V_B$$ → Both Positive Charges.

$$= \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_A}{r_A} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_B}{r_B}$$

$$= \frac{1}{4\pi\varepsilon_0} \left[ \frac{3 \times 10^{-12}}{0.05} + \frac{12 \times 10^{-12}}{0.1} \right]$$

electric potential = 1.6 V [2]



$$V = 1.6182$$

$q_s = 47e$

$m_s = 107u$



$\infty, V = 0$

**(d)** A silver-107 nucleus ($^{107}_{47}Ag$) has speed $v$ when it is a long distance from point P.

Use your answer in **(c)** to calculate the minimum value of speed $v$ such that the nucleus can reach point P.

Loss in K.E = Gain in E.P.E

$$-\frac{1}{2}m\left(V^2 - u^2\right) = \Delta V \times q$$

$V_f - V_i$

$$-\frac{1}{2}\left(107 \times 1 \cdot 66 \times 10^{-27}\right)\left(0 - u^2\right) = (1.6182 - 0) \times \left(47 \times 1 \cdot 6 \times 10^{-19}\right)$$

speed = 12000 m $s^{-1}$ [3]

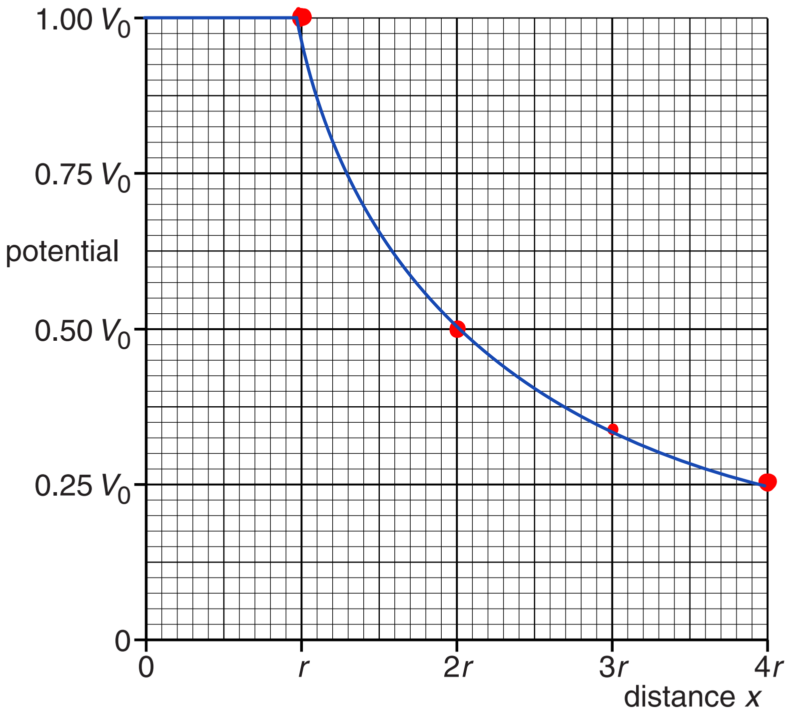
[Total: 10]

**5** An isolated solid metal sphere of radius $r$ is given a positive charge. The distance from the centre of the sphere is $x$.

**(a)** The electric potential at the surface of the sphere is $V_0$.

On the axes of Fig. 5.1, sketch a graph to show the variation with distance $x$ of the electric potential due to the charged sphere, for values of $x$ from $x = 0$ to $x = 4r$.

$$V \alpha \frac{1}{r}$$




$r, V_0$

$2r, 0.5V_0$

$3r, 0.33V_0$

$4r, 0.25V_0$

**Fig. 5.1**

[3]

**(b)** The electric field strength at the surface of the sphere is $E_0$.

On the axes of Fig. 5.2, sketch a graph to show the variation with distance $x$ of the electric field strength due to the charged sphere, for values of $x$ from $x = 0$ to $x = 4r$.

$$E \propto \frac{1}{r^2}$$

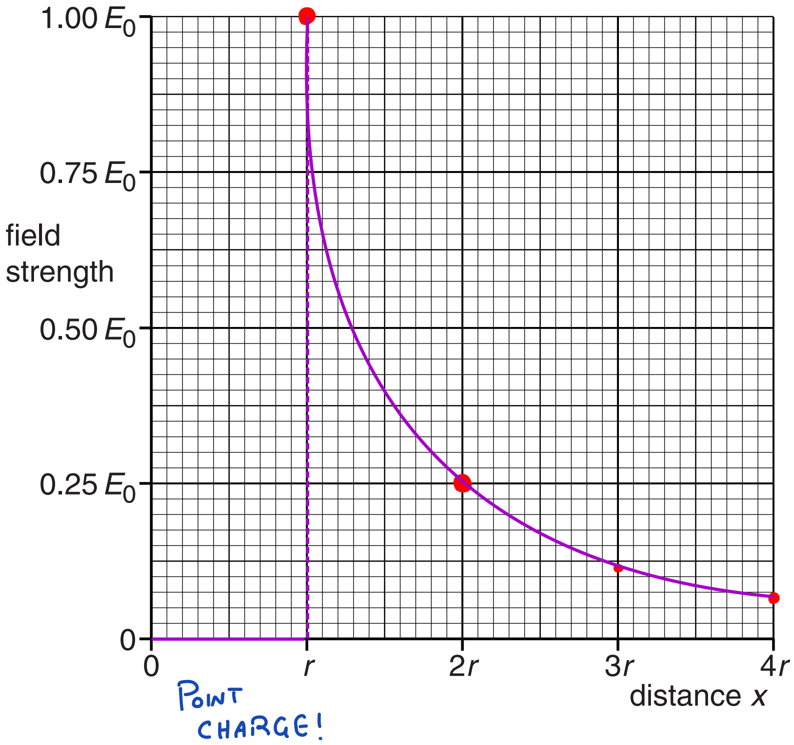



Fig. 5.2

$r, E_0$

$2r, 0.25E_0$

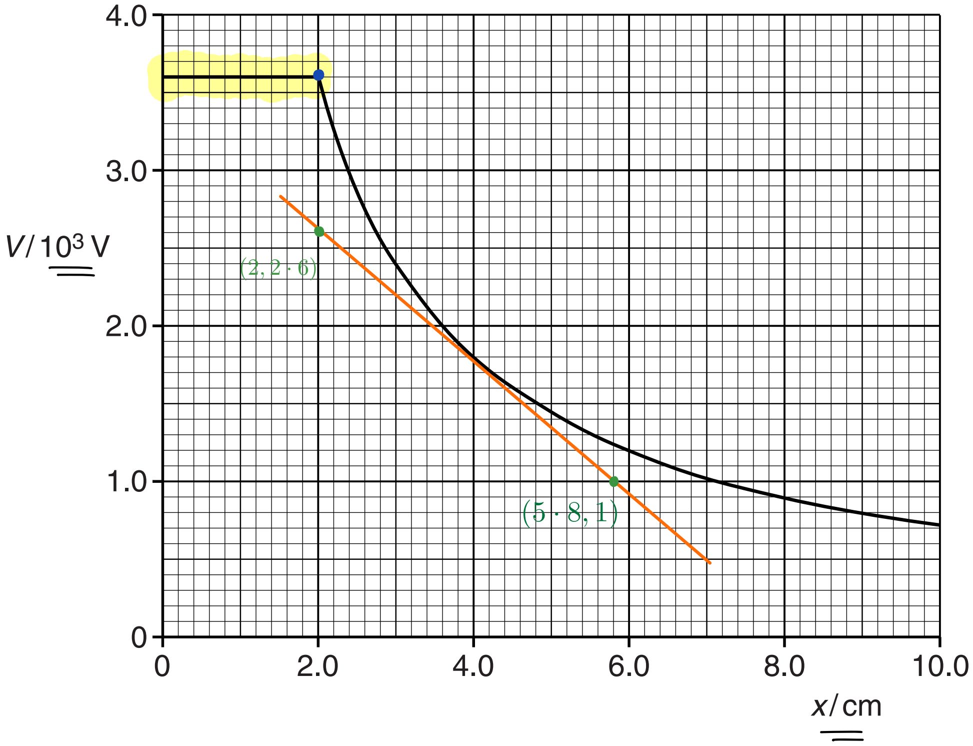
$3r, 0.11E_0$

$4r, 0.0625E_0$

[3]

**5** A charged metal sphere is isolated in space. Measurements of the electric potential $V$ are made for different distances $x$ from the centre of the sphere.

The variation with distance $x$ of the potential $V$ is shown in Fig. 5.1.




$$m = \frac{\Delta V}{\Delta r} = E$$

**Fig. 5.1**

**(a)** Use Fig. 5.1 to determine the electric field strength, in $N C^{-1}$, at a point where $x = 4.0$ cm. Explain your working.

$$M = \frac{(2 \cdot 6 - 1) \times 10^3}{(2 - 5 \cdot 8) \times 10^{-2}} = -4.21 \times 10^4$$

electric field strength = $-4.21 \times 10^4$ $N C^{-1}$ [3]

**(b)** The charge on the sphere is $8.0 \times 10^{-9}$ C.

**(i)** Use Fig. 5.1 to state the electric potential at the surface of the sphere.

potential = $3.6 \times 10^3$ V [1]

**(ii)** The sphere acts as a capacitor. Determine the capacitance of the sphere.

$$C = 4\pi\varepsilon_0 r$$

capacitance = .................................................... F [2]

6 Two solid metal spheres A and B, each of radius 1.5 cm, are situated in a vacuum. Their centres are separated by a distance of 20.0 cm, as shown in Fig. 6.1.

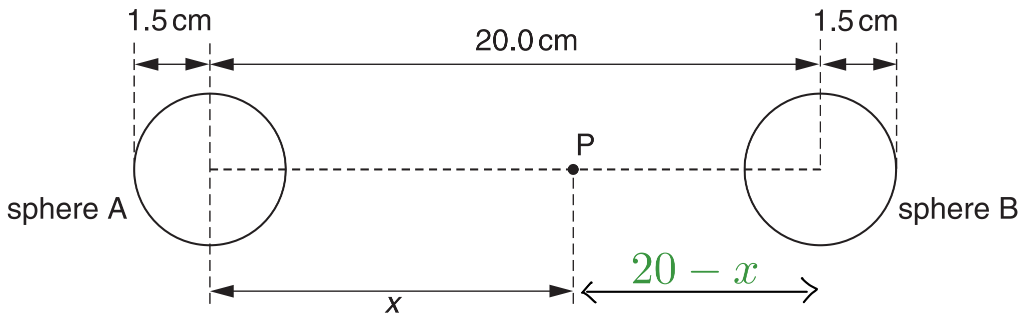



**Fig. 6.1** (not to scale)

Both spheres are positively charged.

Point P lies on the line joining the centres of the two spheres, at a distance *x* from the centre of sphere A.

The variation with distance *x* of the electric field strength *E* at point P is shown in Fig. 6.2.

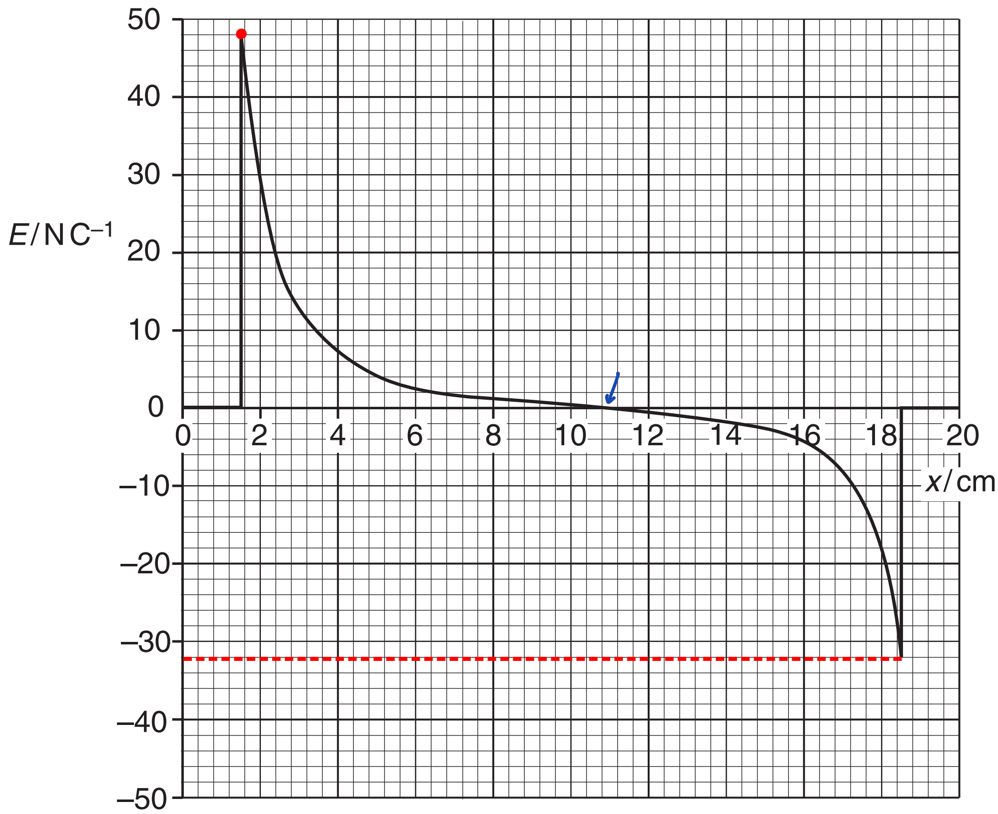



**Fig. 6.2**

**(a)** Use Fig. 6.2 to determine the ratio

$$\frac{\text{magnitude of charge on sphere A}}{\text{magnitude of charge on sphere B}}.$$

Explain your working.

$$\gamma_A = \gamma_B = 1 \cdot 5cm$$

$$\frac{E_A}{E_B} = \frac{\cancel{\frac{1}{4\pi\varepsilon_0}} \cdot \frac{q_A}{\cancel{r_A^2}}}{\cancel{\frac{1}{4\pi\varepsilon_0}} \cdot \frac{q_B}{\cancel{r_B^2}}} = \frac{q_A}{q_B} = \frac{48}{32}$$

ratio = ............1.5............ [3]

**(b)** The variation with distance *x* of the electric potential *V* at point P is shown in Fig. 6.3.

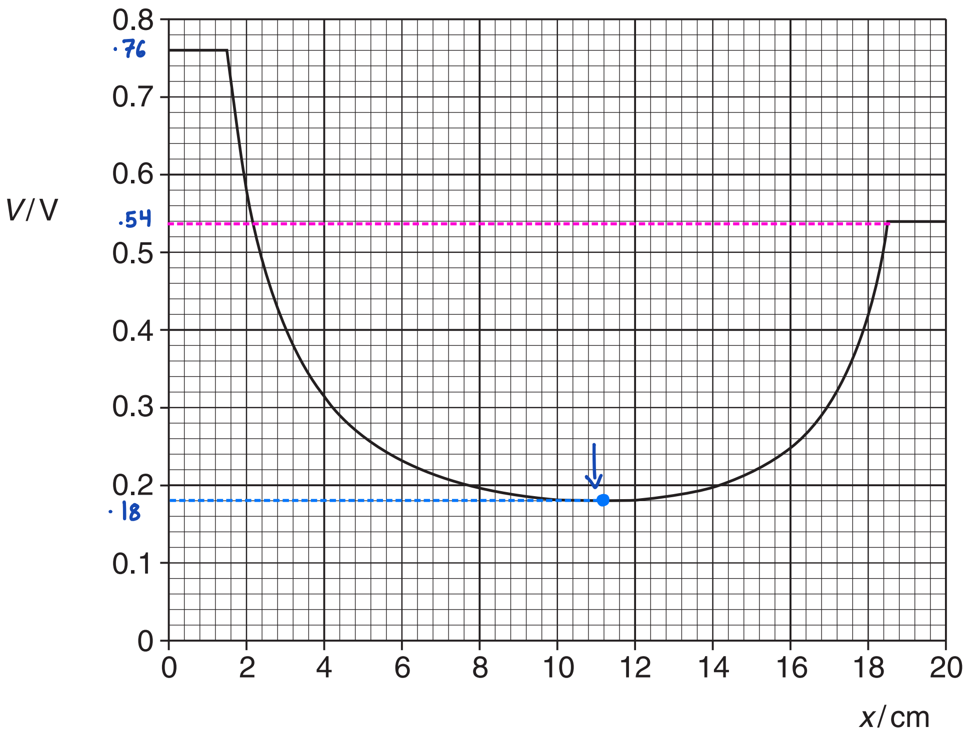



**Fig. 6.3**

An α-particle is initially at rest on the surface of sphere A.
The α-particle moves along the line joining the centres of the two spheres.

Determine, for the α-particle as it moves between the two spheres,

**(i)** its maximum speed,

Loss in E.P.E = Gain in K.E

$$q\alpha \Rightarrow +2\left(1.6 \times 10^{-19}\right) c$$

$$m\alpha \Rightarrow 4u = \left(4 \times 1.66 \times 10^{-27}\right) kg$$

$$-\Delta V \times q = \frac{1}{2} m \left(V^2 - u^2\right)$$

$$-\left(-0 \cdot 18 - 0.76\right) \times \left(2 \times 1 \cdot 6 \times 10^{-19}\right) = \frac{1}{2}\left(4 \times 1.66 \times 10^{-27}\right)\left(v^2 - 0^2\right)$$

$$V^2 = 5.6 \times 10^7 ms^{-1}$$

maximum speed = $7.5 \times 10^3$ m s$^{-1}$ [3]

**(ii)** its speed on reaching the surface of sphere B.

Loss in E.P.E = Gain in K.E

$$-\Delta V \times q = \frac{1}{2} m \left(V^2 - u^2\right)$$

$$-\left(0.54 - 0 \cdot 76\right) \times \left(2 \times 1 \cdot 6 \times 10^{-19}\right) = \frac{1}{2}\left(4 \times 1 \cdot 66 \times 10^{-27}\right)\left(V^2 - 0^2\right)$$

speed = $4 \cdot 6 \times 10^3$ m s$^{-1}$ [2]

[Total: 8]

$$V^2 = 2.12 \times 10^7 ms^{-1}$$

$$V = 4.6 \times 10^3 \ ms^{-1}$$

**4 (a)** State what is represented by an electric field line.

It shows the direction of the electric force acting on a positive test charge. [2]

**(b)** Two point charges P and Q are placed 0.120 m apart as shown in Fig. 4.1.

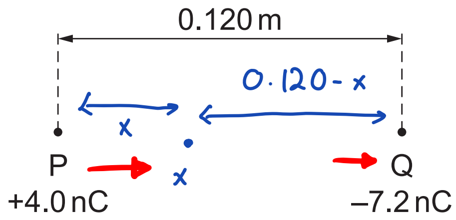



**Fig. 4.1**

**(i)** The charge of P is +4.0 nC and the charge of Q is –7.2 nC.

Determine the distance from P of the point on the line joining the two charges where the electric potential is zero.

$$V = \frac{kQ}{r}$$

$$V_x = V_P + V_Q$$

$$\frac{\cancel{(9\times10^{9})}(4\times\cancel{10^{-9}})}{x} + \frac{\cancel{(9\times10^{9})}(-7.2\times\cancel{10^{-9}})}{0.12 - x} = 0$$

$$\frac{4}{x} = \frac{7.2}{0.12 - x}$$

$$0.48 - 4x = 7.2x$$

$$x = 0.48/11.2$$

distance = 0.043 m [2]

**(ii)** State and explain, without calculation, whether the electric field strength is zero at the same point at which the electric potential is zero.

NO! The Electric field strength will never be zero here because both P and Q apply electric force in the same direction. [1]

**(iii)** An electron is positioned at point X, equidistant from both P and Q, as shown in Fig. 4.2.

$$F \propto \frac{q_1 q_2}{r^2}$$

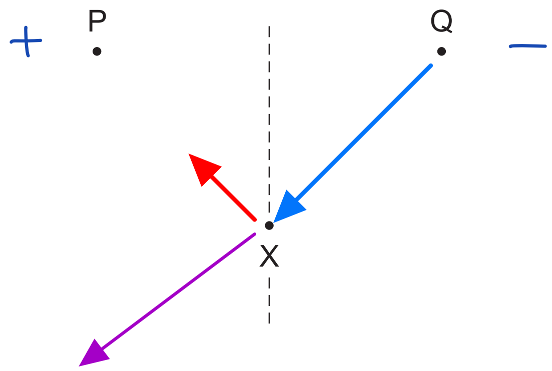



**Fig. 4.2**

On Fig. 4.2, draw an arrow to represent the direction of the resultant force acting on the electron. [1]

[Total: 6]

5 (a) (i) State what is meant by a *field of force*.

It is a region where a particle experiences a force.

[2]

(ii) State **one** similarity and **one** difference between the electric field due to a point charge and the gravitational field due to a point mass.

similarity: Both vary inversely with the square of seperation between there particle's centres.

difference: Gravitational field is always towards the mass whereas the electric field can be towards or away from the charge.

[2]

(b) An isolated solid metal sphere of radius 0.15 m is situated in a vacuum, as illustrated in Fig. 5.1.

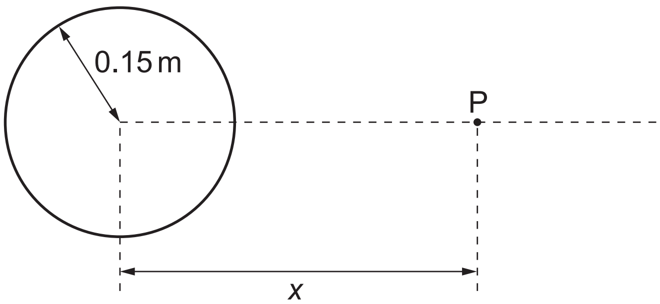



**Fig. 5.1**

The electric field strength at the surface of the sphere is 84 V m$^{-1}$.

Determine:

(i) the charge $Q$ on the sphere

$$E = \frac{KQ\cancel{q}}{r^2} = \frac{kQ}{r^2}$$

$$E = \frac{F}{q}$$

$$84 = \frac{9 \times 10^{9} \times Q}{0.15^2}$$

Q = 2.1 × 10$^{-10}$ C [2]

**(ii)** the electric field strength at point P, a distance $x$ = 0.45 m from the centre of the sphere.

$$E = \frac{KQ}{r^2} = \frac{(9\times10^{9})(2.1\times10^{-10})}{(0.45)^2}$$

electric field strength = 9.3 V m$^{-1}$ [2]

**(c)** Use information from **(b)** to show, on the axes of Fig. 5.2, the variation of the electric field strength $E$ with distance $x$ from the centre of the sphere for values of $x$ from $x$ = 0 to $x$ = 0.45 m.

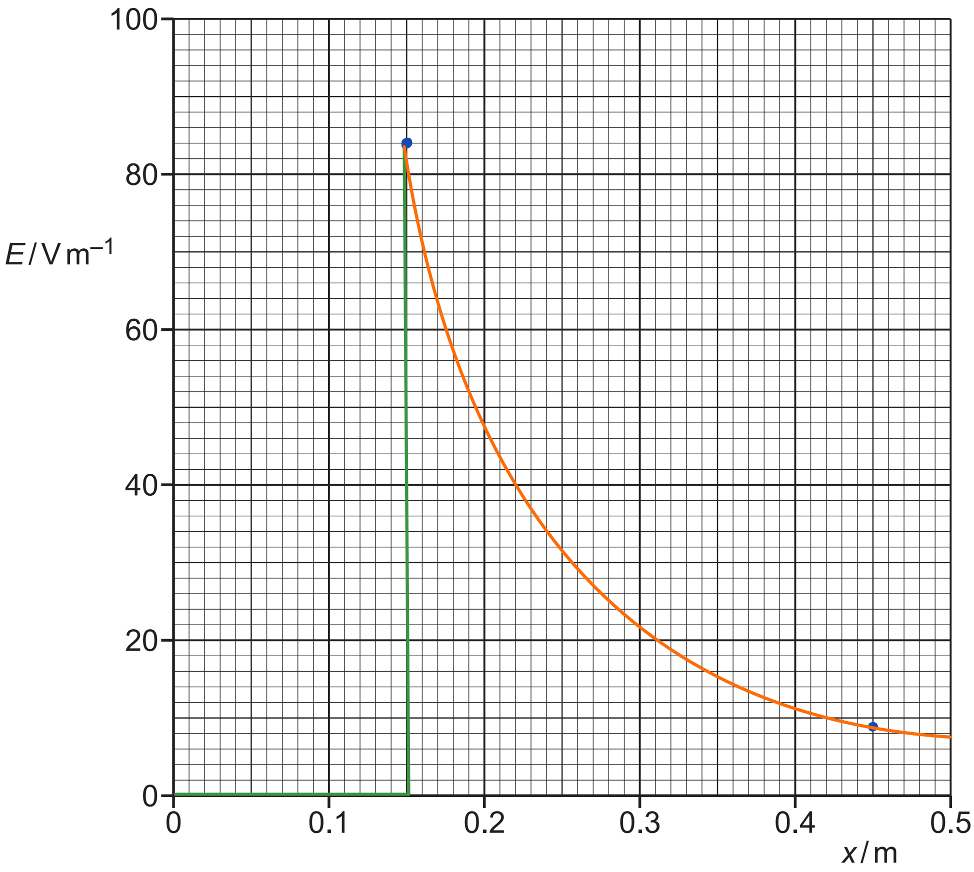



**Fig. 5.2**

[3]

[Total: 11]

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

It is the amount of workdone in moving a unit positive charge from infinity to a point within the electric field. [2]

**(b)** Two point charges A and B are separated by a distance of 12.0 cm in a vacuum, as illustrated in Fig. 5.1.

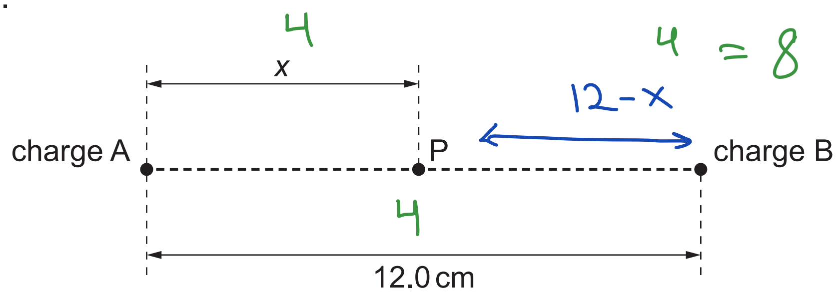



**Fig. 5.1**

The charge of A is $+2.0 \times 10^{-9}$ C.

A point P lies on the line joining charges A and B. Its distance from charge A is *x*.

The variation with distance *x* of the electric potential *V* at point P is shown in Fig. 5.2.

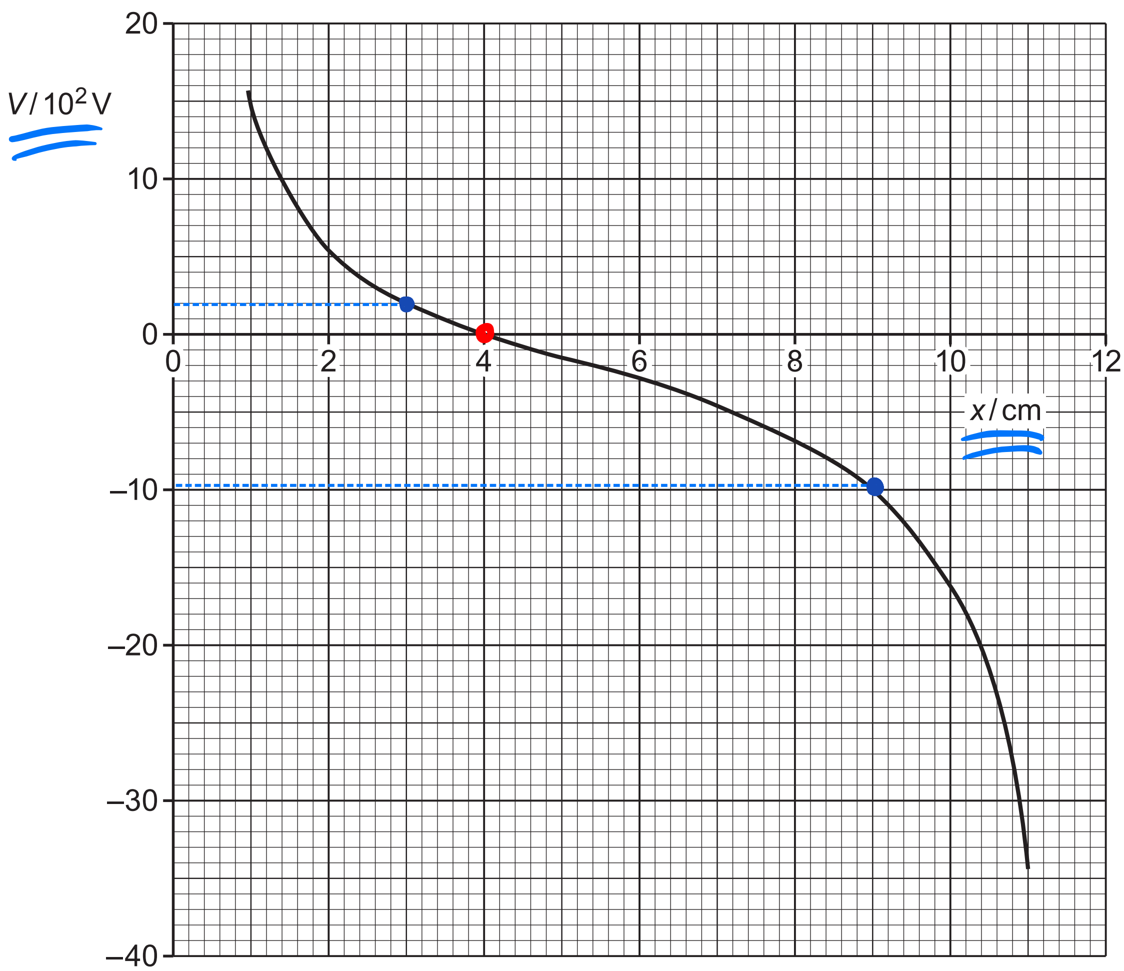



**Fig. 5.2**

$$\frac{(9\times10^{9})(-2\times10^{-9})}{(4\times10^{-2})} + \frac{(9\times10^{9})(Q_B)}{(8\times10^{-2})} = 0$$

Use Fig. 5.2 to determine:

**(i)** the charge of B

$$V_{4cm} = 0 = V_A + V_B$$

$$0 = \frac{KQ_A}{r_A} + \frac{KQ_B}{r_B}$$

$$\frac{(\cancel{9\times10^{9}})(-2\times10^{-9})}{(4\times\cancel{10^{-2}})} = \frac{(\cancel{9\times10^{9}})(Q_B)}{(8\times\cancel{10^{-2}})}$$

$$\frac{(8)(-2\times10^{-9})}{4} = Q_B$$

charge = $-4\times10^{-9}$ C [3]

**(ii)** the change in electric potential when point P moves from the position where $x$ = 9.0 cm to the position where $x$ = 3.0 cm.

$$\Delta V = V_{3cm} - V_{9cm}$$

$$= 2\times10^{-2} - (-10\times10^{2})$$

change = 200 V [1]

$m = 4u \quad q = 2e$

**(c)** An $\alpha$-particle moves along the line joining point charges A and B in Fig. 5.1.

The $\alpha$-particle moves from the position where $x$ = 9.0 cm and just reaches the position where $x$ = 3.0 cm.

Use your answer in **(b)(ii)** to calculate the speed $v$ of the $\alpha$-particle at the position where $x$ = 9.0 cm.

Loss in K.E = Gain in E.P.E

$$\frac{1}{2}\times m\times(v^2 - \underset{0}{u^2}) = \Delta v_q$$

$$\frac{1}{2}\times 4u\times V^2 = 1200\times 2e$$

$$V^2 = \frac{2\times1200\times2e}{4u} \simeq \frac{2400\times2\times1.6\times10^{-11}}{4\times1.66\times10^{-27}} = 1\cdot156\times10^{11}$$

$$V = \sqrt{1\cdot156\times10^{11}}$$

$v$ = $3.4\times10^{5}$ m s$^{-1}$ [3]

[Total: 9]

# Electric Fields WS1

**1 2019 FEB P42 Q05**

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

An area where a charge experiences a force. [1]

**(b)** An isolated solid metal sphere has radius $R$. The charge on the sphere is $+Q$ and the electric field strength at its surface is $E$.

On Fig. 5.1, draw a line to show the variation of the electric field strength with distance $x$ from the centre of the solid sphere for values of $x$ from $x = 0$ to $x = 3R$.


**Fig. 5.1**

[4]

$$E = \frac{KQ}{r^2}$$

$$E \propto \frac{1}{r^2}$$

**(c)** The sphere in **(b)** has radius $R = 0.26\,\text{m}$.

Electrical breakdown (a spark) occurs when the electric field strength at the surface of the sphere exceeds $2.0 \times 10^6\,\text{V m}^{-1}$.

Determine the maximum charge that can be stored on the sphere before electrical breakdown occurs.

$$E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

$$Q = E \times 4\pi\varepsilon_0 r^2$$

$$Q = \left(2.0 \times 10^6\right)(4\pi)\left(8 \cdot 85 \times 10^{-12}\right)(0.26)^2$$

charge = $1.5 \times 10^{-5}$ C [3]

## 2 2019 JUN P41 Q05

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

It is the amount of Force per unit positive charge.

[2]

## 3 2019 JUN P42 Q06

**(a)** State what is meant by *electric potential* at a point.

It is the amount of work done in moving a unit positive charge from infinity to a point within the Electric field.

[2]

**(b)** Two parallel metal plates A and B are held a distance $d$ apart in a vacuum, as illustrated in Fig. 6.1.

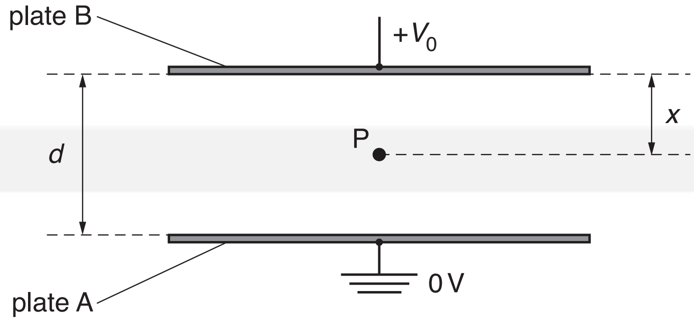



**Fig. 6.1**

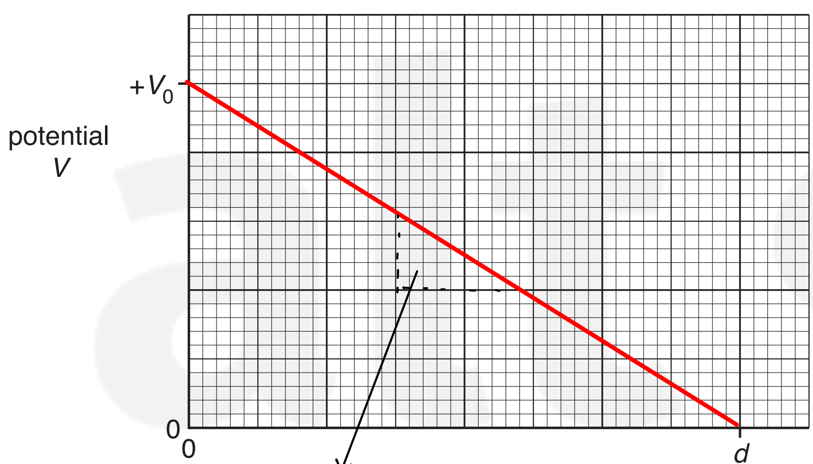
Plate A is earthed and plate B is at a potential of $+V_0$.

Point P is situated in the centre region between the plates at a distance $x$ from plate B. The potential at point P is $V$.

On Fig. 6.2, show the variation with $x$ of the potential $V$ for values of $x$ from $x = 0$ to $x = d$.

B/w two Parralel Plates.

E = constant.




Gradient = − E

**Fig. 6.2**

EFS is negative Potential gradient.

[3]

**(c)** Two isolated solid metal spheres M and N, each of radius $R$, are situated in a vacuum. Their centres are a distance $D$ apart, as illustrated in Fig. 6.3.

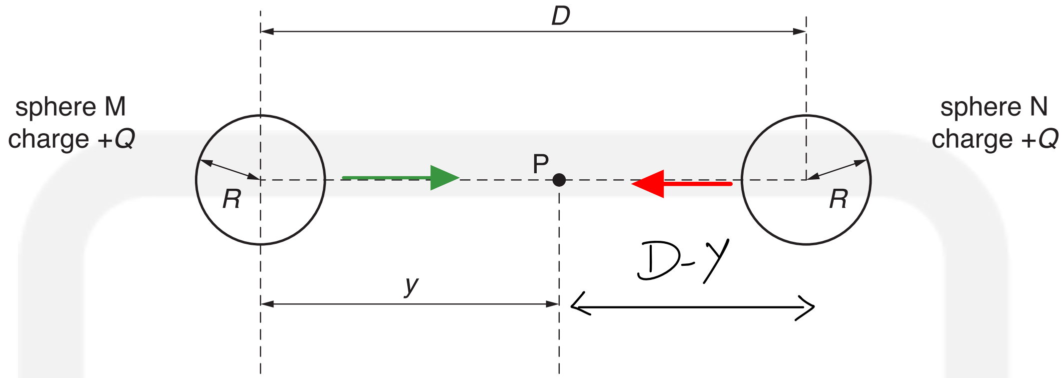


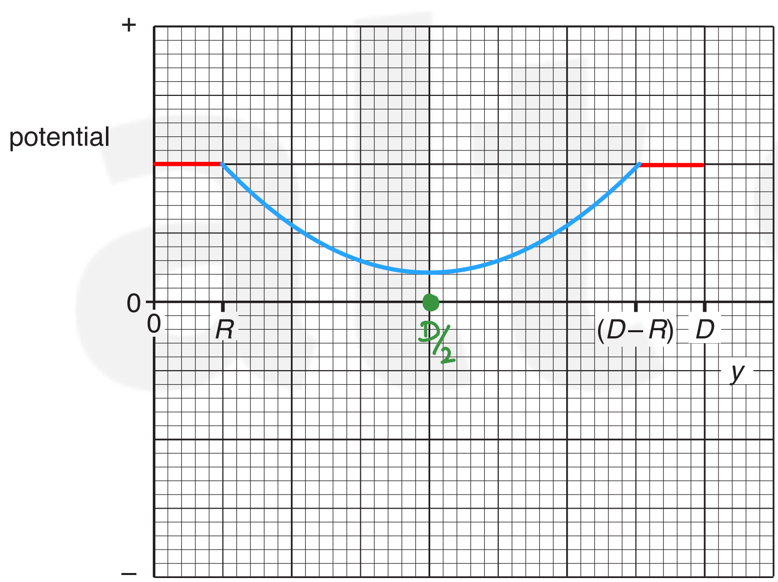

**Fig. 6.3**

Each sphere has charge $+Q$.

Point P lies on the line joining the centres of the two spheres, and is a distance $y$ from the centre of sphere M.

On Fig. 6.4, show the variation with distance $y$ of the electric potential at point P, for values of $y$ from $y = 0$ to $y = D$.

V = never Zero! in case of Like charges.




E inside = 0

V = constant.

$$V = \frac{KQ}{r}$$

**Fig. 6.4**

[4]

$$P = \frac{KQ}{y} + \frac{KQ}{D-y}$$

**6 2020 FEB P42 Q06**

Two positively charged identical metal spheres A and B have their centres separated by a distance of 24 cm, as shown in Fig. 6.1.

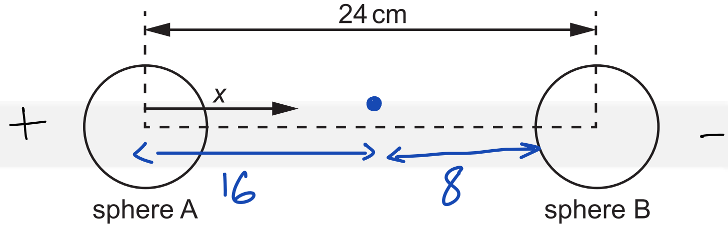



**Fig. 6.1** (not to scale)

The variation with distance $x$ from the centre of A of the electric field strength $E$ due to the two spheres, along the line joining their centres, is represented in Fig. 6.2.

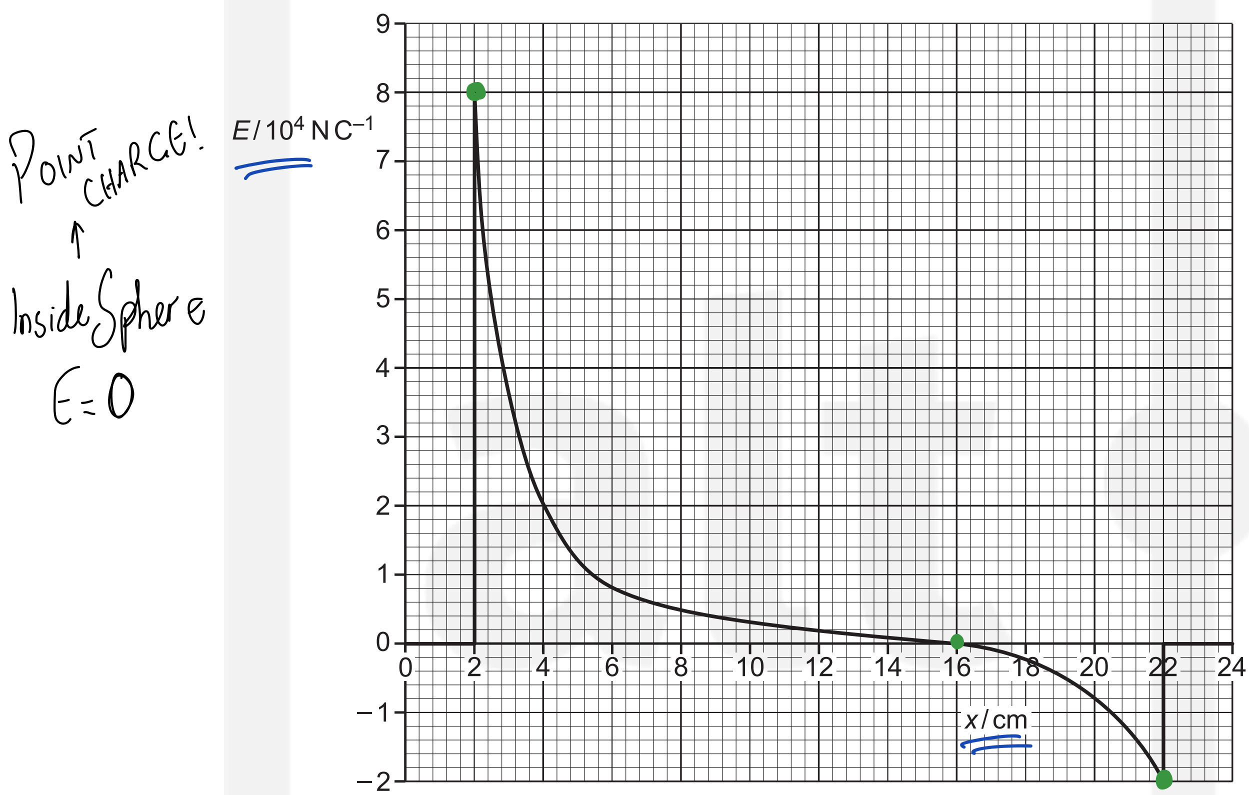



**Fig. 6.2**

**(a)** State the radius of the two spheres.

radius = ........2........ cm [1]

**(b)** The charge on sphere A is $3.6 \times 10^{-9}$ C. Determine the charge $Q_B$ on sphere B.

Assume that spheres A and B can be treated as point charges at their centres.

Explain your working.

$$E = \frac{KQ}{r^2}$$

$$\frac{\cancel{K}Q_A}{rA^2} = \frac{\cancel{K}QB}{rB^2}$$

$$E_A = E_B$$

$$\frac{3.6 \times 10^{-9}}{(16 \times 10^{-2})^2} = \frac{QB}{(8 \times 10^{-2})^2}$$

$Q_B$ = ........ $9 \times 10^{-10}$ ........ C [3]

7 **2020 JUN P41 Q05**

**(a)** State **one** similarity and **one** difference between the fields of force produced by an isolated point charge and by an isolated point mass.

similarity: ..............................................................................................................

..............................................................................................................

difference: ..............................................................................................................

..............................................................................................................

[2]

(ci) Sphere B removed

(b) Electric potential on surface of sphere A.

$$V = \frac{KQ}{r} = \frac{(9 \times 10^{9})(3.6 \times 10^{-9})}{2 \times 10^{-2}} = 1600\,V$$

**2** **2020 NOV P41 Q05**

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

It is the Workdone in moving a unit positive charge from infinity to a point within the electoic field. [2]

**(b)** Two point charges A and B are separated by a distance of 12.0 cm in a vacuum, as illustrated in Fig. 5.1.

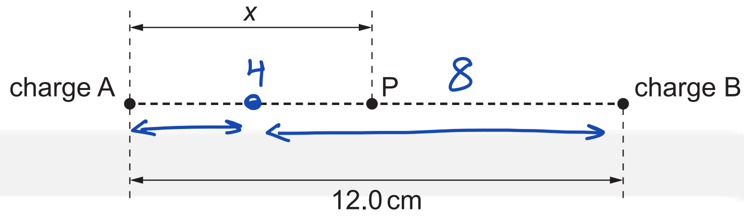



**Fig. 5.1**

The charge of A is $+2.0 \times 10^{-9}$ C.

A point P lies on the line joining charges A and B. Its distance from charge A is $x$.

The variation with distance $x$ of the electric potential $V$ at point P is shown in Fig. 5.2.

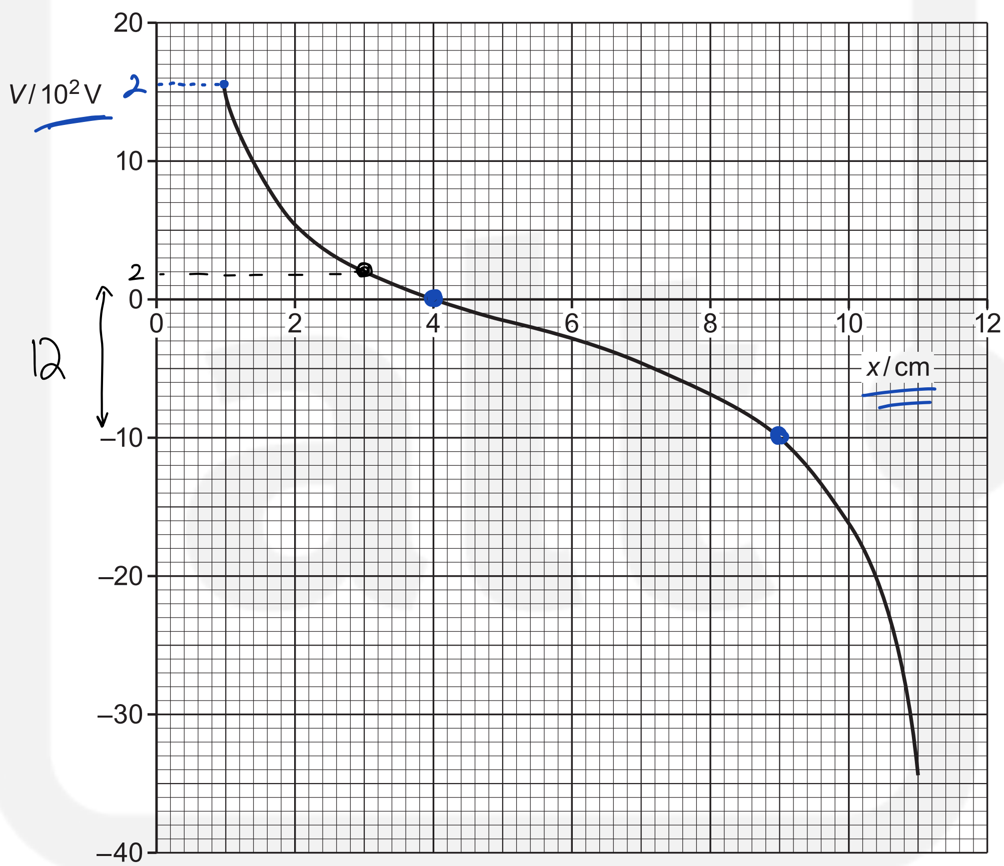



**Fig. 5.2**

Use Fig. 5.2 to determine:

**(i)** the charge of B

$$\Delta V = V_A + V_B$$

$$\frac{kQ_A}{r_A} + \frac{kQ_B}{r_B} = 0$$

$$\frac{\cancel{k}QA}{rA} = -\frac{\cancel{k}Q_B}{rB}$$

$$\frac{2\times10^{-9}}{4\times\cancel{10^{-2}}} = -\frac{Q_B}{8\times\cancel{10^{-2}}}$$

$-4\times10^{-9}$

charge = ........................................................ C [3]

**(ii)** the change in electric potential when point P moves from the position where $x$ = 9.0 cm to the position where $x$ = 3.0 cm.

$\alpha = 4u \quad q = 2e$

change = .........1200......................................... V [1]

**(c)** An $\alpha$-particle moves along the line joining point charges A and B in Fig. 5.1.

The $\alpha$-particle moves from the position where $x$ = 9.0 cm and just reaches the position where $x$ = 3.0 cm.

Use your answer in **(b)(ii)** to calculate the speed $v$ of the $\alpha$-particle at the position where $x$ = 9.0 cm.

Loss in K.E = Gain in E.P.E

$$\frac{1}{2}m\left(V^2 - u^2\right) = \Delta V_q$$

$$V^2 = \frac{2V_q}{m} = \frac{2\,(1200)\,(2e)}{14u}$$

$$= 1 \cdot 1578 \times 10^{11}$$

$$\sqrt{1 \cdot 1578 \times 10^{11}}$$

$v$ = .........$3.4\times10^{5}$......................................... m s$^{-1}$ [3]

## 7 2017 JUN P42 Q06

**(a)** State Coulomb's law.

The magnitude of force between two point charges is proportional to the product of the charges and is inversely proportional to the square of seperation between there centres. [2]

**(b)** Two charged metal spheres A and B are situated in a vacuum, as illustrated in Fig. 6.1.

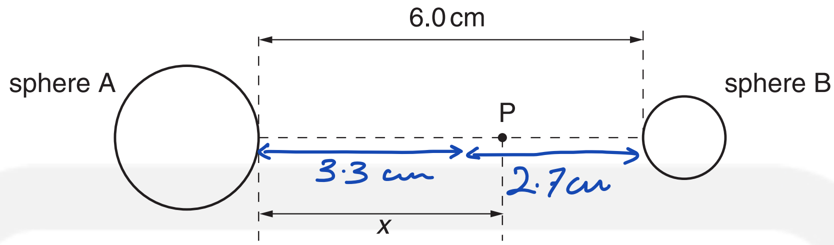



**Fig. 6.1**

The shortest distance between the surfaces of the spheres is 6.0 cm.

A movable point P lies along the line joining the centres of the two spheres, a distance *x* from the surface of sphere A.

The variation with distance *x* of the electric field strength *E* at point P is shown in Fig. 6.2.

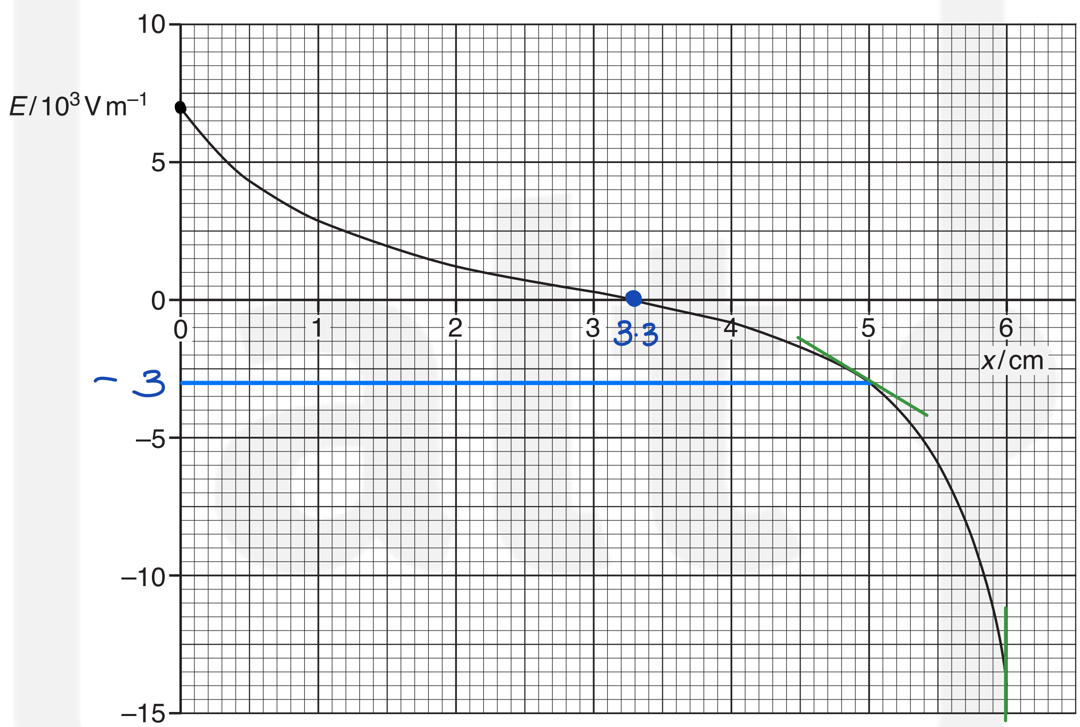



**Fig. 6.2**

**(i)** Use Fig. 6.2 to explain whether the two spheres have charges of the same, or opposite, sign.

Electric field strength is zero so this means electric forces are in opposite directions so the charges must repel and hence they must be like charges. [2]

**(ii)** A proton is at point P where $x = 5.0\,\text{cm}$.
Use data from Fig. 6.2 to determine the acceleration of the proton.

$$\therefore E = \frac{F}{q}$$

$$F = ma = Eq$$

$$a = \frac{Eq}{m} \simeq \frac{(3 \times 10^{3})(1 \cdot 6 \times 10^{-19})}{(1 \cdot 66 \times 10^{-27})}$$

acceleration = $2.9 \times 10^{11}$ $\text{m s}^{-2}$ [3]

**(c)** Use data from Fig. 6.2 to state the value of $x$ at which the rate of change of electric potential is maximum. Give the reason for the value you have chosen.

Since Electric field Strength is the negative potential gradient, this corresponds to the greatest magnitude of E which occurs at $x = 6\,\text{cm}$. [2]

12 **2018 NOV P41 Q06**

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

It is the amount of workdone in moving a unit positive charge from infinity to a point within the electric field. [2]

**(ii)** State the relationship between electric potential and electric field strength at a point.

Electric field Strength is the negative potential gradient. [2]

**(b)** Two parallel metal plates A and B are situated a distance 1.2 cm apart in a vacuum, as shown in Fig. 6.1.

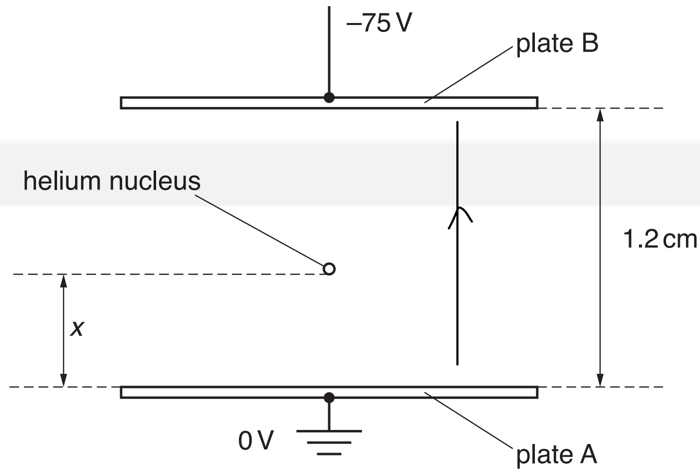



**Fig. 6.1**

Plate A is earthed and plate B is at a potential of –75 V.

A helium nucleus is situated between the plates, a distance $x$ from plate A.

Initially, the helium nucleus is at rest on plate A where $x = 0$.

**(i)** The helium nucleus is free to move between the plates. By considering energy changes of the helium nucleus, explain why the speed at which it reaches plate B is independent of the separation of the plates.

As the Helium nucleus goes from A to B it will lose electric potential energy but it will gain kinetic energy. The speed v will be independent of d because for $\frac{1}{2}mv^2 = Vq$ ; there is no d involved.

[2]

**(ii)** As the helium nucleus ($^4_2$He) moves from plate A towards plate B, its distance $x$ from plate A increases.

Calculate the speed of the nucleus after it has moved a distance $x$ = 0.40 cm from plate A.

$$V = \frac{0 \cdot 4}{1 \cdot 2} \times (0 - (-75) = 25$$

Loss in E.P.E = Gain in K.E

$$\Delta V q = \frac{1}{2} m v^2$$

$$V^2 = \frac{2Vq}{m} = \frac{2 \times 25 \times 2 \times 1{\bullet}6 \times 10^{-19}}{4 \times 1{\bullet}66 \times 10^{-27}}$$

$$V^2 = 2.4 \times 10^9 ms^{-1}$$

speed = $4{\bullet}9 \times 10^4$ m s$^{-1}$ [3]

**13 2018 NOV P42 Q06**

**(a)** State

**(i)** what is meant by the *electric potential* at a point,

..........................................................................................................................

..........................................................................................................................

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

**(ii)** the relationship between electric potential at a point and electric field strength at the point.

..........................................................................................................................

..........................................................................................................................

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

**11** **2021 NOV P22 Q02**

A charged oil drop is in a vacuum between two horizontal metal plates. A uniform electric field is produced between the plates by applying a potential difference of 1340 V across them, as shown in Fig. 2.1.

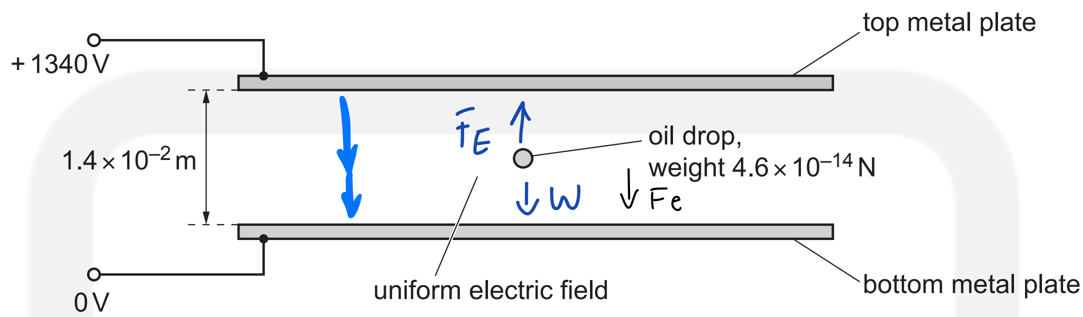



**Fig. 2.1**

The separation of the plates is $1.4 \times 10^{-2}$ m.

The oil drop of weight $4.6 \times 10^{-14}$ N remains stationary at a point mid-way between the plates.

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

$$E = F/q = \frac{V}{d} = \frac{1340}{1.4 \times 10^{-2}}$$

electric field strength = $9.6 \times 10^{4}$ N C$^{-1}$ [2]

**(ii)** Determine the magnitude and the sign of the charge on the oil drop.

$$F_E = Eq \qquad F_G = W = 4.6 \times 10^{-14}$$

$$q = \frac{4.6 \times 10^{-14}}{9.57 \times 10^{4}}$$

magnitude of charge = $4.8 \times 10^{-19}$ C

sign of charge NEGATIVE

[3]

**(b)** The electric potentials of the plates are instantaneously reversed so that the top plate is at a potential of 0 V and the bottom plate is at a potential of +1340 V. This change causes the oil drop to start moving downwards.

**(i)** Compare the new pattern of the electric field lines between the plates with the original pattern.

The spacing remains the same but the direction of field lines changes from downwards to upwards. [2]

**(ii)** Determine the magnitude of the resultant force acting on the oil drop.

$2 \times 4.6 \times 10^{-14}$

resultant force = $9.2 \times 10^{-14}$ N [1]

**(iii)** Show that the magnitude of the acceleration of the oil drop is $20\,\mathrm{m\,s^{-2}}$.

$F = ma$

$9.2 \times 10^{-14} = \left(\frac{4.6 \times 10^{-14}}{9.81}\right) a = 19.62\,\mathrm{ms^{-2}}$

$\approx 20\,\mathrm{ms^{-2}}$ [2]

**(iv)** Assume that the radius of the oil drop is negligible.

Use the information in **(b)(iii)** to calculate the time taken for the oil drop to move to the bottom metal plate from its initial position mid-way between the plates.

$s = \frac{1}{2} a t^2$

time = 0.027 s [2]

$0.7 \times 10^{-2} = \frac{1}{2}(19.62)\, t^2 = 7.135 \times 10^{-4}$

$t = \sqrt{7.135 \times 10^{-4}}$

**(c)** The oil drop in **(b)** starts to move at time $t$ = 0. The distance of the oil drop from the bottom plate is $x$.

On Fig. 2.2, sketch the variation with time $t$ of distance $x$ for the movement of the drop from its initial position until it hits the surface of the bottom plate. Numerical values of $t$ are not required.

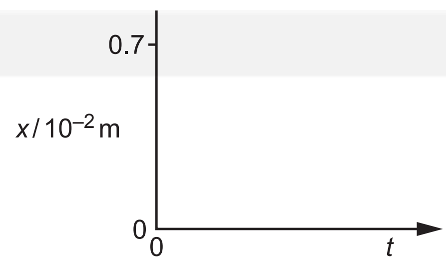



**Fig. 2.2**

[2]

## 12 2021 NOV P23 Q04

An $\alpha$-particle moves in a straight line through a vacuum with a constant speed of $4.1 \times 10^6\,\mathrm{m\,s^{-1}}$. The $\alpha$-particle enters a uniform electric field at point A, as shown in Fig. 4.1.

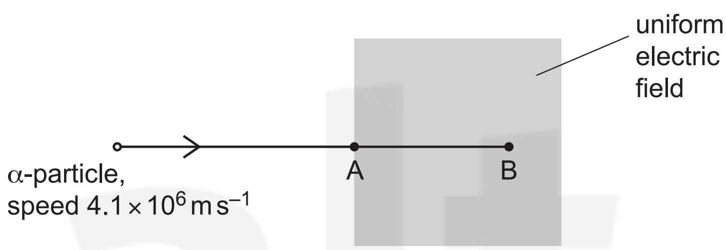



**Fig. 4.1**

The $\alpha$-particle continues to move in the same straight line until it is brought to rest at point B by the electric field. The deceleration of the $\alpha$-particle by the electric field is $2.7 \times 10^{14}\,\mathrm{m\,s^{-2}}$.

**(a)** State the direction of the electric field.

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

**(b)** Calculate the distance AB.

distance = ..................................................... m [2]