

# Point Charges & Electric Potential

## Question paper 5

<b>Level</b>	International A Level
<b>Subject</b>	Physics
<b>Exam Board</b>	CIE
<b>Topic</b>	Electric Fields
<b>Sub Topic</b>	Point Charges & Electric Potential
<b>Paper Type</b>	Theory
<b>Booklet</b>	Question paper 5

**Time Allowed:** 60 minutes

**Score:** /50

**Percentage:** /100

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

- 1 Two charged points A and B are separated by a distance of 6.0 cm, as shown in Fig. 3.1.

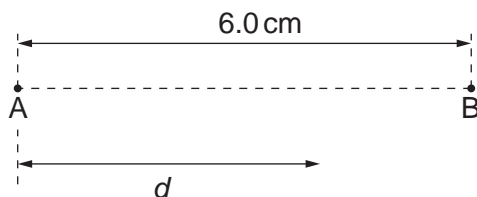


Fig. 3.1

The variation with distance  $d$  from A of the electric field strength  $E$  along the line AB is shown in Fig. 3.2.

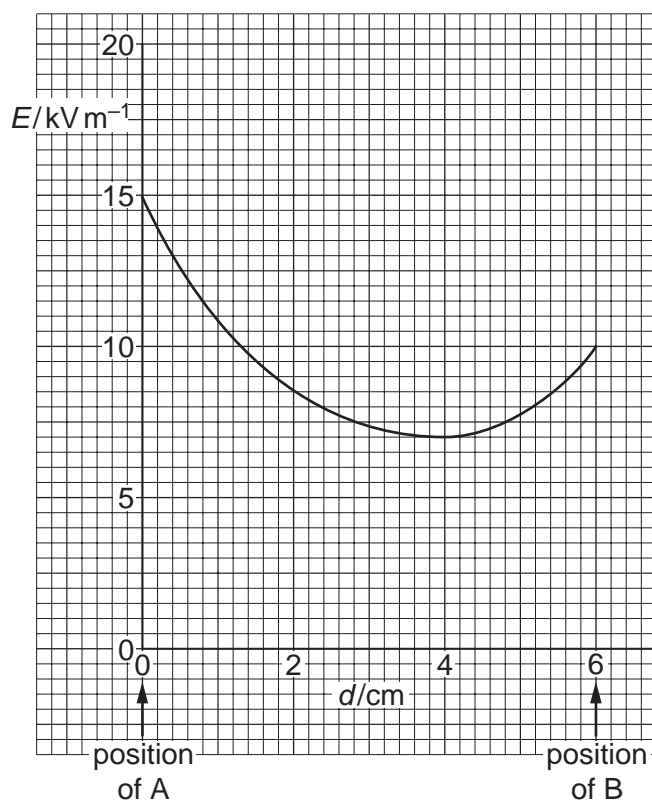


Fig. 3.2

An electron is emitted with negligible speed from A and travels along AB.

- (a) State the relation between electric field strength  $E$  and potential  $V$ .

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

- (b) The area below the line of the graph of Fig. 3.2 represents the potential difference between A and B.

Use Fig. 3.2 to determine the potential difference between A and B.

potential difference = ..... V [4]

- (c) Use your answer to (b) to calculate the speed of the electron as it reaches point B.

speed = .....  $\text{ms}^{-1}$  [2]

- (d) (i) Use Fig. 3.2 to determine the value of  $d$  at which the electron has maximum acceleration.

$d$  = ..... cm [1]

- (ii) Without any further calculation, describe the variation with distance  $d$  of the acceleration of the electron.

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

2 The definitions of electric potential and of gravitational potential at a point have some similarity.

(a) State one similarity between these two definitions.

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

(b) Explain why values of gravitational potential are always negative whereas values of electric potential may be positive or negative.

.....  
.....  
.....  
.....  
..... [4]

3 An isolated conducting sphere of radius  $r$  is placed in air. It is given a charge  $+Q$ . This charge may be assumed to act as a point charge situated at the centre of the sphere.

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

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

(ii) State a formula for the electric field strength  $E$  at the surface of the sphere. Also, state the meaning of any other symbols used.

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

(b) The maximum field strength at the surface of the sphere before electrical breakdown (sparking) occurs is  $2.0 \times 10^6 \text{ V m}^{-1}$ . The sphere has a radius  $r$  of 0.35 m.

Calculate the maximum values of

(i) the charge that can be stored on the sphere,

charge = ..... C [2]

(ii) the potential at the surface of the sphere.

potential = ..... V [2]

- (c) Suggest the effect of the electric field on a single atom near the sphere's surface as electrical breakdown of the air occurs.

.....

.....

..... [2]

- 4 An isolated conducting sphere of radius  $r$  is given a charge  $+Q$ . This charge may be assumed to act as a point charge situated at the centre of the sphere, as shown in Fig. 5.1.

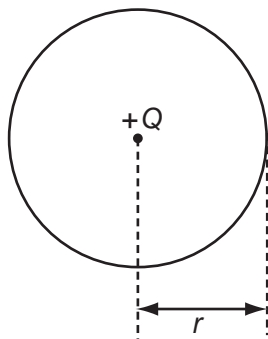


Fig. 5.1

Fig. 5.2. shows the variation with distance  $x$  from the centre of the sphere of the potential  $V$  due to the charge  $+Q$ .

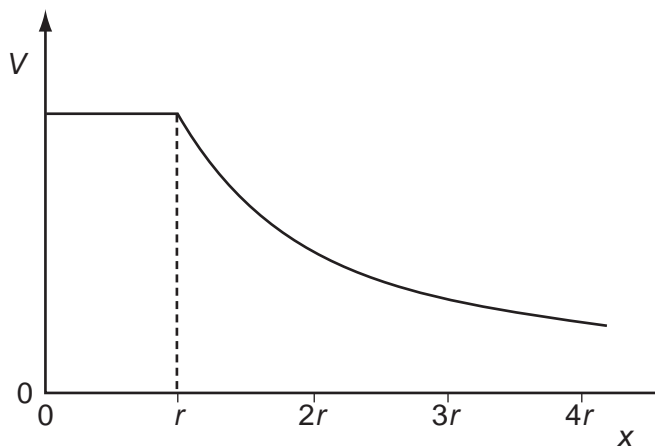


Fig. 5.2

- (a) State the relation between electric field and potential.

.....[1]

- (b) Using the relation in (a), on Fig. 5.3 sketch a graph to show the variation with distance  $x$  of the electric field  $E$  due to the charge  $+Q$ .

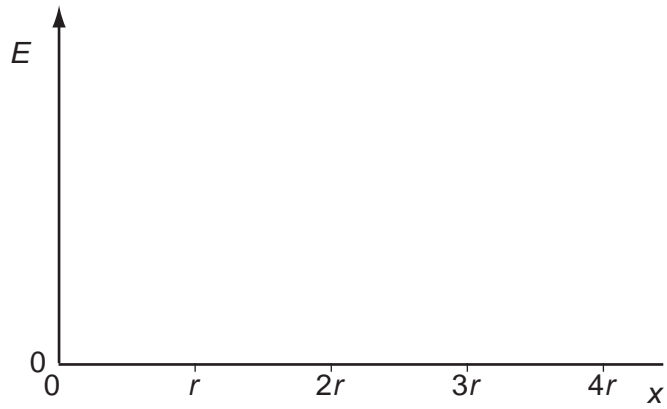


Fig. 5.3

[3]



5 An  $\alpha$ -particle ( ${}^4_2\text{He}$ ) is moving directly towards a stationary gold nucleus ( ${}^{197}_{79}\text{Au}$ ).

The  $\alpha$ -particle and the gold nucleus may be considered to be solid spheres with the charge and mass concentrated at the centre of each sphere.

When the two spheres are just touching, the separation of their centres is  $9.6 \times 10^{-15} \text{ m}$ .

(a) The  $\alpha$ -particle and the gold nucleus may be assumed to be an isolated system. Calculate, for the  $\alpha$ -particle just in contact with the gold nucleus,

(i) its gravitational potential energy,

gravitational potential energy = ..... J [3]

(ii) its electric potential energy.

electric potential energy = ..... J [3]

(b) Using your answers in (a), suggest why, when making calculations based on an  $\alpha$ -particle scattering experiment, gravitational effects are not considered.

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

(c) In the  $\alpha$ -particle scattering experiment conducted in 1913, the maximum kinetic energy of the available  $\alpha$ -particles was about 6 MeV. Suggest why, in this experiment, the radius of the target nucleus could not be determined.

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

6 (a) State the significance of the Millikan experiment.

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

(b) In the Millikan experiment, oil droplets were found to have the following charges.

- $1.56 \times 10^{-19} \text{ C}$
- $4.88 \times 10^{-19} \text{ C}$
- $1.64 \times 10^{-19} \text{ C}$
- $3.14 \times 10^{-19} \text{ C}$
- $4.76 \times 10^{-19} \text{ C}$

Use these data to determine a value for the elementary charge. Explain your working.

.....  
.....

elementary charge = ..... C [2]

- 7 In a particular experiment, a high voltage is created by charging an isolated metal sphere, as illustrated in Fig. 4.1.

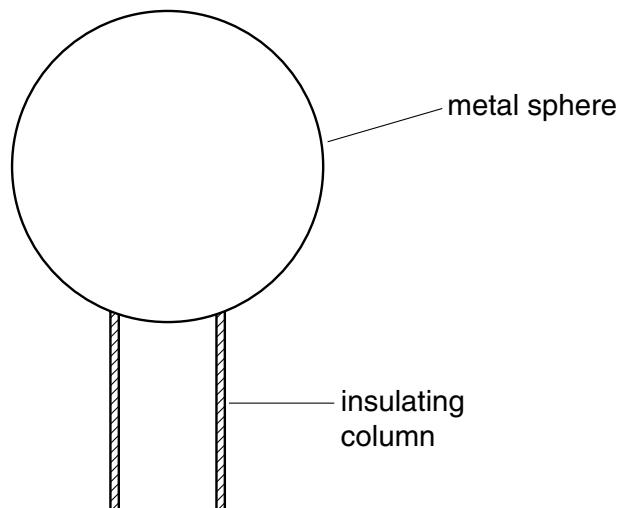


Fig. 4.1

The sphere has diameter 42 cm and any charge on its surface may be considered as if it were concentrated at its centre.

The air surrounding the sphere loses its insulating properties, causing a spark, when the electric field exceeds  $20 \text{ kV cm}^{-1}$ .

- (a) By reference to an atom in the air, suggest the mechanism by which the electric field causes the air to become conducting.

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

- (b) Calculate, for the charged sphere when a spark is about to occur,

- (i) the charge on the sphere,

charge = ..... C [3]

(ii) its potential.

potential = ..... V [2]

(c) Under certain conditions, a spark sometimes occurs before the potential reaches that calculated in (b)(ii). Suggest a reason for this.

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