Point Charges & Electric Potential

Question paper 1

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Electric Fields
Sub Topic	Point Charges & Electric Potential
Paper Type	Theory
Booklet	Question paper 1

Time Allowed: **56 minutes**

Score: **/46**

Percentage: **/100**

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

1 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.

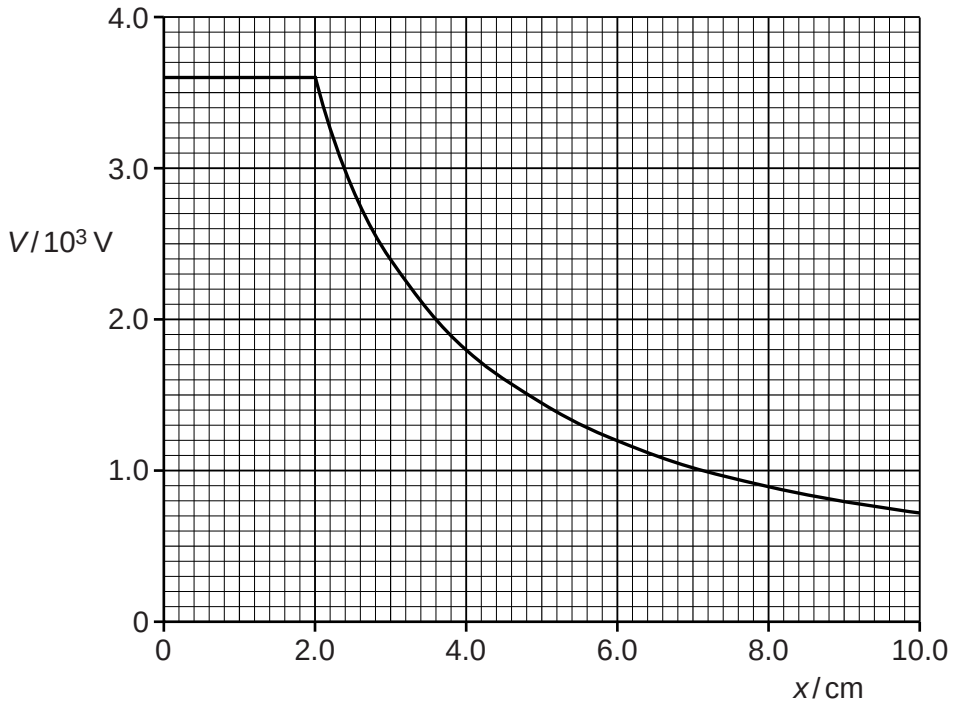

Fig. 5.1

(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.

electric field strength = ... N C^{-1} [3]

(b) The charge on the sphere is 8.0×10^{-9} C.

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

potential = ... V [1]

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

capacitance = ... F [2]

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

.....

.....

.....[2]

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

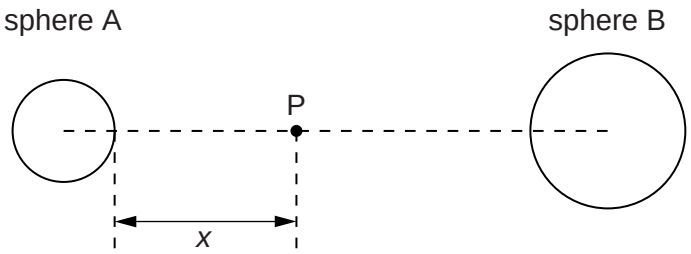

Fig. 5.1

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.

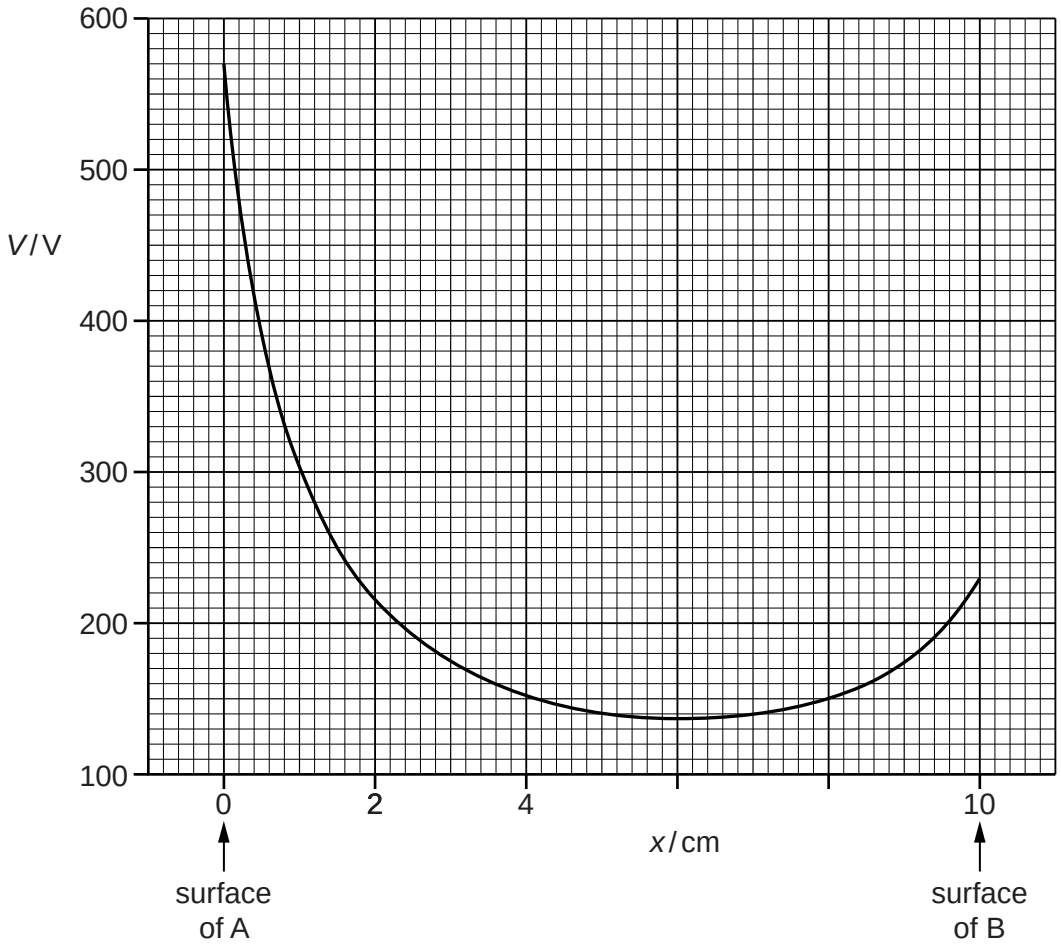

Fig. 5.2

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

.....

.....[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 $x = 10\,\text{cm}$.

.....

.....

.....

.....[3]

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

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

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.

potential difference = ... 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.

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

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

.....

.....

..... [2]

(b) An isolated solid metal sphere is positively charged.

The variation of the potential V with distance x from the centre of the sphere is shown in Fig. 5.1.

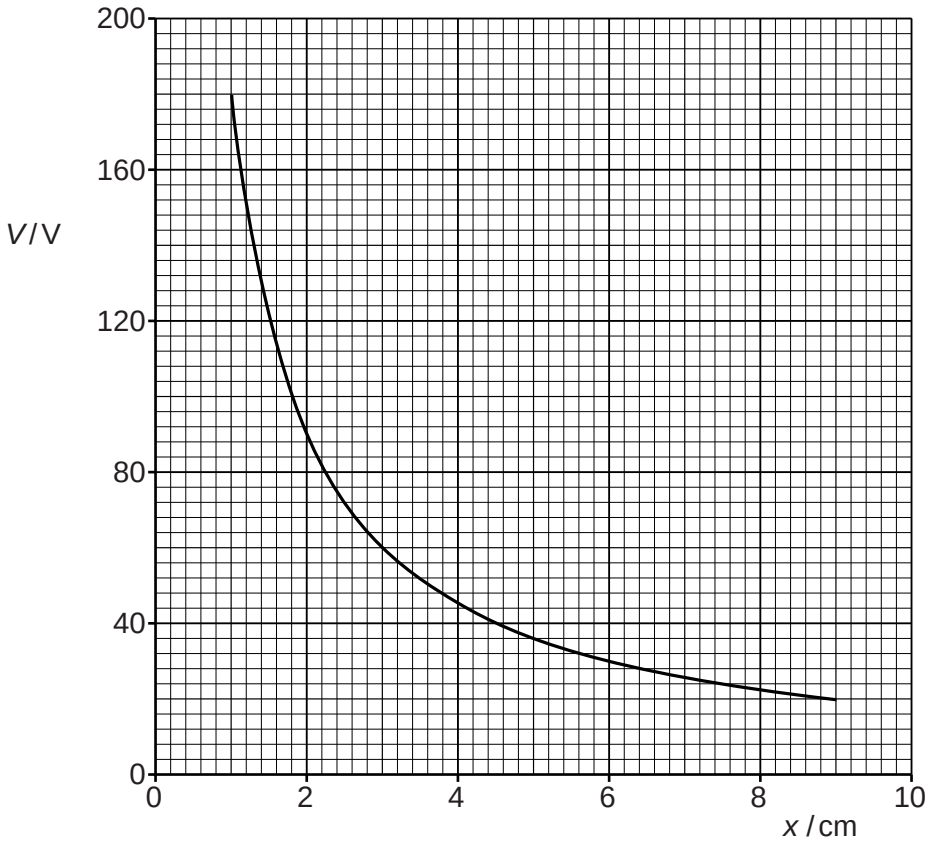

Fig. 5.1

Use Fig. 5.1 to suggest

(i) why the radius of the sphere cannot be greater than 1.0 cm,

.....

..... [1]

(ii) that the charge on the sphere behaves as if it were a point charge.

[3]

(c) Assuming that the charge on the sphere does behave as a point charge, use data from Fig. 5.1 to determine the charge on the sphere.

charge = ... C [2]

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

.....

.....

..... [2]

(b) An isolated metal sphere is charged to a potential V. The charge on the sphere is q.
The charge on the sphere may be considered to act as a point charge at the centre of the sphere.

The variation with potential V of the charge q on the sphere is shown in Fig. 5.1.

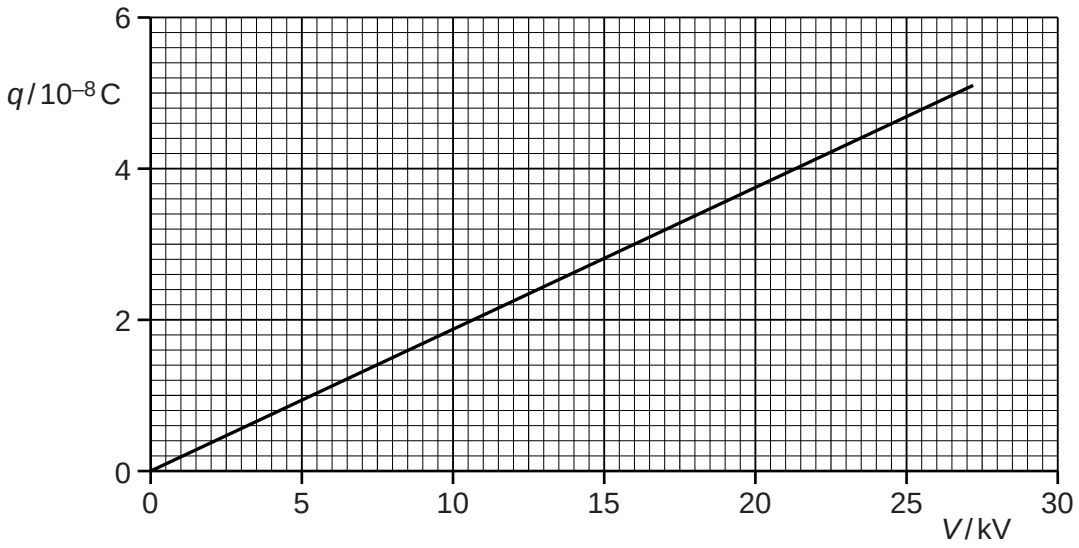

Fig. 5.1

Use Fig. 5.1 to determine

(i) the radius of the sphere,

radius = ... m [2]

(ii) the energy required to increase the potential of the sphere from zero to 24 kV.

energy = ... J [3]

(c) The sphere in **(b)** discharges by causing sparks when the electric field strength at the surface of the sphere is greater than $2.0 \times 10^6\,\text{V m}^{-1}$.

Use your answer in **(b)(i)** to calculate the maximum potential to which the sphere can be charged.

potential = ... V [3]

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 $x = 4r$.

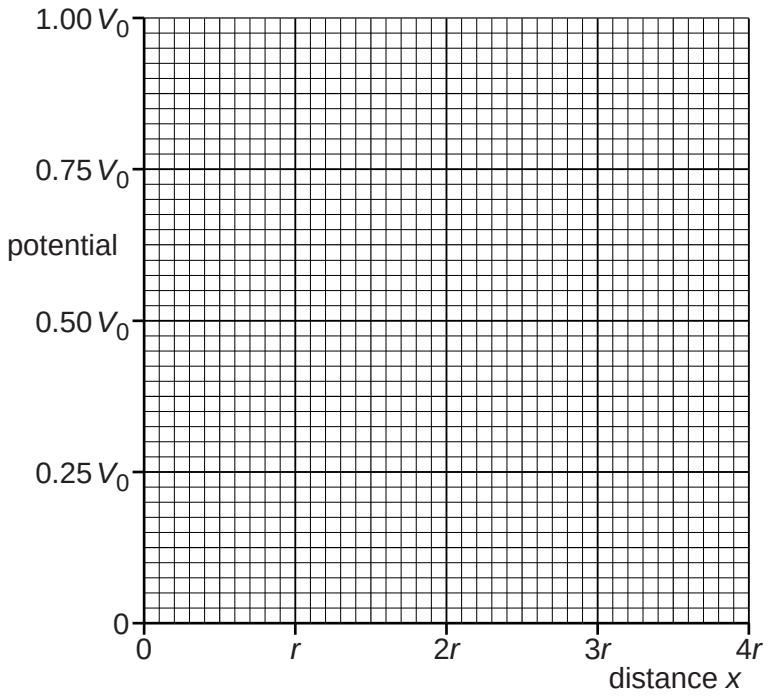

Fig. 5.1

[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 $x = 4r$.

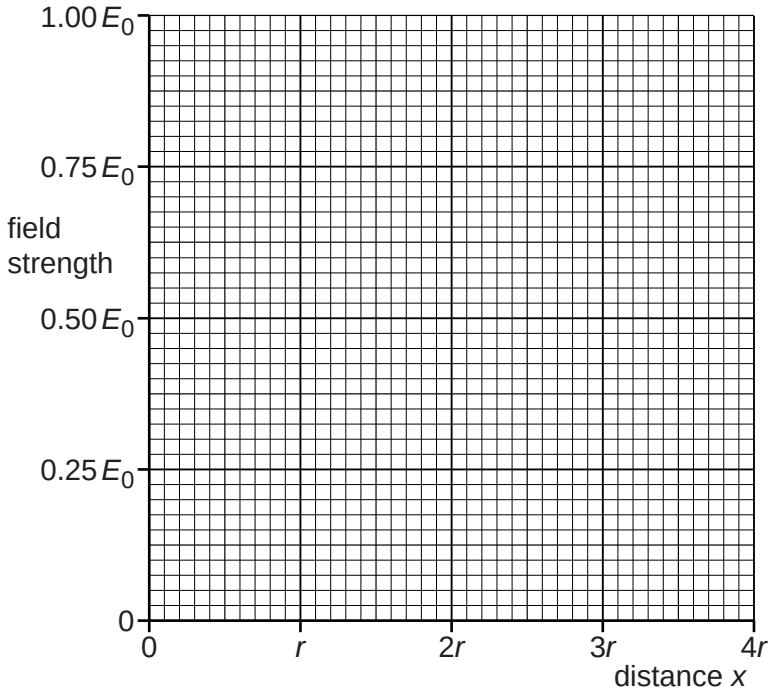

Fig. 5.2

[3]

6 **(a)** State what is meant by *quantisation* of charge.

.....

..... [1]

(b) A student carries out an experiment to determine the elementary charge.
A charged oil drop is positioned between two horizontal metal plates, as shown in Fig. 8.1.

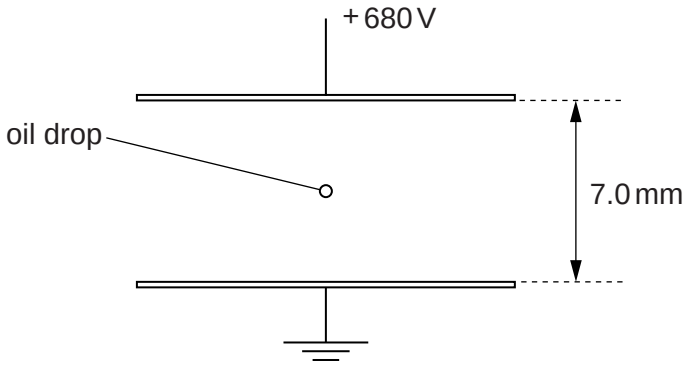

Fig. 8.1

The plates are separated by a distance of 7.0 mm. The lower plate is earthed.
The potential of the upper plate is gradually increased until the drop is held stationary. The potential for the drop to be stationary is 680 V.
The weight of the oil drop, allowing for the upthrust of the air, is 4.8×10^{-14} N.
Calculate the value for the charge on the oil drop.

charge = ... C [2]

(c) The student repeats the experiment and determines the following values for the charge on oil drops.

$3.3 \times 10^{-19}\,C$ $4.9 \times 10^{-19}\,C$ $9.7 \times 10^{-19}\,C$ $3.4 \times 10^{-19}\,C$

Use these values to suggest a value for the elementary charge. Explain your working.

elementary charge = ... C [2]