Point Charges & Electric Potential

Question paper 4

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Electric Fields
Sub Topic	Point Charges & Electric Potential
Paper Type	Theory
Booklet	Question paper 4

Time Allowed: **54 minutes**

Score: **/45**

Percentage: **/100**

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

1 Two point charges A and B each have a charge of $+6.4 \times 10^{-19}$ C. They are separated in a vacuum by a distance of 12.0 μm, as shown in Fig. 4.1.

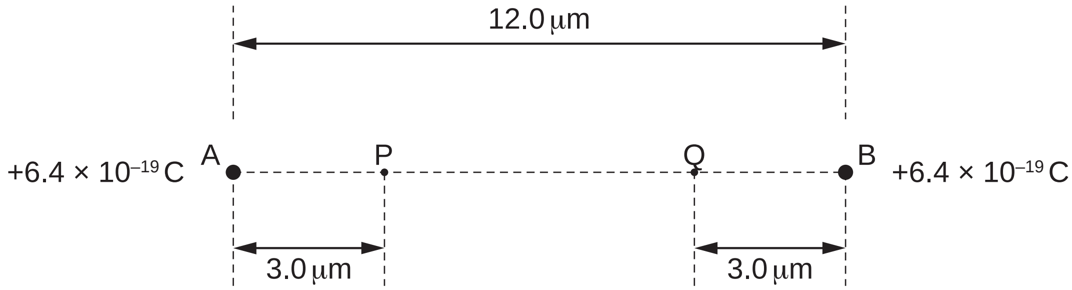

Fig. 4.1

Points P and Q are situated on the line AB. Point P is 3.0 μm from charge A and point Q is 3.0 μm from charge B.

(a) Calculate the force of repulsion between the charges A and B.

force = ... N [3]

(b) Explain why, without any calculation, when a small test charge is moved from point P to point Q, the net work done is zero.

....

....

.... [2]

(c) Calculate the work done by an electron in moving from the midpoint of line AB to point P.

work done = ... J [4]

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

....

....

.... [2]

(b) An α-particle is emitted from a radioactive source with kinetic energy of 4.8 MeV.

The α-particle travels in a vacuum directly towards a gold ($^{197}_{79}Au$) nucleus, as illustrated in Fig. 5.1.

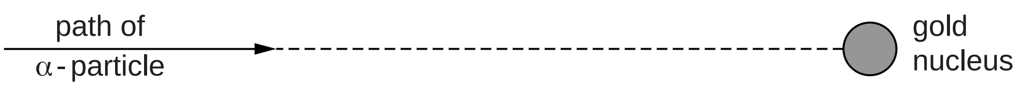

Fig. 5.1

The α-particle and the gold nucleus may be considered to be point charges in an isolated system.

(i) Explain why, as the α-particle approaches the gold nucleus, it comes to rest.

....

....

.... [2]

(ii) For the closest approach of the α-particle to the gold nucleus determine

1. their separation,

separation = ... m [3]

2. the magnitude of the force on the α-particle.

force = ... N [2]

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

....

....

.... [2]

(b) Two isolated point charges A and B are separated by a distance of 30.0 cm, as shown in Fig. 4.1.

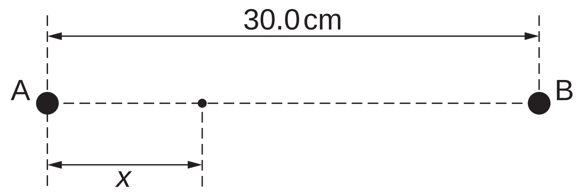

Fig. 4.1

The charge at A is + 3.6 × 10^{-9} C.
The variation with distance *x* from A along AB of the potential *V* is shown in Fig. 4.2.

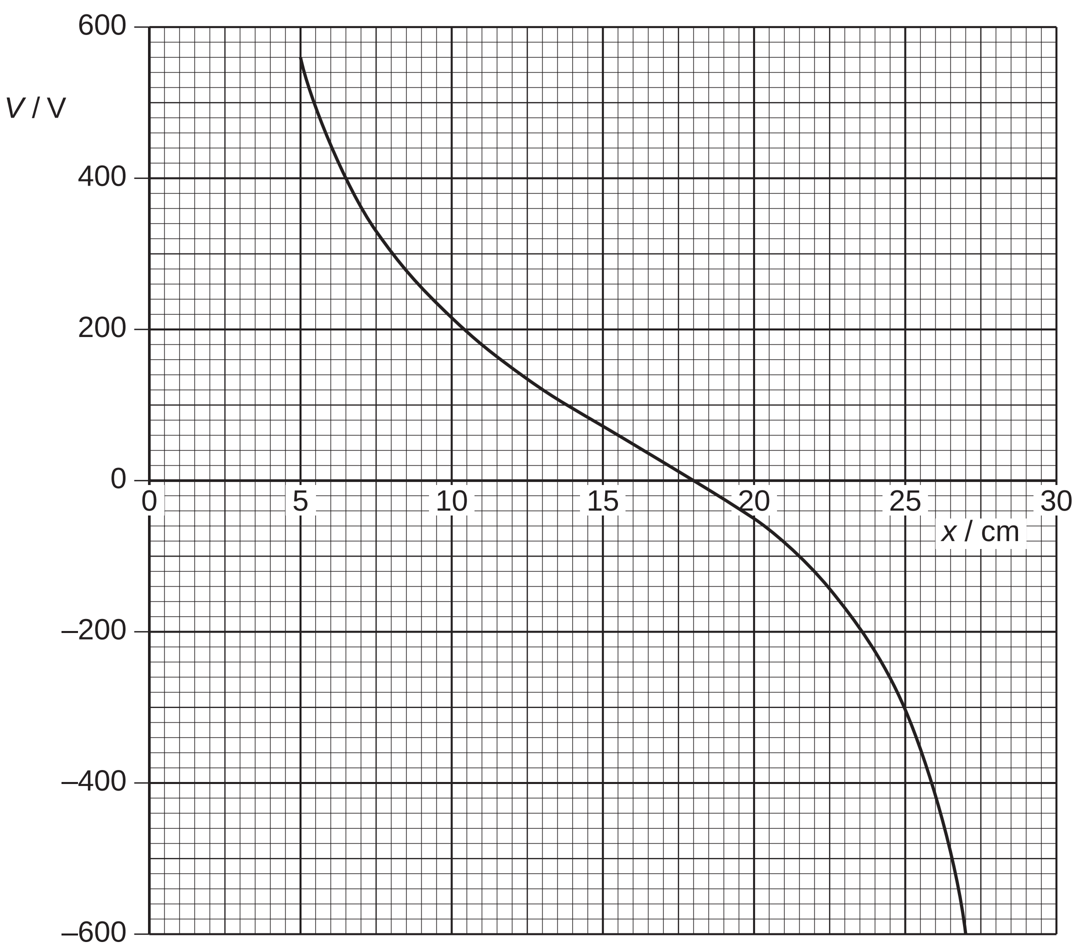

Fig. 4.2

(i) State the value of x at which the potential is zero.

x = ... cm [1]

(ii) Use your answer in **(i)** to determine the charge at B.

charge = ... C [3]

(c) A small test charge is now moved along the line AB in **(b)** from x = 5.0 cm to x = 27 cm.
State and explain the value of x at which the force on the test charge will be maximum.

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....

....

....[3]

4 The Millikan oil-drop experiment enabled the charge on the electron to be determined.

(a) State a fundamental property of charge that was suggested by this experiment.

....

.... [1]

(b) Two parallel metal plates P and Q are situated in a vacuum. The plates are horizontal and separated by a distance of 5.4 mm, as illustrated in Fig. 7.1.

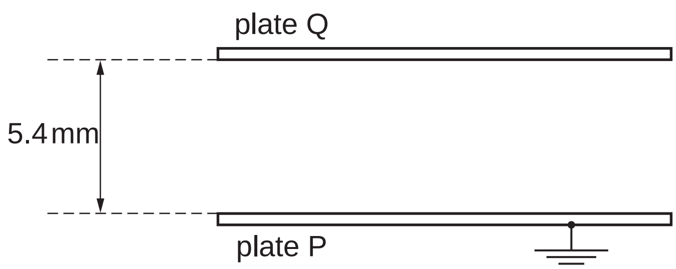

Fig. 7.1

The lower plate P is earthed. The potential difference between the plates can be varied. An oil droplet of mass 7.7×10^{-15} kg is observed to remain stationary between the plates when plate Q is at a potential of +850 V.

(i) Suggest why plates P and Q must be parallel and horizontal.

....

....

.... [2]

(ii) Calculate the charge, with its sign, on the oil droplet.

charge = ... C [3]

(c) The procedure in **(b)** was repeated for three further oil droplets. The magnitude of the charge on each of the droplets was found to be 3.2×10^{-19} C, 6.4×10^{-19} C and 3.2×10^{-19} C.
Explain what value these data and your answer in **(b)(ii)** would suggest for the charge on the electron.

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....

....[1]

5 A small charged metal sphere is situated in an earthed metal box. Fig. 4.1 illustrates the electric field between the sphere and the metal box.

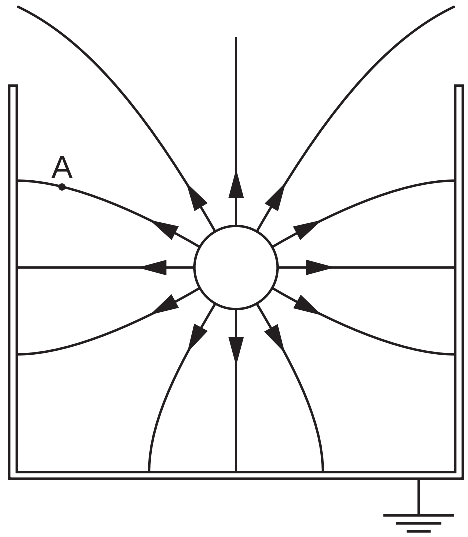

Fig. 4.1

(a) By reference to Fig. 4.1, state and explain

(i) whether the sphere is positively or negatively charged,

....

....

....[2]

(ii) why it appears as if the charge on the sphere is concentrated at the centre of the sphere.

....

....[1]

(b) On Fig. 4.1, draw an arrow to show the direction of the force on a stationary electron situated at point A. [2]

(c) The radius r of the sphere is 2.4 cm. The magnitude of the charge q on the sphere is 0.76 nC.

(i) Use the expression

$$V = \frac{Q}{4\pi\varepsilon_0 r}$$

to calculate a value for the magnitude of the potential V at the surface of the sphere.

V = ...V [2]

(ii) State the sign of the charge induced on the inside of the metal box. Hence explain whether the actual magnitude of the potential will be greater or smaller than the value calculated in **(i)**.

....

....

....

....[3]

(d) A lead sphere is placed in a lead box in free space, in a similar arrangement to that shown in Fig. 4.1. Explain why it is **not** possible for the gravitational field to have a similar shape to that of the electric field.

....

....

....[1]