Point Charges & Electric Potential

Question paper 3

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Electric Fields
Sub Topic	Point Charges & Electric Potential
Paper Type	Theory
Booklet	Question paper 3

Time Allowed: **59 minutes**

Score: **/49**

Percentage: **/100**

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

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

.....

..... [1]

(b) An isolated metal sphere is to be used to store charge at high potential. The charge stored may be assumed to be a point charge at the centre of the sphere. The sphere has a radius of 25 cm. Electrical breakdown (a spark) occurs in the air surrounding the sphere when the electric field strength at the surface of the sphere exceeds 1.8×10^4 V cm^{-1}.

(i) Show that the maximum charge that can be stored on the sphere is 12.5 μC.

[2]

(ii) Calculate the potential of the sphere for this maximum charge.

potential = ... V [2]

2 A charged point mass is situated in a vacuum. A proton travels directly towards the mass, as illustrated in Fig. 4.1.

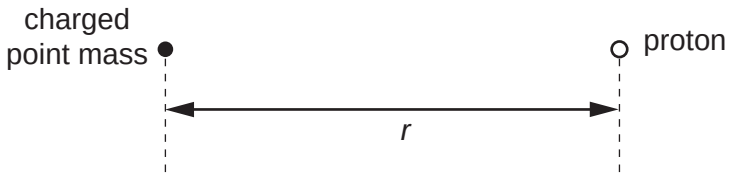

Fig. 4.1

When the separation of the mass and the proton is r, the electric potential energy of the system is U_P.

The variation with r of the potential energy U_P is shown in Fig. 4.2.

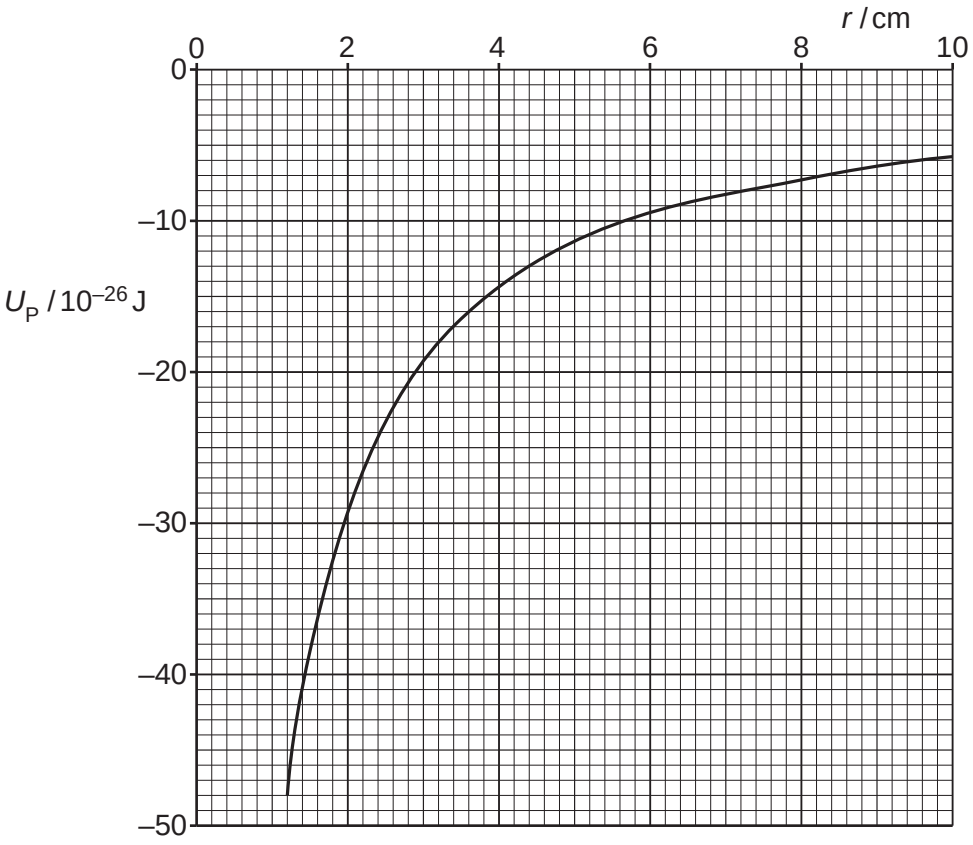

Fig. 4.2

(a) **(i)** Use Fig. 4.2 to state and explain whether the mass is charged positively or negatively.

.....

.....

..... [2]

(ii) The gradient at a point on the graph of Fig. 4.2 is *G*.
Show that the electric field strength *E* at this point due to the charged point mass is given by the expression

$$Eq = G$$

where *q* is the charge at this point.

.....

.....

..... [2]

(b) Use the expression in **(a)(ii)** and Fig. 4.2 to determine the electric field strength at a distance of 4.0 cm from the charged point mass.

field strength = ... $V\,m^{-1}$ [4]

3 **(a)** Describe the main principles of the determination of the charge on an oil drop by Millikan's experiment. You may draw a diagram if you wish.

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.....[7]

(b) In an experiment to determine the fundamental charge, values of charge on oil drops were found by a student to be as shown below.

3.2×10^{-19} C; 6.4×10^{-19} C; 16×10^{-19} C; 9.7×10^{-19} C;

12.8×10^{-19} C; 3.1×10^{-19} C; 6.3×10^{-19} C.

State the value, to two significant figures, of the fundamental charge that is suggested by these values of charge on oil drops.

fundamental charge = ... C [1]

4 Two small charged metal spheres A and B are situated in a vacuum. The distance between the centres of the spheres is 12.0 cm, as shown in Fig. 4.1.

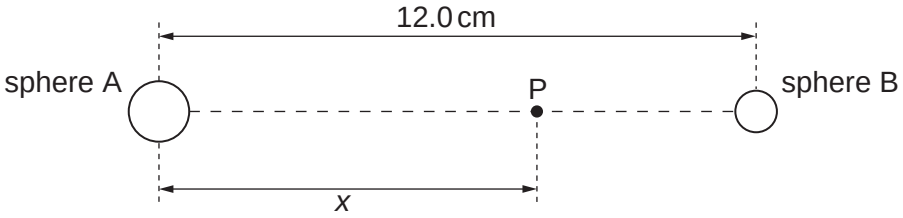

Fig. 4.1 (not to scale)

The charge on each sphere may be assumed to be a point charge at the centre of the sphere.
Point P is a movable point that lies on the line joining the centres of the spheres and is 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. 4.2.

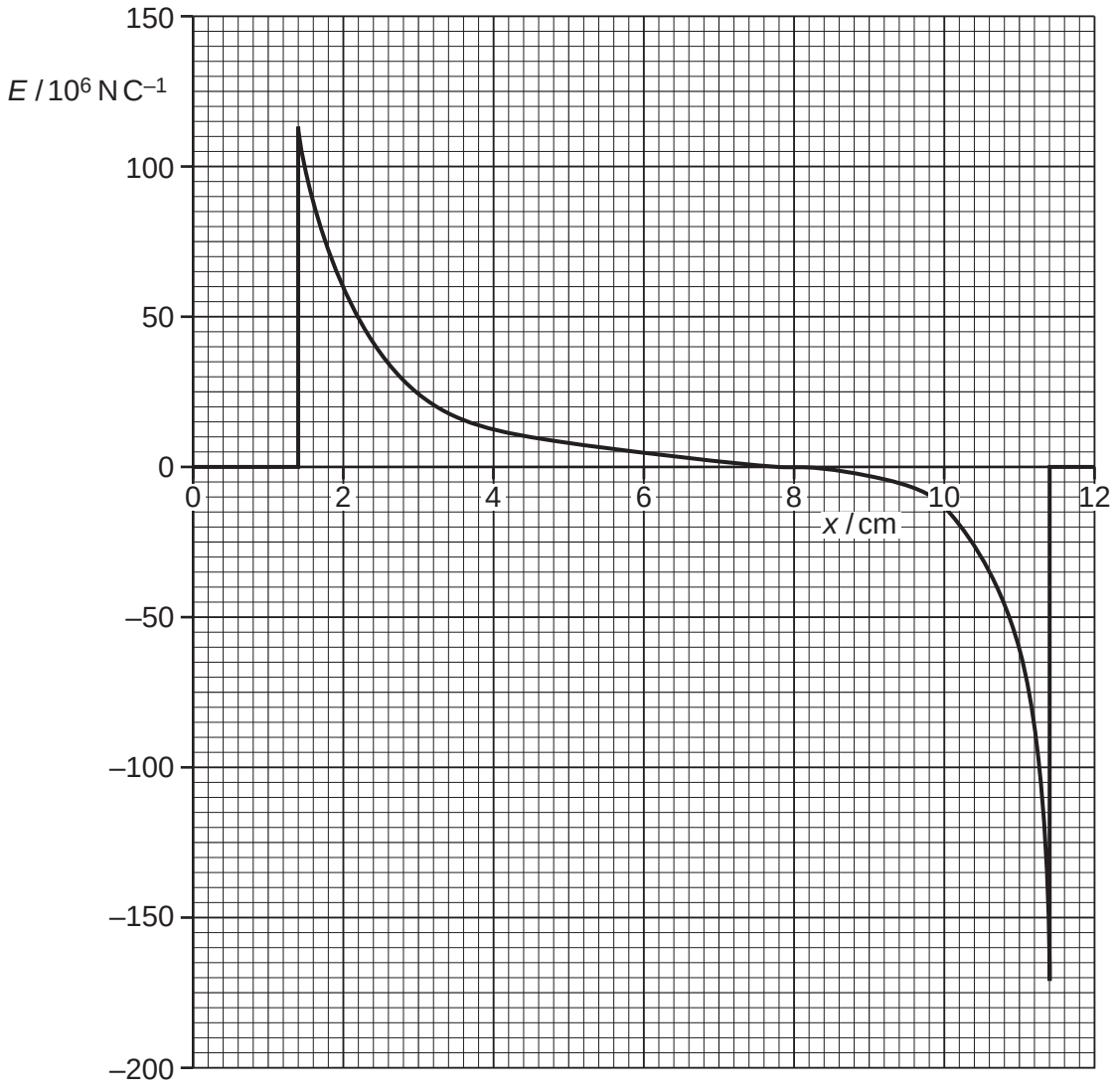

Fig. 4.2

(a) State the evidence provided by Fig. 4.2 for the statements that

(i) the spheres are conductors,

.....

..... [1]

(ii) the charges on the spheres are either both positive or both negative.

.....

.....

..... [2]

(b) **(i)** State the relation between electric field strength E and potential gradient at a point.

.....

..... [1]

(ii) Use Fig. 4.2 to state and explain the distance x at which the rate of change of potential with distance is

1. maximum,

.....

.....

..... [2]

2. minimum.

.....

.....

..... [2]

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

.....

.....

.....[2]

(b) Two small spherical charged particles P and Q may be assumed to be point charges located at their centres. The particles are in a vacuum.

Particle P is fixed in position. Particle Q is moved along the line joining the two charges, as illustrated in Fig. 4.1.

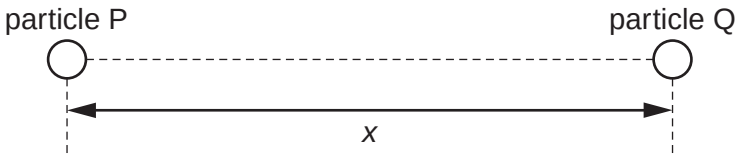

Fig. 4.1

The variation with separation x of the electric potential energy E_P of particle Q is shown in Fig. 4.2.

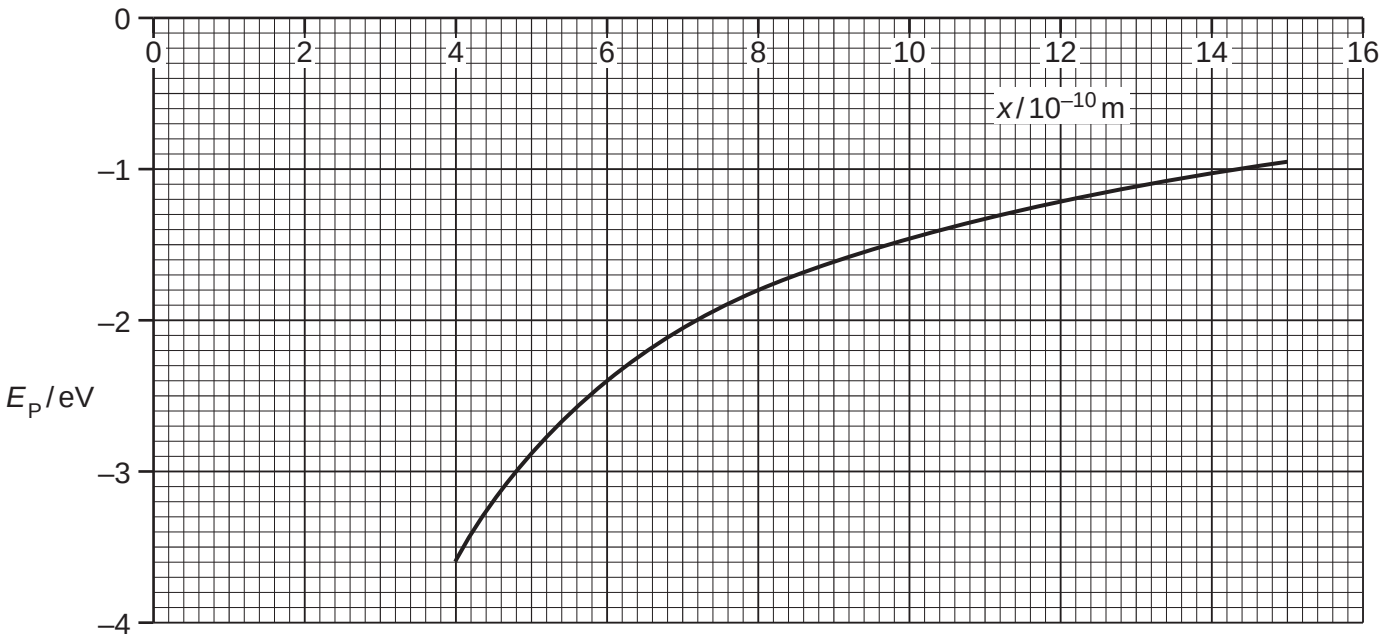

Fig. 4.2

(i) State how the magnitude of the electric field strength is related to potential gradient.

.....

.....[1]

(ii) Use your answer in **(i)** to show that the force on particle Q is proportional to the gradient of the curve of Fig. 4.2.

.....

.....

.....[2]

(c) The magnitude of the charge on each of the particles P and Q is 1.6×10^{-19} C. Calculate the separation of the particles at the point where particle Q has electric potential energy equal to –5.1 eV.

separation = ... m [4]

(d) By reference to Fig. 4.2, state and explain

(i) whether the two charges have the same, or opposite, sign,

.....

.....

.....[2]

(ii) the effect, if any, on the shape of the graph of doubling the charge on particle P.

.....

.....

.....[2]

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

.....

..... [1]

(b) Gravitational fields and electric fields are two examples of fields of force.
State one similarity and one difference between these two fields of force.

similarity: .....

.....

difference: .....

.....

.....
[3]

(c) Two protons are isolated in space. Their centres are separated by a distance R.
Each proton may be considered to be a point mass with point charge.
Determine the magnitude of the ratio

$$\frac{\text{force between protons due to electric field}}{\text{force between protons due to gravitational field}}.$$

ratio = ... [3]