1 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.

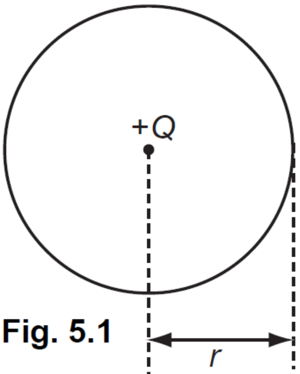

Fig. 5.1

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

(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 $+Q$. [3]

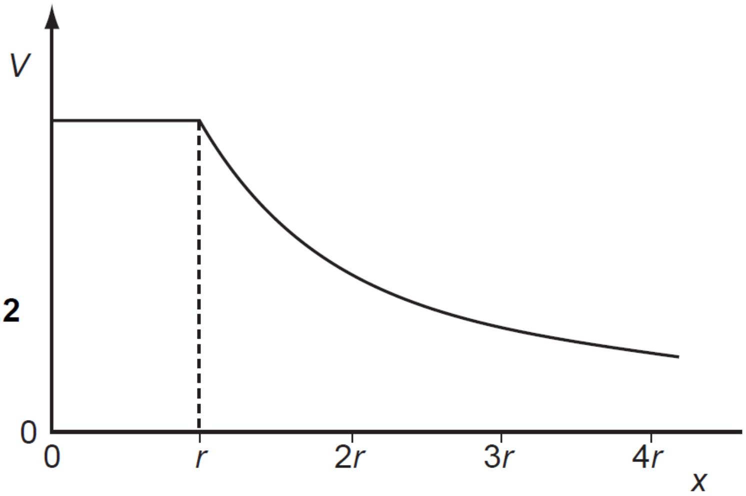

Fig. 5.2

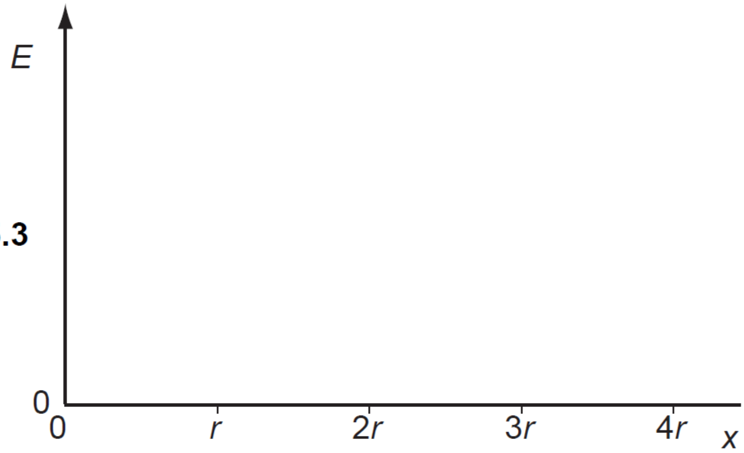

Fig. 5.3

2 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 $2.0 \times 10^6\ \mathrm{V\,m^{-1}}$. 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,

C [2]

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

. 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]

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

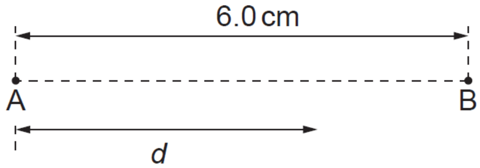

Fig. 3.1

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

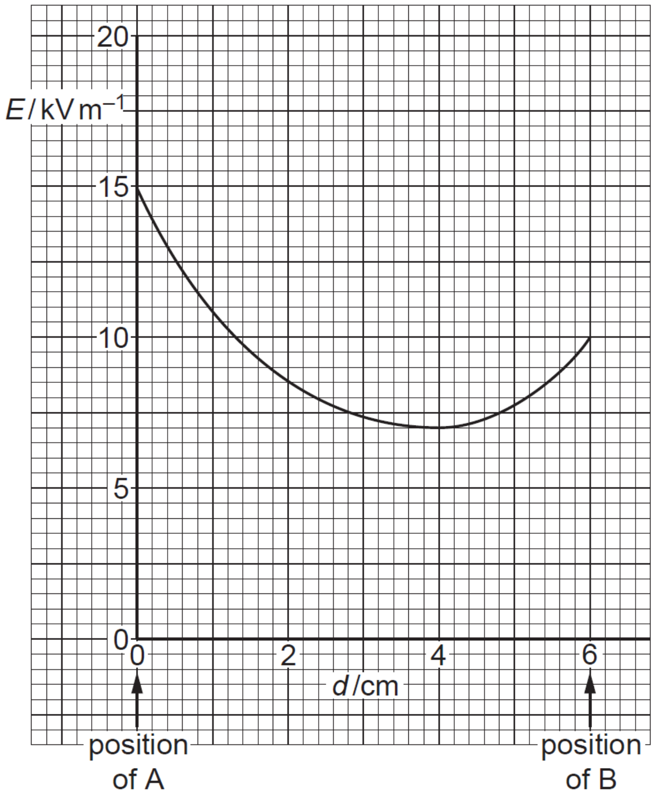

Fig. 3.2

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. [4]

(c) Use your answer to **(b)** to calculate the speed of the electron as it reaches point B. [2]

(d) **(i)** Use Fig. 3.2 to determine the value of d at which the electron has maximum acceleration. [1]

(ii) Without any further calculation, describe the variation with distance d of the acceleration of the electron. [2]

4 Two deuterium (^2_1H) nuclei are travelling directly towards one another. When their separation is large compared with their diameters, they each have speed v as illustrated in Fig. 5.1.

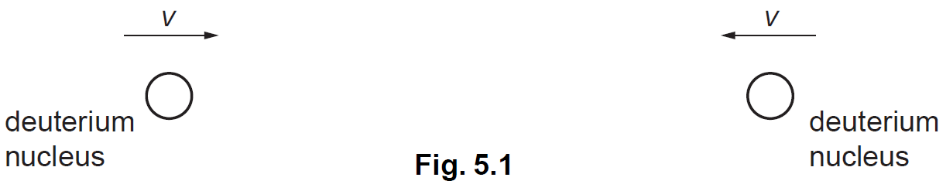

Fig. 5.1

The diameter of a deuterium nucleus is 1.1×10^{-14} m.

(a) Use energy considerations to show that the initial speed v of the deuterium nuclei must be approximately $2.5 \times 10^{6}\,\mathrm{m\,s^{-1}}$ in order that they may come into contact. Explain your working. [3]

(b) For a fusion reaction to occur, the deuterium nuclei must come into contact. Assuming that deuterium behaves as an ideal gas, deduce a value for the temperature of the deuterium such that the nuclei have an r.m.s. speed equal to the speed calculated in **(a)**. K [4]

(c) Comment on your answer to **(b)**. [1]

5 **(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.

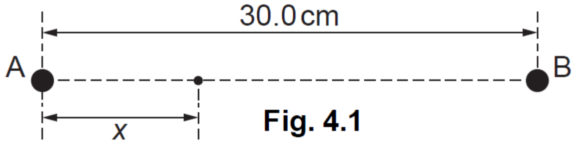

Fig. 4.1

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.

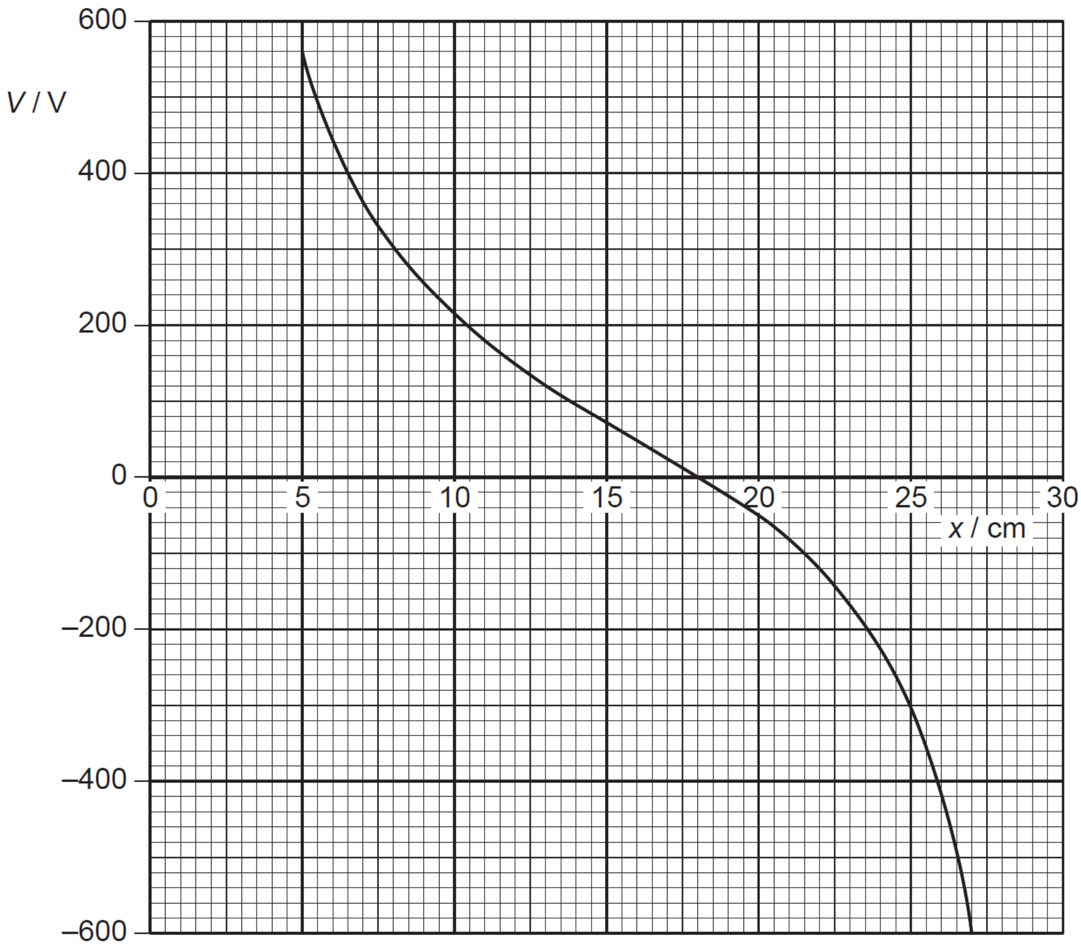

Fig. 4.2

(i) State the value of *x* at which the potential is zero. [1]

(ii) Use your answer in **(i)** to determine the charge at B. [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. [3]

6 A solid metal sphere, of radius *r*, is insulated from its surroundings. The sphere has charge +*Q*. This charge is on the surface of the sphere but it may be considered to be a point charge at its centre, as illustrated in Fig. 5.1.

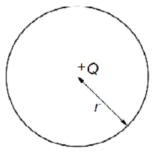

Fig. 5.1

(a) **(i)** Define *capacitance*. [1]

(ii) Show that the capacitance *C* of the sphere is given by the expression $C = 4\pi\varepsilon_0 r$. [1]

(b) The sphere has radius 36 cm. Determine, for this sphere,

(i) the capacitance, F [1]

(ii) the charge required to raise the potential of the sphere from zero to 7.0 × 10^5 V. [1]

(c) Suggest why your calculations in **(b)** for the metal sphere would not apply to a plastic sphere. [3]

(d) A spark suddenly connects the metal sphere in **(b)** to the Earth, causing the potential of the sphere to be reduced from 7.0 × 10^5 V to 2.5 × 10^5 V.
Calculate the energy dissipated in the spark. J [3]