Section B

Answer **two** questions in this section.

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

.....

.....

.....[1]

(ii) Fig. 5.1 shows a charge $+q$ at X in a uniform electric field of electric field strength E.

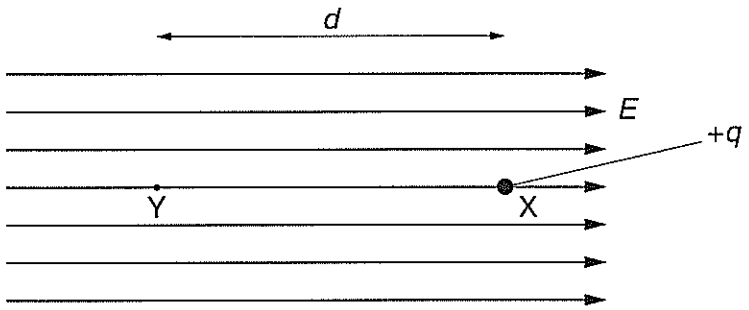

Fig. 5.1

The charge at X is moved to Y through a distance d. Using your definition in **(i)**, deduce an expression for the work done.

.....

.....

.....[1]

(iii) The potential difference between X and Y is V. Using your answer from **(ii)**, deduce an expression for V in terms of E and d.

.....

.....

.....[2]

(b) In the vacuum of an X-ray tube, electrons are accelerated from rest through a potential difference of 60 kV between the cathode and the anode. The current in the tube is 8.6 mA.

Calculate

(i) the number of electrons passing through the tube in one second,

number = ... [2]

(ii) the speed of electrons arriving at the anode,

speed = ... m s^{-1} [4]

(iii) the power supplied by the electrons hitting the anode.

power = ... W [2]

(c) X-ray production uses a negligible fraction of the power reaching the anode in **(b)**, so it has to be cooled by passing a coolant through the anode. The specific heat capacity of the coolant is $3500\,J\,kg^{-1}\,K^{-1}$ and the temperature rise of the coolant is 30 K.

Calculate the rate at which the coolant must be pumped through the anode.

rate = ... $kg\,s^{-1}$ [3]

(d) A conducting sphere of radius 0.10 m carries a charge of +0.060 μC. The electric field around the sphere is shown in Fig. 5.2.

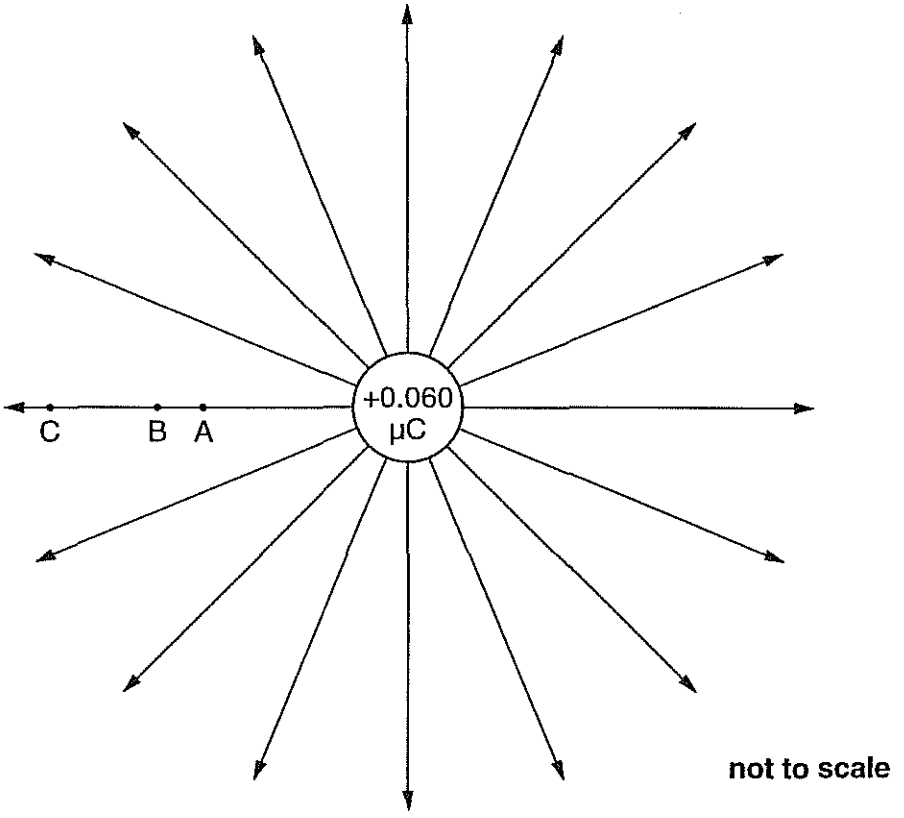

Fig. 5.2

(i) By reference to Fig. 5.2, suggest why it appears as if the charge is concentrated at the centre of the sphere.

.....

.....

.....[1]

(ii) Calculate the magnitude of the electric field strength at the surface of the sphere.

electric field strength = ... $N\,C^{-1}$ [2]

(iii) On Fig. 5.2, A is 0.40 m from the centre of the sphere and B is 0.50 m from the centre of the sphere. The potential difference between A and B is equal to the potential difference between B and C.

Calculate the distance from the centre of the sphere to C.

distance = ... m [2]