5 A charged particle P is situated in a vacuum at a distance x from the centre of a charged conducting sphere of radius r, as illustrated in Fig. 5.1.

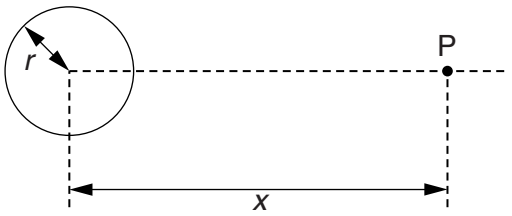

Fig. 5.1

For the particle P outside the conducting sphere, the charge on the sphere may be assumed to be a point charge at its centre.

(a) (i) State Coulomb's law.

.....

.....

.....[2]

(ii) The sphere and the particle P are both charged positively.

1. State the direction of the force acting on particle P.

.....[1]

2. State the position of particle P for the force to be maximum.

.....[1]

3. Determine the ratio

$$\frac{\text{force on particle P at } x = r}{\text{force on particle P at } x = 4r}.$$

ratio = ... [2]

(b) When the charge on the sphere is 6.0×10^{-7} C, the electric field strength at the surface of the sphere is $1.5 \times 10^{6}\,\text{V m}^{-1}$.

Electrical breakdown (a spark) occurs when the electric field strength at the surface of the sphere exceeds $2.0 \times 10^{6}\,\text{V m}^{-1}$.

Determine the additional charge that may be added to the sphere before breakdown occurs.

charge = ... C [3]