4 **(a)** Define *electric field strength at a point*.

....

.... [1]

(b) Two isolated non-conducting charged spheres X and Y are placed near to each other, as shown in Fig. 4.1.

Fig. 4.1

P is a point on the line joining the centres of the spheres where the electric potential is zero.

(i) Explain why it is **not** possible for the resultant electric field to be zero at point P.

....

....

....

.... [2]

(ii) The magnitudes of the charges on spheres X and Y in Fig. 4.1 are Q and $2Q$ respectively. The spheres may be considered as point charges at their centres.

Point P is at a distance x from the centre of sphere X.

1. Show that the distance of point P from the centre of sphere Y is equal to $2x$.

[1]

2. Determine an expression, in terms of Q, x, π and the permittivity of free space ε_0, for the resultant electric field strength E at point P due to the two spheres.

E = ... [2]

[Turn over

(c) Fig. 4.2 shows a spark detector used to detect alpha particles.

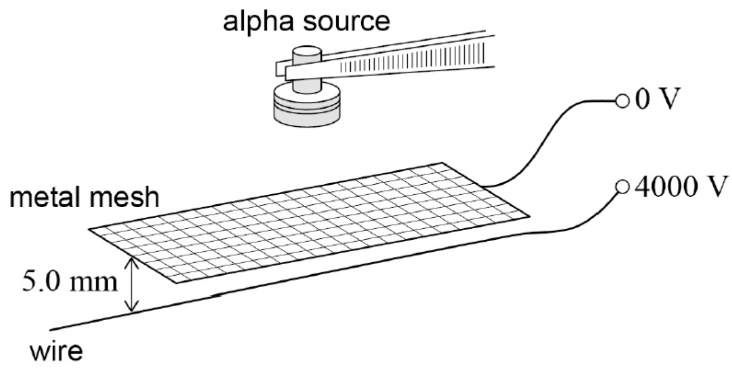

Fig. 4.2

The detector consists of a metal mesh placed 5.0 mm above a wire.
A potential difference of 4000 V is applied between the mesh and the wire.

Molecules in the air between the mesh and the wire are ionised by an alpha particle and a spark is produced.

(i) Fig. 4.3 shows equipotential surfaces between the mesh and the wire.

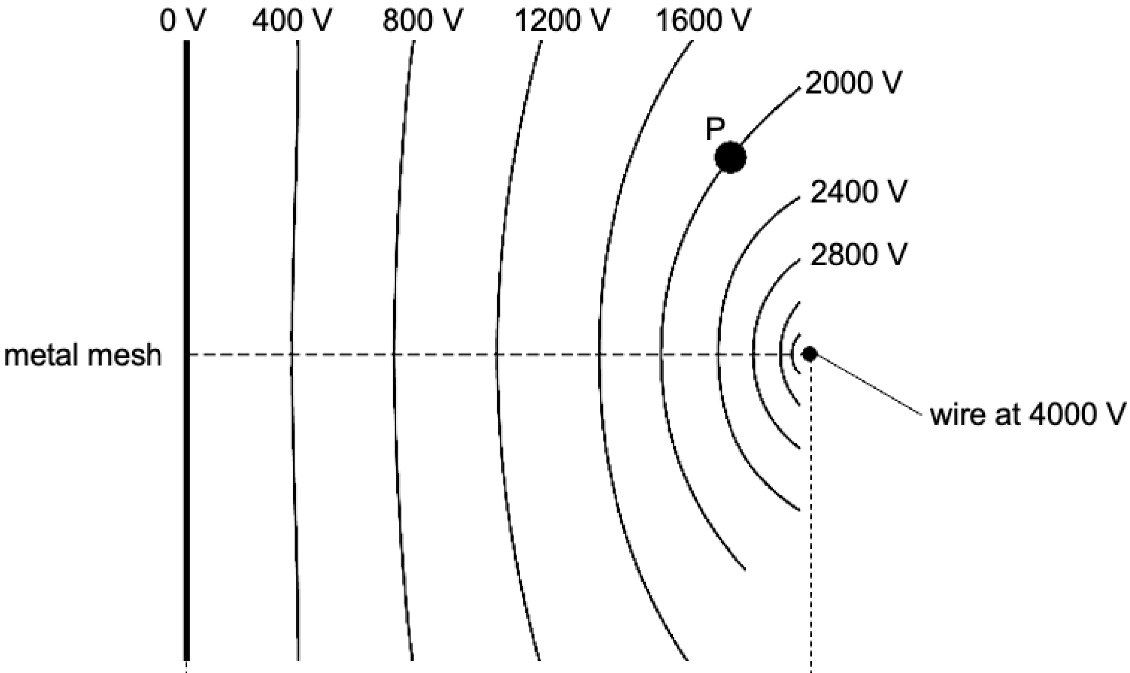

Fig. 4.3

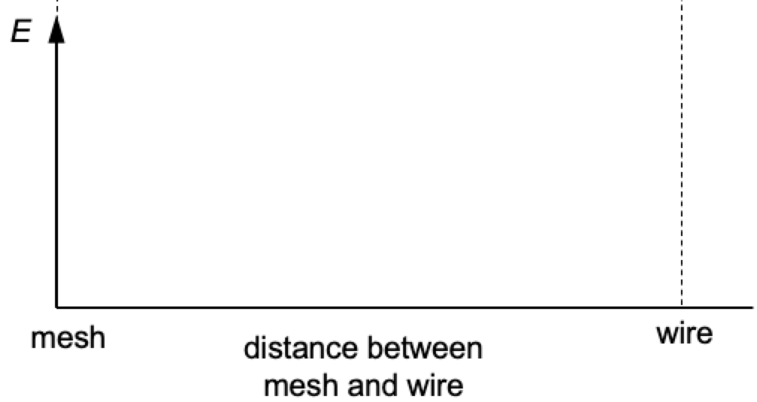

Fig. 4.4

Sketch on Fig. 4.4 the variation of the magnitude of the electric field strength E along the dashed line between the mesh and the wire in Fig. 4.3.

Values are not required on the E-axis. [2]

(ii) An alpha particle passes through the mesh. The alpha particle ionises an argon atom at point **P** on Fig. 4.3, releasing one electron.

The electron and the argon ion have no kinetic energy at point **P.**

The electron then travels to the wire and the argon ion (mass = 6.64×10^{-26} kg) travels to the mesh.

Calculate the ratio $\frac{speed\ of\ electron\ when\ it\ reaches\ the\ wire}{speed\ of\ argon\ ion\ when\ it\ reaches\ the\ mesh}$.

Assume that the air does not affect the motion of the electron or the argon ion.

ratio = ... [2]

(iii) In practice, the air **does** affect the motion of the electron and the motion of argon ion.

Suggest qualitatively how the presence of the air between the mesh and the wire affects the ratio in **(b)(ii).**

....

....

.... [1]

[Total: 11]