

1 (a) Define *electric field strength* at a point in space.

.....  
..... [1]

(b) Fig. 2.1 shows an evenly spaced grid.

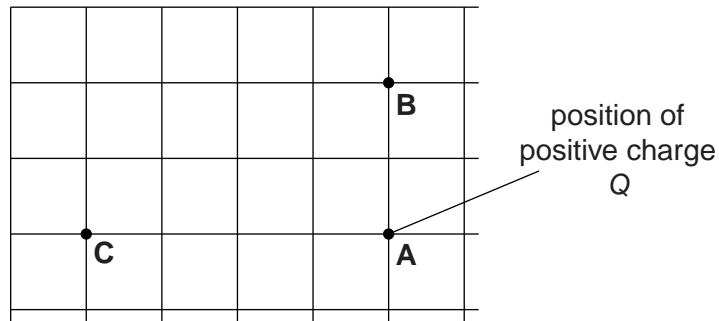


Fig. 2.1

**A**, **B** and **C** are points on the grid. A positive charge  $Q$  is placed on the grid at point **A**. The magnitude of the electric field strength at point **B** due to the charge  $Q$  is  $8.0 \times 10^5 \text{ NC}^{-1}$ .

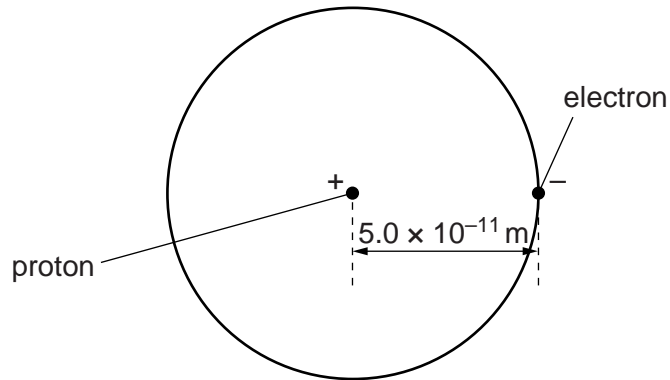
(i) Apart from the magnitudes of the electric field strength, state another difference between the electric field at points **B** and **C**.

.....  
..... [1]

(ii) Determine the magnitude of the electric field strength at point **C**.

electric field strength = .....  $\text{NC}^{-1}$  [2]

(c) The simplest atom is that of hydrogen with one proton and one electron, see Fig. 2.2.



**Fig. 2.2**

The mean separation between the proton and the electron is shown in Fig. 2.2.

(i) Calculate the magnitude of the electrical force  $F_E$  acting on the electron.

$$F_E = \dots\dots\dots \text{N} \quad [3]$$

(ii) The gravitational force  $F_G$  acting on the electron due to the proton is very small compared with the electrical force  $F_E$  it experiences.

Calculate the ratio  $\frac{F_E}{F_G}$ .

$$\text{ratio} = \dots\dots\dots [2]$$

- (iii) A simplified model of the hydrogen atom suggests that the de Broglie wavelength of the electron is four times the mean separation between the proton and the electron shown in Fig. 2.2.

Estimate

- 1 the momentum  $p$  of the electron

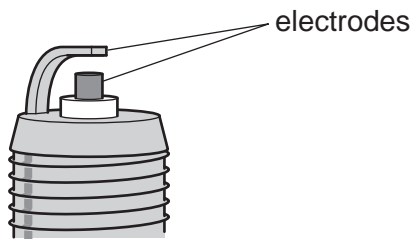
$$p = \dots\dots\dots \text{kgms}^{-1} \quad [3]$$

- 2 the kinetic energy  $E_k$  of the electron.

$$E_k = \dots\dots\dots \text{J} \quad [3]$$

[Total: 15]

2 Fig. 1.1 shows a close up of the two electrodes of a spark plug.



**Fig. 1.1**

The electrodes may be considered as two parallel plates. The electric field strength between the electrodes is almost uniform.

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

.....  
..... [1]

**(b)** The separation between the electrodes is 1.3mm. An electric spark is produced when the electric field strength is  $3.0 \times 10^6 \text{V m}^{-1}$ .

**(i)** Estimate the potential difference  $V$  between the electrodes when the spark is produced.

$V = \dots\dots\dots \text{V}$  [2]

**(ii)** The electric spark lasts for  $4.0 \times 10^{-2}$  s and produces an average current of  $2.7 \times 10^{-9}$  A.

**1** Calculate the charge transferred between the electrodes.

charge = .....C **[2]**

**2** Calculate the number of electrons transferred between the electrodes.

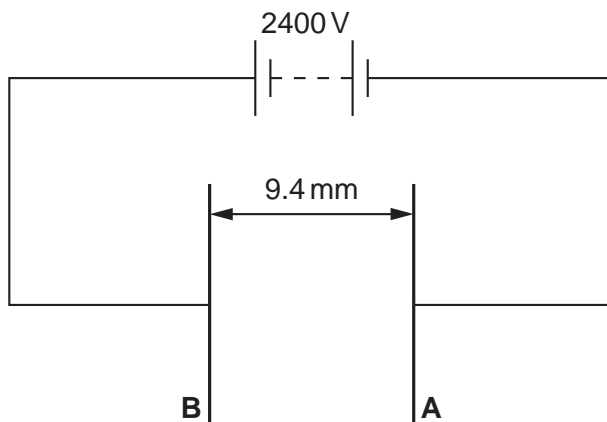
number = ..... **[1]**

**(iii)** Estimate the total energy transferred by the electrons in **(ii)**.

energy = ..... J **[2]**

**[Total: 8]**

- 3 (a) Fig. 1.1 shows a circuit consisting of two parallel plates **A** and **B** connected to a high voltage power supply.



**Fig. 1.1**

The separation of the plates is 9.4 mm and the p.d. across the plates is 2400 V. There is a vacuum between the plates. Electrons are accelerated from plate **A** to plate **B**.

Calculate

- (i) the force acting on an electron when it is between the plates

force = ..... N [2]

- (ii) the gain in kinetic energy of an electron when it travels from **A** to **B**

kinetic energy = ..... J [2]

- (iii) the speed of the electron when it reaches plate **B**. Assume that the speed of the electron is initially zero at plate **A**.

speed = ..... m s<sup>-1</sup> [1]

**(b)** The separation between the plates is doubled but the p.d. across the plates is kept the same. Explain how this would affect the answer to **(a)(ii)**.

.....

.....

.....

..... [2]

**[Total: 7]**

- 4 (a) Explain how the experiments on the scattering of alpha-particles by a metal foil provided evidence for the nuclear model of the atom.

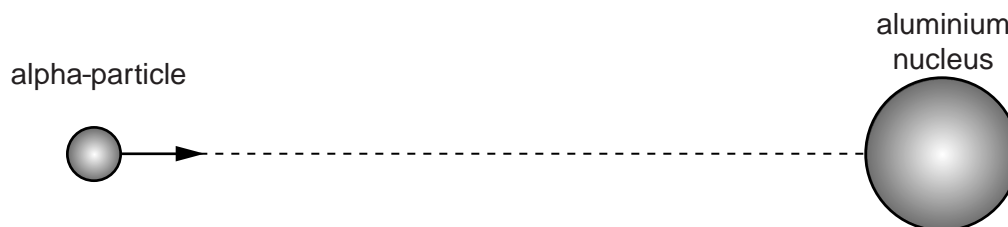


*In your answer, you should make clear how your conclusions link with the observations.*

.....  
.....  
.....  
.....  
.....  
.....

[3]

- (b) Fig. 5.1 shows an alpha-particle ( ${}^4_2\text{He}$ ) of kinetic energy 8.0 MeV moving directly towards a nucleus of aluminium-27 ( ${}^{27}_{13}\text{Al}$ ), initially at rest.



**Fig. 5.1**

- (i) The alpha-particle comes to rest instantaneously a short distance away from the aluminium nucleus. It then reverses its direction of travel. Describe and explain the motion of the aluminium nucleus at the instant the alpha-particle is at rest.

.....  
.....  
.....  
.....

[2]



(ii) Calculate the initial speed of the alpha-particle.

mass of alpha-particle =  $6.6 \times 10^{-27}$  kg

speed = .....  $\text{ms}^{-1}$  [2]

(iii) The electric force experienced by the alpha-particle when it is close to the aluminium nucleus is 270 N. Calculate the separation  $r$  between the alpha-particle and the aluminium nucleus when the alpha-particle experiences this force.

$r =$  ..... m [3]

(iv) Consider the situation where the alpha-particle travels much closer to the aluminium nucleus than in (b)(iii).

Discuss how the strong nuclear force may affect the resultant force on the alpha-particle.

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.....  
.....  
..... [2]