5 **(a)** Define electric potential at a point.

.....

.....

..... [2]

(b) A hydrogen atom may be considered to consist of a proton and an electron separated by a distance of 120 pm, as shown in Fig. 5.1.

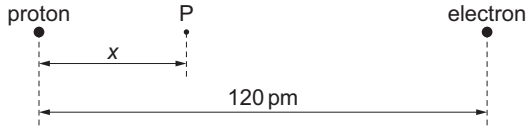

Fig. 5.1

The two particles may be considered as point charges.

Point P lies on the line joining the electron and the proton and is at a variable distance x from the proton.

(i) Show that the electric potential V at point P when x = 10 pm is equal to 130 V.

[2]

(ii) Calculate, to two significant figures, V when x = 30 pm.

V = ...V [2]

(iii) On Fig. 5.1, draw a cross (×) at one position, other than infinity, where the electric potential is zero. [1]

(iv) On Fig. 5.2, sketch the variation of V with x between x = 10 pm and x = 110 pm.

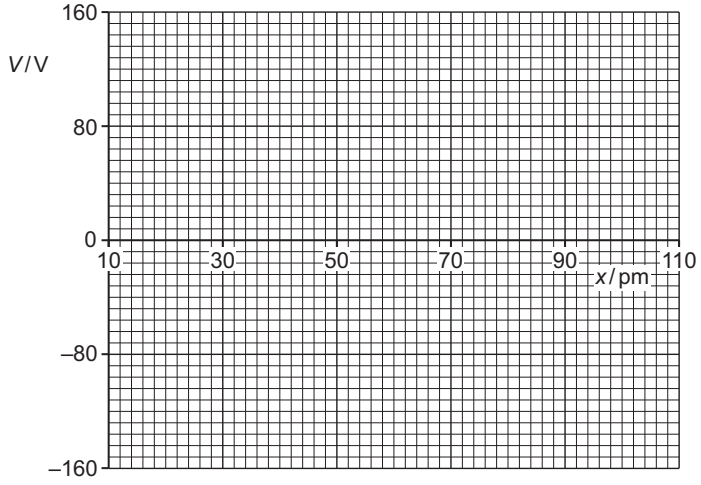

Fig. 5.2

[3]

[Total: 10]

2 A helium atom may be modelled as a nucleus surrounded by two electrons in diametrically opposite circular orbits, each of radius 170 pm, as shown in Fig. 2.1.

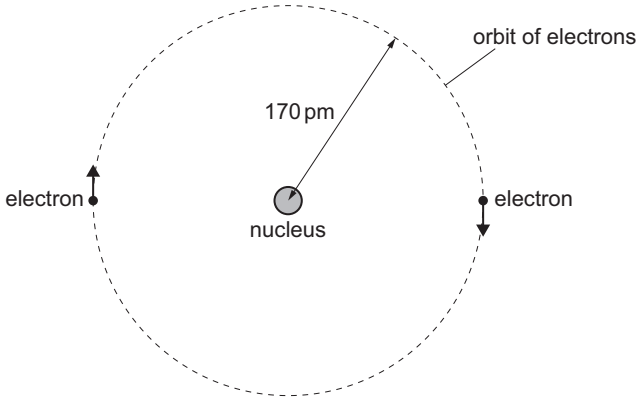

Fig. 2.1

(a) State Coulomb's law.

.....

.....

..... [2]

(b) **(i)** State the charge on the nucleus, in terms of the elementary charge *e*.

charge = ... *e* [1]

(ii) Show that the electric force between the nucleus and one of the electrons is 1.6×10^{-8} N.

[1]

(c) Assume that the force in **(b)(ii)** is the only force on the electrons.

(i) Calculate the speed of the orbiting electrons.

speed = ... $m\,s^{-1}$ [2]

(ii) Calculate the period of the orbit of the electrons.

period = ... s [2]

(d) In practice, the orbit of each electron is affected by the presence of the other electron.

(i) For the position of one of the electrons, determine the ratio

$$\frac{\text{electric field strength due to the other electron}}{\text{electric field strength due to the nucleus}}.$$

ratio = ... [2]

(ii) Use your answer in **(d)(i)** to suggest and explain how the orbit of the electron is affected by the presence of the other electron.

.....

..... [1]

[Total: 11]

6 Two parallel metal plates X and Y are separated by a distance of 0.041 m, as shown in Fig. 6.1.

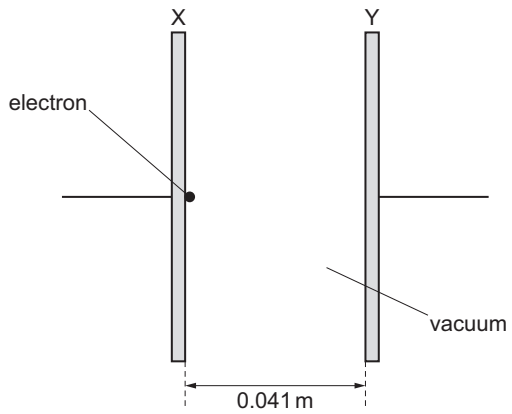

Fig. 6.1

There is a vacuum between the plates. An electron is at rest at the centre of plate X.

A potential difference (p.d.) of 58 kV is applied across the plates. This causes the electron to accelerate towards plate Y.

(a) On Fig. 6.1, use the symbols + and – to indicate which of plates X and Y is the positive plate and which is the negative plate. [1]

(b) **(i)** Calculate the electric field strength *E* between the plates. Give a unit with your answer.

E = ... unit ..... [2]

(ii) Determine the acceleration of the electron.

acceleration = ... $m\,s^{-2}$ [2]

(c) Many electrons are now accelerated from rest from plate X to plate Y in Fig. 6.1. When the electrons hit plate Y, the absorption of their kinetic energies results in the emission of electromagnetic waves.

(i) Show that the minimum wavelength of these electromagnetic waves is 21 pm.

[3]

(ii) State the region of the electromagnetic spectrum that contains these waves.

..... [1]

(iii) Explain how these electromagnetic waves may be used to form images of internal body structures.

.....

.....

.....

..... [2]

[Total: 11]