Section B

Answer **one** question from this Section in the spaces provided.

9 **(a)** In an electron microscope, an electron lens has two cylinders which are at potentials of +500 V and −100 V respectively. An electron beam passes at high speed into the lens from the top.

A cross-section of the two cylinders is shown in **full scale in Fig. 9.1**. The dotted lines are equipotential lines.

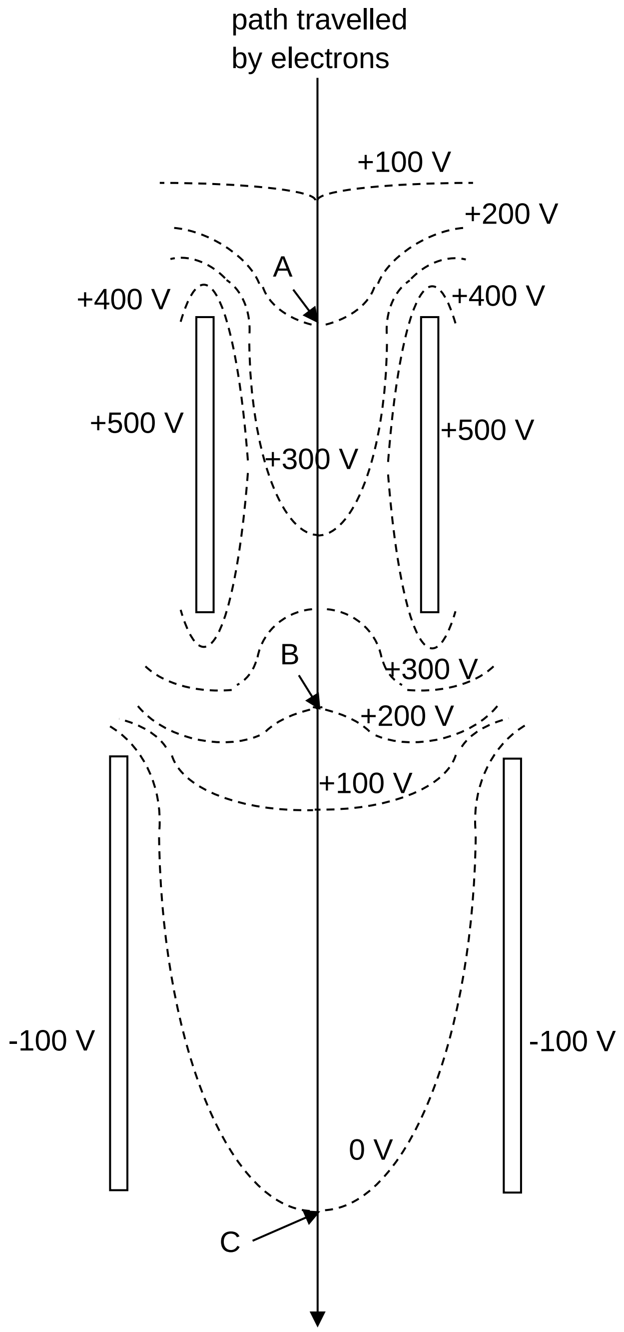

Fig. 9.1 Equipotential lines drawn to scale

(i) Define *electric field strength*.

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....

.... [1]

(ii) With reference to Fig. 9.1, describe how the speed of an electron changes while moving from A to B.

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.... [2]

(iii) Calculate the change in kinetic energy of an electron moving from A to C.

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

(iv) Estimate the electric field strength at B.

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

(v) Show the direction of electric field strength at B in Fig. 9.1. [1]

(vi) Hence, determine the magnitude and direction of the electric force on an electron at B.

magnitude of electric force =...................... N

direction of electric force =...................... [2]

(b) The space observatory SOHO orbits the Sun in a circular orbit as shown in Fig. 9.2.

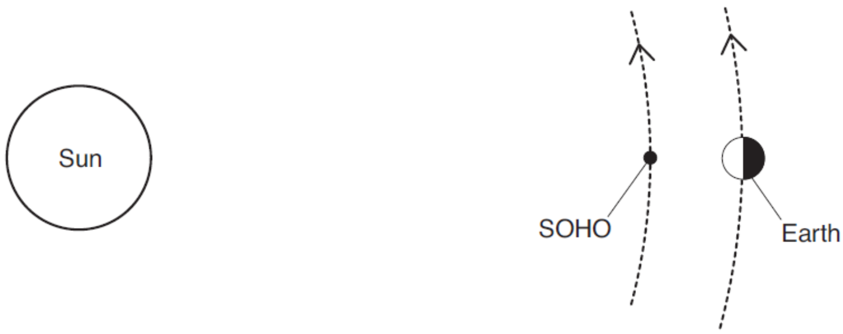

Fig. 9.2

(i) Show that the angular speed ω of an object in a circular orbit of radius R about the Sun is given by

$$\omega = \sqrt{\frac{GM}{R^3}}$$

where M is the mass of the Sun. Explain your working clearly.

[1]

(ii) On Fig. 9.2, draw and label arrows showing all the forces acting on SOHO. [1]

(iii) SOHO has the same angular speed as Earth about the Sun

Using your answer in **(b)(i)** and **(b)(ii)**, explain how this is possible.

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.... [2]

(iv) "*A SOHO with larger mass will have a longer orbital period about the Sun.*"

By considering the forces on SOHO, explain whether the above statement is true. Clearly define any symbols that are used in the explanation.

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.... [1]

(c) Another space observatory satellite orbits the Earth in a circular orbit at a height of 7.0×10^3 km above Earth's surface. The mass of the Earth is 6.0×10^{24} kg.

(i) Determine the orbital speed of this satellite.

orbital speed =...................... m s^{-1} [2]

(ii) A stone of mass 12 kg is to be projected directly opposite to the motion of satellite as shown in Fig. 9.3 such that it can totally escape from Earth's gravitational field.

Determine the minimum speed of projection of the stone.

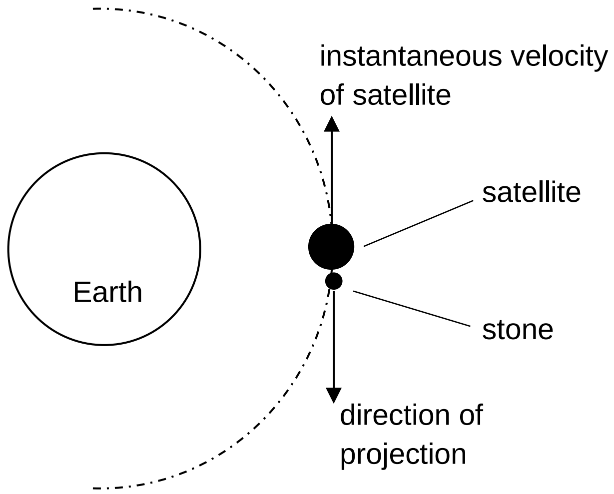

Fig. 9.3

minimum speed of projection =...................... m s^{-1} [2]

(iii) Explain whether projecting the stone from the satellite in a direction away from the centre of the Earth will result in the lowest speed to escape from the Earth's gravitational field.

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.... [1]