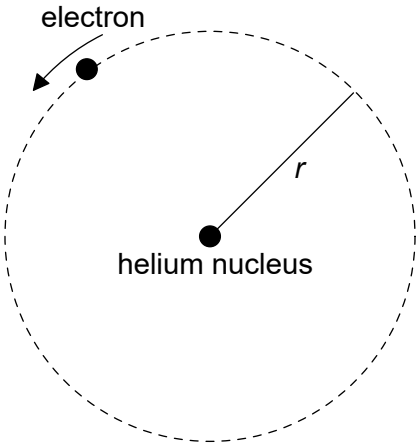
8. (a) In a classical model of the singly-ionized helium atom, a single electron orbits the nucleus in a circular orbit of radius r.



(i) Show that the speed v of the electron with mass m, is given by $v = \sqrt{\frac{2ke^2}{mr}}$. [1]

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(ii) Hence, deduce that the total energy of the electron is given by $E_{TOT} = -\frac{ke^2}{r}$. [2]

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(iii) In this model the electron loses energy by emitting electromagnetic waves. Describe the predicted effect of this emission on the orbital radius of the electron. [2]

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9. (a) A planet of mass m is in a circular orbit around a star. The gravitational potential due to the star at the position of the planet is V.

(i) Show that the total energy of the planet is given by the equation shown. [2]

$$E = \frac{1}{2}mV$$

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(ii) Suppose the star could contract to half its original radius without any loss of mass. Discuss the effect, if any, this has on the total energy of the planet. [2]

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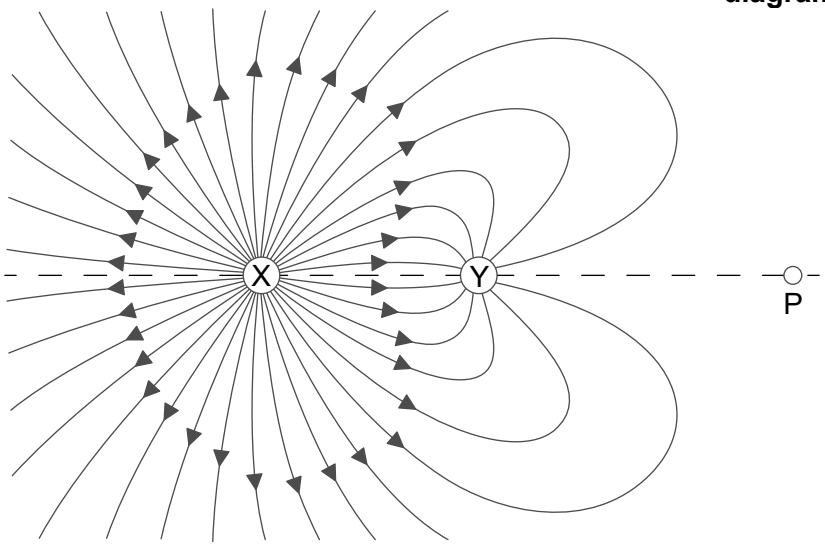
(Question 9 continued)

(b) The diagram shows some of the electric field lines for two fixed, charged particles X and Y.

diagram not to scale



The magnitude of the charge on X is Q and that on Y is q. The distance between X and Y is 0.600 m. The distance between P and Y is 0.820 m.

At P the electric field is zero. Determine, to **one** significant figure, the ratio $\frac{Q}{q}$. [2]

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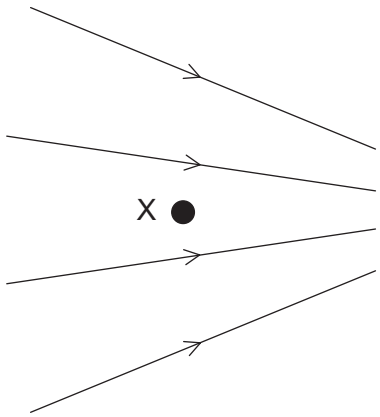
8. A non-uniform electric field, with field lines as shown, exists in a region where there is no gravitational field. X is a point in the electric field. The field lines and X lie in the plane of the paper.



(a) Outline what is meant by electric field strength. [2]

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(b) An electron is placed at X and released from rest. Draw, on the diagram, the direction of the force acting on the electron due to the field. [1]

(This question continues on the following page)

(Question 8 continued)

(c) The electron is replaced by a proton which is also released from rest at X. Compare, without calculation, the motion of the electron with the motion of the proton after release. You may assume that no frictional forces act on the electron or the proton. [4]

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