SECTION B

*This section consists of four questions: B1, B2, B3 and B4. Answer **two** questions.*

B1. This question is in **two** parts. **Part 1** is about momentum and the kinematics of a proposed journey to Jupiter. **Part 2** is about radioactive decay.

Part 1 Momentum and kinematics

(a) State the law of conservation of momentum. *[2]*

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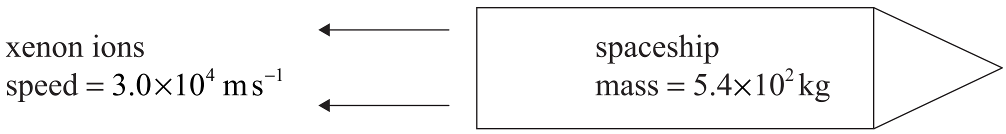
A solar propulsion engine uses solar power to ionise atoms of xenon and to accelerate them. As a result of the acceleration process, the ions are ejected from the spaceship with a speed of $3.0\times10^4\ \mathrm{m\,s^{-1}}$.



(b) The mass (nucleon) number of the xenon used is 131. Deduce that the mass of one ion of xenon is 2.2×10^{-25} kg. *[2]*

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(c) The original mass of the fuel is 81 kg. Deduce that, if the engine ejects 7.7×10^{18} xenon ions every second, the fuel will last for 1.5 years. (1 year = 3.2×10^7 s) *[2]*

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(Question B1, part 1 continued)

(d) The mass of the spaceship is $5.4\times10^{2}\,\text{kg}$. Deduce that the initial acceleration of the spaceship is $8.2\times10^{-5}\,\text{m}\,\text{s}^{-2}$. *[5]*

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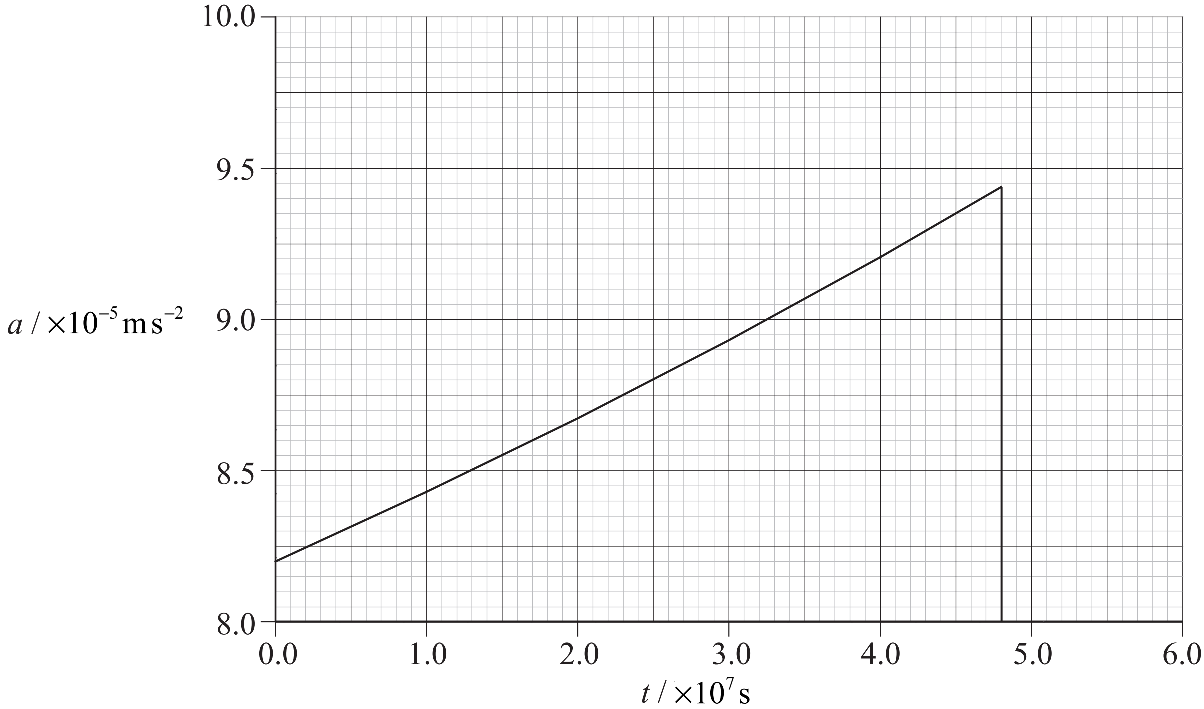
(Question B1, part 1 continued)

The graph below shows the variation with time t of the acceleration a of the spaceship. The solar propulsion engine is switched on at time $t = 0$ when the speed of the spaceship is $1.2 \times 10^3 \, \mathrm{m\,s^{-1}}$.



(e) Explain why the acceleration of the spaceship is increasing with time. *[2]*

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(f) Using data from the graph, calculate the speed of the spaceship at the time when the xenon fuel has all been used. *[4]*

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(Question B1, part 1 continued)

(g) The distance of the spaceship from Earth when the solar propulsion engine is switched on is very small compared to the distance from Earth to Jupiter. The fuel runs out when the spaceship is a distance of 4.7×10^{11} m from Jupiter. Estimate the total time that it would take the spaceship to travel from Earth to Jupiter. *[2]*

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