Question 3

This question relates to Book 2, Chapters 1, 3, 6 and 7, and carries 26% of the marks for this assignment.

A spacecraft, having finished a planetary mission, heads out of the Solar System. Beyond Pluto and Neptune, it encounters a previously unknown planet with a small satellite. Eventually, the weak signals sent out by the craft are received on Earth and the following information is obtained:

- the mass of the planet is 8×10^{24} kg;
- the radius of the planet is 7 000 km;
- the effective temperature is 30 K and very slightly higher than expected from the distance to the Sun and the planetary albedo;
- the planet has a magnetic field;
- only H_2 was detected in the planet's atmosphere although the average molecular mass indicates the presence of about 15% by numbers of molecules/atoms of a substance with an RMM of 4;
- no clouds were observed and the planet has a high albedo.

(a) *(7 marks)* Calculate the average density of the planet (you may assume it is spherical) and hence specify its likely bulk composition.

(b) *(3 marks)* Describe very briefly what can be deduced about the interior of the planet from (i) its effective temperature, (ii) its magnetic field, *giving your reasons*.

(c) *(4 marks)* What are the most likely compositions of the atmosphere and surface of the planet? *Give your reasoning.*

(d) *(7 marks)* Calculate the escape speed for the planet. From Figure 1.10 in Book 2 (page 23) would you expect the planet to have retained H_2? *Give your reasons.*

(e) *(5 marks)* Describe very briefly how the spacecraft might have obtained the following data: (i) the mass of the planet, (ii) the presence of the substance with an RMM value of 4.

Question 4

This question relates to Block 2, Chapters 3–5 and 8, and carries 28% of the marks for this assignment.

(a) The crystallization age is the technical term for the time into the past that a rock last solidified (crystallized).

(i) *(5 marks)* In Chapters 3–5 of Book 2 you met two very different processes in which silicate melts can be produced either at, or some way below, the surface of a rocky planetary body. Name each melting process, explaining *very briefly* why the melts are produced.

(ii) *(11 marks)* Describe the method of radiometric dating of crystallization ages in the particular case where isotopes of rubidium and strontium are used. *Half the marks for (ii) are for a* ***qualitative sketch*** *showing how the amounts of the isotopes ^{87}Rb and ^{87}Sr change with time after a substance has solidified.*

(b) *(8 marks)* SNC meteorites present some fascinating problems. Their crystallization ages, oxygen isotope ratios, and content of trapped gases are generally taken to indicate that they are samples of comparatively young igneous rocks, blasted (without melting) from the surface of Mars by hypervelocity impacts. By far the majority of meteorites, however, are thought to be derived from the asteroid belt, and some such meteorites, such as Juvinas, have basaltic compositions not dissimilar to SNCs. What then is the best evidence that the SNCs did not also come from asteroidal sources? Write a few sentences each on

(i) the evidence from crystallization ages of meteorites,

(ii) whether oxygen isotope evidence, based on analyses of oxides and silicates, is useful, and

(iii) the evidence from gases trapped in meteorites.

NB To get all the marks you must outline the evidence, and explain what (if anything) each type of evidence tells us about the origin of the SNC meteorites.

(c) *(4 marks)* Given what we can infer about the history of Mars from crater studies (Subsection 4.4.4), what is curious about the crystallization ages of the SNC meteorites with respect to

(i) the absence of ages older than those found among the SNCs, and

(ii) the youthfullness of the younger ages among the SNCs.