

which one is now believed to be the most likely theory, and paying particular attention to this theory in your answer. [Note: You can give a perfectly satisfactory answer to this question based on S281 alone. If, however, you choose to bring in information from other OU courses, or elsewhere, you should give references to your sources.] (No more than about 150 words)

(ii) Discuss, with reasons, whether or not you would expect 1993 KA₂ to be near-spherical in shape.

(one or two sentences)

Question 4

This question relates to Book 2, Chapters 1–3, and carries 12% of the marks for this assignment.

Before you attempt this question, you need to read the following extract from an article that appeared in the popular astronomy magazine *Sky & Telescope* in December 1993 about observations of the composition of the surface of Pluto. This article elaborates on the little we say about Pluto in S281, but it does not introduce any important new concepts. [Comment: the term 'micron' means micrometre, μm , but this is not important to your understanding of the extract.]

A team of 10 American and French researchers has discovered that the ices on Pluto's surface are overwhelmingly dominated by nitrogen, not methane as previously thought. Using high resolution spectra obtained in May 1992 with the 3.8-meter United Kingdom Infrared Telescope on Mauna Kea, the researchers found a weak and previously unseen absorption at 2.15 microns attributed to N₂ ice. Tobias C. Owen (University of Hawaii) and his colleagues conclude that, to have been detected at all, the frozen nitrogen must constitute about 98% of the surface ices. It likely exists as either marble-size lumps or heavily fractured sheets. The researchers also confirmed the presence of methane (CH₄) ice, which was first discovered on Pluto in 1976, and discovered a trace of frozen carbon monoxide. But no evidence exists for water ice or frozen carbon dioxide.

The team's findings have far-reaching implications for theories of outer-planet formation and evolution. First the very tenuous atmosphere of Pluto, discovered in 1988 during a stellar occultation, must likewise be dominated by

relatively heavy nitrogen gas rather than lighter methane. The presence of molecular nitrogen also pleases cosmic chemists, who predict that N₂ is abundant in the interstellar medium, and by extension in the nebula from which the planets formed.

Planetary scientists continue to debate how much Pluto and the like-size body Triton have in common. The two apparently formed at comparable distances from the Sun. But much of Triton's volatile material probably boiled away as the huge satellite was dragged into orbit around Neptune, leaving it somewhat denser than Pluto. While the new findings are important, a real understanding of how Pluto and Triton fit in the overall scheme of the outer solar system will have to await much-improved spectroscopic techniques and, especially, future visits by spacecraft. Thus planetary scientists earnestly hope NASA will fund the proposed Pluto Fast Flyby mission for early in the next century.

(a) (3 marks) Bearing in mind Pluto's density (Table 1.1a), suggest, giving your reasons, what its core is likely to be made of, assuming Pluto to be a differentiated body. (one or two sentences)

(b) (9 marks) (i) According to the extract, in what way has our knowledge of the dominant component of Pluto's atmosphere changed, and (based on what you have learned in S281) what are the resulting implications for the likelihood that Pluto would be able to retain its atmosphere for a long time? (one or two sentences)

(ii) Given that nitrogen is so abundant on Pluto (at least on its surface), explain what this implies about the temperature in the solar nebula where (and when) the Pluto-forming material condensed. [Note: For the purposes of this answer, you may ignore the possibility that Pluto's nitrogen is a product of chemical breakdown of ammonia (NH₃).] (one or two sentences)

(iii) The last paragraph of the extract refers to much of Triton's volatile material having been 'boiled off' when Triton was 'dragged into orbit around Neptune'. Explain how the interior of Triton is likely to have been heated during this event. (two or three sentences)