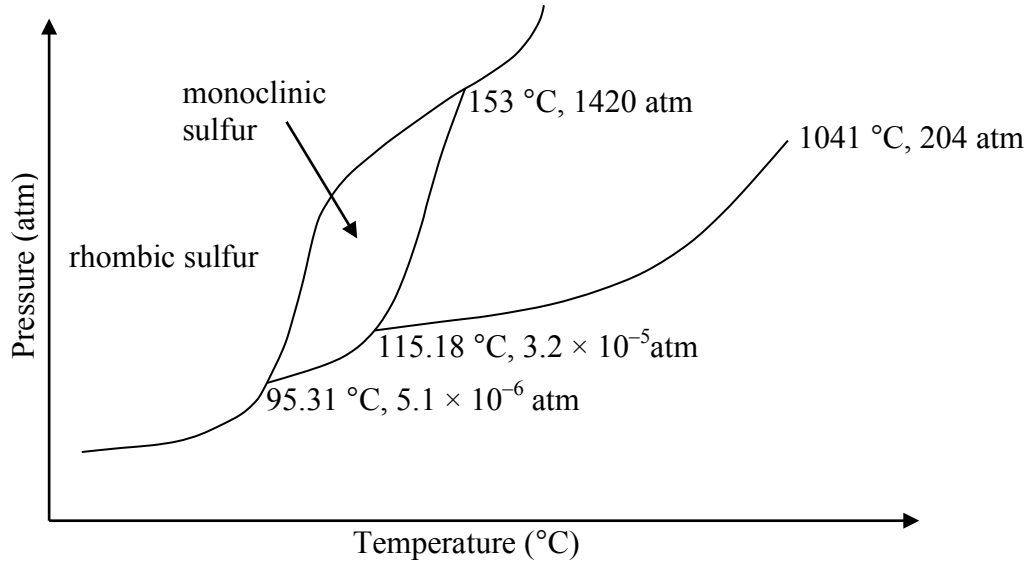
Marks 6

- The diagram below shows the phase diagram of sulfur. Note that 'rhombic' and 'monoclinic' refer to two different crystalline forms of the element.



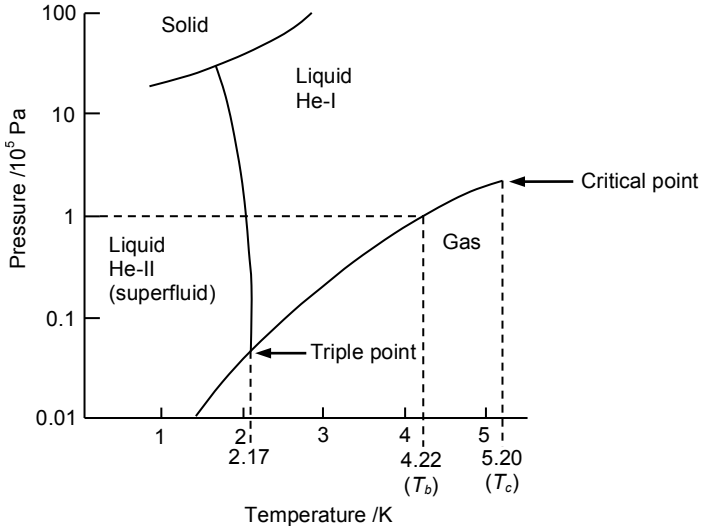
Determine the number of triple points for sulfur and indicate which species are present at each of the triple points.

Which crystalline form of sulfur is predicted to be more dense? Briefly explain your answer.

"Plastic" sulfur is a tough elastic substance that is formed when molten sulfur (m.p. = 115.2 °C) is poured into cold water. On standing, it slowly crystallizes. Predict which crystalline form is formed at room temperature and pressure. Also, explain why "plastic" sulfur is not shown on the above phase diagram.

Marks 6

- The diagram below shows a simplified phase diagram of helium.



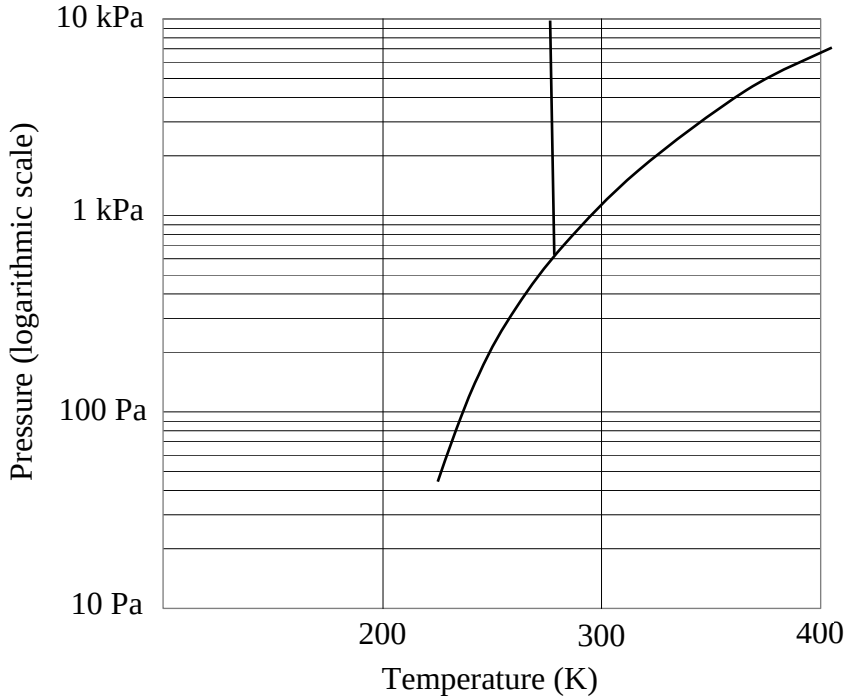
Describe two unusual properties of helium (other than the "superfluid" He-II phase) that are *not* shared by most substances.

Is it possible to liquefy helium above 5.20 K? Explain your answer.

Why is the liquefaction of He very difficult, even at low temperatures?

Marks 4

- The diagram below shows part of the phase diagram of water.



The average pressure on the surface of Mars is around 0.6 kPa. If the night time temperature is –60 °C and a summer day temperature is 20 °C, describe what happens to any water on the surface of Mars as the sun rises.

The highest surface pressure on Mars is thought to occur at the Hellas Basin, a low-lying area created by the impact of a large asteroid. If the pressure in this region is 1.2 kPa, use the phase diagram to estimate the temperature range in which liquid water will occur. Show your working on the phase diagram.

Page Total:

	Marks
• The critical point of H_2O is over 250 °C higher than for H_2S, H_2Se and H_2Te. Describe, at the molecular level, what needs to happen to the interactions between the water molecules to reach the critical point and why this requires a higher temperature in water than in the other group 16 hydrides.	**2**

Page Total:

	Marks
• F_2 and Cl_2 are gases at room temperature, Br_2 is a liquid, and I_2 is a solid. Explain why the melting points and boiling points of the halogens increase going down the group.	**4**

- Consider the boiling points of the following monosubstituted benzenes.

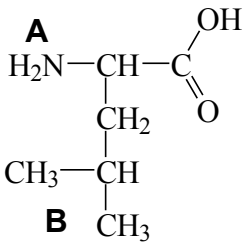
3

	C_6H_6	C_6H_5F	C_6H_5Cl	C_6H_5Br	C_6H_5OH	C_6H_5I
b.p.	80 °C	85 °C	132 °C	156 °C	182 °C	188 °C

Explain this order of boiling points.

Marks 4

- Shown here is the classical form of the amino acid leucine.



List the types of intermolecular interactions in which the sites **A** and **B** could be involved.

A
B

Leucine has an unusually high melting point for a small molecule. Suggest a reason for this.

	Marks
• Ice is less dense than liquid water. The triple point of water is 0.001 °C, 0.006 atm and its critical point is 374 °C, 218 atm. Sketch the phase diagram for water showing all the main features.	**2**