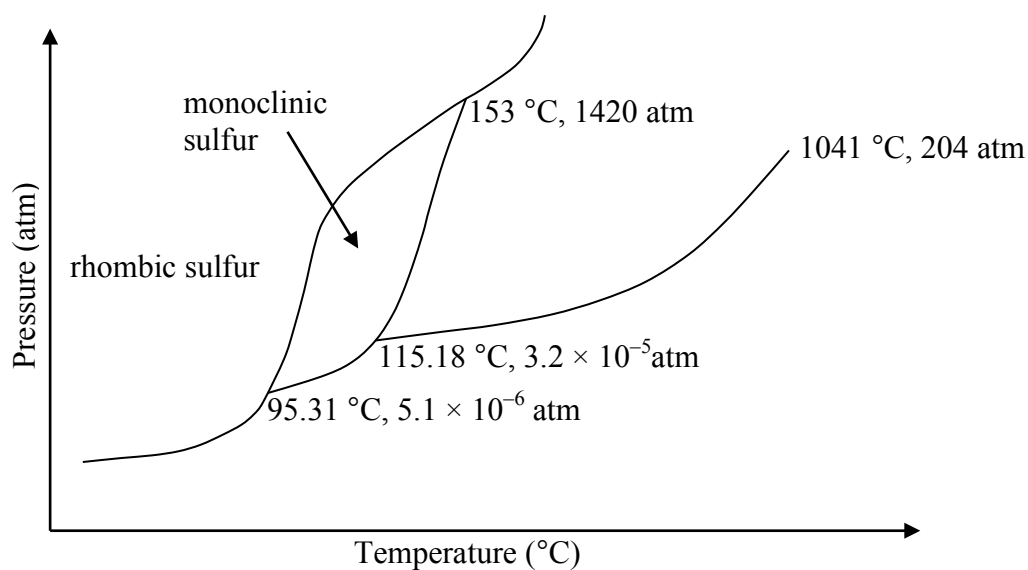


- The diagram below shows the phase diagram of sulfur. Note that 'rhombic' and 'monoclinic' refer to two different crystalline forms of the element.

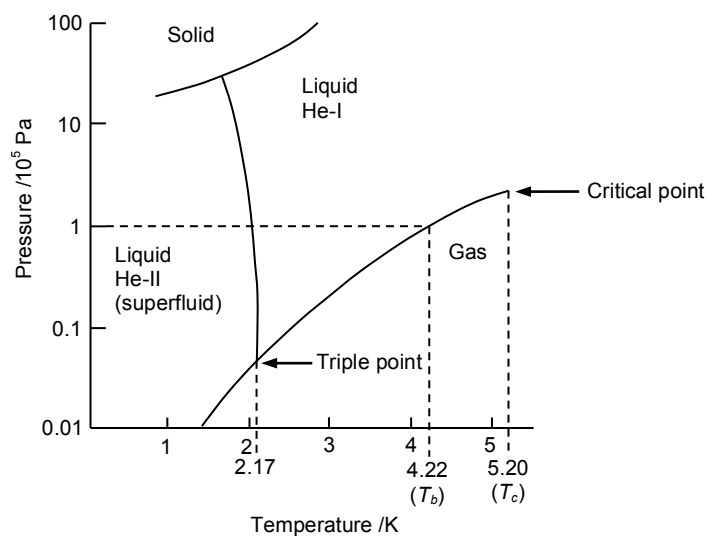


Determine the number of triple points for sulfur and indicate which species are present at each of the triple points.

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.

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



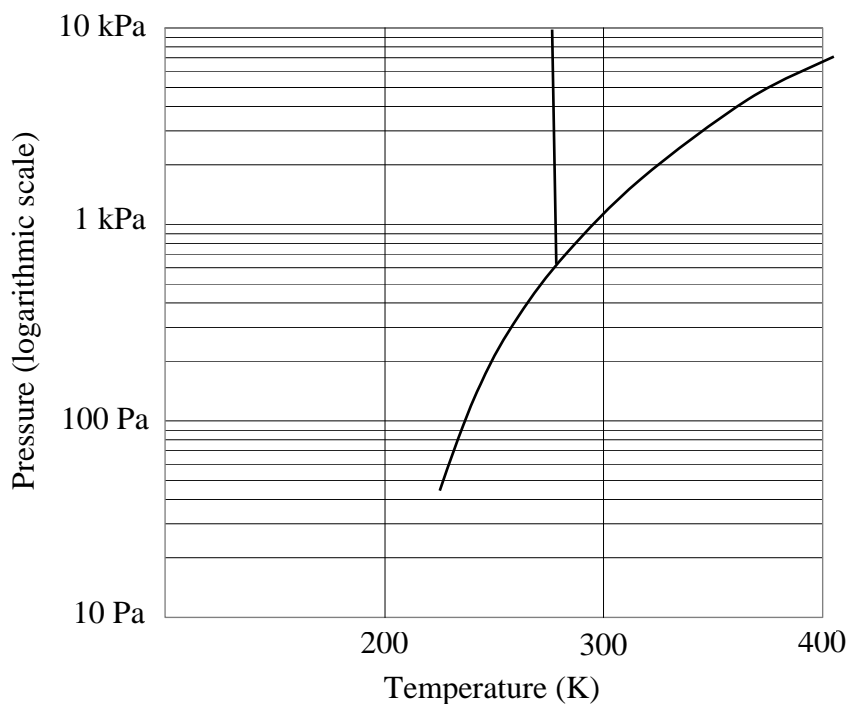
Describe two unusual properties of helium (other than the “superfluid” He-II phase) that are *not* shared by most substances.

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?

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

**Marks**  
**4**



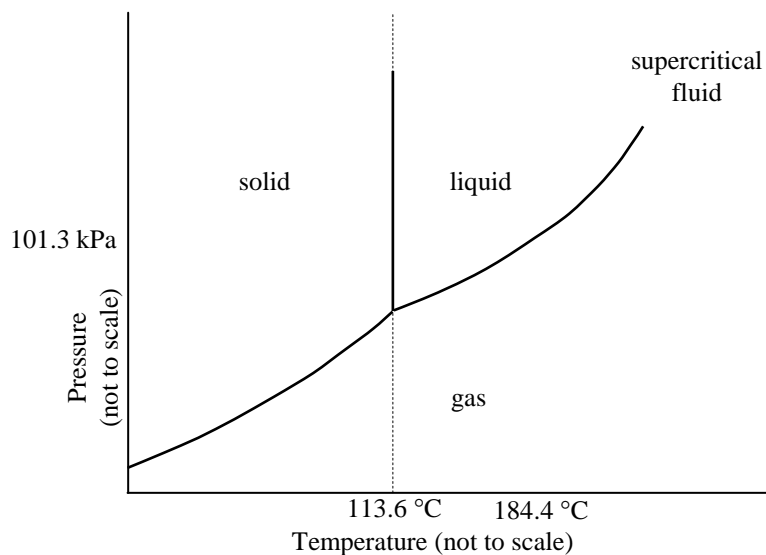
The average pressure on the surface of Mars is around 0.6 kPa. If the night time temperature is  $-60\text{ }^{\circ}\text{C}$  and a summer day temperature is  $20\text{ }^{\circ}\text{C}$ , describe what happens to any water on the surface of Mars as the sun rises.

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.

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**Marks**  
**2**

- The critical point of H<sub>2</sub>O is over 250 °C higher than for H<sub>2</sub>S, H<sub>2</sub>Se and H<sub>2</sub>Te. 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.



Shown above is the phase diagram for iodine. What are the melting and boiling points of iodine at atmospheric pressure?

In what way would you need to change the conditions to make iodine, initially at room temperature and pressure, sublime?

Describe what will happen if pressure is applied to a sample of solid iodine.

- 
- Ice is less dense than liquid water. The triple point of water is  $0.001\text{ }^{\circ}\text{C}$ ,  $0.006\text{ atm}$  and its critical point is  $374\text{ }^{\circ}\text{C}$ ,  $218\text{ atm}$ . Sketch the phase diagram for water showing all the main features.

**Marks**  
**2**

