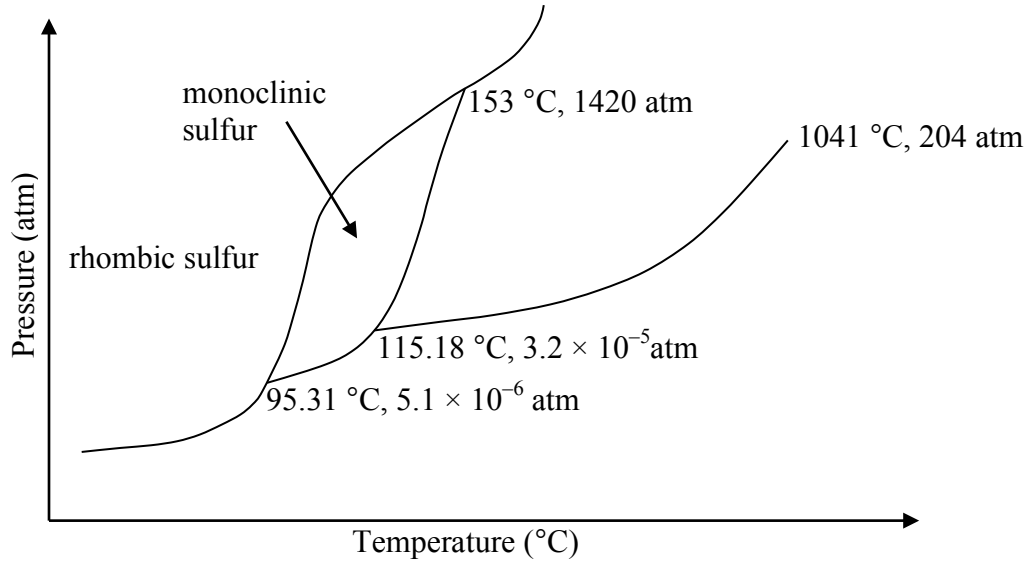
Marks 6

- Solid sulfur can exist in two forms, rhombic sulfur and monoclinic sulfur. A portion of the phase diagram for sulfur is reproduced schematically below. The pressure and temperature axes are not drawn to scale.

  Complete the diagram by adding the labels "vapour" and "liquid" to the appropriate regions.



Which form of solid sulfur is stable at 25 °C and 1 atm?

Describe what happens when sulfur at 25 °C is slowly heated to 200 °C at a constant pressure of 1 atm.

How many triple points are there in the phase diagram?

What phases are in equilibrium at the triple points?

Which solid form of sulfur is more dense? Explain your reasoning.

Marks 7

- A phase diagram of a pure compound has a triple point at 13 °C and 205 mmHg, a normal melting point at 17 °C, and a normal boiling point at 87 °C. Draw a phase diagram for this compound. Label all the different regions of the phase diagram.

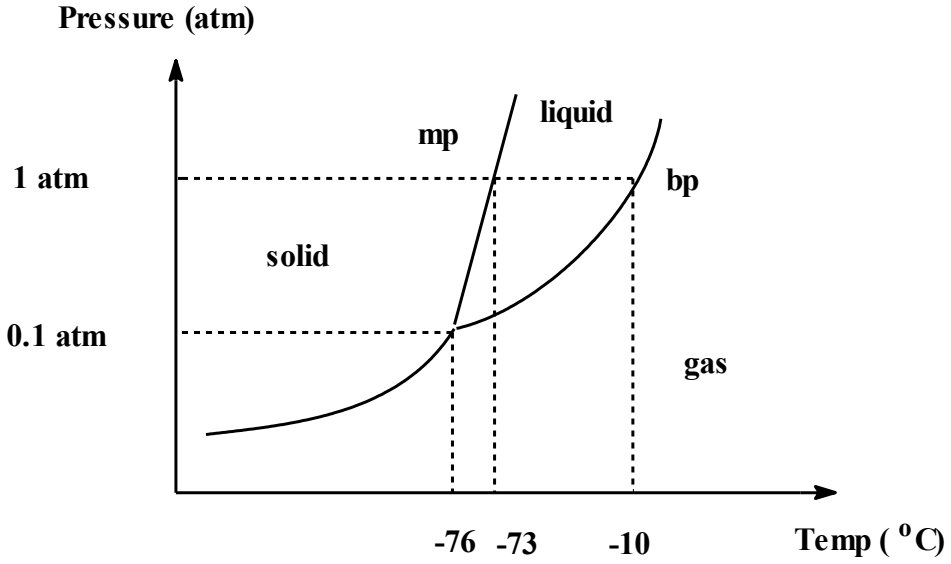
Indicate whether each of the following statements regarding this compound is true or false.

The density of the solid is greater than that of the liquid.	True / False
If the pressure is reduced from 835 mmHg to 85 mmHg at a constant temperature of 11 °C, sublimation occurs.	True / False
At a constant pressure of 835 mmHg, evaporation occurs if the temperature is raised from 13 °C to 81 °C.	True / False

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Marks 4

- The phase diagram for sulfur dioxide, SO_2, is shown below.



Io, the innermost of the four Galilean moons orbiting Jupiter, is the most geologically active body in the solar system. Its surface is covered with a frost of solid SO_2. The atmospheric pressure on Io is 10^{-7} atm and the surface temperature is between 90 and 110 K (–183 to –163 °C). As the temperature is raised on Io, does the SO_2 melt or sublime?

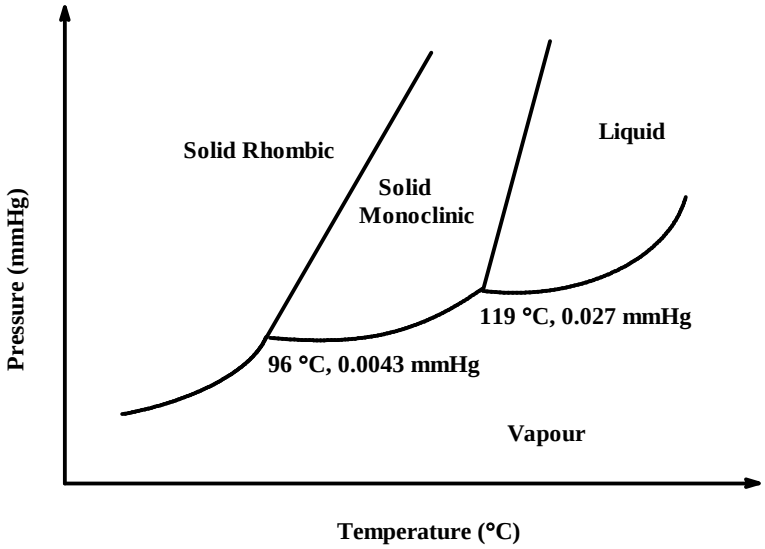
Io has a hot molten magma core. What is the physical state of SO_2 several hundred metres below the surface of Io, where the temperature is –50 °C and the pressure rises to 1 atm?

Is it possible to "ice skate" on a surface of solid SO_2? Explain your answer.

	Marks
• Explain why hydrogen bonding is significant in H_2O (bp 100 °C), but not in H_2Se (bp –41°C) despite both oxygen and selenium being in Group 16 of the Periodic Table.	**2**

Marks 6

- Solid sulfur can exist in both rhombic and monoclinic forms. A portion of the phase diagram for sulfur is reproduced schematically below.



How many triple points are there in the phase diagram?

What phases are in equilibrium at each of the triple points?

What phase is stable at room temperature and 760 mmHg pressure?

Can monoclinic sulfur exist in equilibrium with sulfur vapour at 1.0 atm pressure?

Which solid form of sulfur is more dense? Explain your reasoning.

Describe the phase changes that occur when sulfur at 0.01 mmHg is slowly warmed from 90 °C to 130 °C.

Marks 3

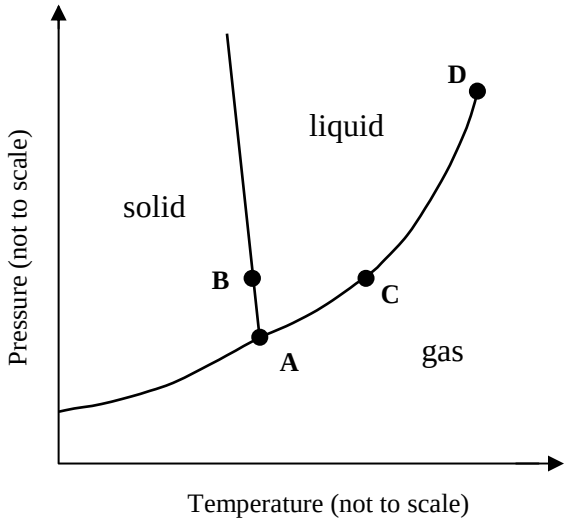
- The figure below illustrates the phase diagram for water. The points on the diagram correspond to:

  A: Triple point (0.0098 °C, 0.610 kPa)

  B: Normal melting point (0 °C, 1.01×10^2 kPa)

  C: Normal boiling point (100 °C, 1.01×10^2 kPa)

  D: Critical point (374.4 °C, 2.18×10^4 kPa)

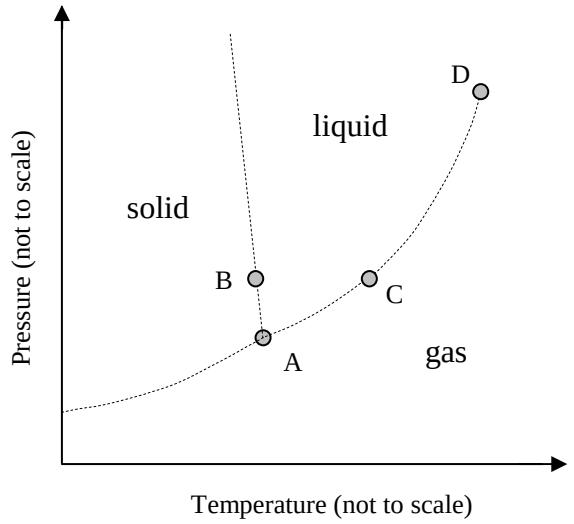


Describe all of the phase changes that occur when water at 1.01×10^2 kPa is slowly warmed from –20 °C to 200 °C.

Describe all of the phase changes that occur when water at 0 °C is slowly compressed from 0.500 kPa to 1000 kPa.

Addition of salt to water raises its boiling point and lowers its melting point. Sketch the phase diagram for water containing salt, showing how it relates to the phase diagram for water (shown as dotted lines below).

Marks 3



In terms of the relative entropies of all relevant species, explain why the boiling point of salt water is higher than that of pure water.

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Marks

- You may recall from a lecture demonstration or your laboratory work that solid CO_2 sublimes under ambient conditions while ice melts. Define the terms sublimation and melting. **3**

What is a triple point (*e.g.* in the phase diagram of CO_2 or H_2O)?

What does the different behaviour of ice and solid CO_2 indicate about the relative positions of their respective triple points?

- Carbon has a number of allotropes, the two major ones being graphite and diamond. The phase diagram of carbon shows that diamond is not the stable allotrope under normal conditions. Why then does diamond exist under normal conditions? **1**

	Marks
• A lecture demonstration showed that a wire with a weight attached can cut through a block of ice (solid water) without the block falling apart. Explain that phenomenon.	**4**
Sketch the phase diagram of water and explain how the above phenomenon manifests itself in the phase diagram.	

Marks
4

- A phase diagram of a pure compound has a triple point at 20 °C and 0.25 atm, a normal melting point at 25 °C, and a normal boiling point at 87 °C.

  Describe what happens when the pressure is reduced from 2 atm to 0.05 atm at a constant temperature of 15 °C?

Describe what happens when the temperature is raised from 13 °C to 87 °C at a constant pressure of 1.25 atm?

Which is more dense, the solid or the liquid? Explain your reasoning.