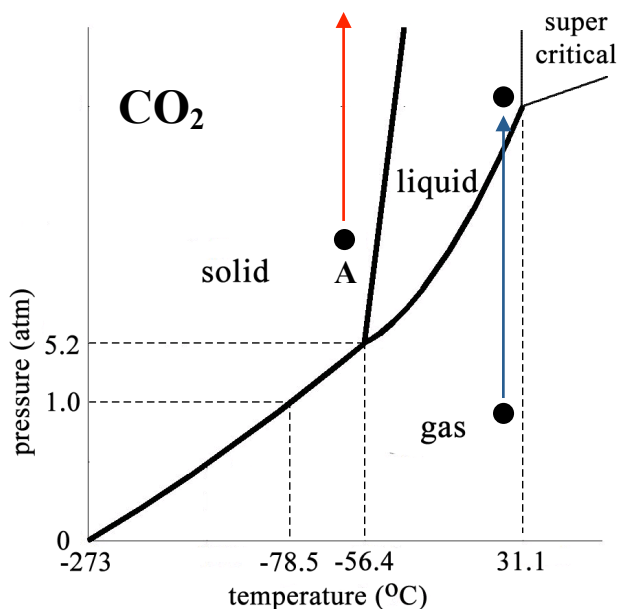
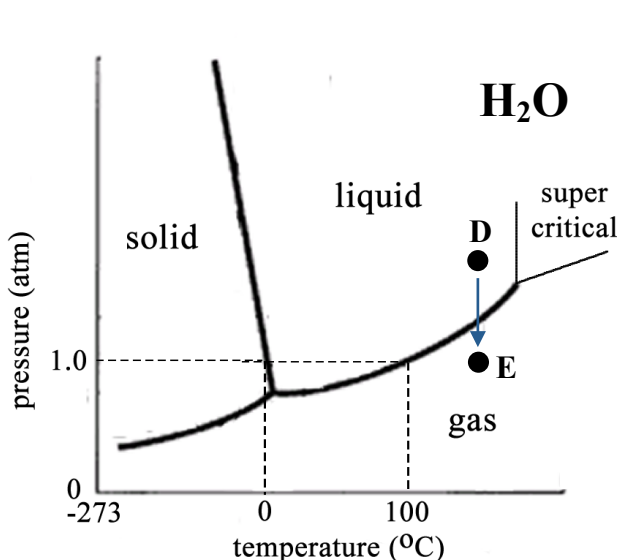


CHEM1102 Worksheet 10 – Answers to Critical Thinking Questions

The worksheets are available in the tutorials and form an integral part of the learning outcomes and experience for this unit.

Model 1: Phase Diagrams for Water and Carbon Dioxide

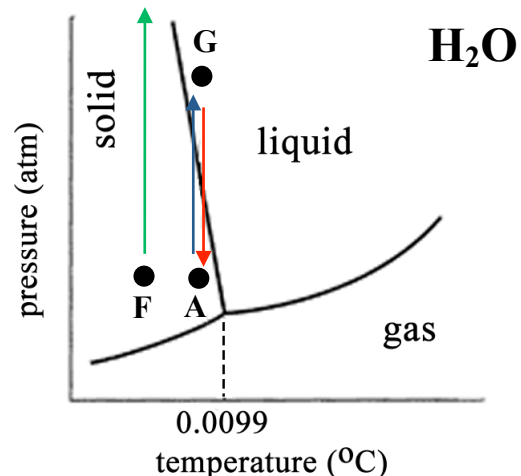
- Liquid.
- See H₂O diagram below. The temperature is greater than the normal boiling point so when the pressure is reduced to 1 atm, the water will boil. The person removing the radiator cap is likely to get badly scolded by the steam.
- See CO₂ diagram below. The gas needs to be put under pressure.



Model 2: Under Pressure

- See blue arrow on H₂O diagram opposite. The snow will partially melt. If the pressure is continued, it may all melt.
- See red arrow on H₂O diagram opposite. The melted snow will refreeze in a more compact and stronger structure than the original snow.
- See green arrow on H₂O diagram opposite. A very high pressure indeed would be needed to melt the snow even at the South Pole. This could definitely not be provided by a hand so making snow balls at the Poles is not possible (without warming the snow to close to the melting point first).

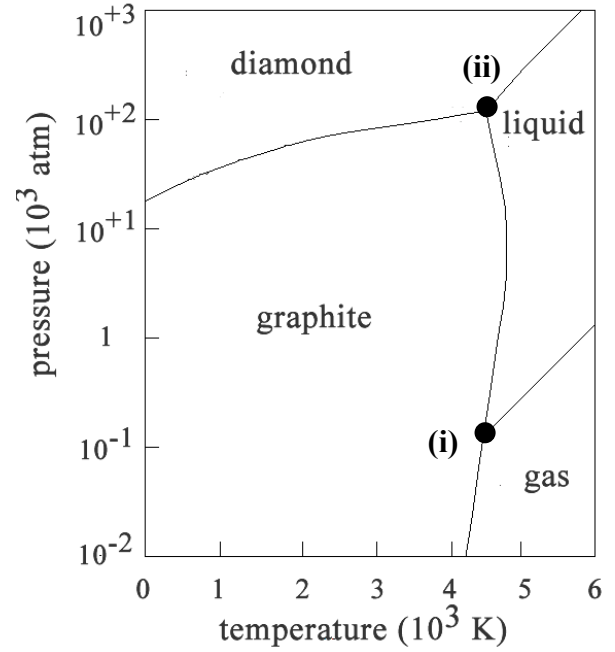
Making snowballs out of frozen water on the other worlds is sadly not possible.



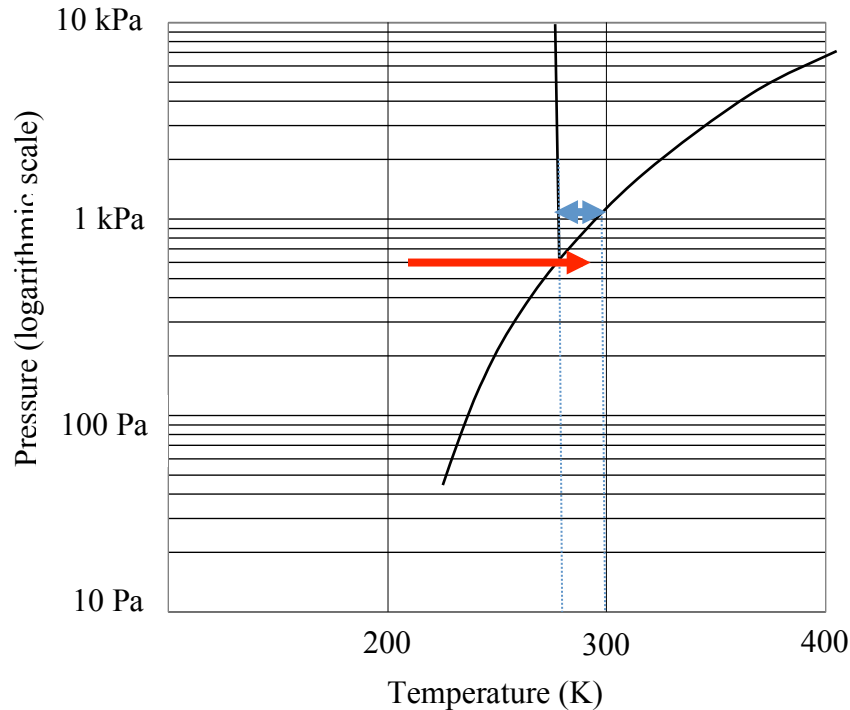
- See red arrow on CO₂ diagram above. Because of the slope of the line representing the solid – liquid transition in CO₂, the solid will never melt simply by applying pressure. Making snowballs on the other worlds out of CO₂ is sadly not possible.

Model 3: Allotropes and Pressure

1. It sublimes.
2. (i) Graphite, liquid and gas.
(ii) Graphite, diamond and liquid.
3. Diamond is more dense: increasing the pressure favours diamond.
4. The structures of diamond and graphite are consistent with this. Diamond consists of a 3-dimensional, covalent network with 4 coordinate carbon atoms. Graphite consists of planar sheets containing 3 coordinate carbon atoms which are separated by relatively long spacings.



- 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.

This process is illustrated by the red arrow in the phase diagram above. The process occurs just *below* the triple point so the phase changes from solid (at -60°C) to gas (at 20°C).

Water sublimates as the sun rises on Mars.

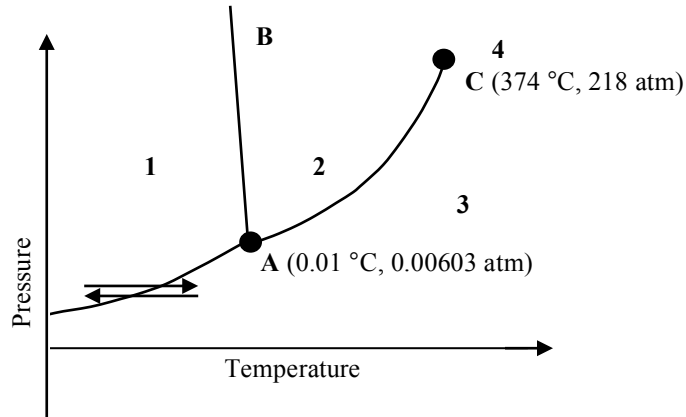
(Note the logarithmic scale on the graph. Each horizontal line between 100 Pa (0.1 kPa) and 1 kPa (1000 Pa) represents an increase of 100 Pa (0.1 kPa).)

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.

At 1.2 kPa, water is a liquid in the temperature range covered by the double-headed blue arrow in the phase diagram above.

Within the accuracy possible on the diagram, this corresponds to the temperature range 280 – 300 K.

- A phase diagram of water is shown below.



Identify the four phases shown as 1-4 in the phase diagram.

1: solid	2: liquid
3: gas	4: supercritical fluid

What are the phase changes highlighted by the forward and reverse arrows called?

Forward: sublimation	Reverse: deposition
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What names are given to the points A and C?

A: triple point	C: critical point
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The boundary line A-B is slightly tilted to the left. What are the physical and biological significances of this?

Solid water (ice) is less dense than liquid water. Ice therefore floats and rivers, lakes and oceans freeze from the top down.

As just the surface of a body of water freezes, the liquid environment for the life-forms below the surface is preserved. If the water in a cell freezes, the ice crystals take up more space than the liquid and this can cause cell walls to break.

What are the physical characteristics of water in phase 4?

It can be considered as either a very dense gas or as a rarefied liquid with physical properties (e.g. density, viscosity, diffusion coefficients) between those of liquids and gases. It is a good solvent.