

Phase Diagrams

Water, carbon dioxide and supercritical fluids

Name _____ Class _____ Date _____

DATA

Water: triple point $0.01\text{ }^{\circ}\text{C}$, 0.00604 atm · critical point $374\text{ }^{\circ}\text{C}$, 218 atm · ice vapour pressure at $-40\text{ }^{\circ}\text{C} \approx 0.00013\text{ atm}$

CO_2 : triple point $-56.6\text{ }^{\circ}\text{C}$, 5.11 atm · critical point $31.0\text{ }^{\circ}\text{C}$, 72.8 atm · sublimes at $-78.5\text{ }^{\circ}\text{C}$ (1 atm) · liquid vapour pressure at $0\text{ }^{\circ}\text{C} \approx 34\text{ atm}$

$1\text{ atm} = 101.325\text{ kPa}$

Sketch the phase diagram when it helps. Show units in every calculation step.

A. Ideas

1. Define (a) triple point (b) critical point (c) supercritical fluid. (d) What does a line on a phase diagram represent?

B. Water

2. Sketch the phase diagram of water and label the solid, liquid and gas regions, the triple point, the critical point and the normal melting and boiling points.

3. State the phase of water at: (a) 1 atm , $50\text{ }^{\circ}\text{C}$ (b) 1 atm , $150\text{ }^{\circ}\text{C}$ (c) 0.001 atm , $-40\text{ }^{\circ}\text{C}$ (d) 300 atm , $400\text{ }^{\circ}\text{C}$

4. Explain why the solid–liquid line of water slopes to the left, unlike that of most substances.

C. Carbon dioxide

5. State the phase of CO₂ at: (a) 1 atm, –100 °C (b) 1 atm, –50 °C (c) 60 atm, 0 °C (d) 80 atm, 50 °C

6. Describe what happens, in order, when solid CO₂ is warmed from –100 °C to 25 °C (a) at 1 atm (b) at 10 atm.

D. Calculations and applications

7. Convert to kPa: (a) the critical pressure of CO₂ (b) the critical pressure of water, also in MPa.

8. Freeze-dried coffee is made by freezing coffee and then lowering the pressure below 0.006 atm. Use the phase diagram of water to explain how the water is removed without melting.