Welcome!

Agenda:
1. QN: Phase Diagrams
2. CO₂ and the Phase Diagram Lab

HW: Reading Phase Diagrams
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1. How can you tell if a substance is melting?  \[ \text{Solid} \rightarrow \text{Liquid} \]
   \[ \uparrow \text{IM Forces} \quad \uparrow \text{Energy} \]

2. How can you tell if a substance is boiling?  \[ \text{Liquid} \rightarrow \text{Gas} \]
   \[ \text{bubbles} \quad \uparrow \text{Forces} \quad \uparrow \text{Energy} \]

3. How can you tell if a substance is subliming?  \[ \text{Solid} \rightarrow \text{Gas} \]
   \[ \uparrow \text{Forces} \quad \uparrow \text{Energy} \]
Right Now Answer:
At a phase change, all of the energy goes to breaking the forces of attraction, so the temperature does not change.
QN: Reading Phase Diagrams

- A phase diagram shows the phase of a material at a given pressure and temperature.
- The triple point is when all three states of matter co-exist (where the three lines meet).
- The critical point is the point at which liquids can no longer form (where the condensation line ends).
14.7 psi = 1 atm = 101.3 kPa

Atmospheric pressure (Standard)

Normal melting/freezing point
Reading Phase Diagrams

Use the phase diagram below to answer the questions.

![Phase Diagram](image)

**Note:** Atmospheric pressure is equal to 101.3 kPa

**Figure 1** Phase diagram for bromine (Br₂). Note that the scale on the x-axis is distorted to emphasize some of the graph’s features.

1. Label each region of the phase diagram as solid, liquid or vapor.
2. Label the triple point (TP), the critical point (CP), the boiling point (BP) and the melting point (MP).
3. Label each line:
   a. Use the letter A to label the line that gives the conditions for equilibrium between solid and liquid phases of bromine.
   b. Use the letter B to label the curve that gives the conditions for equilibrium between liquid and vapor phases of bromine.
   c. Use the letter C to label the curve that gives the conditions for equilibrium between solid and vapor phases of bromine.
4. Draw arrows and label where sublimation (S), vaporization (Vₗ) and melting (M) occur.
5. What is the temperature and pressure of the triple point?

6. What states of matter are present at the triple point?

7. What is the temperature and pressure of the critical point?

8. What states of matter are present above the critical point?

9. What is the temperature and pressure of the normal boiling point?

10. What is the temperature and pressure of the normal melting point?

11. What is the boiling point of bromine when the external pressure is 75 kPa?

12. Bromine vapor at 15°C (condenses, sublimes) when the pressure is raised to 50 kPa.

13. Bromine liquid at 70 kPa (vaporizes, freezes) then the temperature is decreased to -15°C.