Chapter 10 Part 3

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Matter Phases and IMFs

Solids

- Most ordered.
- Defined and rigid external shape
- Strong intermolecular force interaction

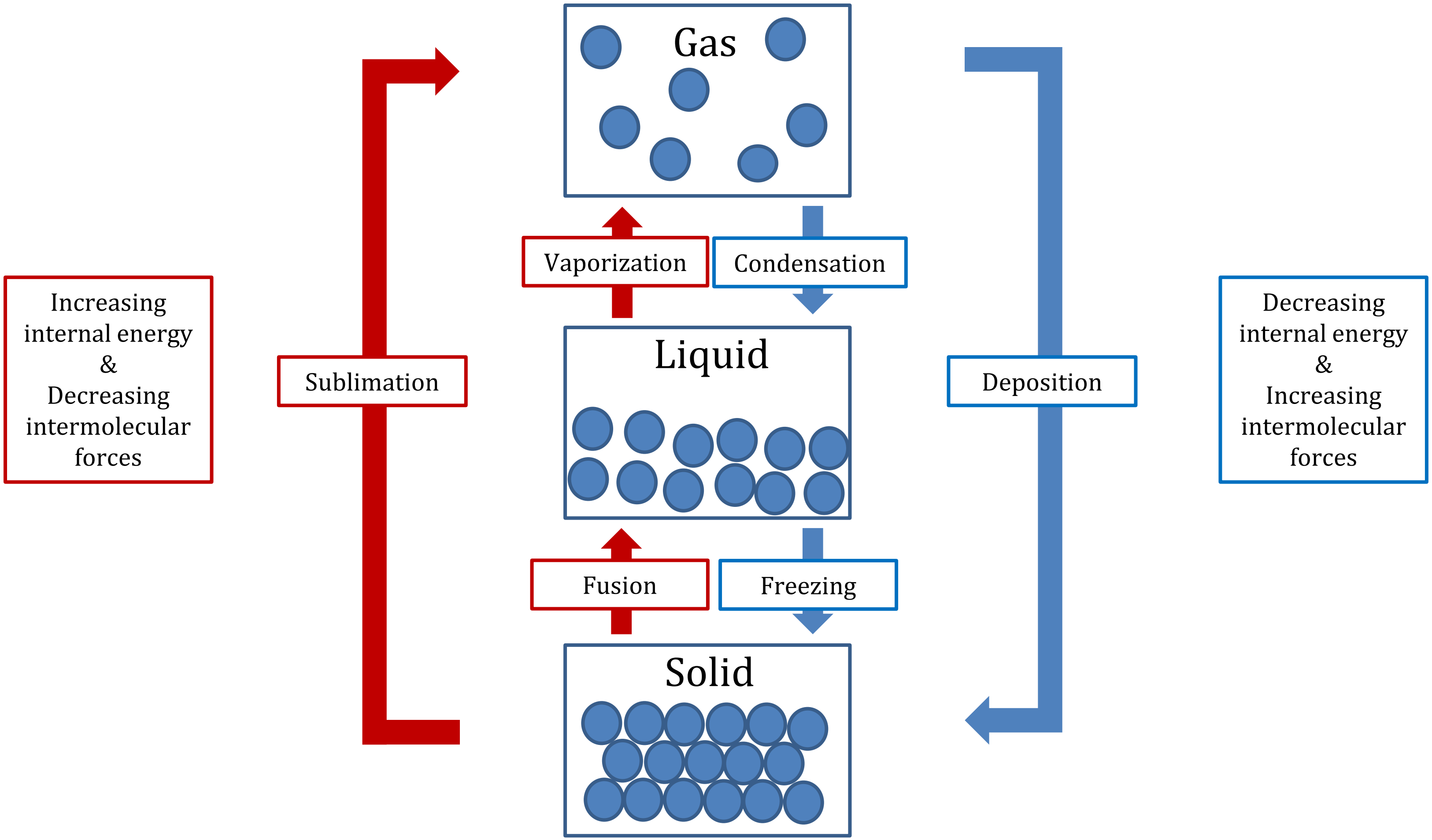
Liquids

- Its shape is often determined by the container it occupies.
- Moderate intermolecular force interaction.

Gases

- Most disordered.
- Does not have a defined external shape.
- Its volume is defined by the container.
- Weak intermolecular interactions

Changes of Phase



Vaporization: Liquid to Gas

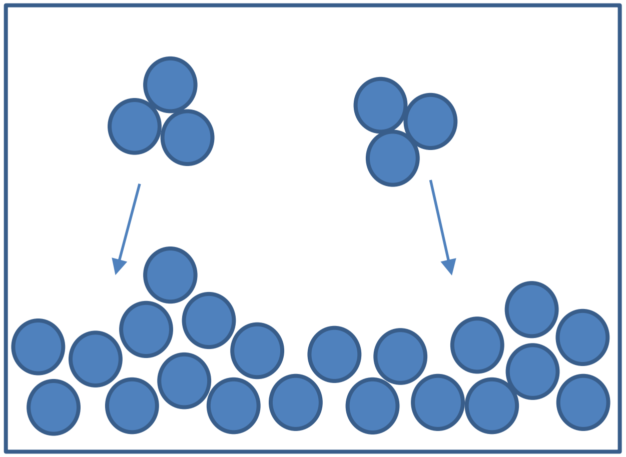
- Vaporization is an endothermic process. It requires the input of energy to overcome the IM attractions between the liquid particles.
- The following factors increase rate of vaporization
  - Raising the temperature
  - Weaker intermolecular forces
  - Greater liquid surface area

Volatility

- Liquids that evaporate easily are said to be **volatile.**
  - e.g., gasoline, fingernail polish remover
- Liquids that do not evaporate easily are called **nonvolatile.**
  - e.g., glycerin

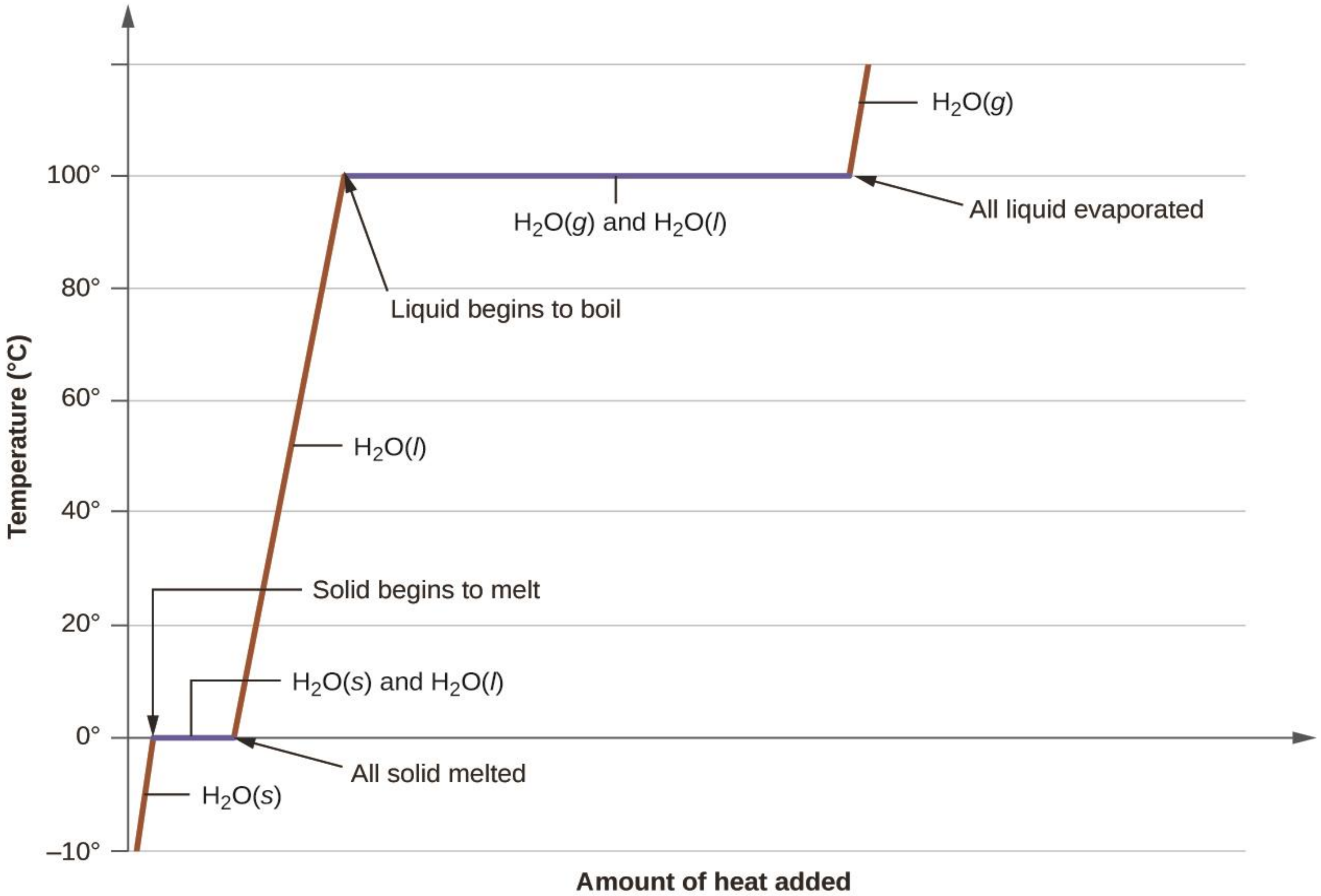
Condensation: Gas to Liquid

- Condensation is an exothermic process. It requires the output of energy to succumb to the IMFs between the liquid particles.
- If intermolecular attractive forces are weaker, less energy must be removed from the gaseous particles for them to condense.
- At low temperatures gas particles can lose enough energy to fall back to the liquid surface
- Gaseous particles can also lose energy through collisions with other gas particles, causing them to form droplets and fall back to the liquid phase.



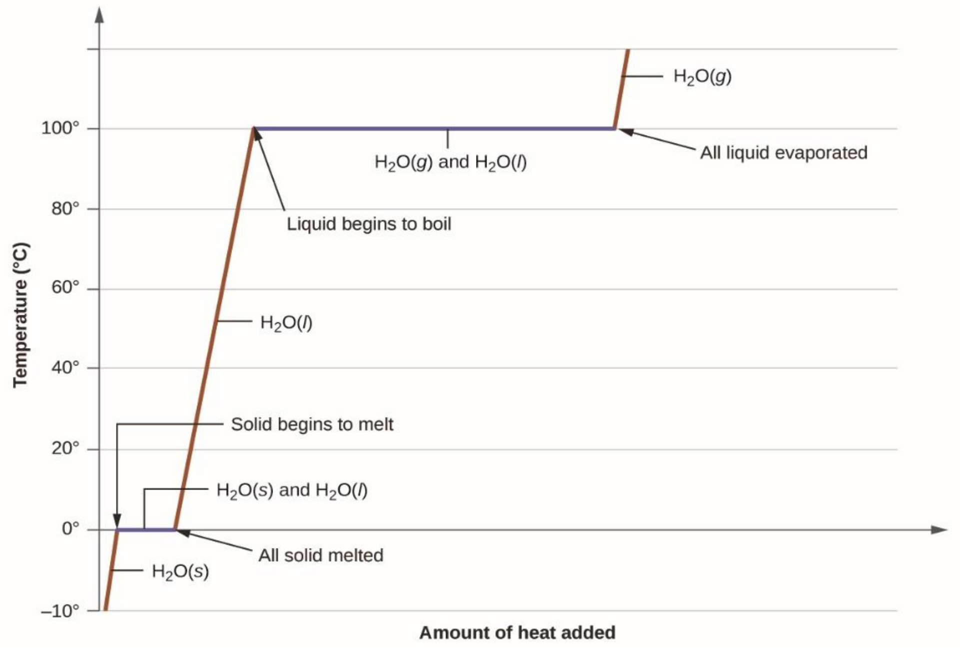
Droplets falling back to the liquid phase

Heating Curves



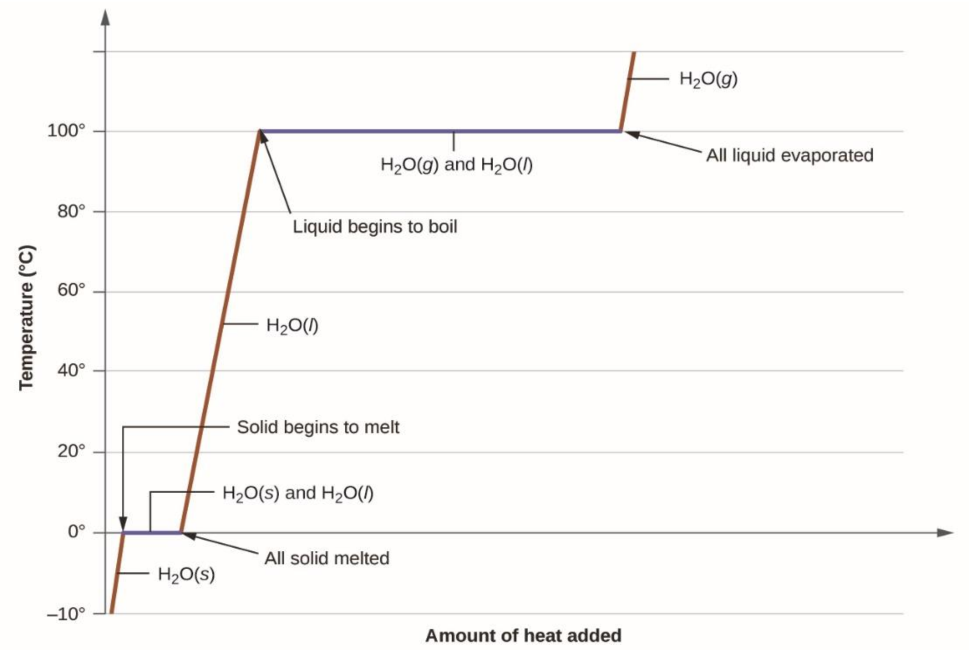
Heating Curves

- As a substance in one phase is heated at a constant rate, its temperature will increase linearly until it reaches a phase transition
- This is indicated by the red lines



Heating Curves

- The phase transitions are indicated by the blue lines
- At each of the phase transition points the temperature of the substance remains constant.
- Instead of raising the temperature, all the added energy goes into the phase transition (e.g. melting the solid.)
- The temperature will remain constant until all the substance is converted to the new phase.

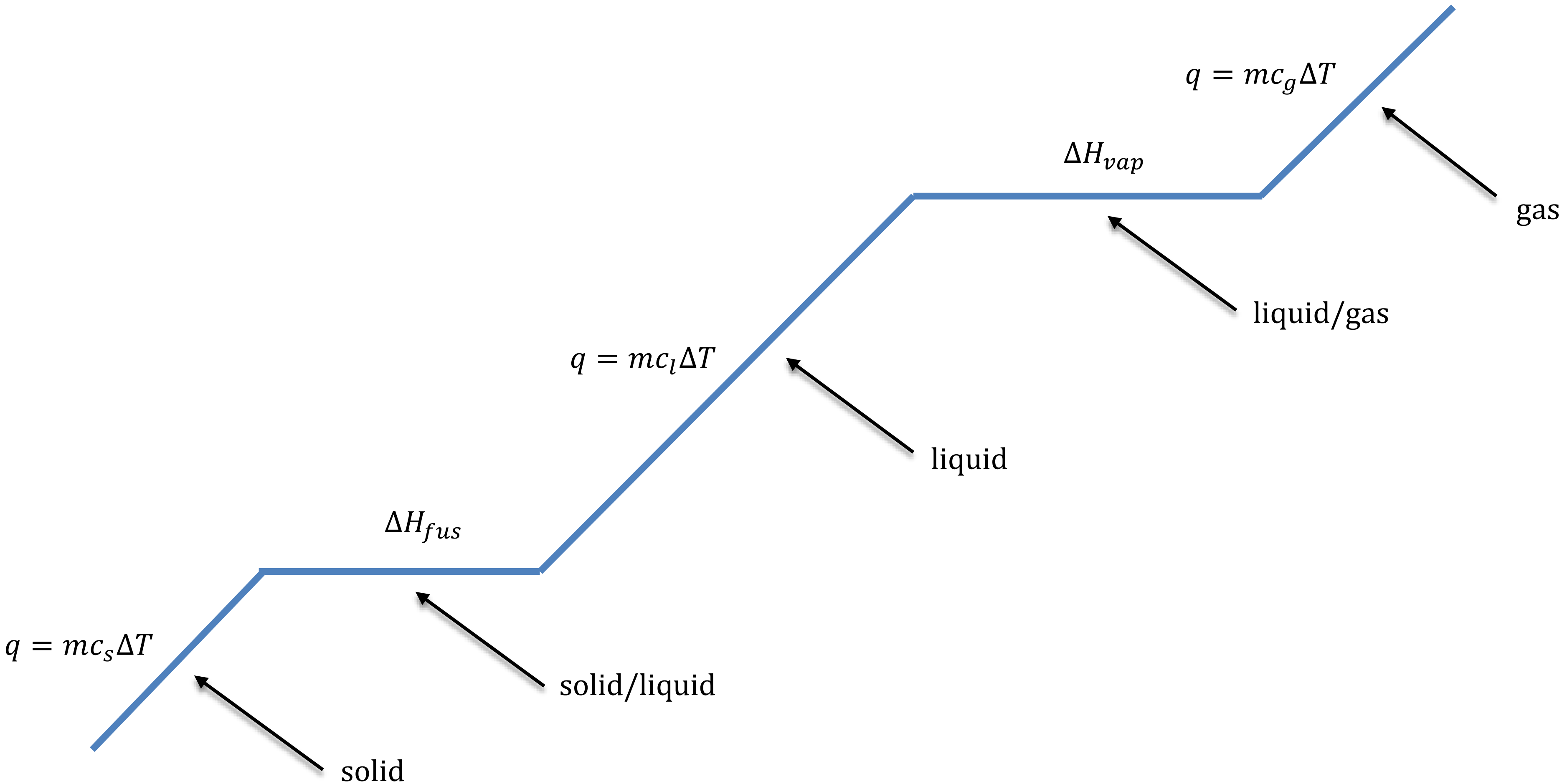


Enthalpies of Fusion and Vaporization

- The enthalpy of fusion ΔH_{fus} is the amount of energy required to fuse (melt) the solid into a liquid
- Involves adding sufficient energy to the solid particles to make them flow throughout one another and behave as liquid particles
- Normally in units of J/g or J/mol

- The enthalpy of vaporization ΔH_{vap} is the amount of energy required to vaporize the liquid into a gas
- Involves adding sufficient energy to the liquid particles to essentially overcome their IMFs and behave as gas particles
- Normally in units of kJ/g or kJ/mol

Heating Curves



Phase Transitions

Determine the amount of energy needed to evaporate 100.0 grams of liquid ammonia at its boiling point. $\Delta H_{vap} = 4.8$ kJ/mol

Changing the temperature within a phase

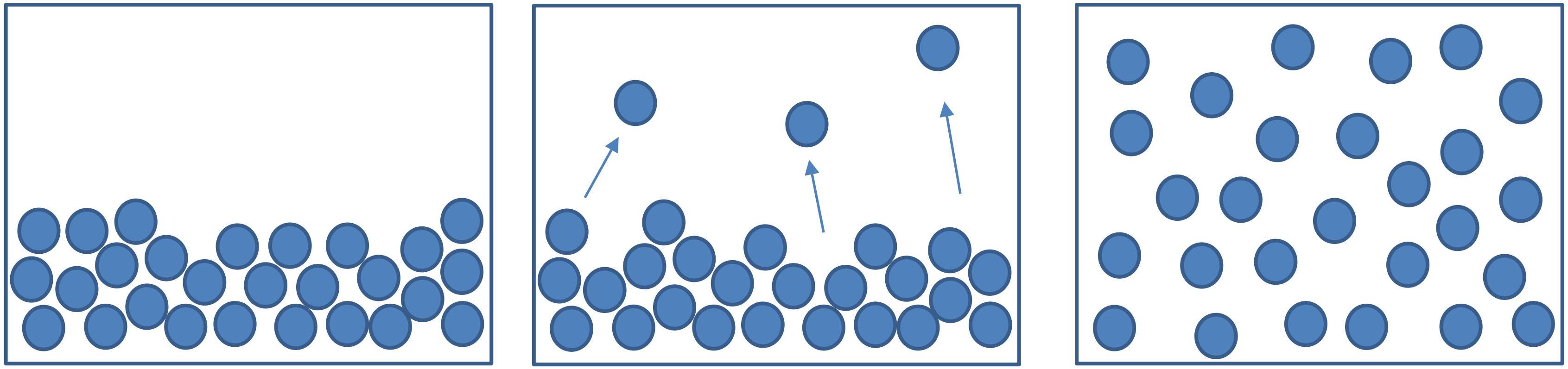
How much heat in joules is required to change the temperature of 7.35 g of water from 21.0 to 98.0°C? The specific heat of water is 4.184 J g^{-1} $°C^{-1}$.

Heating Curves

If a 1.50 g cube of ice is heated from −13.00 °C to water at 59.00 °C, how much heat is absorbed by the system? The freezing point of water is 0.00 °C. The boiling point of water is 100.00°C. The specific heats of ice, water, and steam are 2.06, 4.18, and 2.03 J g^{-1} °C, respectively. The enthalpy of fusion and enthalpy of vaporization of water are 333.55 J/g and 40.66 kJ/mol respectively.

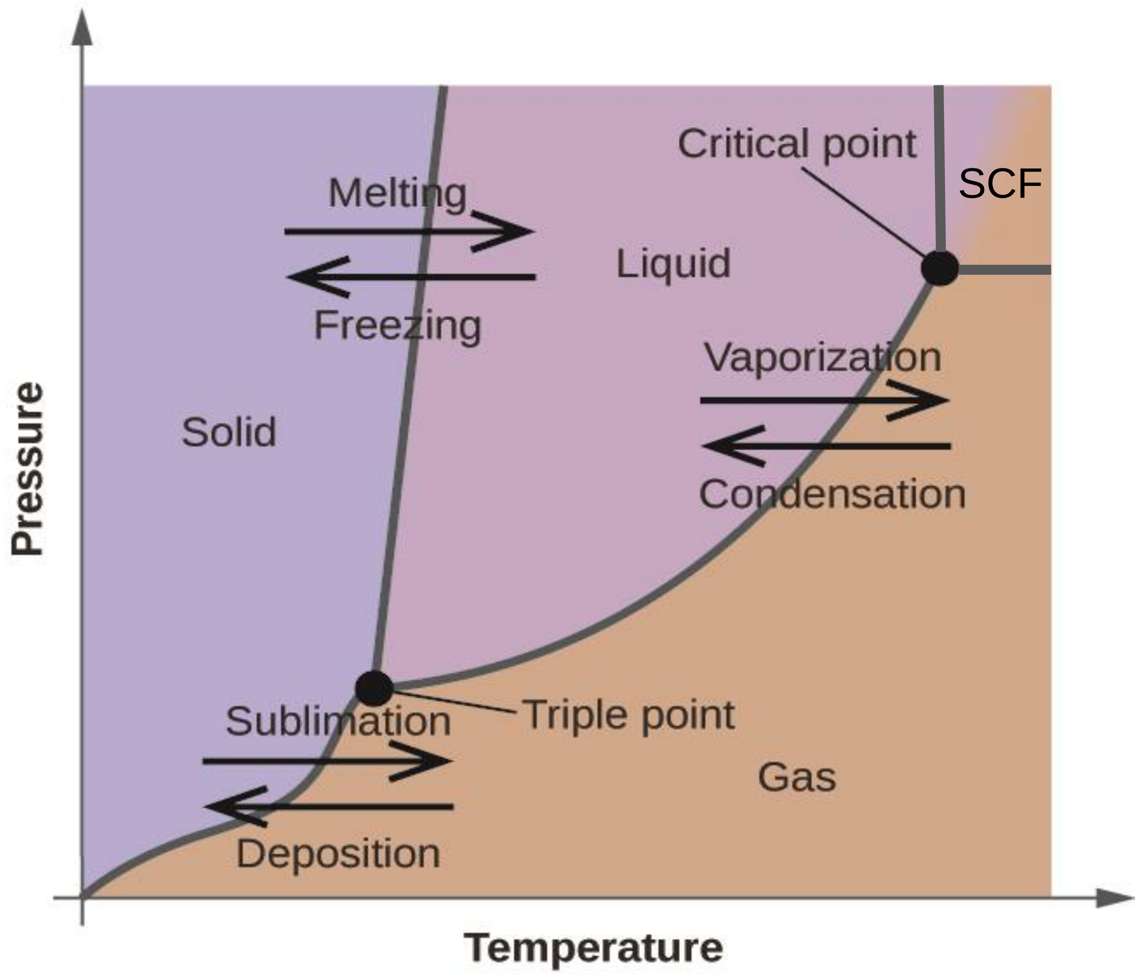
Supercritical Fluid: A 4th Phase of Matter

- When a liquid is heated in a sealed container, a large amount of vapor collects within the container.
- This increases the density of the vapor while decreasing the density of the liquid
- At some temperature, the meniscus between the liquid and vapor disappears and the states commingle to form a supercritical fluid.
- Supercritical fluids have properties of both gas and liquid states as the function as “gaseous liquid” which move in random and rapid motion like gases but also can flow like liquids

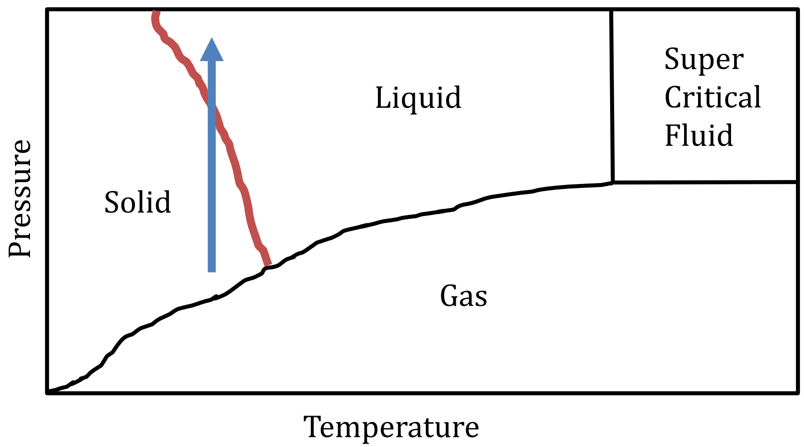


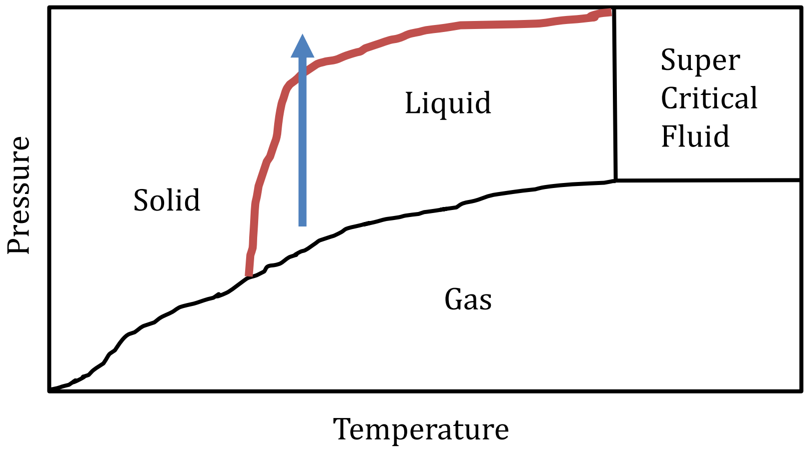
Phase Diagram: A graphical representation of the phases of matter

- Critical point: Lowest temperature & pressure required to have supercritical fluid.
- Triple point: solid, liquid, and gas phases of matter can all exist.



Phase Diagrams





- Negative slope of melting point line
- As pressure increases solids become liquids, so liquid is more dense than solid

- Positive slope of melting point line
- As pressure increases liquids become solids, so solid is more dense than liquid

Reading a Phase Diagram

Determine the phase(s) at each of the following points:

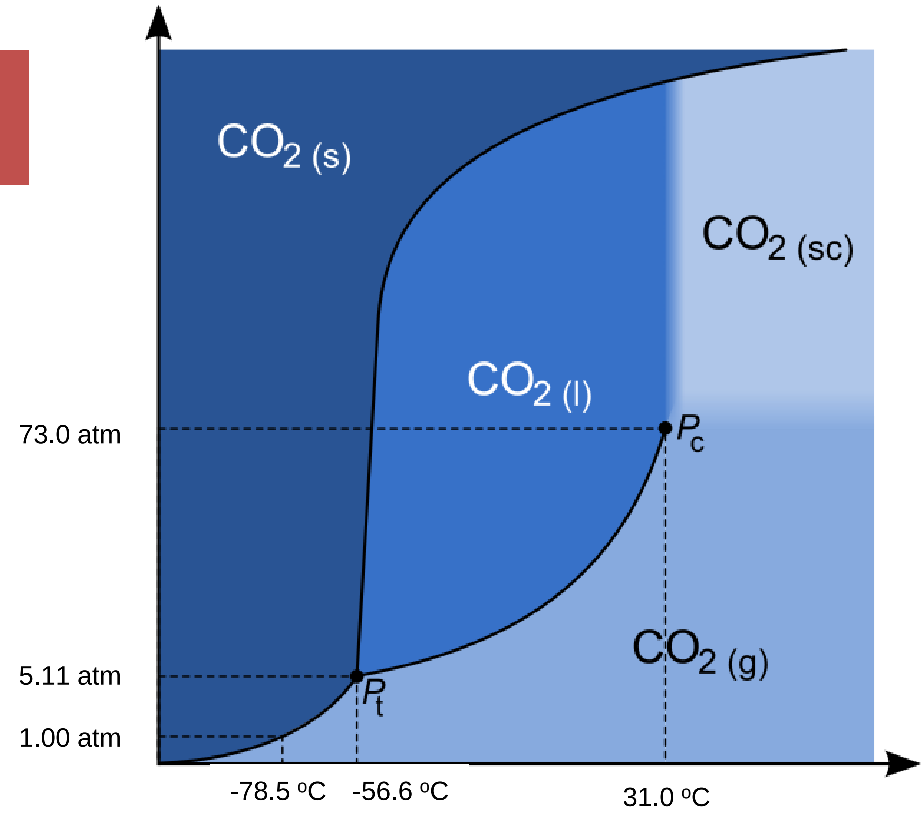
A. 73.0 atm & -80.0 ^oC

B. 5.11 atm & -56.6 ^oC

C. 74.8 atm & 32.0 ^oC

D. Does solid CO_2 float on liquid CO_2?

A. ?



Relating Temperature and Vapor Pressure: the Clausius-Clapeyron Equation

- The Clausius-Clapeyron equation is the linear relationship used to find ΔH°_{vap} when the vapor pressure and temperature are known.
- The graph of the natural logarithm of pressure (ln P) versus the inverse of the temperature $\left(\frac{1}{T}\right)$ is a straight line
- This equation can be used with *two* measurements of vapor pressure and temperature

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

Clausius-Clapeyron Equation

Determine the ΔH_{vap} for propyl amine from the following data

$P_1 = 40.0 \text{ mm Hg}$ $\quad T_1 = 257 \text{ K}$ $\quad R = 8.314 \times 10^{-3} \frac{\text{kJ}}{\text{K mol}}$

$P_2 = 100.0 \text{ mm Hg}$ $\quad T_2 = 274 \text{ K}$ $\quad \Delta H_{vap} = ?$

Clausius-Clapeyron Equation

At 2590 K, methanol has a vapor pressure of 400.0 mm Hg and an enthalpy of vaporization of 252 kJ/mol. What is the vapor pressure of methanol (in mmHg) when the temperature is 2620 K?