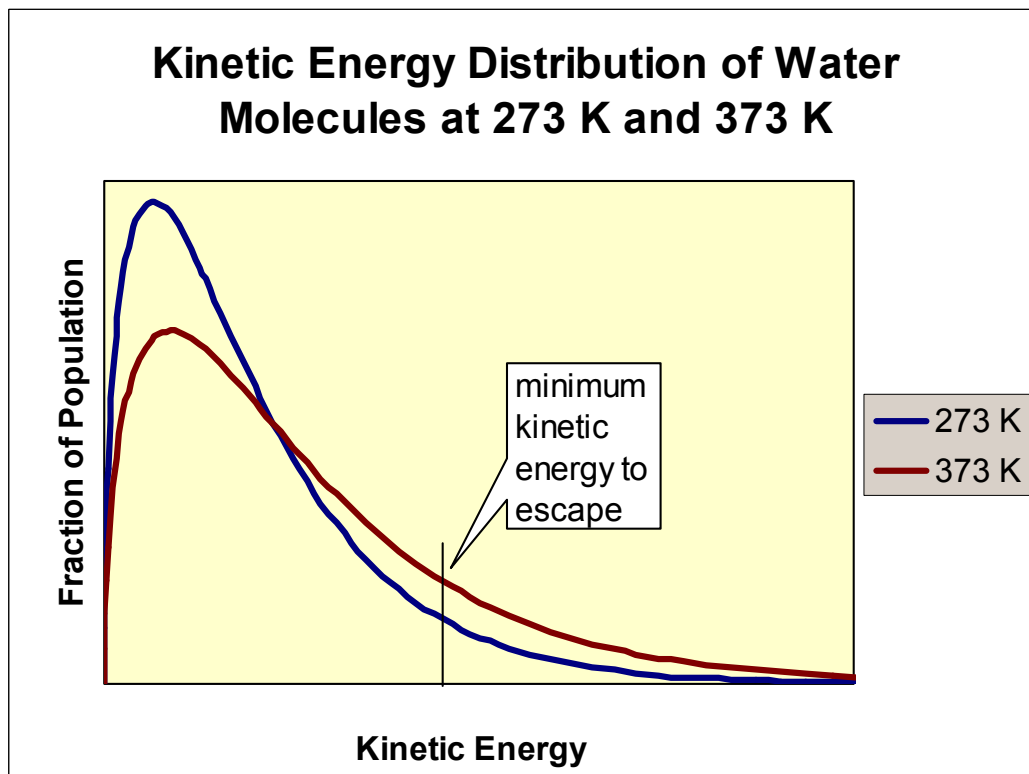


## Evaporation

- ✓ All liquids have a tendency to lose molecules through **evaporation**.
- ✓ A molecule escapes into the vapor when it has enough kinetic energy to overcome the attractive forces between molecules within the liquid.
- ✓ At higher temperatures a larger portion of the population has the necessary kinetic energy to escape the liquid,  $K_{\text{esc}}$ .

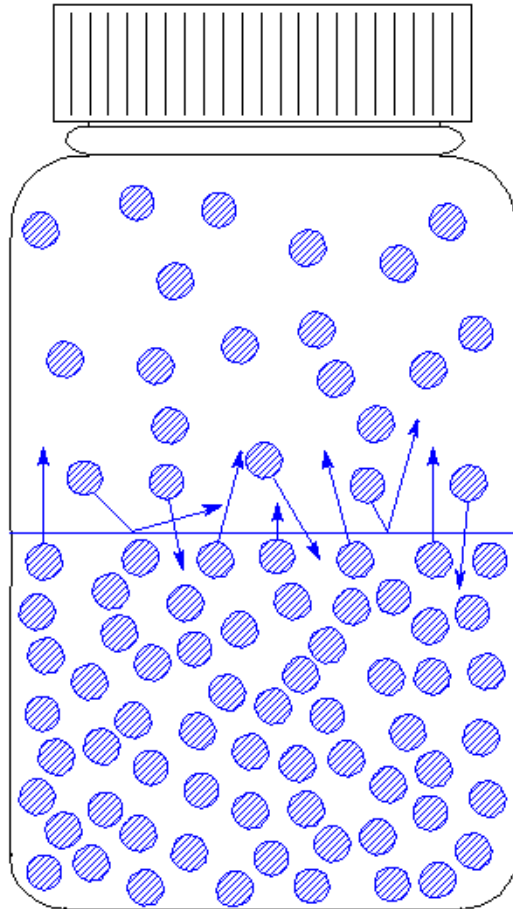


# Enthalpy of Vaporization, Volatility, and Boiling Points

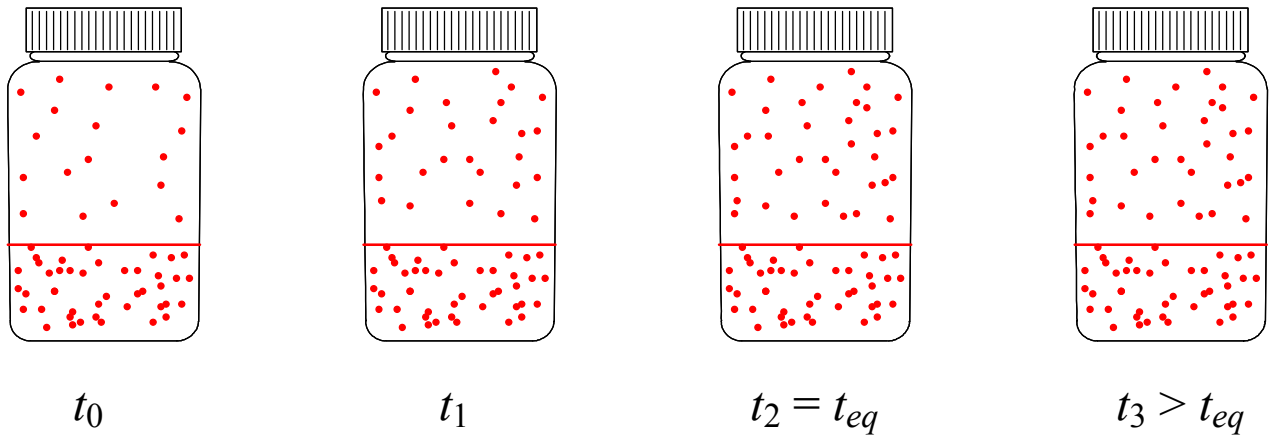
- ✓ **Volatile** substances (L., *volare* = to fly) have low values of  $\Delta H_{\text{vap}}$  and require less heat to escape their liquid phases, implying a lower  $K_{\text{esc}}$

Substance	Formula	$\Delta H_{\text{vap}}^{\circ}$ (kJ/mol)	b.p. (°C)
water	H <sub>2</sub> O	40.7	100.0
ethanol	C <sub>2</sub> H <sub>5</sub> OH	38.6	78.5
carbon tetrachloride	CCl <sub>4</sub>	30.0	76.7
diethyl ether	(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	26.0	34.6

# Evaporation-Condensation in a Closed Container

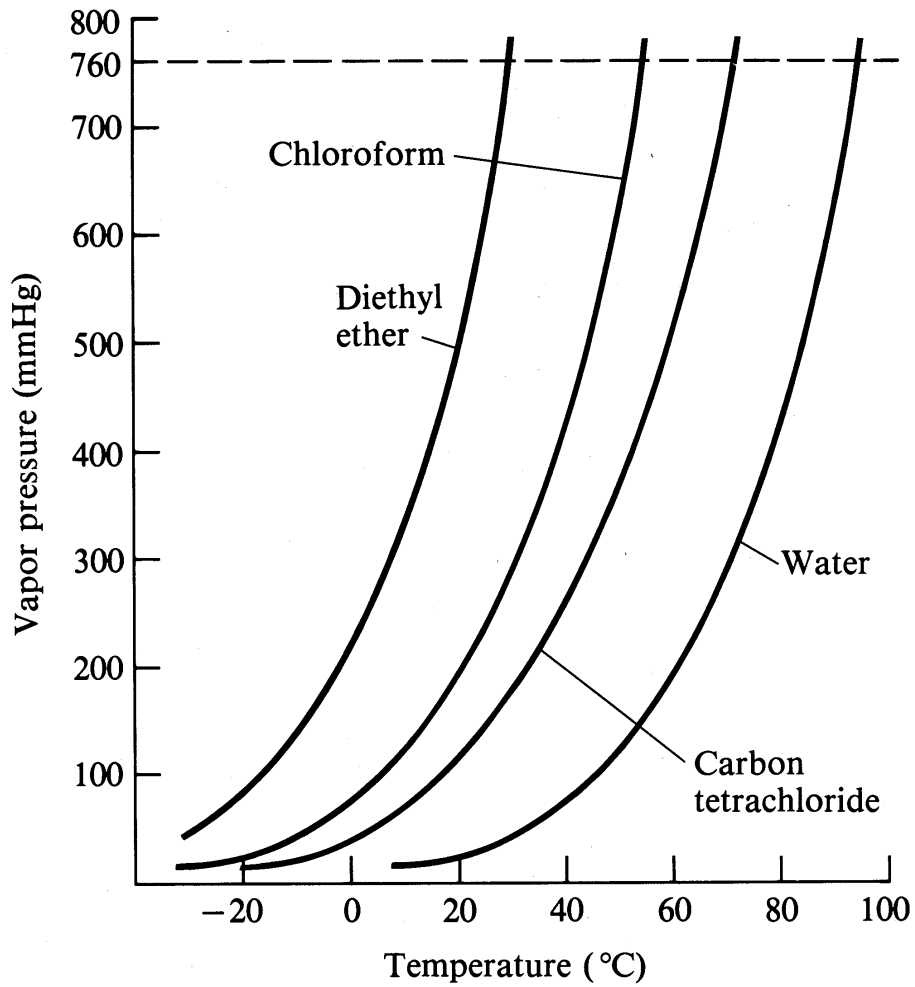


## Development of Liquid-Vapor Equilibrium



- ☞ The partial pressure of the vapor in equilibrium with the liquid is the **vapor pressure**.
- ☞ The vapor pressure depends upon the following:
  1. The nature of the liquid ( $\Delta H_{\text{vap}}$ )
  2. The kinetic energy of the molecules ( $\propto T$ )
  3. The vapor concentration ( $\propto T$ )
- ☞ All vapor pressures increase with increasing temperature.

## Vapor Pressure vs. Temperature for Typical Liquids



## Critical Point

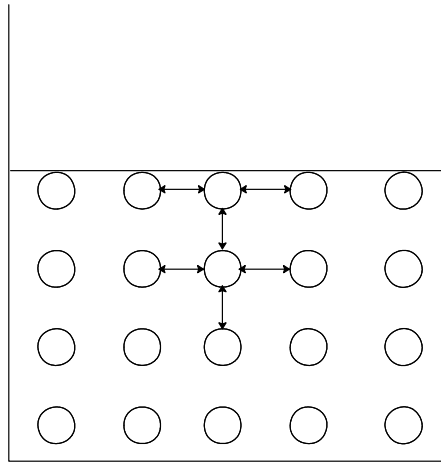
- ✓ More applied pressure is required to condense a vapor at higher temperature.
- ✓ Higher temperature means more rapid molecular motion, which makes it more difficult to establish the attractive forces needed for condensation.
- ☞ The limit on the ability to condense a vapor with applied pressure at high temperature defines the **critical point**.
  - ☞ The **critical temperature**,  $T_c$ , is the point above which a gas cannot be liquified, regardless of the pressure.
  - ☞ The **critical pressure**,  $P_c$ , is the minimum pressure needed to cause condensation at the critical temperature.
- ✓ Water's critical point is the  $T_c = 374\text{ }^\circ\text{C}$  and  $P_c = 217.7\text{ atm}$ .

## Supercritical Fluids

- ☞ Above the critical point the substance exists as a **supercritical fluid**.
- ✓ Supercritical fluids have high kinetic energy molecules forced together by high pressures.
  - ☞ Densities are similar to liquid densities.
  - ☞ Can have useful properties as solvents.
- ✓ Supercritical CO<sub>2</sub> is produced above  $T_c = 30.99\text{ }^\circ\text{C}$  and  $P_c = 72.8\text{ atm}$ .
  - ☞ Good solvent for oils, but not polar substances.
  - ☞ Used for decaffeinating coffee and a new dry cleaning method.

## Surface Tension of Liquids

- ✓ The absence of intermolecular attractions above the surface of liquid creates a barrier or "skin".



- ✓ Surface tension allows light objects with greater density than water to "float" on the surface (e.g., powdered sulfur, water bugs).
- ✓ Surface tension causes water to "bead" on a polished metal surface.

