# Liquids and Solids

Unit 8

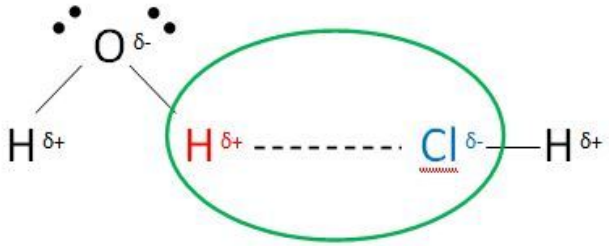
Module 2

# Module Concepts

- Terms used to describe liquids
- Relating properties of liquids to strength of attractive forces between molecules

# Terms Used to Describe Liquids

- *Polar* - those liquids that will dissolve in (aka are *miscible* in) water
  - Water is considered a polar solvent.
  - Polar molecules, like HCl, can form attractive forces with the water molecules through the electrostatic attraction between oppositely charged ends of the molecules. This results in the "Like Dissolves Like" principle.



# Terms Used to Describe Liquids

- ***Nonpolar*** - those liquids that will not dissolve in (aka are *immiscible* in) water.
  - Nonpolar liquids, those without permanent dipoles, cannot form strong attractive forces with polar liquids. (Example: Vegetable Oil in water)
  - These liquids will, however, dissolve in other NONPOLAR liquids according to the "Like Dissolves Like" principle.

# Terms Used to Describe Liquids

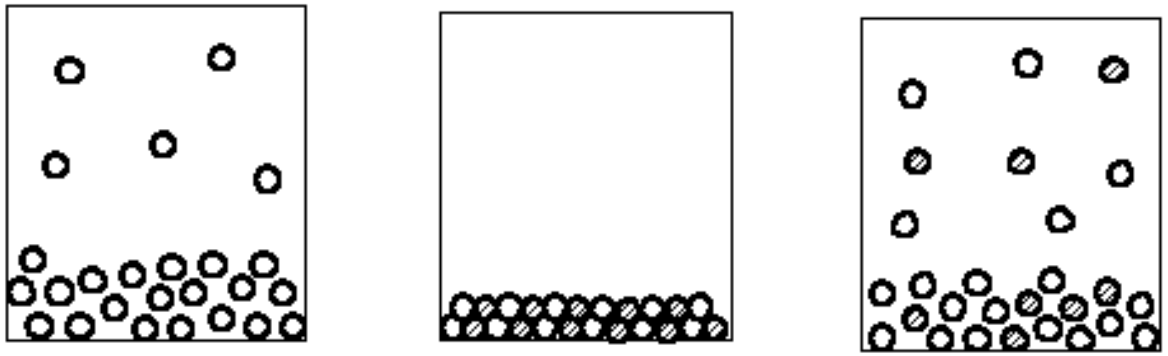
- *Volatile* - liquids that evaporate quickly.
- *Non-volatile* – liquids that evaporate slowly.
  - *Volatility relates to the strength of attractive forces between particles of the liquid*, because in order for a liquid to evaporate (convert to a gas), all the attractive forces between the particles of the liquid must be broken. *(Recall from KMT that there are no attractive forces between particles in the gas phase, but there are attractive forces between particles in the liquid phase.)*

# Volatility – Cont'd

- *Strong* attractive forces between particles result in *low volatility*, whereas *weak* attractive forces result in *high volatility*. WHY? Attractive forces must be broken in order for a substance to evaporate. More attractive forces means more energy must be absorbed to break all the attractive forces so that the substance can convert to a gas.

# Volatility – Cont'd

- Which of these liquids is most volatile? Least?



A B C

Answer: Most Volatile = C (most particles in gas phase)

Least Volatile = B (fewest particles in gas phase)

# Terms Used to Describe Liquids

- ***Equilibrium Vapor Pressure*** - In a closed container holding a volatile liquid, the volume of liquid is found to decrease and then level off.

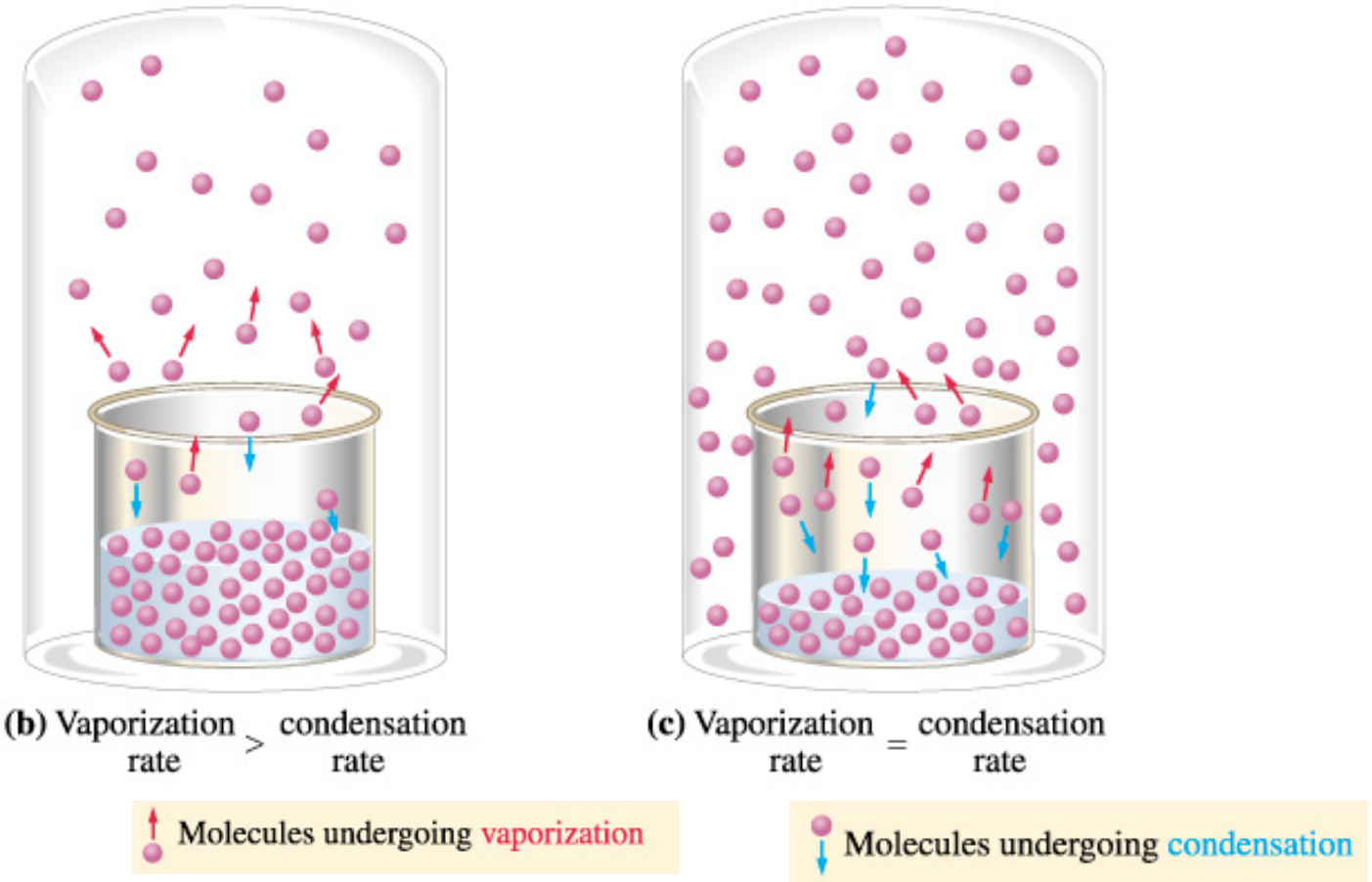
(a) Vaporization

Molecules undergoing vaporization

# Vapor Pressure – Cont'd

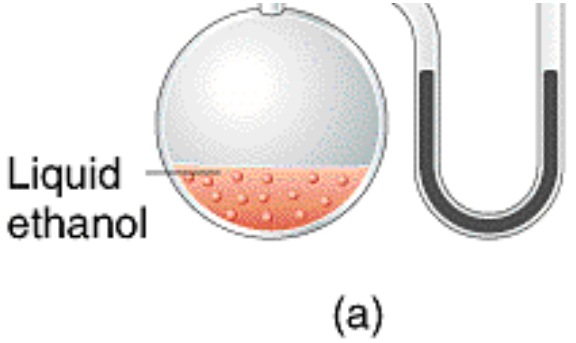
- This decrease in volume results from the conversion of some of the liquid into gas. This conversion of liquid to gas continues until an *equilibrium* is established between the liquid and gas phases.
- This equilibrium does not mean the conversion of liquid to gas stops, it just means that ***the rate of evaporation equals the rate of condensation***.
- This equilibrium can only be achieved in a *closed* system.

# Equilibrium - picture (c)

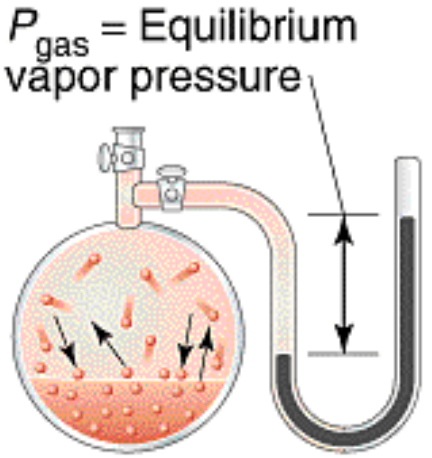


# Vapor Pressure – Cont'd

Since a gas is present in the closed container, collisions of the gas particles with the walls of the container result in a pressure being exerted. This pressure is called the *equilibrium vapor pressure*. (The pressure is measured as the height difference created between the liquid levels in a U-Tube manometer as the gas pushes on it from inside the round bottom flask.)




(a)



# Vapor Pressure Relationships

- *Vapor pressure depends on volatility*. The more volatile a substance, the more readily it converts to gas. The more gas present, the greater the number of collisions with the walls of the container. The greater the number of collisions with the walls of the container, the greater the equilibrium vapor pressure. This would be a *DIRECT* relationship between equilibrium vapor pressure and volatility.

# Vapor Pressure Relationships

- Since volatility depends on strength of attractive forces, vapor pressure also depends on strength of attractive forces. The stronger the attractive forces, the lower the vapor pressure and vice versa. Thus, vapor pressure and attractive forces are *INVERSELY* related. Can you explain why?

# Vapor Pressure Relationships

- Stronger attractive forces keep a substance in the liquid phase. Less gas equals fewer particle collisions with the walls of the container. Fewer particle collisions with the walls of the container results in lower pressure. So, strong attractive forces result in lower equilibrium vapor pressure. This would be an *inverse* relationship between attractive forces and equilibrium vapor pressure.

# Vapor Pressure Relationships

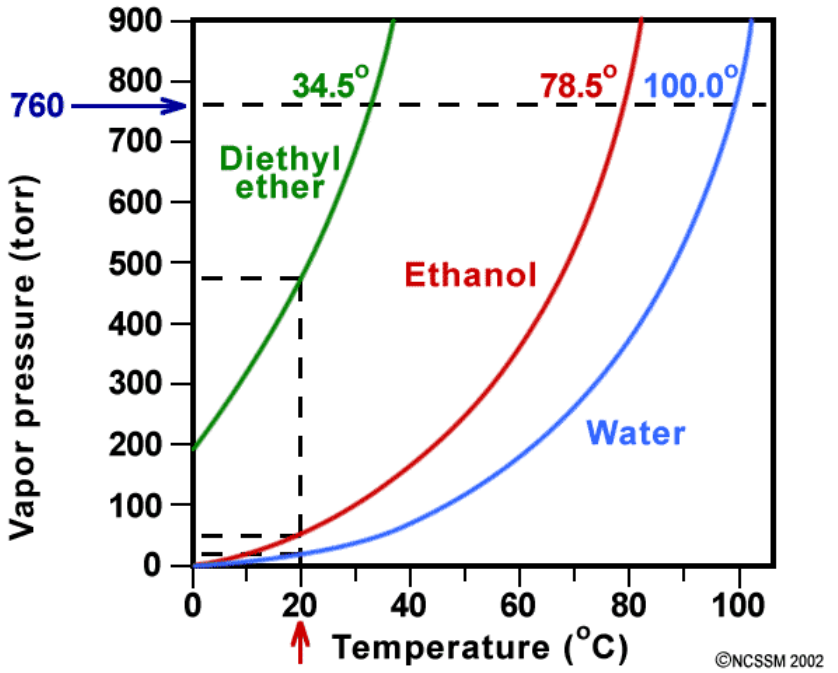
- *Vapor pressure also depends on temperature*. As temperature increases, so does the equilibrium vapor pressure. This represents a *direct* relationship between temperature and vapor pressure. Why? Your turn to explain! (Hint: pressure is created by gas particles colliding with the walls of their container.)

# Terms Used to Describe Liquids

- *Boiling Point* – the temperature at which a liquid boils and turns into a gas. This happens when the vapor pressure of a liquid equals the external (aka atmospheric) pressure surrounding the liquid.

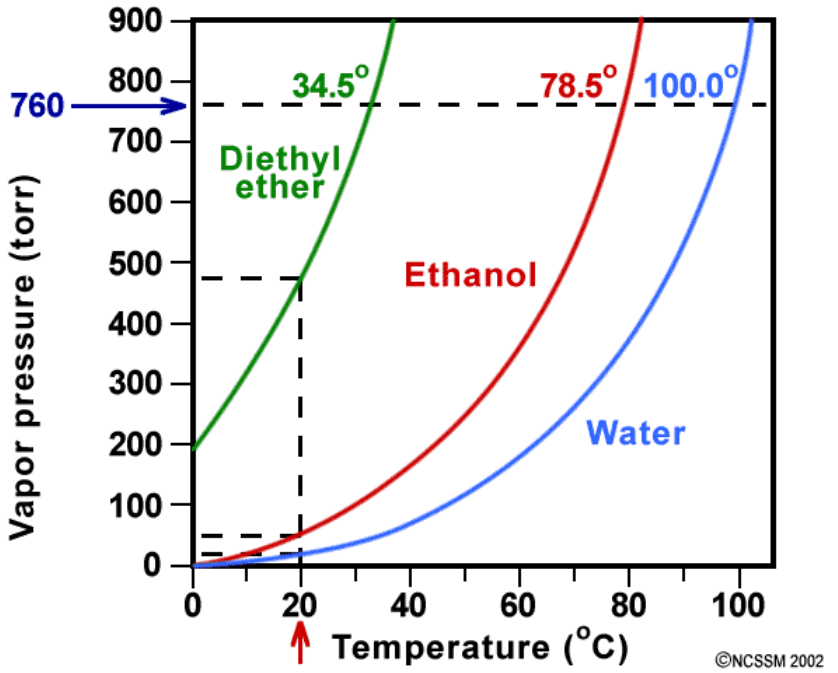
# Boiling Point

- Normal atmospheric pressure is 760 torr. The point where each curve crosses the line of atmospheric pressure represents the boiling point of the liquid.



# Boiling Point

- Which one of these liquids has the lowest boiling point? The highest?



# Boiling Point

- The higher the boiling point of a substance, the *stronger* the attractive forces are between molecules. This is because ALL attractive forces must be broken in order for a substance to boil and become a gas. If those forces are strong, it takes a lot of energy to break all the attractive forces. This means the substance must be raised to a higher temperature to achieve a kinetic energy that is high enough to overcome those forces of attraction.

# Terms Used to Describe Liquids

- ***Viscosity*** - a measure of the resistance a liquid has to flowing (aka, liquid "thickness"). Liquids which flow slowly are very viscous. Molasses would be a very viscous liquid. Can you think of other viscous liquids?

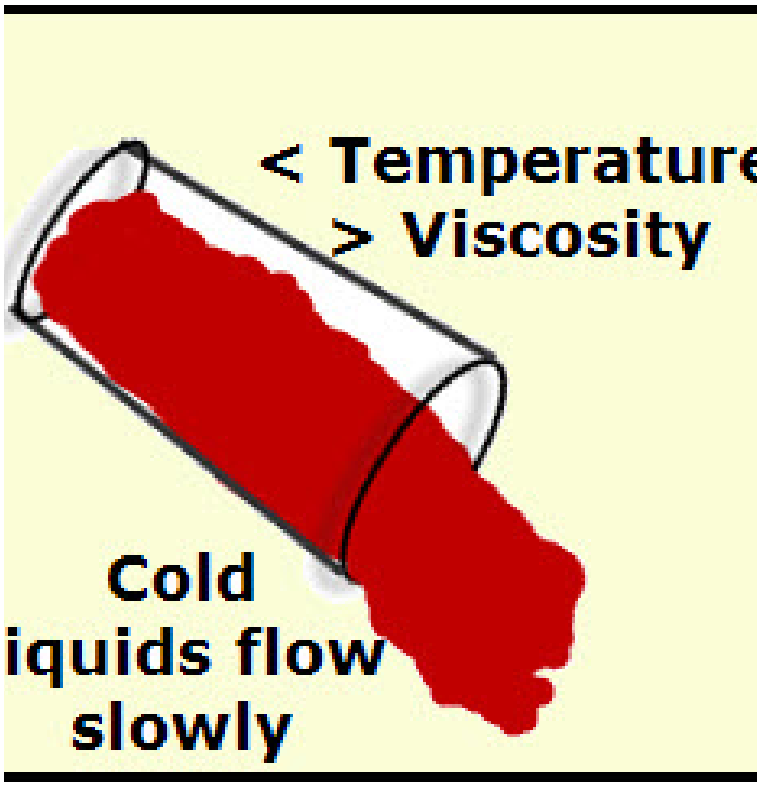
# Viscosity – Cont'd

# Viscosity – Relationships

- Viscosity depends on strength of attractive forces. The stronger the attractive forces between particles of a liquid, the more viscous the liquid and vice versa.

# Viscosity - Relationships

Viscosity is inversely proportional to temperature. The lower the temperature, the greater the viscosity and vice versa. (Ever heard of the expression “Slow as Molasses in January?”)

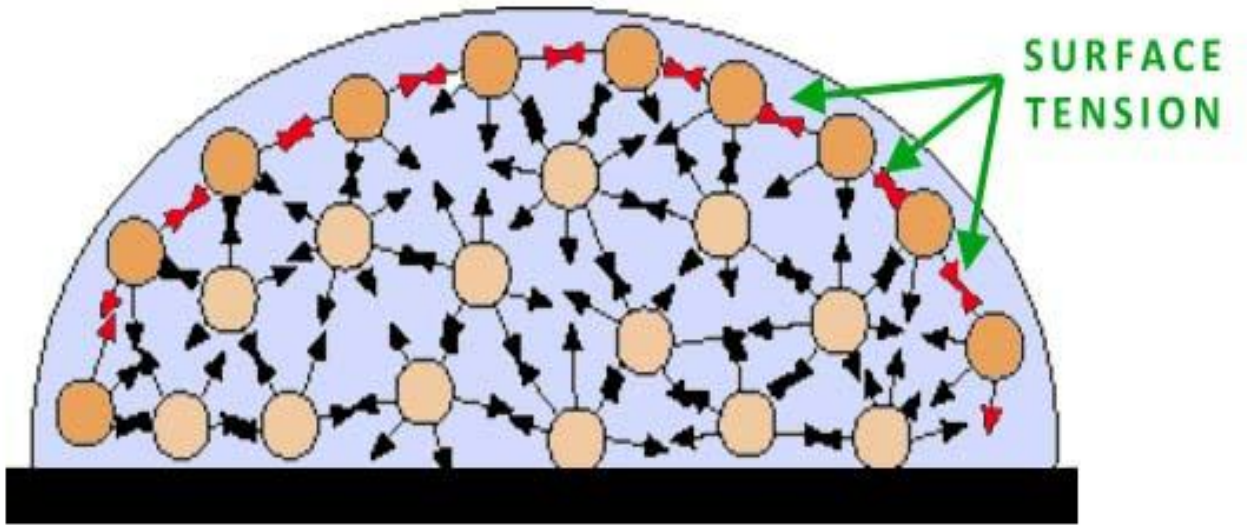


# Terms Used to Describe Liquids

***Surface Tension*** - the tendency of a liquid to minimize its surface area. It's why liquids bead up on certain surfaces and why spiders can walk on water.

# Surface Tension – Cont'd

- Surface tension is also related to attractive forces. If the intermolecular (between molecules) attractive forces are strong, then the molecules in the liquid are more attracted to themselves rather than the molecules on the surface. Thus, liquids with strong attractive forces have high surface tension.



# Terms Used to Describe Liquids

- *Capillary Action* -the ascension of liquids through a slim tube, cylinder or permeable substance due to adhesive and cohesive forces interacting between the liquid and the surface. Capillary action is how plants and trees draw water from the ground.