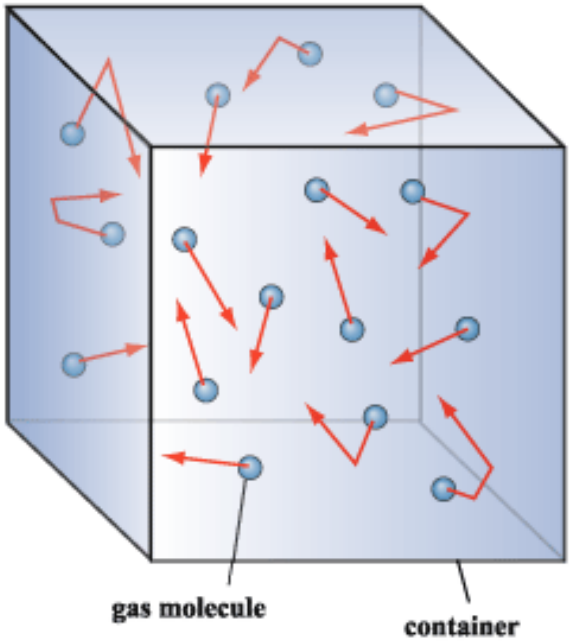
CHAPTER 10: STATES OF MATTER

CP Chemistry

CHAPTER 10.1
KINETIC MOLECULAR THEORY

Kinetic-Molecular Theory of Matter

- All particles of matter are in constant motion – even the solids!

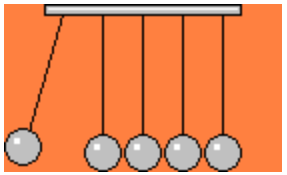


Kinetic Molecular Theory

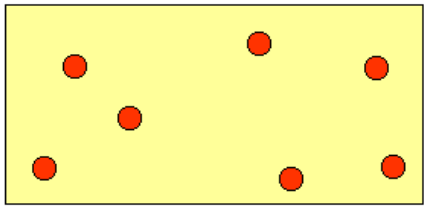
This is a **model** for the behavior of an **ideal gas**. It is useful for predicting the behavior of gases.

Kinetic Molecular Theory

1. Gases are composed of tiny particles and mainly empty space



2. Collisions are perfectly elastic
3. Gas particles move in constant, rapid, random motion



4. There are no attractive forces between gas particles
5. Volume of individual gas particles is zero
6. The temperature of the gas depends on the average kinetic energy. ($KE = \frac{1}{2}mv^2$)

Kinetic Molecular Theory

- Applies to only ideal gases
- Ideal Gas: hypothetical gas that perfectly fits all the assumptions of the kinetic-molecular theory
- Real Gases
  - Expand, are fluid, have relatively low densities, compressible, and diffuse & effuse

CHAPTER 10.2 LIQUIDS

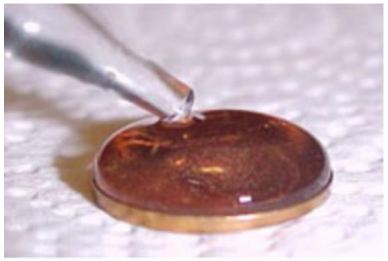
10.2 Liquids

Properties of Liquids:

1. Definite volume
2. Indefinite shape
3. Free flowing particles; fluidity
4. Condensed state of matter with higher density
5. Relatively incompressible
6. Ability to diffuse
7. Surface tension

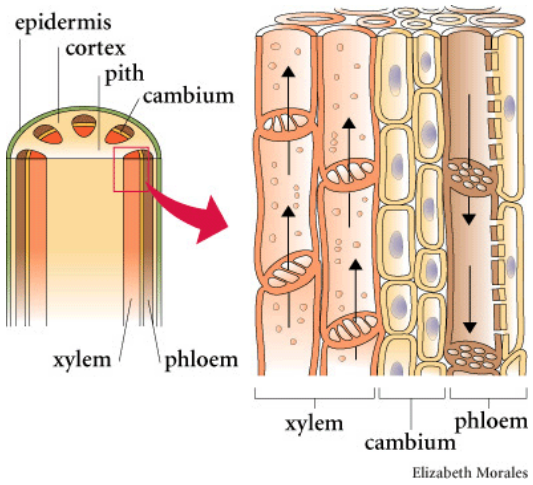
Surface Tension

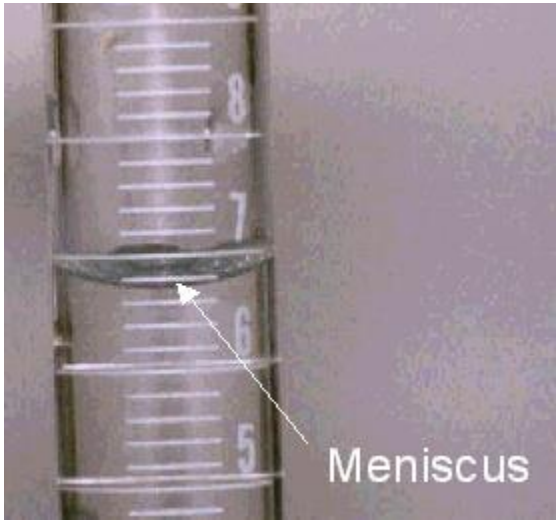
- **Definition**: The force that tends to pull adjacent parts of a liquid's surface together, thereby decreasing surface area to the smallest possible size.
- Causes bugs and leaves to walk/float on water



Capillary Action

- Definition: the attraction of the surface of a liquid to the surface of a solid
- Related to surface tension
- Responsible for a meniscus, xylem & phloem, & paper product absorption

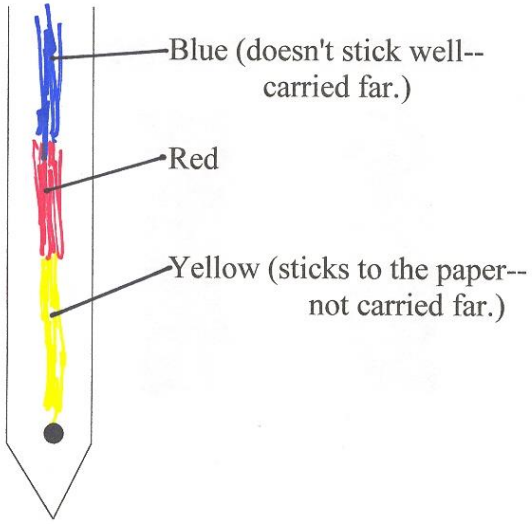


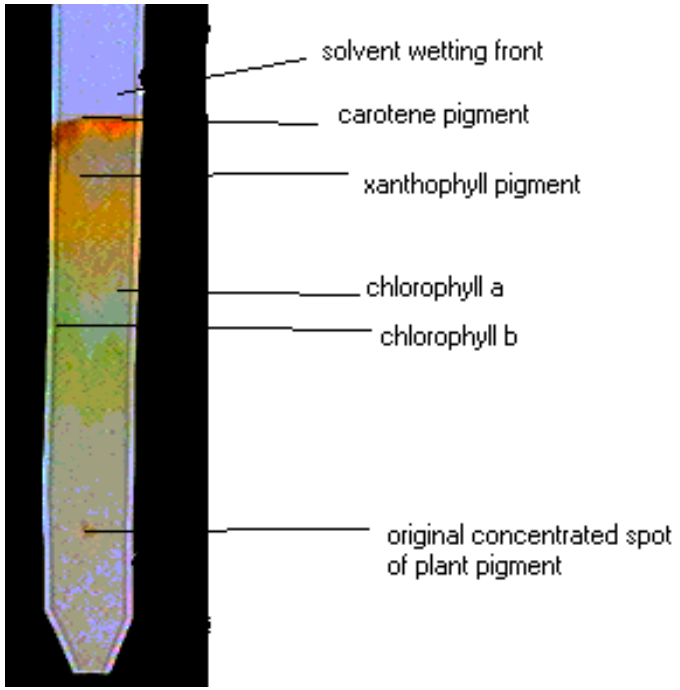


Capillary Action

Paper Chromatography

Paper chromatography separates mixtures using a solvent (water) that carries a solute (ink) up a strip of paper.



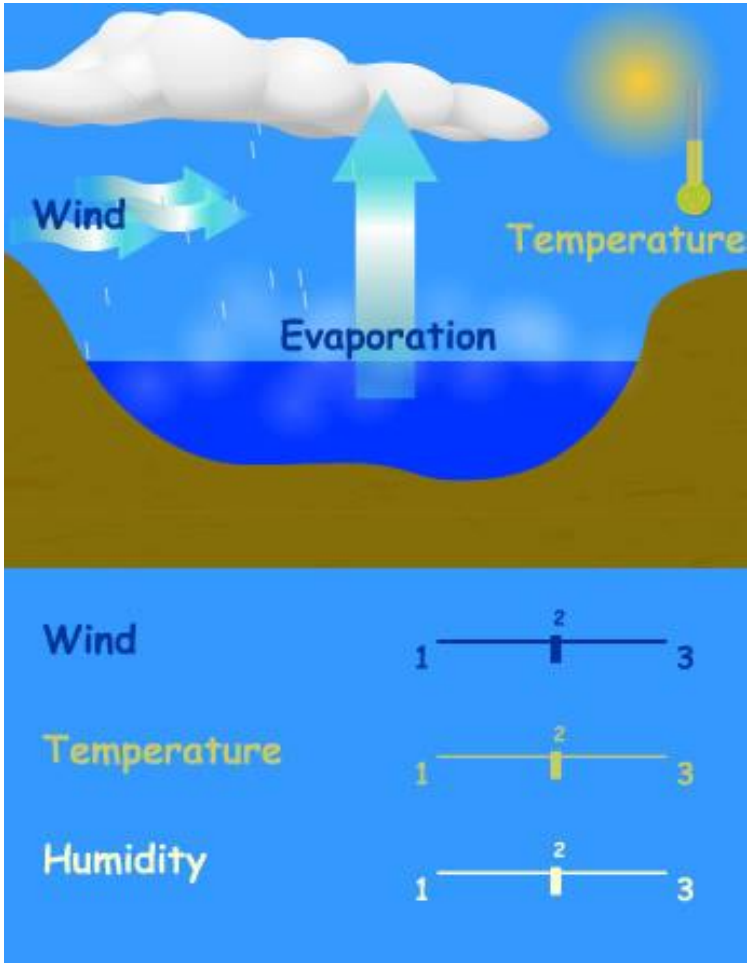


Vaporization

- Definition: term used for the conversion of a liquid to a gas or vapor below its boiling point
- General term for the escape of molecules at the surface
- Can be an open or closed container

Evaporation

- Process by which particles escape from the surface of a non-boiling liquid and enter the gas state



Vaporization Pressure

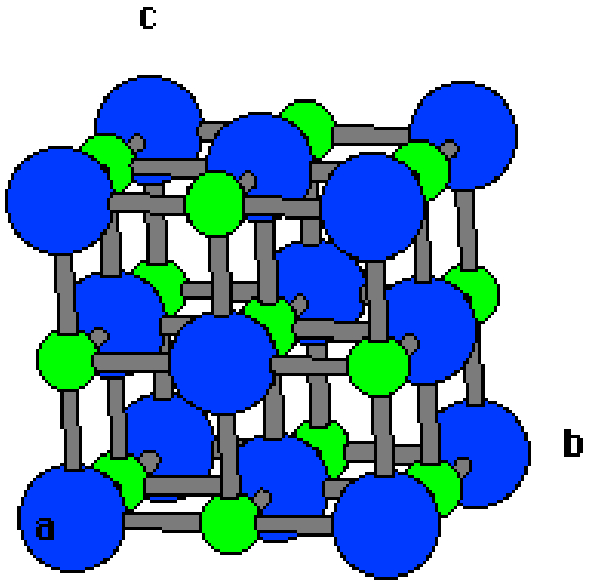
- Vapor pressure: The pressure of a vapor over its liquid
- Vapor Pressure: vaporized particles collide with the walls of a sealed container, and create a pressure above the surface of the liquid.
- particles enter the vapor
- some particles condense back to the liquid

Ex: The "Sssst" in soda!

CHAPTER 10.3 SOLIDS

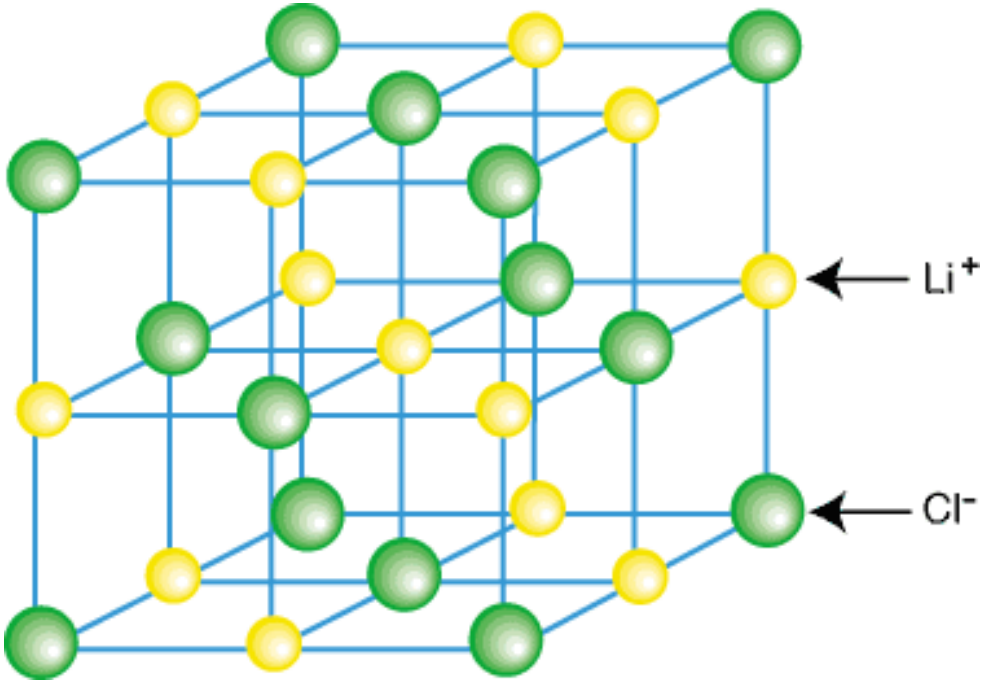
Types of Solids

- Crystalline Solids: highly regular arrangement of their components
- [table salt (NaCl), pyrite (FeS_2)].

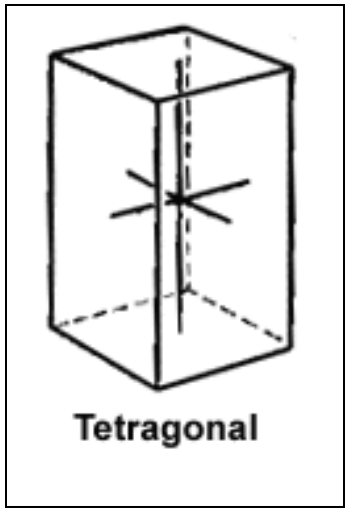


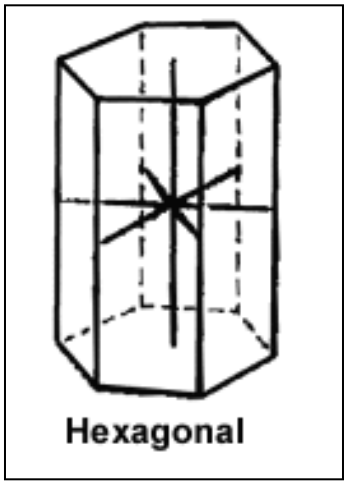
Crystalline Solids

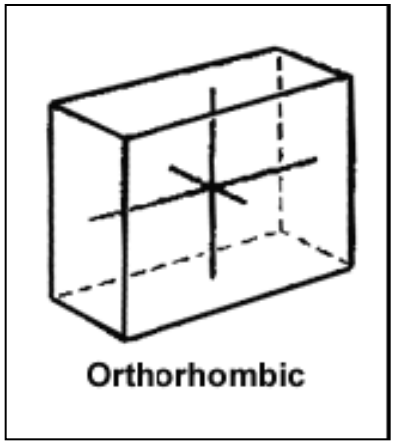
Lattice: A 3-dimensional system of points designating the centers of components (atoms, ions, or molecules) that make up the substance.

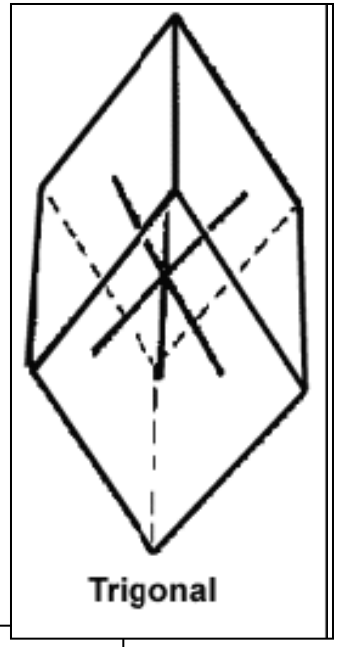


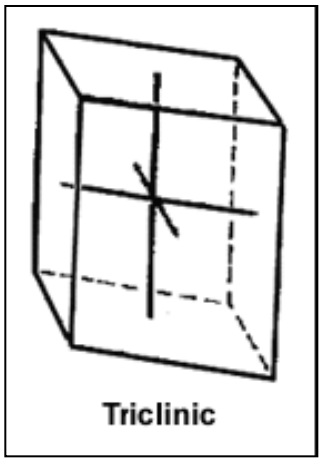
7 Basic Crystal Units

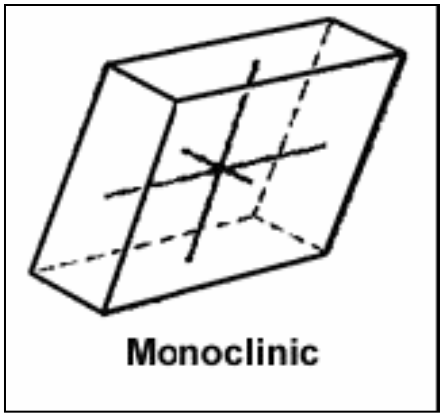


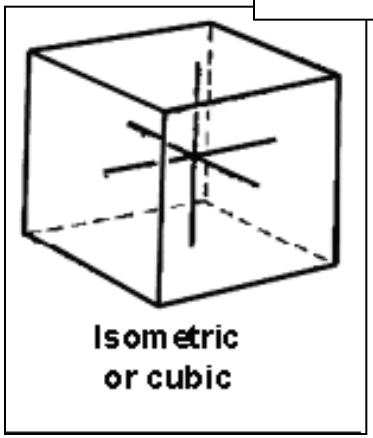






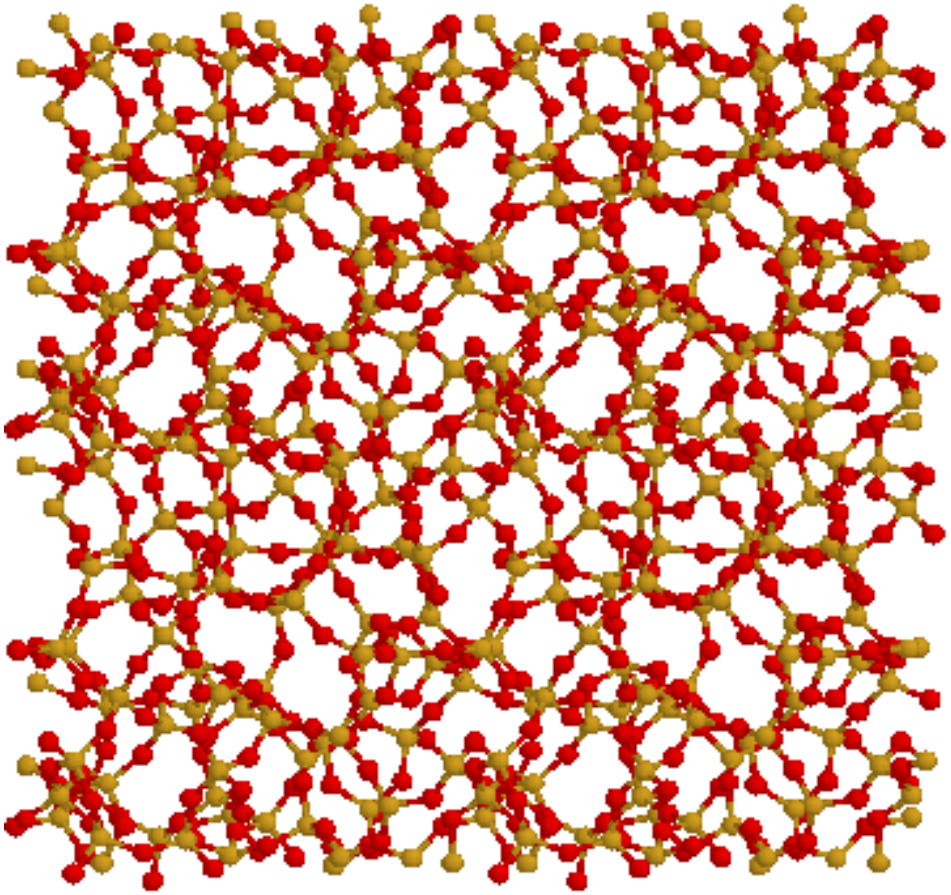






Types of Solids

- Amorphous solids: considerable disorder in their structures (glass and plastic).



Forces and Phases

- Substances with very little intermolecular attraction exist as gases
- Substances with strong intermolecular attraction exist as liquids
- Substances with very strong intermolecular (or ionic) attraction exist as solids

Intermolecular Forces

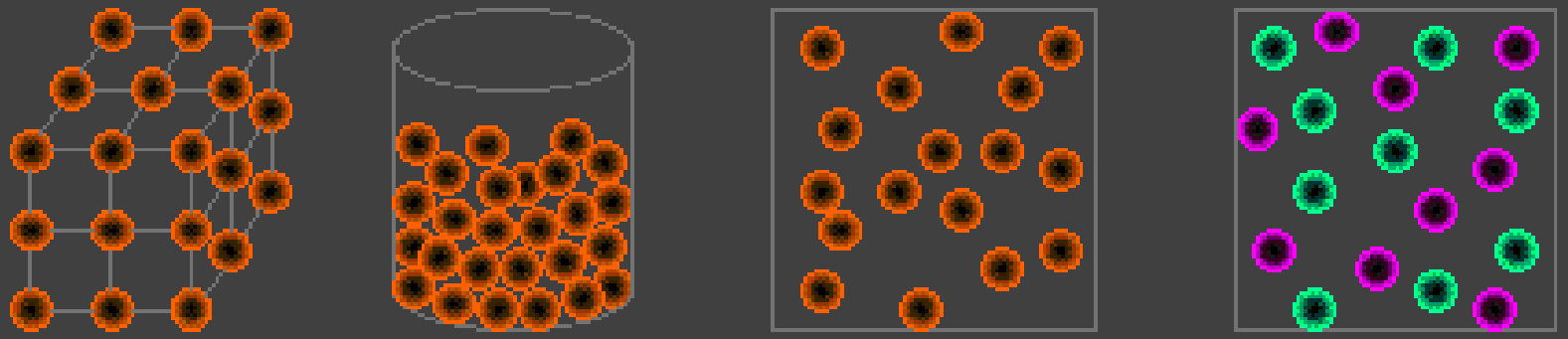
Forces of attraction between different molecules rather than bonding forces within the same molecule.

- **Dipole-dipole attraction**
- **Hydrogen bonds**
- **Dispersion forces**

Phase Differences

- Solid – definite volume and shape; particles packed in fixed positions; particles are not free to move
- Liquid – definite volume but indefinite shape; particles close together but not in fixed positions; particles are free to move
- Gas – neither definite volume nor definite shape; particles are at great distances from one another; particles are free to move

States of Matter



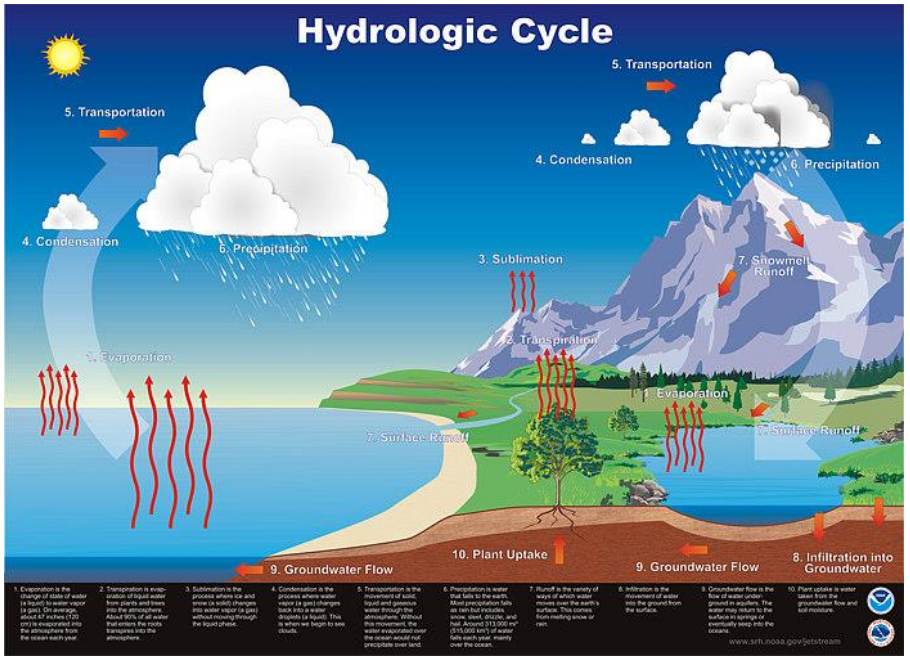
SOLID LIQUID GAS PLASMA

ADD HEAT

CHAPTER 10.4
CHANGES OF STATE

Changes of State

- Common ones:
  - Condensation
  - Vaporization
  - Melting
  - Freezing
  - Sublimation
  - Deposition



Phases

Phase: A phase is any part of a system that has uniform composition and properties.

Equilibrium: is a dynamic condition in which two opposing changes occur at equal rates in a closed system.

Phases

Condensation: is the process by which a gas changes to a liquid. A gas that is in contact with its solid or liquid phase is called a *vapor*.

Vaporization: is the process by which a liquid changes to its gas phase.

Phases

Melting: is the process by which a solid changes to a liquid.

Freezing: is the process by which a liquid changes to a solid; also referred to as fusion.

Phases

Sublimation: is the process by which a solid changes directly to a gas, without going through a liquid state.

Deposition: is the process by which a gas changes directly to a solid, without going through a liquid state.

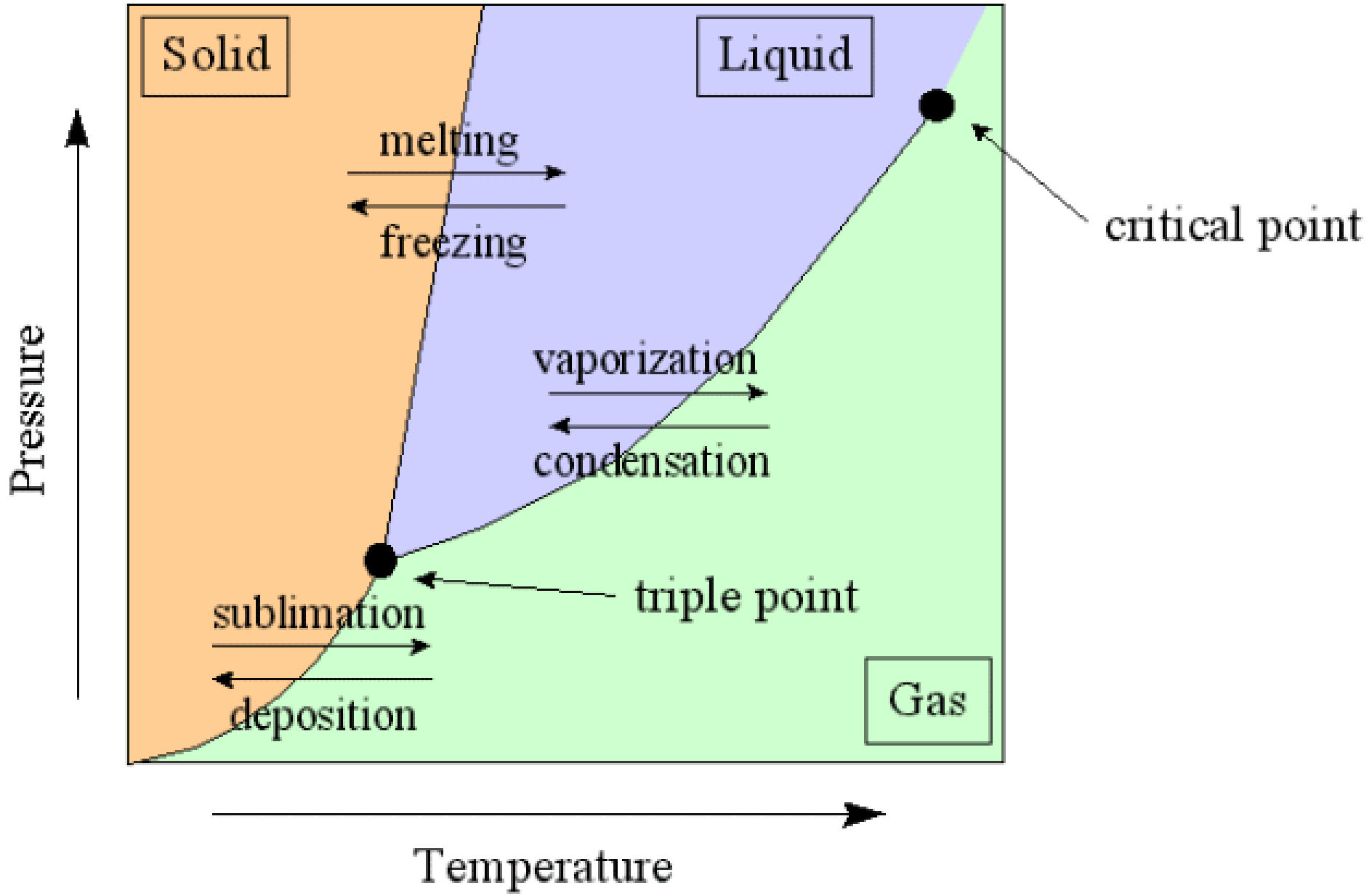
Equilibrium

- **Dynamic Equilibrium:** After time, the amount of particles vaporizing equals the particles condensing
- rate of evaporation = rate of condensation
  Particles are still vaporizing and still condensing…it doesn't stop!!!

Phase Diagram

- A diagram that represents the phases of a substance as a function of temperature and pressure.

Phase Diagram for Water



Phase Diagram

- **Critical temperature:** the highest temperature at which the solid and liquid phases can exist. (Above the critical temperature, the substance can only be found as a gas)

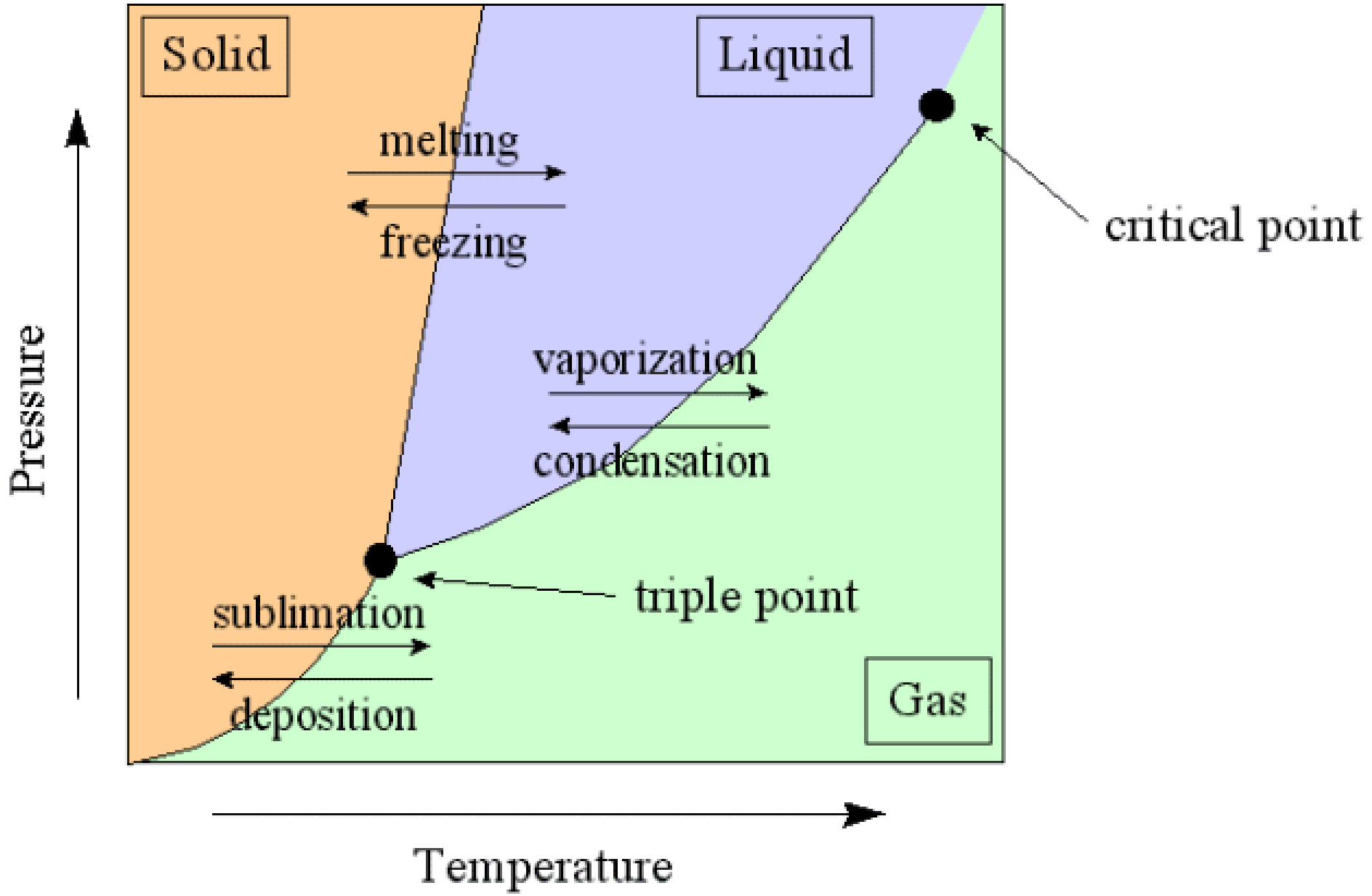
Phase Diagram

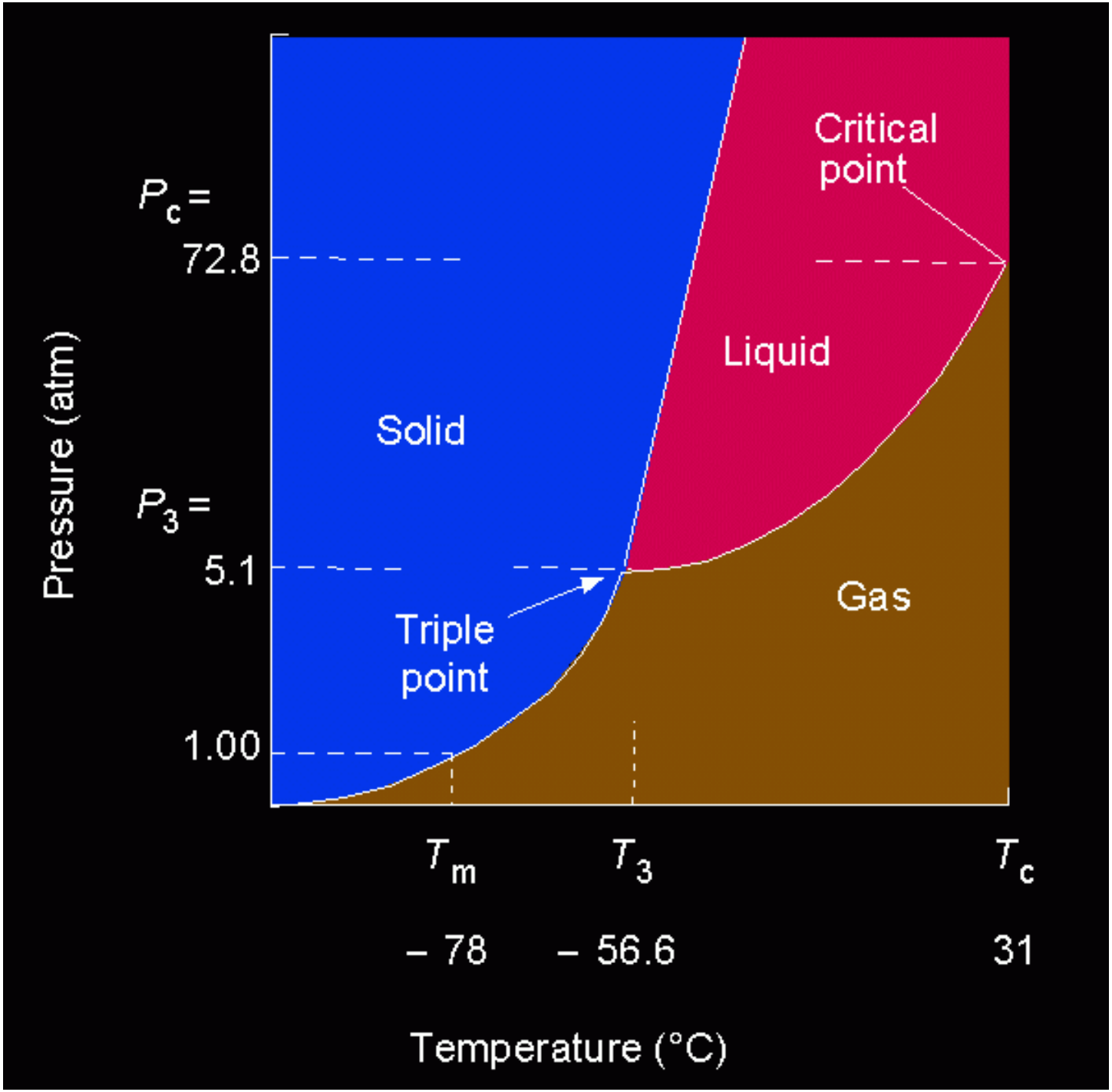
- **Critical pressure:** the pressure required to liquefy a gas at its critical temperature (The pressure needed to turn the gas into a liquid)

Phase Diagram

- **Critical point:** temperature and pressure above which a substance can only exist as a gas (substance cannot exist as a solid or liquid above this temperature)

Phase Diagram for Water




Critical point
P_c =
72.8
Liquid
Solid
P_3 =
5.1
Gas
Triple point
1.00
Pressure (atm)
T_m
T_3
T_c
– 78
– 56.6
31
Temperature (°C)

CO_2

Vapor Pressure

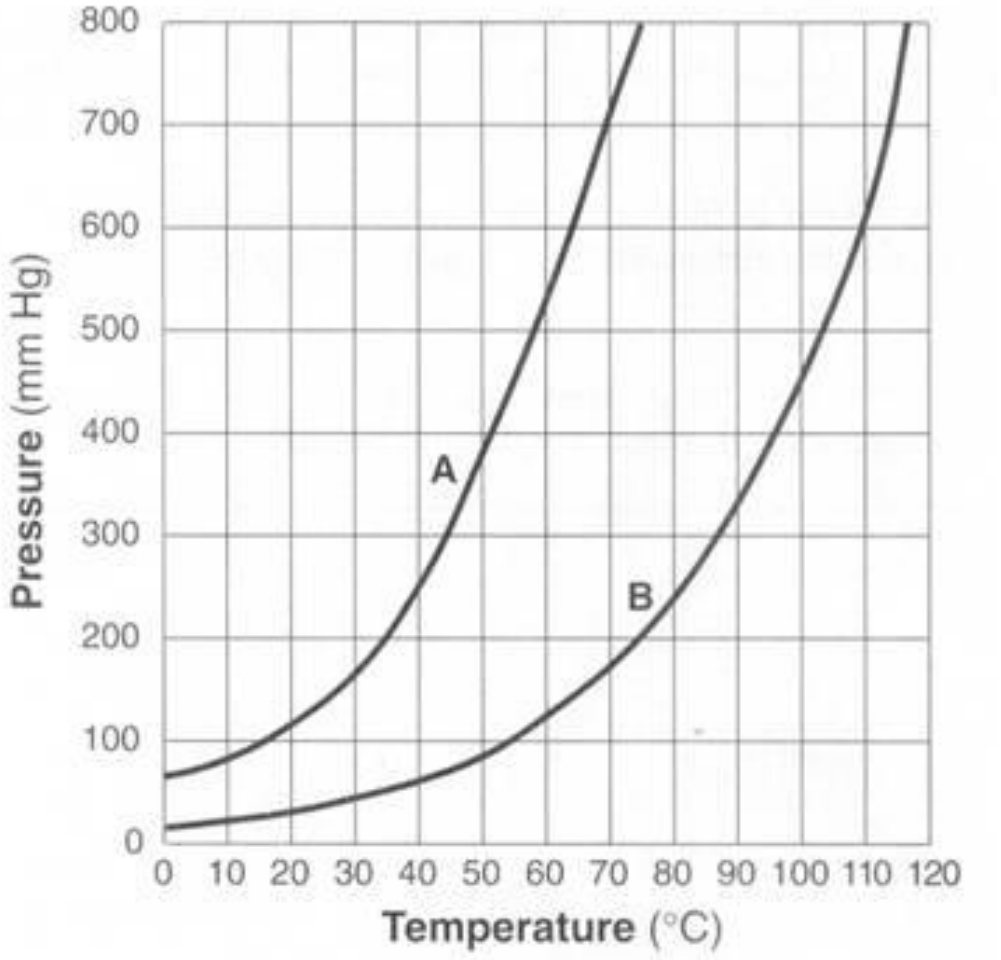
- A liquid will begin to boil when its vapor pressure equals the external pressure
- Thus, as the pressure in the room changes, the boiling point of the liquid will change as well.

Vapor Pressure

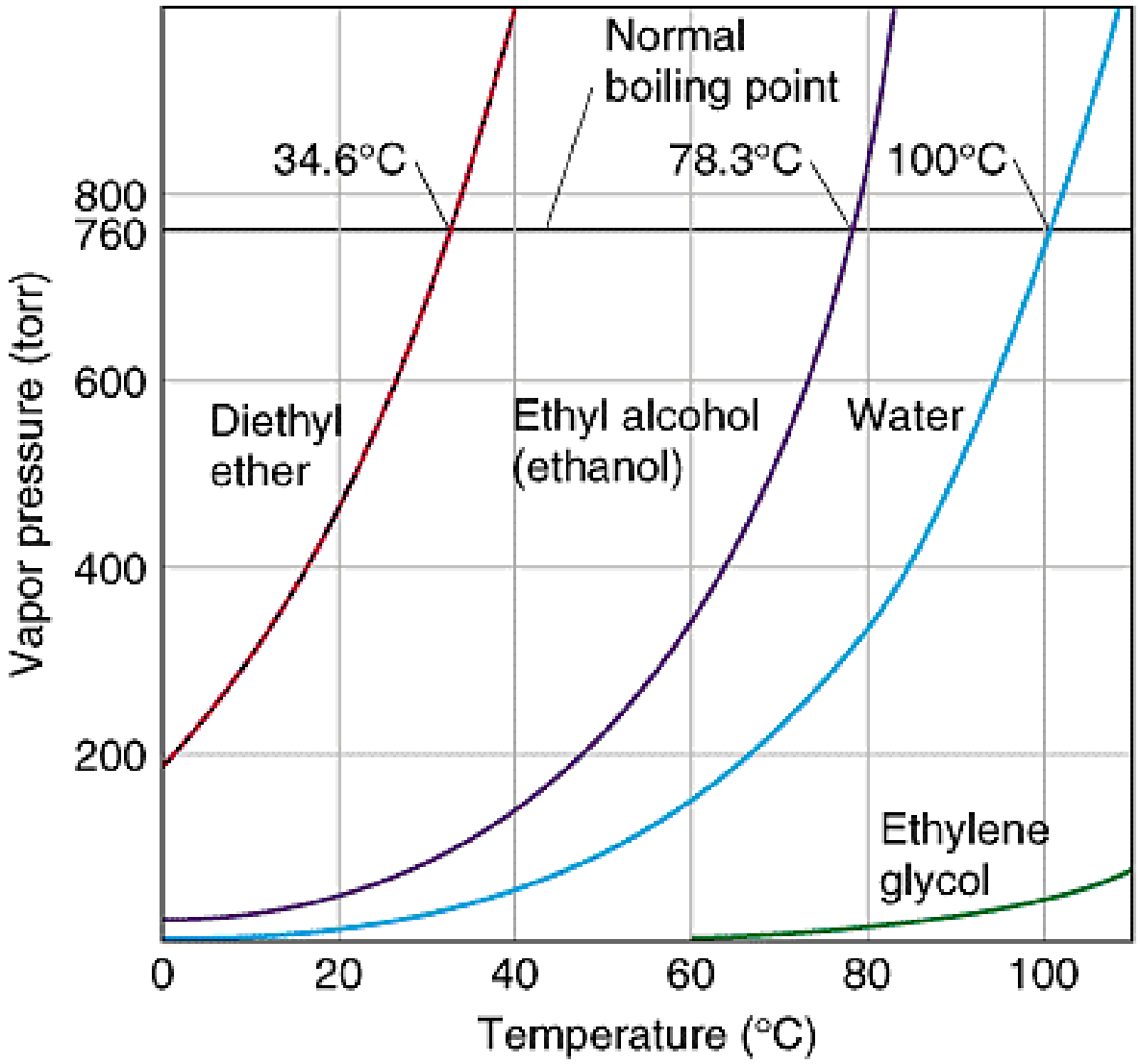
- At standard pressure (1 atm) the temperature at which a liquid will boil is called the **normal boiling point**
- You can use a vapor pressure graph to determine the boiling point of a liquid at any pressure

Vapor Pressure Diagrams

At standard pressure (760mmHg), liquid A will boil around 72°C. Liquid B will boil around 115°C. At what temps will they boil at 400mmHg?



Vapor Pressure Diagrams



Distillation Apparatus