CHEM. I Ch. 10 Notes ~ KINETIC THEORY and STATES OF MATTER

NOTE: Vocabulary terms are in **boldface and underlined**. Supporting details are in *italics.*

10.1 topics
States of Matter: SOLID, LIQUID, GAS, PLASMA

I. Kinetic Theory of Matter
   A. **kinetic energy** *(K.E.)—energy of motion*
   B. **Kinetic Theory of Matter**

- *Matter is composed of PARTICLES.*
- *Particle movement is rapid, constant, and random* (**Brownian motion**)
- *All collisions are perfectly ELASTIC (complete energy transfer).*

   C. Comparison of physical states
      1) gases have the least restriction on motion compared to the other phases of matter, so they have the most particle movement
      2) solids have the most restriction on motion compared to the other phases of matter, so they have the least particle movement

II. **Gases:** matter with variable shape and variable volume
   A. kinetic theory and gases

- *Gases are composed of PARTICLES.*
- *Particle movement is rapid, constant, and random* (**Brownian motion**)
- *All collisions are perfectly ELASTIC (complete energy transfer).*

   B. **ideal gas**—gases with perfectly elastic collisions and no intermolecular forces (contrast with **real gas**)
   C. gas pressure
      1) **gas pressure**—*collisions* of gas particles on objects
      2) **atmospheric pressure**—*collisions of "air" particles* on objects
      3) SI unit of pressure = Pa (Pascal)
      4) standard pressure: (this is the "P" from STP)

STANDARD ATMOSPHERIC PRESSURE:
1 atm = 760. mm Hg = 760. torr = 101.3 kPa = 14.7 psi

      5) examples of pressure conversions

E1) Convert a pressure of 847 mm Hg to kPa.

$$847\ \cancel{\text{mm Hg}} \times \frac{101.3\ \text{kPa}}{760.\ \cancel{\text{mm Hg}}} = \boxed{113\ \text{kPa}}$$

E2) What is 8.9 psi expressed in atm?

$$8.9\ \cancel{\text{lb/in}^2} \times \frac{1\ \text{atm}}{14.7\ \cancel{\text{lb/in}^2}} = \boxed{0.61\ \text{atm}}$$

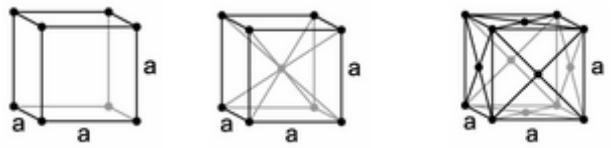
E3) 344 mm Hg = _____ psi

$$344\ \text{mm Hg} \times \frac{14.7\ \text{psi}}{760.\ \cancel{\text{mm Hg}}} = \boxed{6.65\ \text{psi}}$$

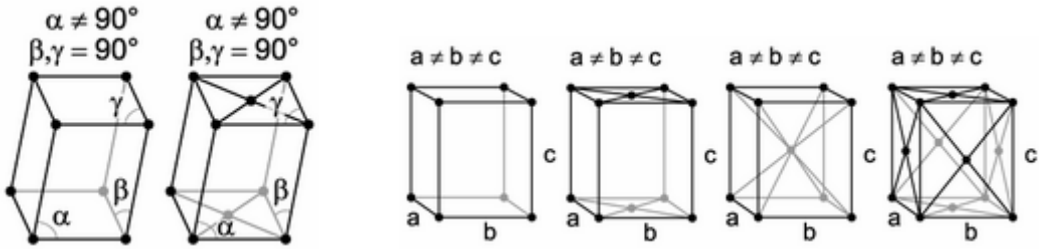
III. **Liquids**: matter with variable shape and fixed volume (more details later)

IV. **Solids**

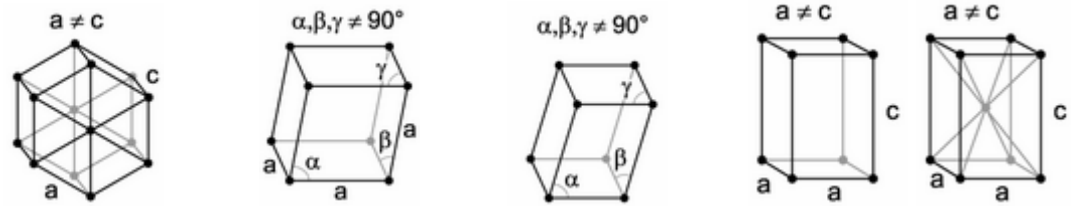
A. **freezing**—*conversion of a liquid to a solid*
B. **sublimation**—*conversion of a solid directly to a liquid or vapor*
C. **melting**—*conversion of a solid to a liquid at the* **melting point** *(m.p.)*
D. Types of solids
1) **crystalline**
a) **crystal lattice**—*organized repeating pattern in 3-D*
b) **unit cell**—*smallest repeating unit in a crystal*
c) **allotropes**—two or more different arrangements for the same element in the same state (C: graphite, diamond, "buckyballs")
d) common types of crystals *(from www.nationmaster.com)*



simple body-centered face-centered
CUBIC (3)

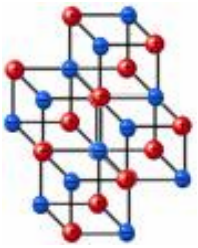


simple centered simple base-centered body-centered face-centered
MONOCLINIC (2) **ORTHORHOMBIC** (4)

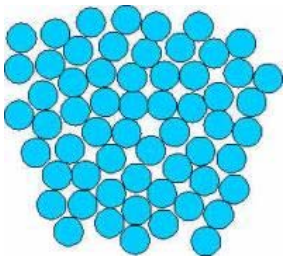


HEXAGONAL **RHOMBOHEDRAL** **TRICLINIC** simple body-centered
TETRAGONAL (2)

2) **amorphous**—solids without a set structure
a) incomplete crystal lattice formed
b) rubber, plastics, glass
c) glass is also called a **supercooled liquid**



CRYSTAL LATTICE



AMORPHOUS SOLID

V. Other Forms of Matter
- A. **amorphous materials** (amorphous solids)
- B. **liquid crystals**—an intermediate phase formed when solids partially melt in only one or two dimensions (LCD = liquid crystal display)
- C. **plasmas**
  1) *gaseous mixture of cations and electrons*
  2) most common form of matter in the universe but least common on Earth itself
  3) exists at high temperatures

10.2 topics

VI. Kinetic Energy (K.E.) and Changes of State
- A. Temperature and particle motion
  1) temperature—the measure of the *average K.E.* of particles in a sample
  2) **Kelvin** *(K) – SI base unit of temperature; measures average K.E.*
     a) Kelvin temp **α** K.E. (*Kelvin temp is directly proportional to K.E.*)
     b) When temp increases, particle motion increases. When temp decreases, particle motion decreases. (A temp of 300 K has twice the kinetic energy as 150 K.)
     c) *0 Kelvin* = **absolute zero** = *no molecular motion*
     d) No degrees sign (°) is used with Kelvin numbers
     e) There will never be negative numbers for Kelvin temperatures!.
  3) Kelvin-Celsius conversion equation **K = C + 273**

E4) Express 366.13 K in degrees Celsius.

K = C + 273 366.13 = C + 273 C = 93 °C

E5) Convert a temperature of 45 °C to Kelvin.

K = C + 273 K = 45 + 273 = 318 K

- B. Changing state; **phase changes**

IMPORTANT:	**Temperature does not change during a phase change. Increasing the temperature will only make the change happen faster.**

1) evaporation and condensation
   a) **evaporation** *(vaporization)—conversion of a liquid to a gas or vapor below the boiling point (b.p.)*

b) **condensation**—*conversion from a gas or vapor to a liquid*
c) **dynamic equilibrium** *(equilibrium = balance)— when evaporation rate equals the condensation rate*

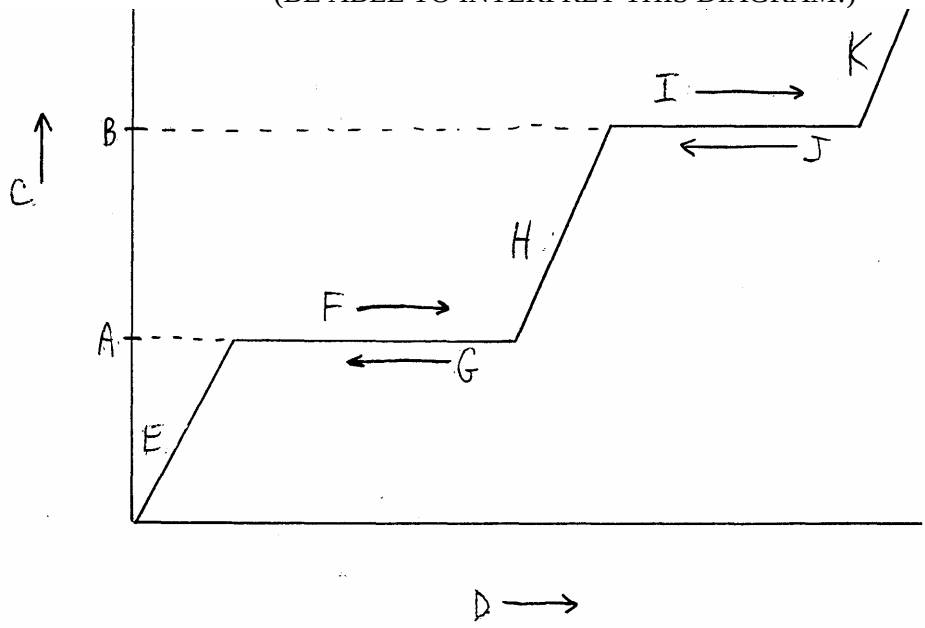
2) **boiling**—*conversion from a liquid to a gas or vapor at the boiling point*
   a) **vapor pressure**—pressure of evaporated particles in a partially filled, sealed container
   b) **boiling point** ***(b.p.)***—temperature at which the vapor pressure equals the external atmospheric pressure
   c) **normal boiling point**—b.p. of liquids at standard pressure
   d) **heat of vaporization**—the amount of heat necessary to boil or condense 1 mole of a substance at its boiling point

3) sublimation and deposition
   a) **sublimation**—*changing from a solid directly to a vapor*
   b) **deposition**—changing from a vapor/gas directly to a solid

4) melting and freezing
   a) **melting**—changing from a solid to a liquid
   b) **freezing**—changing from a liquid to a solid
   c) **heat of fusion**—the amount of heat absorbed or given off to melt or freeze 1 mole of substance at its freezing point

PHASE CHANGES OF WATER

(BE ABLE TO INTERPRET THIS DIAGRAM!)



A = freezing point
B = boiling point
C = temperature
D = time
E = solid
F = melting
G = freezing
H = liquid
I = boiling
J = condensing
K = gas

VII. **Phase Diagrams**

A. *graph of the relationships between all phases of a substance*

B. consists of three curves and a **triple point**, which is the point where all three meet

C. **critical point**—the point at which the physical properties of the liquid and gaseous states are identical

PHASE DIAGRAM (courtesy of FSU)