Ch. 1 Notes – CHEMISTRY: THE SCIENCE OF MATTER

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

I. What is **chemistry**?

A. some definitions of chemistry

- *the study and investigation of the structure and properties of matter*
- the science that systematically studies the composition, properties, and activity of substances and various forms of matter
- a science that deals with the composition, structure, and properties of substances and with the transformations that they undergo
- scientific study of matter, its properties, and interactions with other matter and energy
- the study of the composition of substances and the changes they undergo

B. some *branches of chemistry*

- *Analytical* – chemical composition
- *Astrochemistry* – of the cosmos (planetary atmospheres, comets, etc.)
- *Biochemistry* – rxns. (reactions) of living organisms
- *Environmental* – environmental issues: pollution, water quality, etc.
- *Food and Cooking* – reactions during cooking, ingredients, etc.
- *Geochemistry* – geological issues; petrology, etc.
- *Inorganic* – focuses on inorganic compounds (without carbon)
- *Nuclear* – focuses on rxns. changing of matter to energy
- *Organic* – focuses on carbon compounds
- *Physical* – physical characteristics and reaction mechanisms
- *Thermochemistry* – thermodynamics

~~~~~~~~~~~~~~~~~~~~~~~~~ THE PUZZLE OF MATTER ~~~~~~~~~~~~~~~~~~~~~~~~~

II. A Picture of Matter

A. composition, structure, and behavior

1) **matter**—*a substance that takes up space and has mass*
2) **mass**—*the amount of matter in an object*
3) **properties** of matter—*characteristics and behavior; can be physical or chemical*

B. examining matter

1) *macroscopic view*—matter large enough to be seen
2) *submicroscopic view*—dealing with atoms

III. Using Models in Chemistry

scientific model—tools to help you understand the relationship between the macroscopic and submicroscopic views of matter

IV. Classifying matter

A. classification by composition: can be **qualitative** or **quantitative**

1) **qualitative** —*verbal,* not numerical, *description* (rough, bright, red...)
2) **quantitative** —*description by numbers* (10 lbs., 98.6°, 5'4" tall…)

B. pure substance vs. mixture

1) **pure substance**—*matter with the same definite composition and properties*

examples of *elements* and *compounds*: C H_2O NaCl NH_3

2) **mixture**—*physical blend of two or more substances*
(gas-gas, liquid-gas, gas-liquid, liquid-liquid, solid-liquid, solid-solid)

C. mixed matter
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a) mixtures can be *heterogeneous* or *homogeneous*
    a) *heterogeneous—not uniform*; has different "phases"
       examples: granite, Italian salad dressing
    b) *homogeneous*—a called a **solution**; *uniform;* has one "phase"
       examples: salt water, air, **alloys**
b) phase—area of uniform composition and properties
c) parts of a solution
    a) **solute**—*the substance being dissolved*
    b) **solvent**—*the substance doing the dissolving*
d) **aqueous solutions** *(aq)—water containing dissolved materials*
e) can be separated by physical means: evaporation, filtration, distillation, etc.

D. separation of matter into pure substances
1) **physical change**
    a) *alterations that do not change the substance's identity and composition*
    b) e.g.: paper that is shredded is still paper; sugar dissolved in water is still sugar
    c) *key words: boil, freeze, melt, condense, dissolve, crush, break, cut…*
2) **physical properties**—*characteristics that can be observed and measured without changing the chemical composition of the substance*

conductivity	melting point	malleability
density	ductility	odor
solubility	boiling point	refractive index

a) Intensive property—does not depend on the amount of matter
b) Extensive property—depends on the amount of matter

V. Substances: Pure Matter

A. **elements**
1) *simplest form of matter retaining the properties of that matter*
2) examples : Ag Pb O W

COMMON ELEMENTS TO KNOW:

Ag, Al, Ar, As, Au, B, Ba, Be, Bi, Br, C, Ca, Cl, Co, Cr, Cs, Cu, F, Fe, Fr, H, He, Hg, I, K, Kr, Li, Mg, Mn, N, Na, Ne, Ni, O, P, Pb, Ra, Rb, S, Sb, Si, Sr, Sn, U, W, Zn

3) chemical symbols
    a) each element has a different symbol
    b) capitalize the first letter only
    c) word roots from English and other languages (Latin)

B. organizing the elements: *periodic table of the elements*

One of the main goals of this class is to "decode" this table and learn how to derive information from it.

C. **compounds**
1) *more than one element* in a type of matter
2) can only be separated by chemical methods
3) examples: $NaHCO_3$ CO H_2CO $CaCO_3$

D. formulas of compounds
1) **formula**—*correct combination of chemical symbols*
2) tells which elements and how many there are

VI. Identifying Matter by its Properties

A. states of matter

1) *solid—matter with a definite, fixed shape and volume*
2) *liquid*
   a) *matter with variable shape and fixed volume*
   b) exhibits flow
   c) takes the shape of its container
3) *gas*
   a) *matter with variable shape and volume*
   b) exhibits flow
   c) takes the shape and volume of its container
   d) gas is used to describe a substance that is normally stable as a gas at room temperature ("oxygen gas")
   e) vapor is used to describe a substance when it found as a gas even though the normal state is not ("water vapor")
   f) **volatile**—changing to a gas easily at room temperature
4) *plasma—low-density ionized gases*

B. Density

1) **density = mass / volume**
2) **D = M / V** M = D x V V = M / D
   (be comfortable with algebraic manipulation of equations!)
3) density usually decreases as temp. increases (due to increased volume)
4) examples…

EXAMPLE 1:
A metal bar has a mass of 35.50 g and a volume of 262 cm^3. What is its density in g/cm^3?

$$\mathbf{D = \frac{M}{V}} = \frac{35.50\ g}{262\ cm^3} = \boxed{0.135\ \frac{g}{cm^3}}$$

EXAMPLE 2:
500.0 mL of a liquid has a density of 0.447 g/mL. What is its mass?

$$D = \frac{M}{V} \qquad \mathbf{M = DV} \qquad M = 0.447\ \frac{g}{\cancel{mL}} \times 500.0\ \cancel{mL} = \boxed{224\ g}$$

EXAMPLE 3:
4.2 g of a substance has a density of 0.89 g/m^3. How much space, in m^3, does it occupy?

$$D = \frac{M}{V} \qquad \mathbf{V = \frac{M}{D}} \qquad V = \frac{4.2\ \cancel{g}}{0.89\ \cancel{g}/m3} = \boxed{4.7\ m^3}$$

VII. Chemical Properties and Changes

A. atoms and chemical change

1) **chemical properties**—*ability to form new substances as a result of chemical reactions (rxns.)*
2) **chemical changes**—*alterations that changes substance's identity and composition to something new, through a* **chemical reaction**
   a) e.g.: burning firewood, rotting of fruit
   b) *key words: rust, decompose, corrode, burn, ferment, grow, decay…*
3) **chemical reactions**—the changing of substance(s) into new ones
   a) *reactants*—starting substances in a rxn.

b) *products*—new substances formed in a rxn.

("Reactants react to produce the products.") $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

c) clues that a chemical rxn. has occurred

energy is given off (gets hotter) color change production of a gas
energy is absorbed (gets colder) odor change usually not easily reversible
production of a solid (precipitate; ppt.)

4) **<u>Law of Conservation of Mass</u>**—*in a physical or chemical change, matter cannot be created nor destroyed, it merely changes form*

a) reactant mass = product mass

b) exceptions are nuclear rxns.

B. chemical reactions and energy

1) **<u>energy</u>—***the capacity to do work*

2) some types of energy

a) *potential*—energy at rest; energy of position

b) *kinetic*—energy of motion

c) *thermal*—heat energy

d) *radiant*—light energy

e) *chemical*—energy in chemical bonds

3) *Law of Conservation of Energy— in a physical or chemical change, energy cannot be created nor destroyed, it merely changes form*

4) energy changes in reactions

a) **<u>exothermic</u>**—*giving off heat*

b) **<u>endothermic</u>**—*absorbing heat*