

- insulators
- brittle (for the solids)

Metalloids

- semiconductors
- behave more like nonmetals than metals



## CHAPTER 2: Compounds &amp; Chemical Reactions

Elements combine to form compounds whose properties are, in general, completely different from those of the elements

Formulas

some elements occur naturally as diatomics  $H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2$

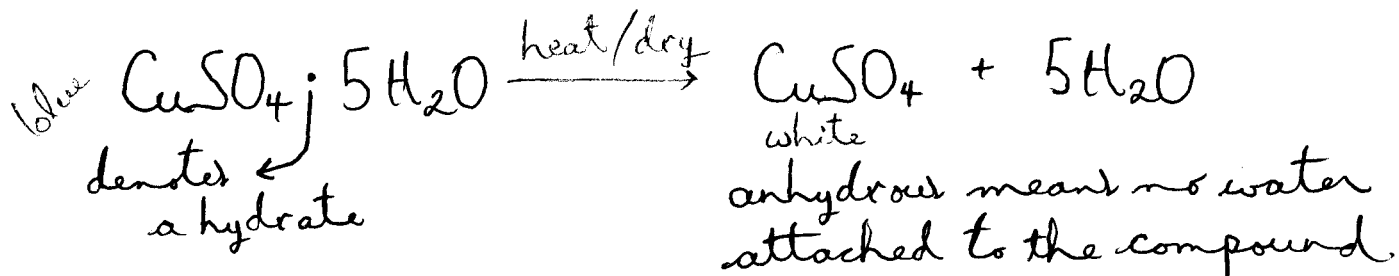
compounds have a fixed composition

ex rust = iron oxide =  $Fe_2O_3$  two atoms of iron combine with three atoms of oxygen to form a molecule of  $Fe_2O_3$

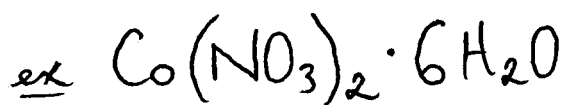
urea =  $CO(NH_2)_2$

brackets used to indicate structure

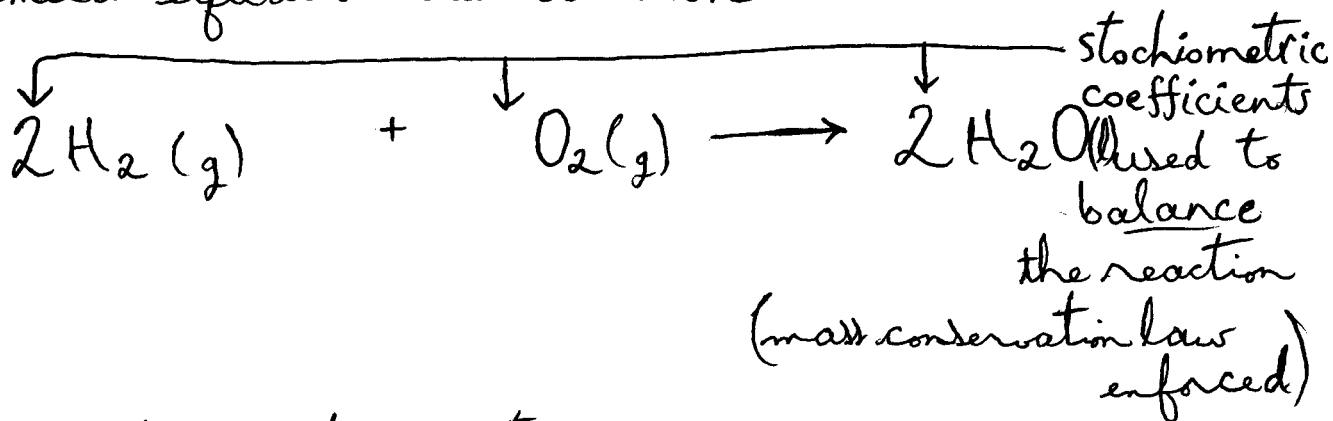
Hydrates are solids that contain water that can be removed



Chem 1311 | You must be able to count atoms in a formula (14)



Chemical equations describe a chemical reaction



Energy, heat, and temperature

Chemical reactions either emit or absorb energy. However, energy is conserved overall (cannot be created or destroyed)

$$E = K + U \quad \text{Total energy} = \text{kinetic energy} + \text{potential energy}$$

$$K = \sum_{i=1}^N \frac{1}{2} m_i v_i^2 \quad i \text{ counts atoms (N total)}$$

ex if we heat a beaker of water, the molecules start moving faster ( $v$  increases) and eventually they can escape into the air as vapor.

$U$  : can be thought of as stored energy  
ex energy is stored in a chemical bond

$$\text{Temperature} = T = \frac{2}{3k_B} \underbrace{\frac{1}{N} \sum_{i=1}^N \frac{1}{2} m_i v_i^2}_{\text{average kinetic energy of the atoms}}$$

constant

heat: defined as energy transferred between two objects due to a temperature difference between them.

molecule - collection of atoms attached to each other by chemical bonds, electrically neutral.

chemical bond - attaches atoms together  
- atoms share their electrons, bond is thus electrical in nature

Look at some molecules formed by non-metals  
(most of organic chemistry and biochemistry)

hydrides = H + non-metal  
formulas are predictable from the periodic table

hydrocarbons - C and H these are organic compounds from petroleum, natural gas, ...  
- simplest is methane = CH<sub>4</sub>

In general, the simplest series is the alkanes, C<sub>n</sub>H<sub>2n+2</sub>

methane	CH <sub>4</sub>	} gases at room temperature and atmospheric pressure
ethane	C <sub>2</sub> H <sub>6</sub>	
propane	C <sub>3</sub> H <sub>8</sub>	
butane	C <sub>4</sub> H <sub>10</sub>	
pentane	C <sub>5</sub> H <sub>12</sub>	} liquids "
hexane	C <sub>6</sub> H <sub>14</sub>	

Chem 1311 | alcohols - replacing H with OH gives an alcohol (16)

$\text{CH}_4$  to  $\text{CH}_3\text{OH}$  methanol

$\text{C}_2\text{H}_6$  to  $\text{C}_2\text{H}_5\text{OH}$  ethanol

Nomenclature → inorganic

Chemists need a systematic method for assigning names to compounds because there are so many compounds known and new compounds are made all the time.

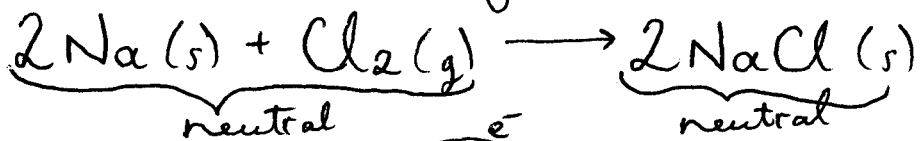
Binary compounds of 2 non-metals

- use # of atoms of each element as a prefix (Greek, mono usually omitted)

exception  $\text{H}_n$ -nonmetal :  
name doesn't indicate the # of H's (n) because it's clear  
(see pg. 51 of text)

Common names - a few compounds have common (non-systematic) names used by chemists

Ionic compounds → metal reacted with nonmetal  
→ formed by a transfer of electrons  $e^-$



But really  $\text{Na} + \text{Cl} \longrightarrow \text{Na}^+ + \text{Cl}^-$  and then these charged particles (called ions) pack together into a crystal structure to maximize the electrostatic forces.

In the  $\text{NaCl}(s)$  crystal structure, each ion is surrounded by six of the other kind

$\text{NaCl}(s)$  does not consist of molecules which can be identified. Rather, many ions pack together.

By writing  $\text{NaCl}(s)$  we are simply indicating that the ratio of Na and Cl is 1:1. We use the smallest ratio, so we do not write  $\text{Na}_2\text{Cl}_2$ .

We call  $\text{NaCl}$  a "formula unit"

cation  $\rightarrow$  +ve ion (metal)

anion  $\rightarrow$  -ve ion (non-metal)

Table 2.3 elements in the same group tend to gain or lose the same # of  $e^-$ ; namely the # required to reach a noble gas.

### Rules for Nomenclature

1. cation written first
2. formula unit is electrically neutral
3. use smallest integer ratio

Chem 13111 Transition metals can form more than one ion (18)

ex Iron  $\text{Fe}^{2+}$  or  $\text{Fe}^{3+}$

ex Copper  $\text{Cu}^+$  or  $\text{Cu}^{2+}$

Stock system - use a roman numeral in brackets to indicate the charge, after the English name

### Rules

- use English name of metal, with a roman numeral only if the metal can form multiple ions.
- if the anion is composed of a single element, use "-ide" ending

name does not include the # of atoms involved because you can figure it out from the periodic table.

- if the anion is polyatomic (composed of > 1 element) or the cation is  $\text{NH}_4^+$  use the name from Table 2.5

Transition metals can form more than one ion.

ex Iron  $\text{Fe}^{2+}$  or  $\text{Fe}^{3+}$

ex Copper  $\text{Cu}^+$  or  $\text{Cu}^{2+}$

Stock system - use roman numeral

$\text{Fe}^{2+}$  iron (II)

$\text{Fe}^{3+}$  iron (III)

Old (Latin) system

-ous for lower charge

-ic for higher charge

$\text{Fe}^{2+}$  ferrous

$\text{Fe}^{3+}$  ferric

$\text{Cu}^+$  cuprous

$\text{Cu}^{2+}$  cupric

Must memorize  
the box on page 66.  
(+ the tables in ch. 2)

## Properties of Ionic Solids

- hard and brittle crystalline structure that does not deform (falls apart instead)
- electrostatic interactions result in high melting points

Al (s) aluminum metal melting point  $660^{\circ}\text{C}$

Al<sub>2</sub>O<sub>3</sub> aluminum oxide melting point  $2050^{\circ}\text{C}$

- not conductive (no mobile charge carriers)

But conductive when melted or dissolved in water  
(charge carriers can move)

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## Chapter 3 : Measurement

### UNITS

measurements in science (ex temperature) usually involve units (but not always: pH)

Science uses the SI system of units. A partial list: (Table 3.1)

Measurement	Base unit	Symbol
length		
mass		
time		
temperature		