

## Session 2: LECTURE OUTLINE (SECTIONS C & D)

- I. Compounds
  - a. Binary
  - b. Organic
  - c. Inorganic
  - d. Molecular
  - e. Ionic
    - i. Cation
    - ii. Anion
- II. Chemical Formulas
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    - vi. Tube structure
    - vii. Density surface
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- III. Nomenclature
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  - e. Common organic compounds
- IV. Note about oxidation numbers

Suggested Problems: pp F29-F30 C.1, C.3, C.9, C.11, C.13  
pp F36-F37 D.1, D.3, D.5, D.7, D.9, D.11, D.13, D.15

## Compounds

- are electrically neutral pure substances that consist of two or more different elements chemically combined with their atoms present in a definite ratio.
- are classified as organic or inorganic
  - organic compounds contain C and usually H
  - inorganic compounds are everything else
  - atoms can either bond together to form molecules or can be present in compounds as ions
    - molecular compounds contain molecules which are a discrete group of atoms bonded together in a specific arrangement
      - typically are formed from all nonmetals
      - molecular formula represents the number and type of element in the discrete unit
    - ionic compounds contain ions
      - a cation is a positively charged ion
      - an anion is a negatively charged ion
      - typically formed from a metal and a nonmetal
      - chemical formula is referred to as the formula unit, because it represents the smallest whole number ratio of cation to anion in the crystal, which is an array of anions and cations held together by electrostatic interaction
      - *not discrete*

## Molecular formula

- chemical formula that shows how many atoms of each type of element are present in a single molecule of the compound, eg water has the molecular formula H<sub>2</sub>O. The subscript 2 following the H, indicates that each molecule of water contains 2 atoms of H, no subscript after the O, indicates that each molecule of water contains 1 atom of O.

- some elements exist in nature as diatomic (2 atom) molecules. You should memorize the following elements that exist as diatomic molecules:  $H_2$ ,  $O_2$ ,  $N_2$ ,  $F_2$ ,  $Cl_2$ ,  $Br_2$ ,  $I_2$ .

### Structural formula

- indicates how the atoms are linked together in the molecule
- in the structural formula lines linking elemental symbols are indicating chemical bonds (link between two atoms)
  - o one line indicates a single bond
  - o two lines indicate a double bond
  - o three lines indicate a triple bond
- there are many different ways to represent a structural formula ranging from lines and symbols, to ball and stick, to space filling and electrostatic potential, study these different images on pp F25 and F26. We will be looking at these structural formulas in more detail in chapters 2 and 3 when we discuss chemical bonding.

### Ionic Compounds

- ionic compounds are combinations of anions and cations held together by a strong electrostatic attraction
- monoatomic cation is formed when a neutral atom loses an electron, if one electron is lost the cation carries a charge of +1, as in the case of the sodium cation,  $Na^+$ , if two electrons are lost from a neutral atom, the cation carries a charge of 2+, as in the case of the calcium ion,  $Ca^{2+}$ 
  - o periodic table can help us predict the charge on monoatomic cations, we will explore why in detail in chapters 1 and 2, but for now notice the correlations in figure C.5 on p F27
  - o *metallic elements typically form cations*
- monoatomic anion is formed when a neutral atom gains an electron, if one electron is gained, the anion carries a charge of  $1^-$ , such as the chloride anion,  $Cl^-$ , if two electrons are gained the anion carries a charge of  $2^-$ , such as the oxide anion,  $O^{2-}$ .

- periodic table can help us predict the charge on monoatomic anions, we will explore why in more detail in chapters 1 and 2, but for now notice the correlations in figure C.6 on p F27
  - *nonmetallic elements typically form anions when in combination with metals*
- based on the charge of the cation and the anion we can predict the chemical formula because the ions will combine electrostatically to form neutral crystals
    - eg  $\text{Na}^+$  and  $\text{Cl}^-$  each ion has a charge of 1, so they combine in a 1 to 1 ratio to form NaCl
    - eg  $\text{Ca}^{2+}$  and  $\text{Cl}^-$  each ion has a different charge, so to form a neutral compound the ions must combine in a 1 to 2 ratio to form the compound  $\text{CaCl}_2$
  - diatomic or polyatomic ions consist of 2 or 3 or more elements bonded together that carry a charge
    - one must memorize the name and the charge of the polyatomic ions to predict the ionic formula

## Nomenclature

- naming binary ionic compounds consist of two elements  
metal cation + nonmetal anion + “ide”

KBr	potassium bromide
$\text{CaCl}_2$	calcium chloride
$\text{Ba}_3\text{N}_2$	barium nitride

*Transition metals that can have more than one oxidation state have a Roman numeral added to indicate charge on cation*

$\text{Cu}_2\text{O}$	copper (I) oxide
$\text{CuF}_2$	copper (II) fluoride

- ionic compounds containing polyatomic ions are named similarly

$\text{NaNO}_3$	sodium nitrate
$\text{Fe}(\text{OH})_3$	iron (III) hydroxide
$\text{NH}_4\text{CN}$	ammonium cyanide

*Tool box D.1 on p F32 outlines clearly how to name ionic compounds; practice example D.1 is a good example to try*

- naming binary molecular inorganic compounds  
two nonmetals bound together  
prefixes used to indicate # of element in the compound

Number	Prefix
2	di
3	tri
4	tetra
5	penta
6	hexa
7	hepta
8	octa
9	nona
10	deca

(if element begins with "O", omit final a from prefix, for example : heptoxide )

$\text{SO}_2$	sulfur dioxide
$\text{SO}_3$	sulfur trioxide
$\text{As}_4\text{O}_6$	tetraarsenic hexoxide

*Tool box D.2 on p F34 outlines clearly how to name inorganic molecular compounds; practice example D.2 is a good example to try*

Organic nomenclature is quite involved, and you will learn in detail how to name organic molecules in organic chemistry. For now you should at least be familiar with the following introductory material concerning naming organic molecules. You should also be aware that the rules for naming organic molecules are different from those of naming simple binary inorganic molecules such as  $\text{CO}_2$  (carbon dioxide) while the simple hydrocarbon,  $\text{C}_2\text{H}_2$ , is not called dicarbon dihydride, but rather ethyne.

- naming common organic molecular compounds
  - compounds containing hydrogen and carbon are referred to in general as hydrocarbons
    - hydrocarbons with no multiple bonds are called alkanes
    - hydrocarbons with double bonds are called alkenes
    - hydrocarbons with triple bonds are called alkynes
- hydrocarbons are the basic frame work of all organic compounds, and the names of organic molecules are based on the frame work which is based on the number of carbon atoms in the “frame”
  - table D.4 lists the name of the alkane corresponding to the number of carbons in the “frame”, you should look over this table and be familiar with the more common alkanes: methane, ethane, propane, butane and pentane
  - there are different classes of organic chemicals based on what “functional group” has replaced a H on the C “frame”
    - alcohol group is the  $-\text{OH}$
    - carboxylic acid group –  $\text{COOH}$
    - haloalkane – contains halogen: F, Cl, Br, or I

**Note: Oxidation numbers** are mentioned in Chapter 2 on p67.

To understand chemical compounds and how to predict the formulas and structures of compounds you should be familiar with the term **oxidation number**. This concept will be reviewed in detail in session 11 when oxidation/reduction chemical reactions are covered. For now, you should at least be aware of the term and know that in an ionic compound the charge on the atomic ions are also referred to as the oxidation number on the ion. For example, a sodium ion has a charge of  $1^+$  or you could say an oxidation number of  $+1$ . In a molecular compound the oxidation number doesn't literally have the same physical significance as in ionic compounds, but assigning oxidation numbers is useful in predicting molecular formula and indicating a transfer of electrons across a chemical change. For a polyatomic ion, which is a molecular compound that carries a charge, the sum of the assigned oxidation numbers equals the charge on the polyatomic ion. There are a detailed set of rules for assigning oxidation numbers on p F75 in Tool box K.1. These rules will be reviewed in detail in Session 11.