MODULE B

Basic Chemistry

Lesson #3 – Part 2

Nomenclature &

Oxidation-Reduction Reactions

Objectives

- *At the end of this module, the student will*
  - *Define terms associated with the naming of organic compounds and oxidation-reduction reactions.*
  - *Describe the steps for naming inorganic compounds, (ionic compounds, covalent compounds, and compounds with polyatomic ions).*
  - *Define the components of a chemical reaction.*
  - *Give an example of an oxidation-reduction reaction in Respiratory Therapy.*
  - *Explain how the different chemical reactions take place.*

Web Sites

- http://www.geocities.com/Athens/Thebes/5118/ic/names1.htm
- http://en.wikipedia.org/wiki/Systematic_name

Nomenclature

- Definition: A system of words used to name things in a particular discipline.
- The name of a compound has to include enough information to tell chemists the composition and structure of the compound.
- There are over 18 million compounds.

Nomenclature

Ions

- Simple ions
- Polyatomic ions

Inorganic Compounds

- Ionic compounds
- Molecular compounds

Simple Ions

- **Metal Cations with only one form** (representative)
  - Identify the metal
  - Add "ion"
    - K^+ = Potassium ion
- **Metal Cations with more than one form** (transition)
  - Identify the metal
  - Give the charge on the ion a roman numeral in parentheses
  - Add "ion"
    - Cr^{+2} = Chromium (II) ion

+

Simple ions

- Anions (representative)
  - Replace the ending of the element with "ide"
  - Add "ion"
    - Cl- = Chloride ion

Practice

- Na+
- Al $^{3+}$ (representative)
- Cr $^{3+}$ (transition)
- Br-

Polyatomic Ions

- Ions with more than one atom
  - CO_3^{-2}
- Most contain oxygen
  - HCO_3^-
- Most are anions
  - OH^-
- Memorize names & formulas
  - No easy way.

Names of polyatomic ions

- NO_2^- nitrite ion
- NO_3^- nitrate ion
- NH_4^+ ammonium ion
- PO_4^{-3} phosphate ion
- HPO_4^{-2} hydrogen phosphate ion
- H_2PO^{-4} dihydrogen phosphate ion
- CO_3^{-2} carbonate ion
- HCO_3^- bicarbonate ion (hydrogen carbonate)

Names of polyatomic ions

- SO_3^{-2} sulfite ion
- SO_4^{-2} sulfate ion
- HSO_4^- bisulfate ion (hydrogen sulfate)
- OH^- hydroxide ion
- $CH_3CO_2^-$ acetate ion
- $Cr_2O_7^{-2}$ dichromate ion
- CN- cyanide ion
- OCl^- hypochlorite ion
- MnO_4^- permanganate ion

Polyatomic Ions in compounds

- One element or ion + a polyatomic ion
- Steps:
  - Use the name of the ion
  - Add the name of the polyatomic ion
- Example: $MgSO_4$ (magnesium sulfate)
  - Magnesium + sulfate

***Note**: SO_4 **is not** sulfur tetroxide*

Naming compounds

- **Rule**: The more positive portion of the compound is named first.
  - Metal
  - Positive polyatomic ion
  - Hydrogen
  - Least negative non-metal (farthest left)
- **Rule**: The more negative portion is named and written last.

Practice

- $NaNO_3$
- $NaHCO_3$
- $Ca(NO_3)_2$
- $Mg(OH)_2$
- NaOH

Ionic compounds

- One metal + one non-metal bonding
- Steps:
  - Name the positive (cation) ion
  - Name the stem of the negative (anion) ion
  - Add ide
- Example: NaCl = Na+ and Cl-
  - Sodium + Chlor + ide (Sodium chloride)

Stems

- ox oxygen
- chlor chlorine
- brom bromine
- iod iodine
- nitr nitrogen

Practice

- CaBr
- KCl
- HCl
- CaO

Molecular compounds

- One non-metal and one non-metal
- Steps:
  - Use the prefix of the first element
  - Add element name
  - Use the prefix of the second element
  - Use the stem of the second element
  - Add ide
- Example: P_2O_3 Diphosphate trioxide
  - di + phosphate + tri + ox + ide

Prefixes

- Mono one
- Di two
- Tri three
- Tetra four
- Penta five
- Hexa six
- Hepta seven
- Octa eight

Covalent compounds

- Rules:
  - Mono means one and is only used before the second element. If no prefix appears before the first element, assume one.
  - If two vowels appear together, drop the vowel from the prefix
- Example: CO (carbon monoxide)
  - ___?__ carbon + mon**o** + ox + ide

Practice

- N_2O
- CO_2
- H_2O

Chemical Reactions

Objectives

- *At the end of this module, the student will*
  - *Define the components of a chemical reaction.*
  - *Give an example of an oxidation-reduction reaction in Respiratory Therapy.*
  - *Explain how the different chemical reactions take place.*

Chemical reactions

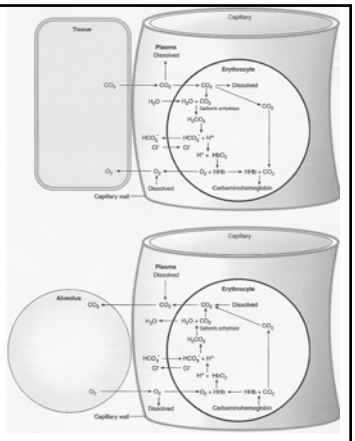
- Example of a reaction:

$$CO_2 + H_2O \underset{C.A.}{\rightleftharpoons} H_2CO_3 \rightleftharpoons HCO_3^- + H^+$$

One small reaction in a long chain of reactions.

Reactions taking place at cells

Reactions taking place at lungs



More about chemical reactions

- **Definitions**:
  - **Chemical reaction** – Two substances colliding with enough energy to overcome the repulsion of electrons. (electron movement)
  - **Chemical equation** – Shorthand method of describing a chemical change using symbols, arrows and formulas

More about chemical reactions

- **Definitions**:
  - **Activation energy** – Something that can increase molecular collisions and change the rate of the chemical reaction.
    - Heat
    - Increased concentrations of substances
    - Pressure
    - Catalyst
  - **Catalyst** – Substance that speeds a reaction without being chemically changed in the process (carbonic anhydrase)

More about chemical reactions

- Definitions:
  - **Balance** – Atoms on one side of an arrow must equal the atoms on the other side of the arrow.
  - **Law of Conservation** – Matter cannot be created or destroyed – only changed.

More about chemical reactions

- **Definitions**:
  - **Reactants** – substances entering into a reaction.
  - **Products** – Substances formed by the reaction.
  - **Conditions** – circumstances that may need to be present for the reaction to take place

$$H_2CO_3 \longrightarrow HCO_3^- + H^+$$

$$H_2CO_3 \longleftarrow HCO_{3-} + H^+$$

Speed of chemical reactions

- **Speed of reactions**:
  - Slow
    - Decay
    - Rust
  - Moderate
    - Cement setting
  - Fast
    - Explosion of dynamite
    - Coals burning

Types of chemical reactions

- **Types of reactions**:

A. Synthesis (Combination)
   - A + B ⟶ AB

B. Decomposition (Breakdown)
   - AB ⟶ A + B

C. Exchange (Replace)
   - AB + CD ⟶ AD + CB

Synthesis Reaction

- Combination of 2 or more substances (reactants) to form different, more complex substances (products).
- Substances formed are usually compounds or or polyatomic ions.
- Bonds are formed in these reactions.
- Energy is required for this reaction to occur.

Synthesis example

- Reactions involving oxygen are often called combustion reactions.

$$C + O_2 \xrightarrow{\text{“heat”}} CO_2$$

Synthesis reaction

- Oxidation-Reduction Reaction
  - Batteries
  - Oxygen analyzers
  - Blood gas electrodes

Oxidation-Reduction reaction

- Oxidation – Loss of electrons during a chemical reaction.
- Reduction – Gain of electrons during a chemical reaction.
- Memory-Aid Acronym: OIL RIG
  - OIL – Oxidation Is Loss
  - RIG – Reduction Is Gain

Agents in an Oxidation-Reduction Reaction

- **Oxidizing agent** – *Accepts* the electrons (anion) and is being reduced.
- **Reducing agent** – *Releases* the electrons (cation) and is being oxidized

http://library.kcc.hawaii.edu/external/chemistry/

Simple electrolyte cell

- **Components of these systems:**
  - **Cathode** (-) attracts cations (+), oxidation takes place and electrons are released
  - **Anode** (+) attracts anions (-), reduction takes place where electrons are accepted
    - Opposites attract
- Causes flow of electrons and electrical current

Decomposition Reaction

- One complex substance (a compound) undergoes a reaction to form two or more new (simpler) substances (elements or compounds).
- During this reaction, chemical bonds are broken.
- This often releases heat energy.

Decomposition Example

Baking soda reaction:

$2NaHCO_3 \longrightarrow Na_2CO_3 + CO_2 + H_2O$

(solid) (solid) (gas) (liquid)

Decomposition Example

- Breakdown of complex nutrients in a cell to release energy for other cellular functions.
  - Carbohydrates
  - Proteins
  - Fats
  - Products of these reactions are essentially "waste products".

Energy

- It is common for the *energy released* during a decomposition reaction to be used *to drive* a synthesis reaction.

Decomposition = release of energy

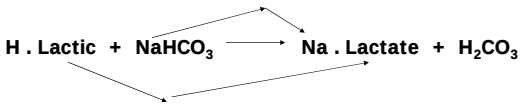
Synthesis = use of energy

Exchange Reaction

- Breakdown of substances (reactants) to form different substances (products).
- Bonds are both decomposed and synthesized in these reactions.
- Energy is required and released in this reaction.

Example

- Exchange reaction:



Single-replacement Exchange

- An element and a compound react where the first element replaces an element in the compound.

$Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu$

Double-replacement Exchange

- Two compounds exchange ions.

$AgNO_3 + HCl \longrightarrow HNO_3 + AgCl$

Neutralization

- An acid reacts with a base , generally producing a salt, water (or weak acid) and heat.

$HCl + NaOH \longrightarrow NaCl + H_2O$

(strong acid) (base) (salt) (water)

Clinical Example

- When glucose is converted to carbon dioxide and water by using oxygen in the following relationship:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

- If a person eats a candy bar containing 14.2 g of glucose, how many grams of water will be produced?
  - 14.2 grams of $C_6H_{12}O_6$ = ? grams of H_2O