MODULE B

Basic Chemistry

Lesson #3 – Part 1

Chemical Bonding

OBJECTIVES

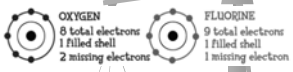
- *At the end of this module, the student will be able to...*
  - *Define terms associated with chemical bonding.*
  - *Explain what an electron dot structure or Lewis diagram is used for.*
  - *Define what a fixed weight ratio is.*
  - *Describe how a chemical reaction takes place.*
  - *Explain the "Rule of eights" and state the exception to the rule.*
  - *Explain the difference between a compound and a polyatomic ion.*
  - *Explain how molecular and ionic compounds are different.*
  - *Define covalent and ionic bonding.*
  - *Explain electronegativity.*
  - *Define electrolyte and explain their purpose and how they are measured.*

MAJOR TOPICS

1. Valence electrons
2. Introduction to chemical reactions
3. Compounds & bonding
4. Electrolytes

Valence Electrons

- Electron shells want to be full.
  - Some have too many electrons (oxygen, Fluorine)
    - They like to find someone who has electrons to spare.



  - Some have too few (Sodium, Magnesium)
    - They like to find someone who needs electrons.

Periodic Table and Valence Electrons

- The columns of the periodic table give a clue to how many electrons are available.
  - Column 1 (Group Ia) has one free electron.
  - Column 2 (Group IIa) has two free electrons.
  - Column 5 (Group Va) needs three electrons.
  - Column 6 (Group VIa) needs two electrons.
  - Column 7 (Group VIIa) needs one electron.
  - Column 8 (Group VIIIa), the noble gases, have eight electrons in their outer shell and are full.
  - The other columns are a bit trickier.

Lewis Diagram

- Electron Dot Structures or Lewis Diagrams
  - The Lewis diagram is a quick method of showing the number of valence electrons *(number in the outside shell)*

H.

Na.

:***C***:

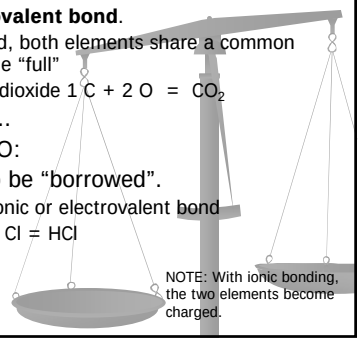
:***O***:

Valence Electrons and Bonds

- Electrons can be shared.
  - This is called a **covalent bond**.
  - In a covalent bond, both elements share a common electron to become "full"
  - Example: Carbon dioxide 1 C + 2 O = CO_2

    .. ..
    :O: :C: :O:
- Electrons can also be "borrowed".
  - This is called an ionic or electrovalent bond
  - Example: 1 H + 1 Cl = HCl

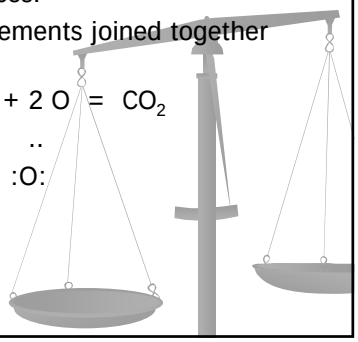
NOTE: With ionic bonding, the two elements become charged.



Molecule

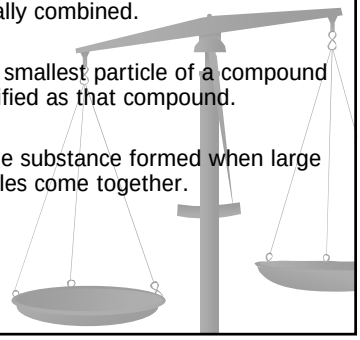
- A pure substances.
- Two or more elements joined together chemically.
- EXAMPLE: 1 C + 2 O = CO_2

  .. ..
  :O: :C: :O:



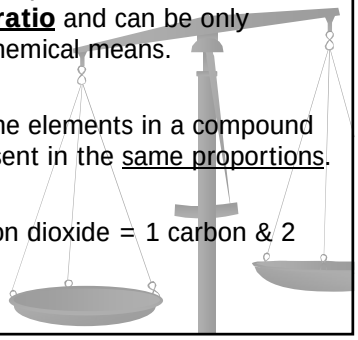
Compound

- A pure substances composed of 2 or more elements chemically combined.
- A *molecule* is the smallest particle of a compound that can be identified as that compound.
- A compound is the substance formed when large groups of molecules come together.



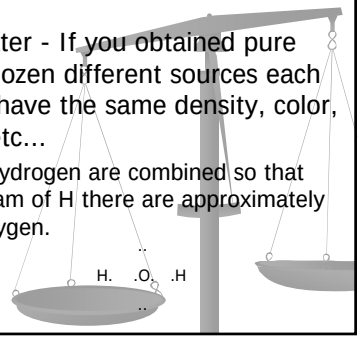
Compound

- The atoms in compounds will be found in a **fixed weight ratio** and can be only separated by chemical means.
- The atoms of the elements in a compound are always present in the same proportions.
- Example: Carbon dioxide = 1 carbon & 2 oxygen



Fixed weight ratio

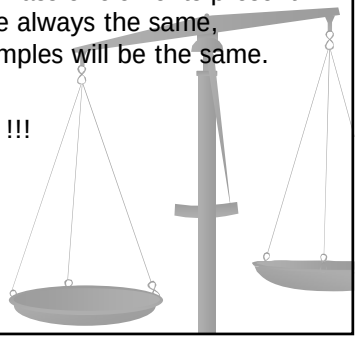
- EXAMPLE: Water - If you obtained pure water from a dozen different sources each sample would have the same density, color, boiling point, etc...
  - Oxygen and Hydrogen are combined so that for every 1 gram of H there are approximately 8 grams of oxygen.
  - Always H_2O



H. .O. .H

Law of Constant Composition

- The portion by mass of elements present in a compound are always the same, therefore all samples will be the same.
- Pure substance !!!

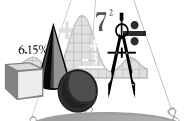


Compounds

- There are over 18 million known compounds to date.
- Small compound: CO (2 atoms)
- Large compound: DNA (billions of atoms)

Introduction to Chemical Reactions

- When valence electrons from one element are lost to, gained from or shared with another element it is a *chemical reaction*.



Stability

- When bonding occurs and the outside shells of all elements involved are filled, the substance is *stable*.
- When bonding occurs and the outside shells of all elements involved are not filled, the substance is a polyatomic ion and is *not stable yet*.
  - Elements are neutral (+ = -)
  - Compounds are stable (outside shells filled)
  - Polyatomic ions are neither stable or neutral

Review: Octet Rule

- The "Octet Rule" (Rule of Eights) states that in the formation of most molecules from atoms 1-20, atoms are attempting to obtain a **stable** configuration of eight valence electrons.
- This may mean they will not be **neutral** anymore (the electrons and protons may not be equal).
- EXCEPTION: Hydrogen and Helium want 2 electrons in their outer shell.

Results of a Chemical Reaction

- Two different things can be formed when elements enter into a chemical reaction
  - Compounds
  - Polyatomic ions

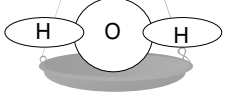
Results of a Chemical Reaction - Compound

- **Compound** - When the electrons move and the new substance is "*stable*" it is called a compound. (H_2O)

2 H **+** **1 O**

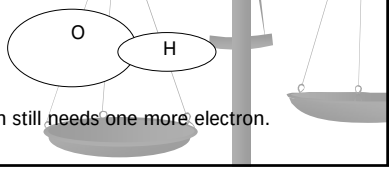
Each H shares 1electron from Oxygen

The 0xygen shares 1 electron from each H



Results of a Chemical Reaction – Polyatomic Ion

- **Polyatomic Ion** - If electrons movement occurs but the substance is not "stable" it is still an **ion**. (OH^-)
  - Ions still need to bond again to become "stable".



Oxygen still needs one more electron.

Compounds & Bonding

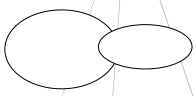
A. Molecular Compounds - **Sharing**
- Covalent bonding
  - Non-Polar
  - Polar

B. Ionic (Polyatomic) Compounds - **Exchanging**
- Ionic bonding

Molecular Compounds

- Covalent bonding – *non-metal + non-metal*
  - Non-Polar – sharing electrons equally (O_2)

  - Polar – not sharing equally



Covalence is the number of pairs that are shared.

Molecular Compounds

- Covalent bonds are particularly important in physiology.
- The major elements of the body (C, O, H & N) almost always bond by sharing electrons.

Covalent bonding

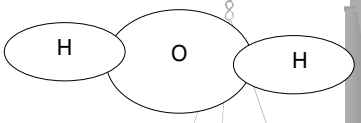
- Non-Polar – sharing electrons equally (O_2)
  - Equal electronegativity
  - Diatomic molecules (O_2, H_2, Cl_2, F_2, Br_2, I_2, N_2)

Electronegativity

- Strength of the pull of electrons
  - Elements on the <u>right side</u> of the chart have a greater pull on electrons then those on the left
    - *Closer to filling their outside shell by accepting electrons*
  - Elements at the <u>top</u> of the chart have a greater pull than elements at the bottom
    - *Bottom have more shells so valence electrons are farther from the nucleus at the bottom resulting in less impact from protons*

Covalent bonding

- Polar – not sharing equally
  - Small difference in electro negativity



- **Note**: When Hydrogen is involved, it can be also be known as a hydrogen bond.

Ionic Compounds

- **Ionic bonding** – *metal + non-metal*
  - **Cations**
    - Electron donors
    - End up with (+) charge
  - **Anions**
    - Electron acceptors
    - End up with (-) charge
- **Electrovalence** is the number of electrons lost or gained in a reaction.

Ionic Bonding

- An ionic bond usually forms
  - Acids
  - Bases
  - Salts.

Salt - NaCl

- Na is a metal and an electron donor

Na atom + energy = cation (Na+) + electron (e-)

- Cl is a non-metal and an electron acceptor

Cl atom + electron (e-) = anion (Cl-) + energy

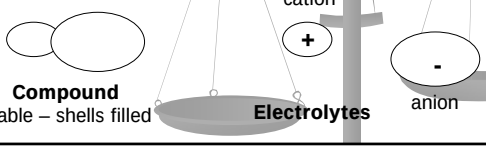
Energy is involved in chemical reactions (kcal are used or released).

Physical & chemical properties

Sodium (Na)	**Chlorine (Cl)**	**Salt – sodium chloride (NaCl)**
Soft silvery active metallic solid cut with a knife **poisonous**	greenish gas Strong & irritating odor **poisonous** reacts with water to give an explosive reaction	white crystalline solid **edible** dissolves in water (forming Na+ & Cl-)

Electrolytes

- Ionic compound *<u>in a liquid</u>*
  - Anions & cations constantly join & separate
    - Sometimes joined & stable
    - Sometimes separate with a (+) or (-) charge

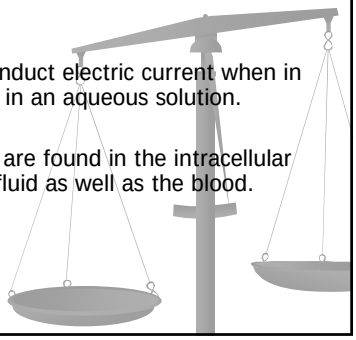


Compound
Stable – shells filled

Electrolytes

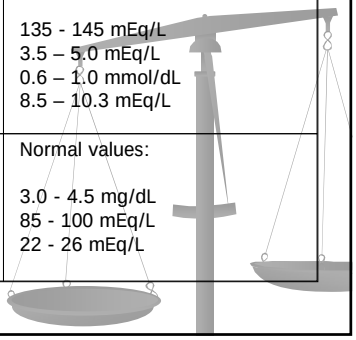
Electrolytes

- Cations and anions in solution are called <u>electrolytes</u>.
- These ions will conduct electric current when in the liquid state or in an aqueous solution.
- Many electrolytes are found in the intracellular and extracellular fluid as well as the blood.



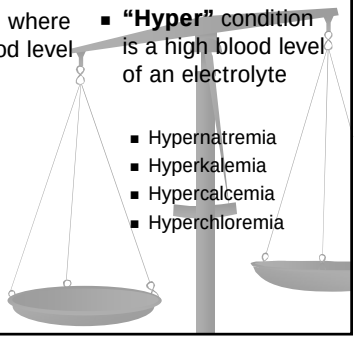
Electrolytes

Cations:	Normal values:
Na^+	135 - 145 mEq/L
K^+	3.5 – 5.0 mEq/L
Mg^{2+}	0.6 – 1.0 mmol/dL
Ca^{2+}	8.5 – 10.3 mEq/L
Anions:	Normal values:
P^{-3}	3.0 - 4.5 mg/dL
Cl^-	85 - 100 mEq/L
HCO_3^-	22 - 26 mEq/L



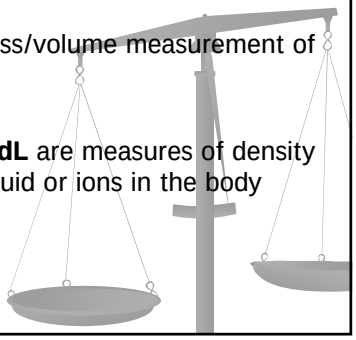
Electrolytes

- **"Hypo"** condition where there is a low blood level of an electrolyte
  - Hyponatremia
  - Hypokalemia
  - Hypocalcemia
  - Hypochloremia
- **"Hyper"** condition is a high blood level of an electrolyte
  - Hypernatremia
  - Hyperkalemia
  - Hypercalcemia
  - Hyperchloremia



Measuring electrolytes

- **<u>Density</u>** is a mass/volume measurement of matter**.**
- **mEq/L or mg/dL** are measures of density of a solid in a liquid or ions in the body fluids.



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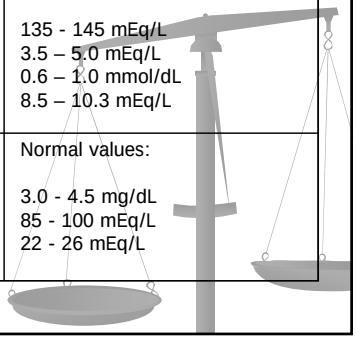
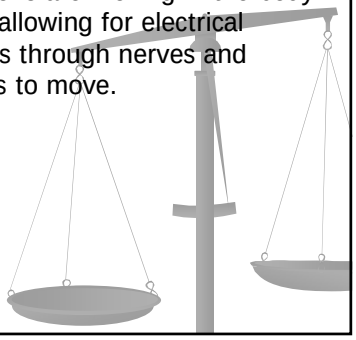


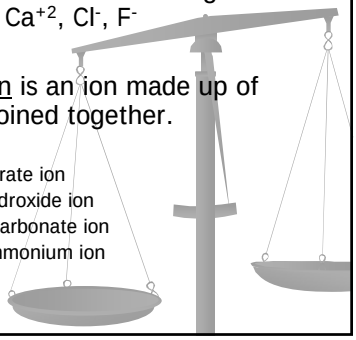
Electrolytes in the body

- Anions and cations are moving in the body fluids and cells allowing for electrical impulses to pass through nerves and causing muscles to move.



Ions

- A simple ion is formed from a single atom such as H^+, K^+, Ca^{+2}, Cl^-, F^-
- A polyatomic ion is an ion made up of several atoms joined together.
  - Examples:
    - NO_3^- Nitrate ion
    - OH^- Hydroxide ion
    - HCO_3^- Bicarbonate ion
    - NH_4^+ Ammonium ion



Examples of compounds

- H_2O – water
- CO_2 – Carbon dioxide
- HCl - hydrochloric acid
- NaOH - Sodium Hydroxide
- NH_4Cl - Ammonium Chloride
- $NaHCO_3$ - Sodium Bicarbonate
- H_2CO_3 - Carbonic Acid
- NaCl - Sodium Chloride
- $C_6H_{12}O_6$ - Glucose
- H_2SO_4 - Sulfuric Acid

ASSIGNMENTS

- Read: Chemistry Book to assist in completing the objectives.
- Do Self-Assessment