10-1. Chemical Change

The medieval search for a way to change ordinary metals into gold is called **alchemy**. A **chemical reaction** results in the formation of a new substance whose properties are different from those of the individual substances that participate in the reaction.

10-2. Two Classes of Matter

Two classes of matter are **Pure Substances**, and **mixtures**.

**Chemical Process**
- burning
- fermentation
- rusting

**Physical Property**
- combustible
- reactive
- Edible

**Chemical Process**
- filtering
- distillation
- reverse osmosis

**Physical Property**
- hardness
- color
- texture

In a compound, the elements are present in a specific ratio by mass according to the **law of definite proportions**. In a mixture, the components are not present in a specific ratio by mass.
10-3. Atomic Theory

The English schoolteacher John Dalton (1766-1844) proposed an atomic theory, an old idea from Democritus. Some atoms form molecules. Not all compounds are molecules.

10-4. Metals and Nonmetals

Metals
- All metals, except mercury, are **solid** at room temperature.
- Metals have a characteristic metallic luster.
- All metals are opaque.
- Metals can be **shaped** by bending or hammering.
- Metals are good **conductors** of heat and electricity.
- **Most** elements are metals.

Nonmetals
- Nonmetals may be **solid**, **liquid**, or **gaseous**.
- Nonmetals **do not** have a luster.
- Most nonmetals are **transparent** in thin sheets.
- Solid nonmetals are **brittle**.
- Nonmetals are **insulators**.

10-5. Chemical Activity

- **Active** elements combine readily to form compounds.
- **Inactive** elements have little tendency to react chemically.
- Active elements liberate more heat when they react than do inactive elements.
- Active elements usually form stable compounds.

10-6. Families of Elements

- The **halogens**, or “salt formers,” are active nonmetals. They are in group 7.
- The **alkali metals** are active metals and have low melting points. They are in group 1.
- The **alkaline earth metals** are less active than the alkali metals. They are in group 2.
- The **inert gases** are inactive nonmetals. They are in group 8.

10-7. The Periodic Table

The Russian chemist Dmitri Mendeleev formulated the **periodic law** about 1869 which states that when elements are listed in order of atomic number, elements with similar chemical and physical properties appear at regular intervals. The **periodic table** is a listing of the elements according to atomic number in a series of rows such that elements with similar properties form vertical columns.

http://www.webelements.com/
10-8. Groups and Periods

The periodic table arranges chemical families of elements in vertical columns called groups. The horizontal rows of elements of the periodic table are called periods. The transition elements are placed between groups 2 and 3 and include: the rare-earth metals (atomic numbers 57-71), the actinides (atomic numbers 89-105).

10-11 Types of Bonds

- **Covalent Bonds** (share electrons)
- **Ionic Bonds** (transfer electrons)
  - Held together by electrostatic attractions (+ and – ions attract)
- **Metallic Bonds** (sea of electrons)

10-9. Shells and Subshells

The electrons in an atom that have the same principal quantum number n occupy the same shell. The electrons in an atom that have the same orbital quantum number l occupy the same subshell. The larger the value of l, the more electrons the subshell can hold. A shell or subshell that contains its full quota of electrons is said to be closed.

10-10. Explaining the Periodic Table

The Grand Secret of Chemistry—All atoms want to become like the noble gases with filled shells or electronic orbitals. They do this by gaining or losing electrons to become ions.

10-12. The Covalent Bond

Covalent compounds are substances whose atoms are joined by one or more pairs of electrons in a covalent bond.

Polar covalent compounds are those in which the shared electron pairs are closer to one atom than to the other, making one part of the molecule relatively negative and another part relatively positive.

\[
\text{H}^5+ + \text{Cl}^5- \rightarrow \text{O}^5- + \text{H}^5+ + \text{H}^5+
\]
10-13. Ionic Bond

An ionic bond is formed when electrons are transferred between two or more atoms and the resulting ions of opposite charge attract each other.

10-14. Ionic Compounds

When a metal atom combines with a nonmetal atom to form an ionic compound, the chemical formula of the ionic compound formed can be determined by knowing how many electrons the metal atom loses and how many electrons the nonmetal atom gains.

10-15. Atom Groups

Atom groups appear as units in many compounds and remain together during chemical reactions. The sulfate group SO₄²⁻ is an example of an atom group. A precipitate is an insoluble solid that results from a chemical reaction in solution. When two or more atom groups of the same kind are present in the formula of a compound, parentheses are placed around the group. Example: Ca(NO₃)₂.

10-16. Naming Compounds

A compound ending in -ide usually is composed of only two elements. Hydroxides which contain the OH⁻ ion are an exception. Sodium Chloride=NaCl

A compound ending in -ate contains oxygen and two or more other elements. Calcium Sulfate=CaSO₄

When the same pair of elements occurs in two or more compounds, a prefix (mono = 1, di = 2, tri = 3, tetra = 4, penta = 5, hexa = 6, and so on) may be used to indicate the number of one or both kinds of atoms in the molecule. Carbon Dioxide = CO₂

When one of the elements in a compound is a metal that can form different ions, the ionic charge of the metal is given by a roman numeral. Copper(II) Chloride= CuCl₂
10-17. Chemical Reactions

In a chemical equation the formulas of the reacting substances (reactants) appear on the left-hand side and the formulas of the products appear on the right-hand side.

\[
\text{CH}_4 + \text{O}_2 \rightarrow \text{H}_2\text{O} + \text{CO}_2
\]

Chemical equations must be balanced, meaning that the number of atoms of each kind of element must be the same on both sides of the equation. Unbalanced chemical equations have unequal numbers of at least one kind of atom on both sides of the equation. Is the reaction below balanced?

\[
\text{K}_2\text{CrO}_7 + \text{SO}_2 \rightarrow \text{K}_2\text{SO}_4 + \text{CrO}_2
\]
### Lecture Quiz 10

1. What type of element is Sulfur, metal or nonmetal? **Nonmetal**
2. What is the difference between a chemical process and a chemical property? **Process involves change and property describes something.**
3. What type of bond does KBr have? **Ionic**
4. What would be the name of CaCl$_2$? **Calcium Chloride**
5. What would be the formula for Calcium Carbonate? **CaCO$_3$**