Atomic Theory of Matter

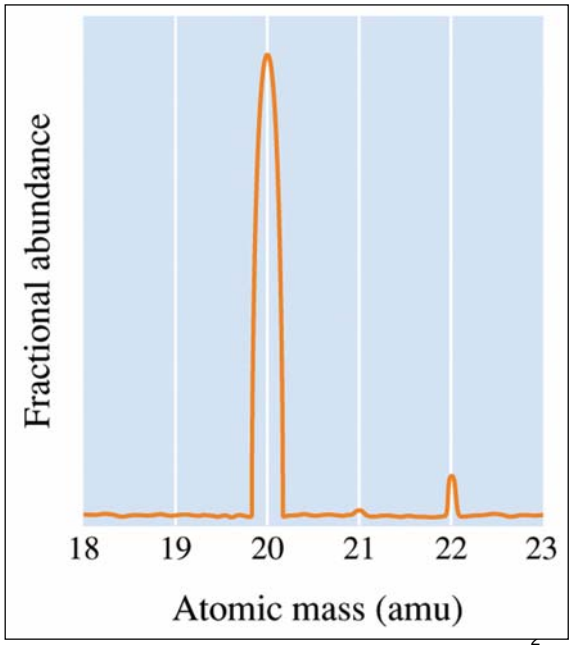
- Nuclear structure; Isotopes
  - **Isotopes** are atoms whose nuclei have the same atomic number but different mass numbers; that is, the nuclei have the same number of protons but different numbers of neutrons.
  - Chlorine, for example, exists as two isotopes: chlorine-35 and chlorine-37.

$^{35}_{17}Cl$ $^{37}_{17}Cl$

  - The **fractional abundance** is the fraction of a sample atoms that is composed of a particular isotope.

<-- Material up to
and
including this part will
be covered
in Midterm 1!
(Including calculations with natural abundance of
isotopes!

The Mass
Spectrum of Neon



Atomic Weights

- Dalton's Relative Atomic Masses
  - Since Dalton could not weigh individual atoms, he devised experiments to measure their masses relative to the hydrogen atom.

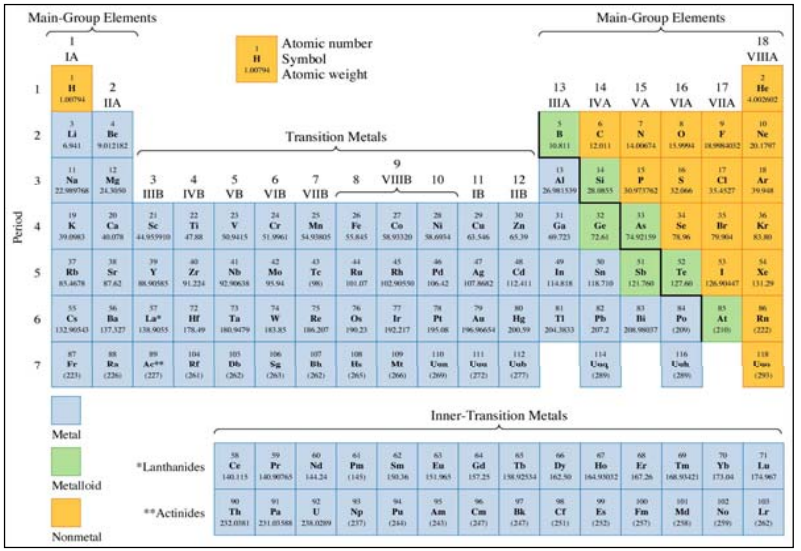
Atomic Weights

- Dalton's Relative Atomic Masses
  - Dalton's atomic weight scale was eventually replaced in 1961, by the present carbon–12 mass scale.
  - One **atomic mass unit (amu)** is, therefore, a mass unit equal to exactly 1/12 the mass of a carbon–12 atom.
  - On this modern scale, the **atomic weight** of an element is the average atomic mass for the naturally occurring element, expressed in atomic mass units.

The Periodic Table

- In 1869, Dmitri Mendeleev discovered that if the known elements were arranged in order of atomic number, they could be placed in horizontal rows such that the elements in the vertical columns had similar properties.
  - A tabular arrangement of elements in rows and columns, highlighting the regular repetition of properties of the elements, is called a **periodic table.**

A modern form of the periodic table.



The Periodic Table

- Periods and Groups
  - A **period** consists of the elements in one horizontal role of the periodic table.
  - A **group** consists of the elements in any one column of the periodic table.
  - The groups are usually numbered.
  - The eight “A” groups are called **main group** (or representative) elements.

The Periodic Table

- Periods and Groups
  - The “B” groups are called **transition elements.**
  - The two rows of elements at the bottom of the table are called **inner transition elements.**
  - Elements in any one group have similar properties.

The Periodic Table

- Periods and Groups
  - The elements in group IA, often known as the **alkali metals,** are soft metals that react easily with water.
  - The group VIIA elements, known as the **halogens,** are also reactive elements.

The Periodic Table

- Metals, Nonmetals, and Metalloids
  - A **metal** is a substance or mixture that has a characteristic luster and is generally a good conductor of heat and electricity.
  - A **nonmetal** is an element that does not exhibit the characteristics of the metal.
  - A **metalloid**, or semi-metal, is an element having both metallic and nonmetallic properties.

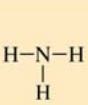
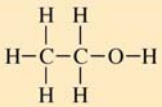
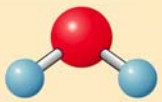
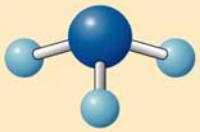
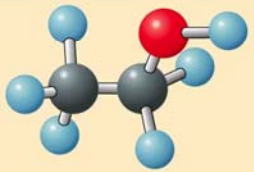
Chemical Formulas; Molecular and Ionic Substances

- The chemical formula of a substance is a notation using atomic symbols with subscripts to convey the relative proportions of atoms of the different elements in a substance.

Chemical Formulas; Molecular and Ionic Substances

- Molecular substances
  - A **molecule** is a definite group of atoms that are chemically bonded together – that is, tightly connected by attractive forces.
  - A **molecular substance** is a substance that is composed of molecules, all of which are alike.
  - A **molecular formula** gives the exact number of atoms of elements in a molecule.
  - **Structural formulas** show how the atoms are bonded to one another in a molecule.

Molecular and structural formulas and molecular models.

	Water	Ammonia	Ethanol
Molecular formula	H_2O	NH_3	C_2H_6O
Structural formula	H–O–H		
Molecular model (ball-and-stick type)			
Molecular model (space-filling type)			

Chemical Formulas; Molecular and Ionic Substances

- Ionic substances
  - Although many substances are molecular, others are composed of ions.
  - An **ion** is an electrically charged particle obtained from an atom or chemically bonded group of atoms by adding or removing electrons.
  - Sodium chloride is a substance made up of ions. (See Figure 2.21)

Chemical Formulas; Molecular and Ionic Substances

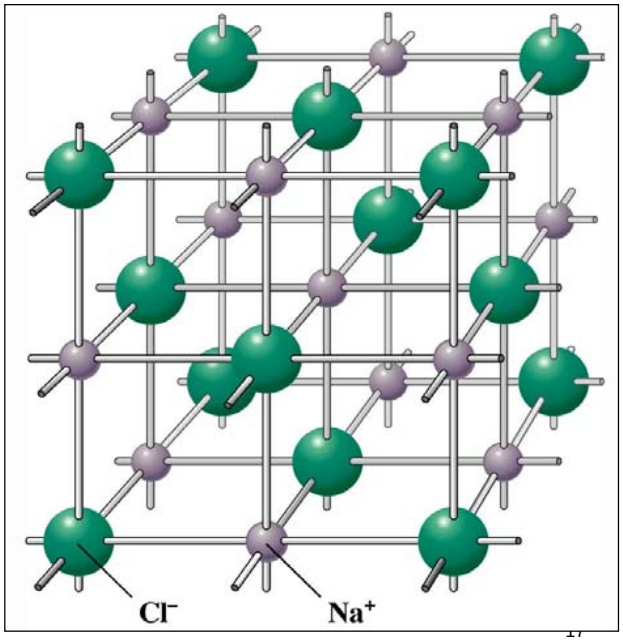
- Ionic substances
  - When an atom picks up extra electrons, it becomes a negatively charged ion, called an **anion**.
  - An atom that loses electrons becomes a positively charged ion, called a **cation**.
  - An **ionic compound** is a compound composed of cations and anions.

Chemical Formulas; Molecular and Ionic Substances

- Ionic substances
  - The **formula** of an ionic compound is written by giving the smallest possible whole-number ratio of different ions in the substance.
  - The **formula unit** of the substance is the group of atoms or ions explicitly symbolized by its formula.

A model of a portion of NaCl

crystal.



Chemical Substances; Formulas and Names

- Naming simple compounds
  - Chemical compounds are classified as **organic** or **inorganic.**
  - **Organic compounds** are compounds that contain carbon combined with other elements, such as hydrogen, oxygen, and nitrogen.
  - **Inorganic compounds** are compounds composed of elements other than carbon.

Chemical Formulas; Molecular and Ionic Substances

- Organic compounds
  - An important class of molecular substances that contain carbon is the **organic compounds**.
  - Organic compounds make up the majority of all known compounds.
  - The simplest organic compounds are hydrocarbons, or compounds containing only hydrogen and carbon.
  - Common examples include methane, CH_4, ethane, C_2H_6, and propane, C_3H_8.

Chemical Substances; Formulas and Names

- Ionic compounds
  - Most ionic compounds ***contain metal and nonmetal atoms***; for example, NaCl.
  - You **name an ionic compound** by giving the name of the cation followed by the name of the anion.
  - A **monatomic ion** is an ion formed from a single atom.
  - Table 2.4 lists some common monatomic ions of the main group elements.

Chemical Substances; Formulas and Names

- Rules for predicting charges on monatomic ions
  - Most of the main group metals form cations with the charge equal to their group number.
  - The charge on a monatomic anion for a nonmetal equals the group number minus 8.
  - Most transition elements form more than one ion, each with a different charge.

Chemical Substances; Formulas and Names

- Rules for naming monatomic ions
  - Monatomic cations are named after the element. For example, Al^{3+} is called the aluminum ion.
  - If there is more than one cation of an element, a Roman numeral in parentheses denoting the charge on the ion is used. This often occurs with transition elements.
  - The names of the monatomic anions use the stem name of the element followed by the suffix **– ide**. For example, Br^- is called the bromide ion.

Chemical Substances; Formulas and Names

- Binary molecular compounds
  - A **binary compound** is a compound composed of only two elements.
  - Binary compounds composed of a metal and a non-metal are usually ionic and are named as ionic compounds.
  - Binary compounds composed of two nonmetals are usually ***molecular*** and are named using a **prefix system**.

Chemical Substances; Formulas and Names

- Binary molecular compounds
  - The name of the compound has the elements in the order given in the formula.
  - You name the first element using the exact element name.
  - Name the second element by writing the stem name of the element with the suffix "–ide."
  - If there is more than one atom of any given element, you add a prefix. Table 2.7 lists the Greek prefixes used.