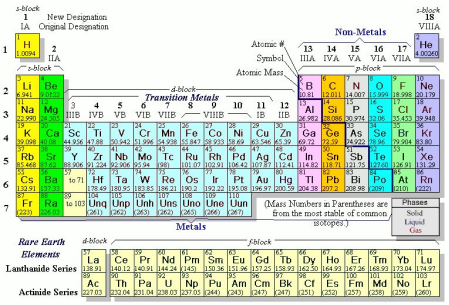
Periodic Table

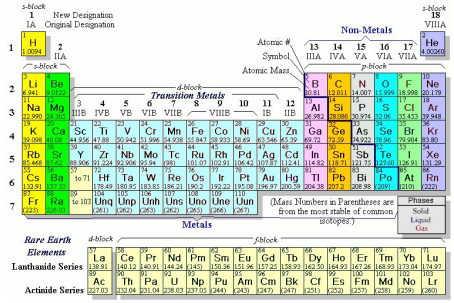


Periodic Table

- Many more chemical reactions exist than anyone can imagine. Certain patterns of chemical reactivity have been recognized for > 100 years. Each chemical element shows a pattern of chemical reactivity and are the basis for the periodic table.

Periodic Table

- One way to list the elements would be in a long horizontal line broken into seven rows. Each row is placed below the previous row so that elements with similar chemical properties appear in the same **column** (group) of the table. As we move across a **row** (period) of the periodic table (PT), the elements generally increase in mass and change dramatically in their chemical properties.



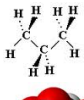
Periodic Table

- In 1869, Dmitri Mendeleev and Julius Meyer independently discovered how to arrange the chemical elements in a table so that elements with similar chemical properties were in the same columns.
- Based primarily on chemical reactivity patterns and elemental masses.
- Today's PT retains this form but we can explain the arrangement of elements in the PT in terms of atomic structure.

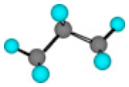
Molecular Formulas

- Answers to the question "What is it?" may take the form of pictures or drawings as chemists use chemical formulas, chemical names and various types of molecular pictures to describe molecules.

Structural formula



Space-filling model



Ball-and-stick model

Line structure

Chemical Formulas

- A chemical compound is a combination of atoms of different elements. Because a compound contains more than one element, there is more than one way to write its formula.

HCl

- To avoid confusion, chemists have adopted a standard order for writing chemical formulas. For binary compounds-those containing only two elements-the following rules apply:

Chemical Formulas

- Except for H, the element farther to the left in the PT appear first: KCl, PCl_3, Al_2S_3 and Fe_3O_4.
- If H is present, it appears last except when the other element is from column 16/17: LiH, NH_3, B_2H_6 and CH_4 but H_2O_2, H_2S, HCl and HI.
- If both elements are from the same column of the PT, the lower one appears first: SiC and BrF_3.

Chemical Formulas

- The formulas of C-containing compounds start with C followed by H. After that, any other elements appear in alphabetical order: C_2H_6O, C_4H_9BrO, CH_3Cl and $C_8H_{10}N_4O_2$.

Structural Formulas

- Gives the # of atoms and how the atoms are connected to one another. The atoms in molecules have specific arrangements because they are held together by attractive forces called bonds. A bond is the result of coulombic attraction between positively charged nuclei and negatively charged electrons. We will discuss this later in the course. For now, it is sufficient to know that a pair of electrons shared between two atoms generates a chemical bond.

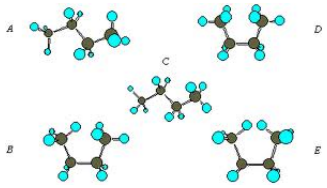
Structural Formulas

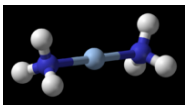
- In a structural formula, the bonds between atoms are represented by lines connecting the elemental symbols.
- Examples

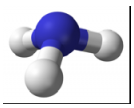
Three-Dimensional Models

- A molecule is a 3D array of atoms. Many of a molecule's most important properties, such as odor and chemical reactivity, depend on its 3D shape. In **ball-and-stick models**, balls represent atoms, and sticks represent chemical bonds. The balls are labeled with elemental symbols or different colors (each atom is a different color).

Three-Dimensional Models







Line Structures

- Describing and understanding C chemistry requires the ability to visualize 3D molecular structure but writing complete structural formulas becomes very tedious for all but the simplest molecules. Hence, **line structures**, have been developed. Rules:
- 1. All bonds except C-H are shown as lines.
- 2. C-H bonds are not shown in the line structure.

Line Structures

- 3. Single bonds are shown as a single line; double bonds are shown as two lines; triple bonds are shown as three lines.
- 4. C atoms are not labeled.
- 5. All atoms except C and H are labeled with the elemental symbols.
- 6. H atoms are labeled when they are attached to any atoms other than C.

Line Structures

- Examples

Naming Chemical Compounds

- Guidelines for naming binary compounds are as follows:
- 1. The element that appears first retains its elemental name.
- 2. The second element bears a root derived from its elemental name and ends with the suffix –ide.

Naming Chemical Compounds

Element	Root
As	Arsen-
Br	Brom-
C	Carb-
Cl	Chlor-
F	Fluor-
H	Hydr-
I	Iod-
N	Nitr-
O	Ox-
P	Phosph-
S	Sulf-
Se	Selen-

Naming Chemical Compounds

- 3. When there is more than one atom of a given element in the formula, the name of the element usually contains a prefix that specifies the # of atoms present. If the numerical prefix ends with the letter o or a and the name of the element begins with a vowel, the last letter of the prefix is dropped. For example, use monoxide instead of monooxide and tetroxide instead of tetraoxide.

Naming Chemical Compounds

#	Prefix	Example	Name
1	Mon(o)-	CO	Carbon monoxide
2	Di-	SiO_2	Silicon dioxide
3	Tri-	NI_3	Nitrogen triiodide
4	Tetr(a)-	CCI_4	Carbon tetrachloride
5	Pent(a)-	PCI_5	Phosphorus pentachloride
6	Hex(a)-	SF_6	Sulfur hexafluoride
7	Hept(a)-	IF_7	Iodine heptafluoride

Ionic Compounds

- Some substances exist as collections of cations and anions arranged so that the + and – charges are balanced. Any stable sample of matter is electrically neutral. This principle helps determine how ionic compounds are organized.
- Many ionic compounds contain atomic ions. The elements classified as metals have a strong tendency to lose electrons and form atomic cations. Almost every compound whose formula contains a metallic element from group 1/2 is ionic.

Ionic Compounds

- The transition metals (TMs) often form ionic species but these elements also form numerous compounds by sharing electrons. Al, Sn and Pb also tend to form atomic cations.
- Examples

Li^+, Na^+, K^+, Cs^+

Mg^{2+}, Ca^{2+}, Ba^{2+}

Cu^+ or Cu^{2+}

Ag^+, Cd^{2+}, Zn^{2+}

Ionic Compounds

- Although many elements form stable atomic cations, only six form stable atomic anions.

Examples

F^-, Cl^-, Br^-, I^-, O^{2-} and S^{2-}

Ionic Compounds

- Molecular ions are also called **polyatomic ions** to distinguish them from neutral molecules and atomic ions.

Examples

H_3O^+	hyydronium ion
NH_4+	ammonium ion
OH^-	hydroxide
CN^-	cyanide

Ionic Compounds

- Most polyatomic anions, called oxyanions, contain a central atom surrounded by one or four oxygen atoms. Rules:
- 1. The name has a root taken from the central atom (carbonate, CO_3^{2-} and nitrite, NO_2^-).
- 2. When an element forms two different oxyanions, the one with fewer oxygen atoms ends in –ite and the other ends in –ate (SO_3^{2-}, sulfite and SO_4^{2-}, sulfate)

Ionic Compounds

- 3. Cl, Br and I each form four different oxyanions that are distinguished by prefixes and suffixes. BrO^-, hypobromite; BrO_2^-, bromite; BrO_3^-, bromate; BrO_4^-, perbromate.
- 4. Polyatomic anions with a charge more negative than -1 may add a hydrogen ion (H^+) to give another anion. HCO_3^-, hydrogencarbonate; HPO_4^{2-}, hydrogenphosphate; $H_2PO_4^-$, dihydrogenphosphate.