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Lecture 1: Atoms, Chemical bonds and Hydrocarbons

1.1 Composition of the Atom

- The basic structural unit of an element is the atom.
- The nucleus is the very small and very dense core at the center of the atom containing:

1. Protons: positively charged particles.
   The number of protons is indicated by the atomic number, Z.
2. Neutrons: neutral particles.
   The number of neutrons is calculated from the mass number minus the atomic number, A–Z.
3. Electrons are negatively charged particles that are located in a diffuse region. For a neutral atom,
   The number of electrons equals the number of protons.

- Isotopes are atoms of the same element that have a different number of neutrons. Isotopes of the same element have the same chemical properties.
  For example, all of the following are isotopes of hydrogen:

$^{1}_{1}H$	$^{2}_{1}H$	$^{3}_{1}H$
Hydrogen	Deuterium	Tritium

- The atomic mass is the weighted average of the masses of the isotopes of an element in atomic mass units;
  1 amu = 1.66 * 10^{-24} grams (g).

1.2 The Periodic Law and the Periodic Table

- The periodic law relates the structure of elements to their chemical and physical properties. The modern periodic table groups the elements according to these properties.
- **Periods** are horizontal rows, numbered 1 through 7 from top to bottom. The lanthanide series is part of period 6; the actinide series is part of period 7.
- Vertical columns are referred to as **groups** or families.

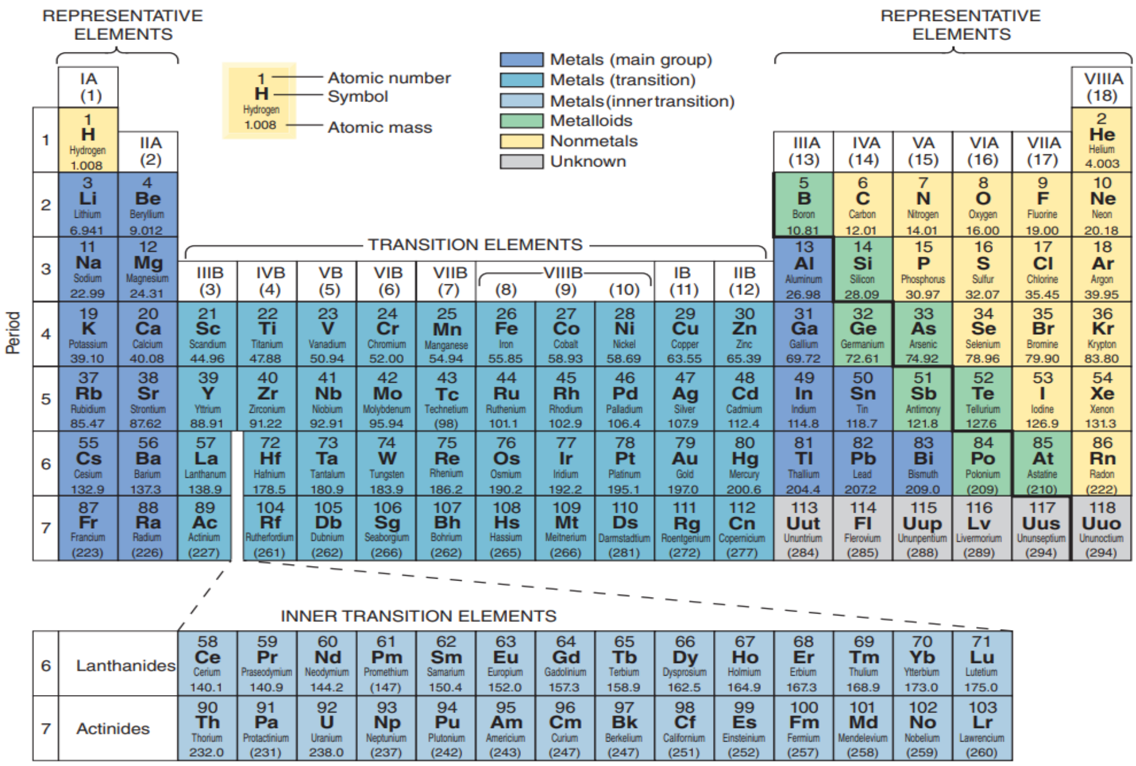


Figure (1.1): The periodic table (الجدول الدوري للأطلاع فقط)

1.3 Chemical Bonding

Chemical bonding: is the attractive force between atoms in a compound can be classified as

- Covalent, atoms sharing electrons
- Polar covalent and nonpolar covalent
- Ionic, consisting of cations and anions

Electronegativity is a measure of the ability of an atom to attract electrons in a chemical bond, and the difference in electronegativity is used in classifying chemical bonds.

- Difference of 0.5 and less—nonpolar covalent
- Difference between 0.5 and 2.0—polar covalent
- Difference of 2.0 or larger—ionic

1.4 Naming Compounds and Writing Formulas of Compounds

The system for naming compounds (nomenclature) is different for ionic and covalent compounds

1. Ionic compounds: name cation followed by the anion.
Some examples follow:

Formula	Cation	and	Anion Stem	+ ide	=	Compound Name
NaCl	sodium		chlor	+ ide		sodium chloride
Na_2O	sodium		ox	+ ide		sodium oxide
Li_2S	lithium		sulf	+ ide		lithium sulfide
$AlBr_3$	aluminum		brom	+ ide		aluminum bromide
CaO	calcium		ox	+ ide		calcium oxide

With many elements, such as transition metals, several ions of different charge may exist. Fe^{2+}, Fe^{3+} and Cu^{+}, Cu^{2+} are two common examples. Clearly, an ambiguity exists if we use the name iron for both Fe^{2+} and Fe^{3+} or copper for both Cu^{+} and Cu^{2+}. Two systems have been developed to avoid this problem: the Stock system and the common nomenclature system.

For systematic name:			
Formula	**Cation Charge**	**Cation Name**	**Systematic Name**
$FeCl_2$	2 +	Iron(II)	Iron(II) chloride
$FeCl_3$	3 +	Iron(III)	Iron(III) chloride
Cu_2O	1 +	Copper(I)	Copper(I) oxide
CuO	2 +	Copper(II)	Copper(II) oxide
For common nomenclature:			
Formula	**Cation Charge**	**Cation Name**	**Common -ous/ic Name**
$FeCl_2$	2 +	Ferr*ous*	Ferrous chloride
$FeCl_3$	3 +	Ferr*ic*	Ferric chloride
Cu_2O	1 +	Cupr*ous*	Cuprous oxide
CuO	2 +	Cupr*ic*	Cupric oxide

Monatomic ions are ions consisting of a single atom. The ions that are particularly important in biological systems are highlighted in red. **Polyatomic ions**, such as the hydroxide ion, OH^-, are composed of two or more atoms bonded together. These ions, although bonded to other ions with ionic bonds, are themselves held together by covalent bonds.

TABLE 3.2 Common Monatomic Cations and Anions

Cation	Name	Anion	Name
H^+	Hydrogen ion	H^-	Hydride ion
Li^+	Lithium ion	F^-	Fluoride ion
Na^+	Sodium ion	Cl^-	Chloride ion
K^+	Potassium ion	Br^-	Bromide ion
Cs^+	Cesium ion	I^-	Iodide ion
Be^{2+}	Beryllium ion	O^{2-}	Oxide ion
Mg^{2+}	Magnesium ion	S^{2-}	Sulfide ion
Ca^{2+}	Calcium ion	N^{3-}	Nitride ion
Ba^{2+}	Barium ion	P^{3-}	Phosphide ion
Al^{3+}	Aluminum ion		
Ag^+	Silver ion		

Note: The ions of principal biological importance are highlighted in red.

(الجدول للاطلاع فقط)

TABLE 3.3 Common Polyatomic Cations and Anions

Ion	Name
H_3O^+	Hydronium
NH_4^+	Ammonium
NO_2^-	Nitrite
NO_3^-	Nitrate
SO_3^{2-}	Sulfite
SO_4^{2-}	Sulfate
HSO_4^-	Hydrogen sulfate
OH^-	Hydroxide
CN^-	Cyanide
PO_4^{3-}	Phosphate
HPO_4^{2-}	Hydrogen phosphate
$H_2PO_4^-$	Dihydrogen phosphate
CO_3^{2-}	Carbonate
HCO_3^-	Bicarbonate
ClO^-	Hypochlorite
ClO_2^-	Chlorite
ClO_3^-	Chlorate
ClO_4^-	Perchlorate
CH_3COO^- (or $C_2H_3O_2^-$)	Acetate
MnO_4^-	Permanganate
$Cr_2O_7^{2-}$	Dichromate
CrO_4^{2-}	Chromate
O_2^{2-}	Peroxide

Note: The most commonly encountered ions are highlighted in red.

(الجدول للاطلاع فقط)

2. Covalent compounds: name first element first and then second element (with -ide ending). Use prefixes of di-, tri-, etc., to denote the number of atoms of each element in the compound
   Example: **Name the covalent compound N_2O_4**
   The name is dinitrogen tetroxide.

A Medical Perspective: Kidney stones most often result from the combination of calcium cations (Ca^{2+}) with anions such as oxalate ($C_2O_4^{2-}$) and phosphate (PO_4^{3-}). Calcium oxalate and calcium phosphate are ionic compounds that are only sparingly soluble in water. They grow in a three-dimensional crystal lattice. When the crystals become large enough to inhibit the flow of urine in the kidney or bladder, painful symptoms necessitate some strategy to remove the stones.

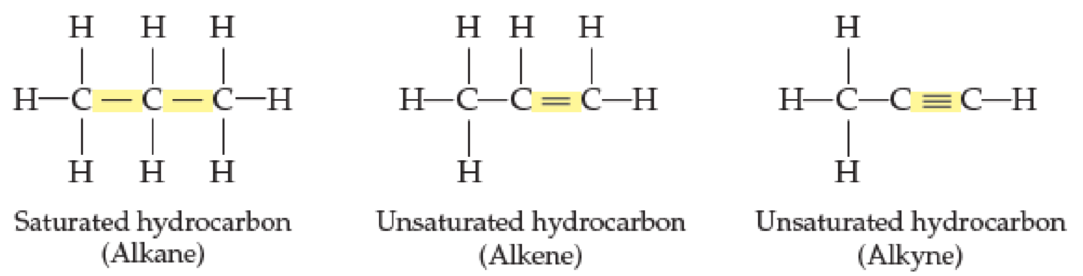
1.5 Properties of Ionic and Covalent Compounds

Properties	Ionic compound	Covalent compound
Physical State	All ionic compounds (for example, NaCl, KCl, and NaNO3) are solids at room	Covalent compounds may be solids (glucose), liquids (water, ethanol), or gases (carbon dioxide, methane).
Melting and Boiling Points	Ionic compounds have higher melting points and boiling points than covalent compounds.	
Structure of Compounds in the Solid State	Ionic solids are crystalline, characterized by a regular structure,	Covalent solids may either be crystalline or have no regular structure. In the latter case, they are said to be amorphous
Solutions of Ionic and Covalent Compounds	When ionic compounds dissolve in water, the ions dissociate and the solution conducts electricity. These compounds are electrolytes.	When covalent compounds dissolve in water, the compound does not dissociate. They are nonelectrolytes.

1.6 The Chemistry of Carbon

- Organic chemistry is the study of carbon-containing compounds.
- All organic compounds are classified as hydrocarbons or substituted hydrocarbons.

- Hydrocarbons contain only carbon and hydrogen atoms and may be aliphatic (alkanes, alkenes, and alkynes) or aromatic (containing a benzene ring).
- Aliphatic hydrocarbons may be saturated (only C—C and C—H single bonds) or unsaturated (at least one C=C double or triple bond).

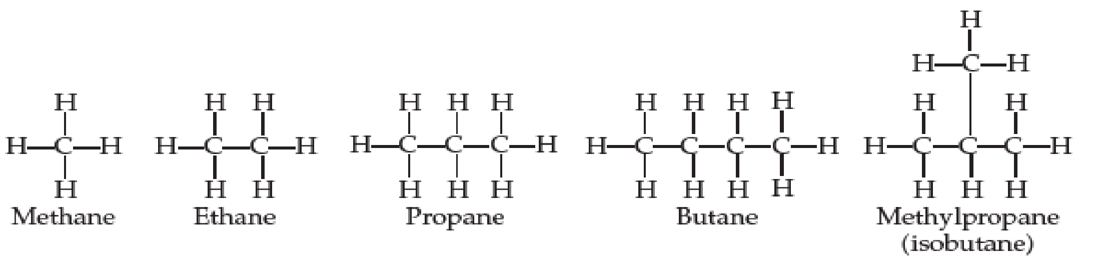


1. Alkanes

- Alkanes are saturated hydrocarbons with the general formula CnH2n+2.
- Alkanes are nonpolar, water-insoluble, and have low melting and boiling points.

CH_4	C_2H_6	C_3H_8	C_4H_{10}
Methane	Ethane	Propane	Butane

........(Molecular formulas)



Structural formulas

- Two organic molecules with the same molecular formula but different bonding patterns have different physical and chemical properties. Such molecules are structural or constitutional **(Isomers).**

- Cycloalkanes are organic molecules having C—C single bonds in a ring structure.

2. Alkenes and Alkynes

- Alkenes and alkynes are unsaturated hydrocarbons because they have at least one C=C double bond (alkenes) or triple bond (alkynes). Alkenes have the general formula CnH2n and alkynes have the general formula CnH2n- 2.