Pharmaceutical analytical chemistry I

Lecture 2

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Units of measurement

Units of measurement

- In chemistry :units standard quantities used to specify measurements are critical. If we get them wrong, the consequences العواقب can be disastrousكارثيه .
- The most common unit systems are:

⇒ the metric system, used in most of the world,

⇒ the English system, used in the United States.

Scientists use the International System of Units (SI), which is based on the metric system

❑ ***There are seven basic units in SI system:***

1. **Kilogram (Kg):** unit of mass
2. **Second (S):** unit of time
3. **Kelvin (K):** unit of temperature
4. **Ampere (A):** unit of electricity
5. **Mole (mol):** amount of substance
6. **Candela (cd):** unit of luminous intensity (measure of the wavelength-weighted power emitted by a light source).
7. **Meter (m):** Unit of length.

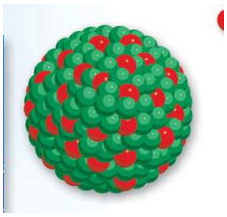
Atoms, molecules and ions

Atoms

The Atomic Theory

Dalton's atomic theory describing nature of matter can be summarized as follows:

1. Elements are composed of extremely small particles called atoms.
2. All atoms of a given element are identical, having the same size, mass, and chemical properties. The atoms of one element are different from the atoms of other elements.
3. Compounds are composed of atoms of more than one element.
4. A chemical reaction involves only the separation, combination, or rearrangement of atoms; it does not result in their creation or destruction.



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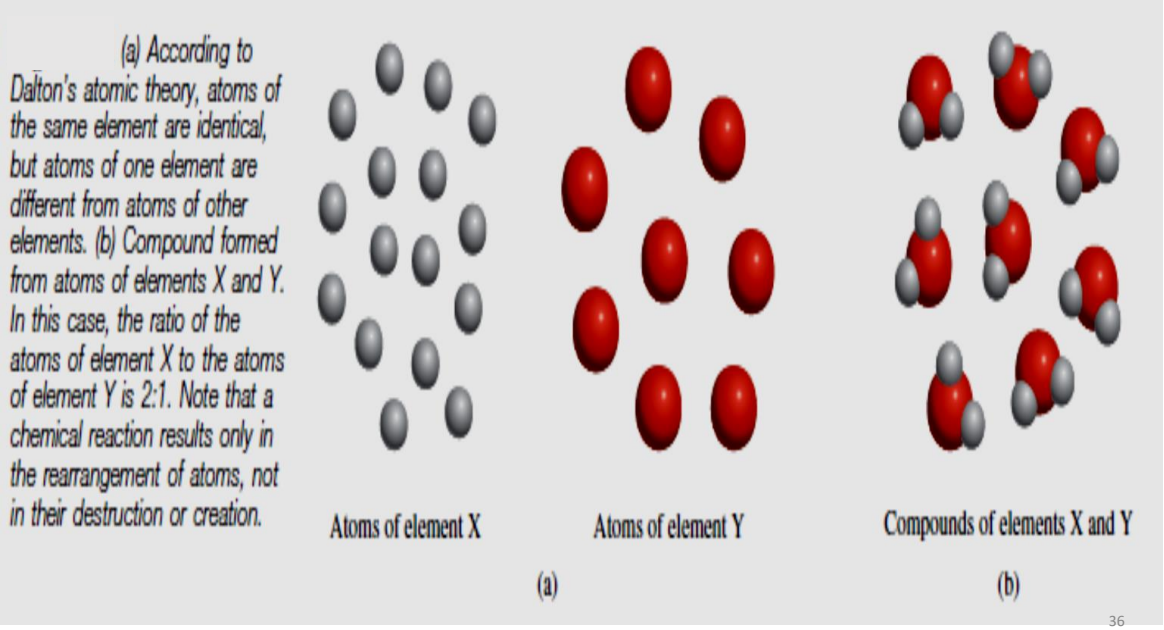

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Structure of the atom:

Atom is smallest constituent of matter , it consists of nucleus and surrounding electrons

The nucleus is made of one or more protons and a number of neutrons.

Protons and neutrons are called nucleons. More than 99.94% of an atom's mass is in the nucleus.

The protons have a positive electric charge, the electrons have a negative electric charge, and the neutrons have no electric charge.

If the number of protons and electrons are equal, that atom is electrically neutral.

If an atom has more or fewer electrons than protons, then it has an overall negative or positive charge, respectively, and it is called an ion

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Atomic Number, Mass Number, and Isotopes

1- Atomic number (Z): *is the number of protons in the nucleus of each atom of an element.*

- In a neutral atom the number of protons is equal to the number of electrons, so the atomic number also indicates the number of electrons present in the atom.
- The chemical identity of an atom can be determined from its atomic number:

the atomic number of fluorine is 9. This means that each fluorine atom has 9 protons (and 9 electrons).

Or every atom that contains 9 protons is correctly named "fluorine."

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2-The mass number (A) : *is the total number of neutrons and protons present in the nucleus of an atom of an element.*

All atomic nuclei contain both protons and neutrons, except hydrogen, which has one proton and no neutrons.

In general:

mass number = number of protons + number of neutrons
= atomic number + number of neutrons

The atomic number and atomic mass of an element is written as: ${}^{A}X_{Z}$

3- Isotopes: *atoms that have the same atomic number but different mass numbers.*

For example, there are three isotopes of hydrogen:

- *hydrogen,* has one proton and no neutrons.
- *deuterium* isotope contains one proton and one neutron,
- and *tritium* has one proton and two neutrons.

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- Q. Give the number of protons, neutrons, and electrons in each of the following species:
- (a) $^{20}Na_{11}$, (b) $^{22}Na_{11}$ (c) ^{17}O,
  (d) carbon-14.

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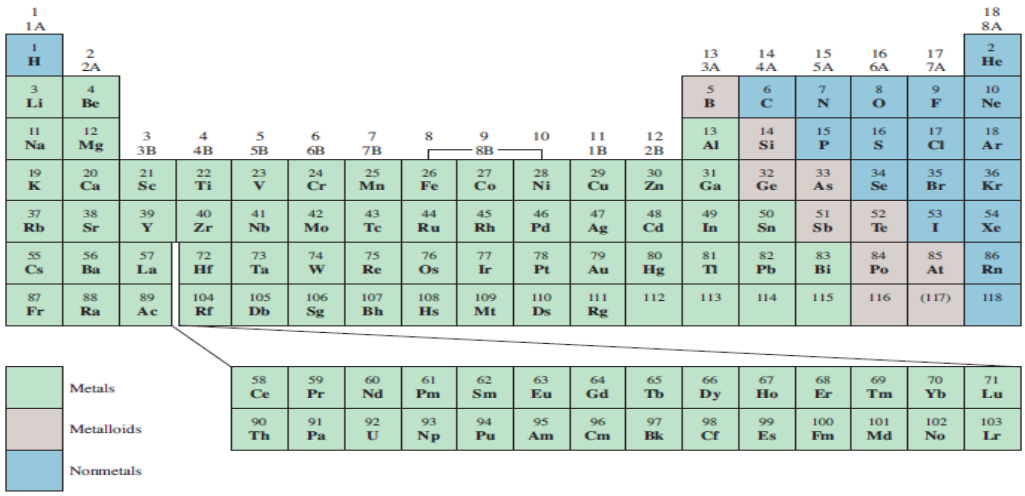
The periodic table



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- **The periodic table is :** *a chart in which elements having similar chemical and physical properties are grouped together.*
- elements are arranged by atomic number in *horizontal rows* called ***periods*** and in *vertical columns* known as ***groups***

- The elements can be divided into three categories—metals, nonmetals, and metalloids:

- *A **metal***: a good conductor of heat and electricity .

- *A **non-metal***: usually a poor conductor of heat and electricity.

- *A **metalloid*** has properties that are intermediate between those of metals and non-metals.

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Groups are divided into two categories or families, First family is "A series“ while the second family is “B series”
However, some element groups have been given special names:

Group 1A elements
- *Li, Na, K, Rb, Cs, and Fr* are called ***alkali metals***

Group 2A elements
- *Be, Mg, Ca, Sr, Ba, and Ra* are called ***alkaline earth metals*.**

Group 7A
- *F, Cl, Br, I, and At* are known as ***halogens***

Group 8A
- *He, Ne, Ar, Kr, Xe, and Rn* are called ***noble gases,*** or *rare gases* .

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- Group B are called “transition elements”, of which **lanthanide series**, or rare earth series, **and actinide series** are set aside from main body of periodic table to avoid making periodic table too wide.
- The lanthanide and actinide series are **sometimes known as the inner transition metals .**

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- Each group in periodic table has the same physicochemical properties, (why ?) because they have the same number of electron in the outer shell.

Period 1: H : $1s^1$

Period 2 : Li : $1s^2\ 2s^1$

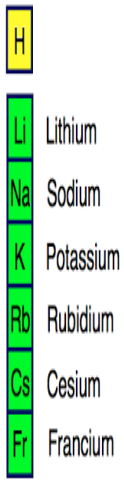
Period 3: Na : $1s^2\ 2s^2\ 2p^6\ 3s^1$

Period 4: K: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$

Period 5: Rb: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^1$

Period 6: Cs: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^1$

Period 7: Fr: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2\ 4f^{14}\ 5d^{10}\ 6p^6\ 7s^1$



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Molecules, ions and isomers

- A ***molecule*** is an *aggregate of at least two atoms in a definite arrangement held together by chemical forces* (called *chemical bonds*).
- A molecule may contain atoms of the same element or atoms of two or more elements joined in *a fixed ratio*.
- A molecule is electrically neutral.

- **Example:** 1- Hydrogen gas is a pure element, but it consists of molecules made up of two H atoms .

2- Water: is a molecule that contains hydrogen and oxygen in a ratio of two H atoms and one O atom.

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- A molecule could be either:

diatomic molecule	Polyatomic molecule
• Contains only two atoms - The two atoms could be of the same element , including: hydrogen (H_2), nitrogen (N_2) and oxygen (O_2), group 7A elements—fluorine (F_2), chlorine (Cl_2), bromine (Br_2), and iodine (I_2). - a diatomic molecule can contain atoms of different elements: such as: hydrogen chloride (HCl) and carbon monoxide (CO).	• Contains more than two atoms . They can be atoms of the same element, as in ozone (O_3), which is made up of three atoms of oxygen, or they can be combinations of two or more different elements like water (H_2O) and ammonia (NH_3) .

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Ions: An ***ion is an atom or a group of atoms that has a net positive or negative charge.***

Number of positively charged protons in nucleus of an atom remains same during chemical reactions, but negatively charged electrons may be lost or gained

• ***Cation , an ion with a net positive charge. : resulting from*** loss of one or more electrons from a neutral atom
For example, a sodium atom (Na) can readily lose an electron to become a sodium cation, which is represented Na^+

Na Atom	Na^+ Ion
11 protons	11 protons
11 electrons	10 electrons

• ***Anion is an ion with a net negative charge : resulting from*** gain of one or more electrons from a neutral atom
Example: A chlorine atom (Cl), can gain an electron to become the chloride ion Cl^-

Cl Atom	Cl^- Ion
17 protons	17 protons
17 electrons	18 electrons

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Ions:

Monatomic ions *because they contain only one* *atom. Example:* Na^+ , Cl^-, Mg^{2+}, Fe^{2+}, S^{2-}, and N^{3-}

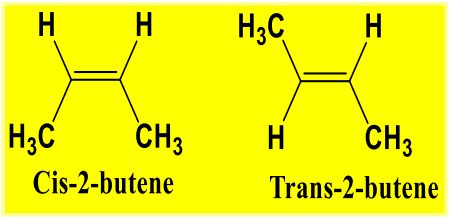
Polyatomic ions *:* two or more atoms can combine to form an ion that has a net positive or net negative charge
Example: *OH^- (hydroxide ion),* *CN^-* (cyanide ion), and NH_4^+ (ammonia)

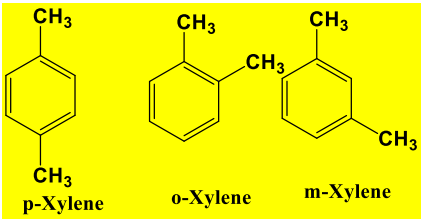
Common Polyatomic Ions

Names of Common Polyatomic Ions

Ion	Name	Ion	Name
NH_4^+	ammonium	CO_3^{2-}	carbonate
NO_2^-	nitrite	HCO_3^-	hydrogen carbonate (bicarbonate is a widely used common name)
NO_3^-	nitrate		
SO_3^{2-}	sulfite		
SO_4^{2-}	sulfate	ClO^-	hypochlorite
HSO_4^-	hydrogen sulfate (bisulfate is a widely used common name)	ClO_2^-	chlorite
		ClO_3^-	chlorate
		ClO_4^-	perchlorate
OH^-	hydroxide	$C_2H_3O_2^-$	acetate
CN^-	cyanide	MnO_4^-	permanganate
PO_4^{3-}	phosphate	$Cr_2O_7^{2-}$	dichromate
HPO_4^{2-}	hydrogen phosphate	CrO_4^{2-}	chromate
$H_2PO_4^-$	dihydrogen phosphate	O_2^{2-}	peroxide

- Isomers: are molecules with the same number of molecular formula (same atoms) but different configuration (orientation).





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(a) What are the atomic number (Z), mass number (A), and symbol of the chlorine isotope with 18 neutrons?

(b) How many protons, electrons, and neutrons are present in an atom of $^{52}_{24}Cr$?

SOLUTION

(a) Look up the atomic number (Z) for chlorine on the periodic table. The atomic number specifies the number of protons.	$Z = 17$, so chlorine has 17 protons.
The mass number (A) for an isotope is the sum of the number of protons and the number of neutrons.	A = number of protons + number of neutrons = 17 + 18 = 35
The symbol for an isotope is its chemical symbol with the atomic number (Z) in the lower left corner and the mass number (A) in the upper left corner.	$^{35}_{17}Cl$
(b) For any isotope (in this case $^{52}_{24}Cr$) the atomic number located at the lower left indicates the number of protons. Since this is a neutral atom, the number of electrons equals the number of protons.	Number of protons = Z = 24 Number of electrons = 24 (neutral atom)
The number of neutrons is equal to the mass number (upper left) minus the atomic number (lower left).	Number of neutrons = 52 − 24 = 28

FOR PRACTICE

(a) What are the atomic number, mass number, and symbol for the carbon isotope with seven neutrons?

(b) How many protons and neutrons are present in an atom of $^{39}_{19}K$?