جامعة المستقبل
AL MUSTAQBAL UNIVERSITY
كلية العلوم

Analytical Chemistry

1st stage

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Lecture 2: Periodic Table

Department of Medical Biotechnology

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1.1 Classification of Elements

One of the simplest methods for classifying elements is to divide them into three categories:

Metals

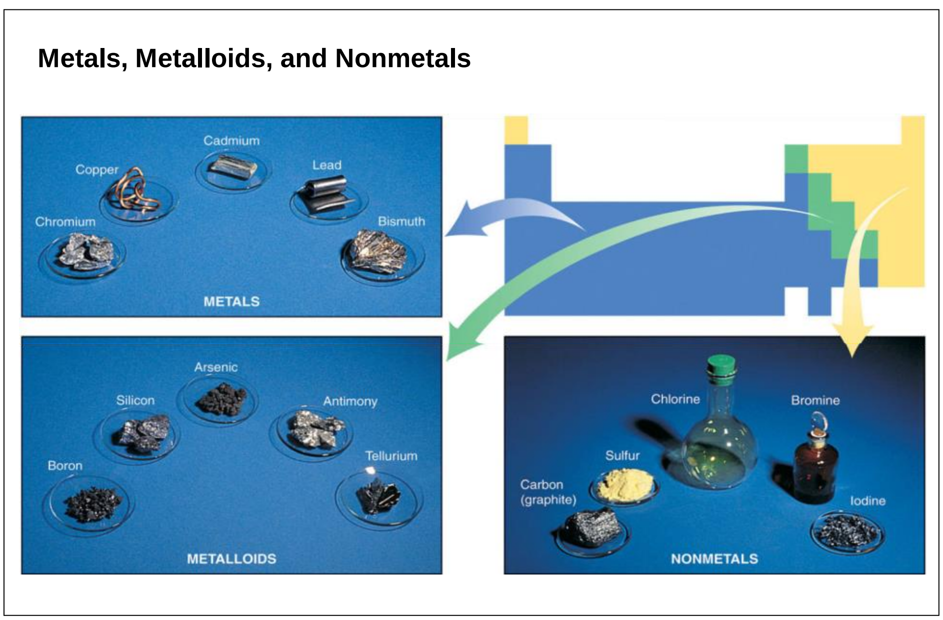
- Good conductors of heat and electricity.
- Malleable and ductile with a shiny appearance.
- Found on the left and center of the periodic table (e.g., Fe, Cu).

Non-Metals

- Poor conductors of heat and electricity.
- Brittle in solid form and often exist as gases or dull solids.
- Found on the right side of the periodic table (e.g., O, N).

Metalloids

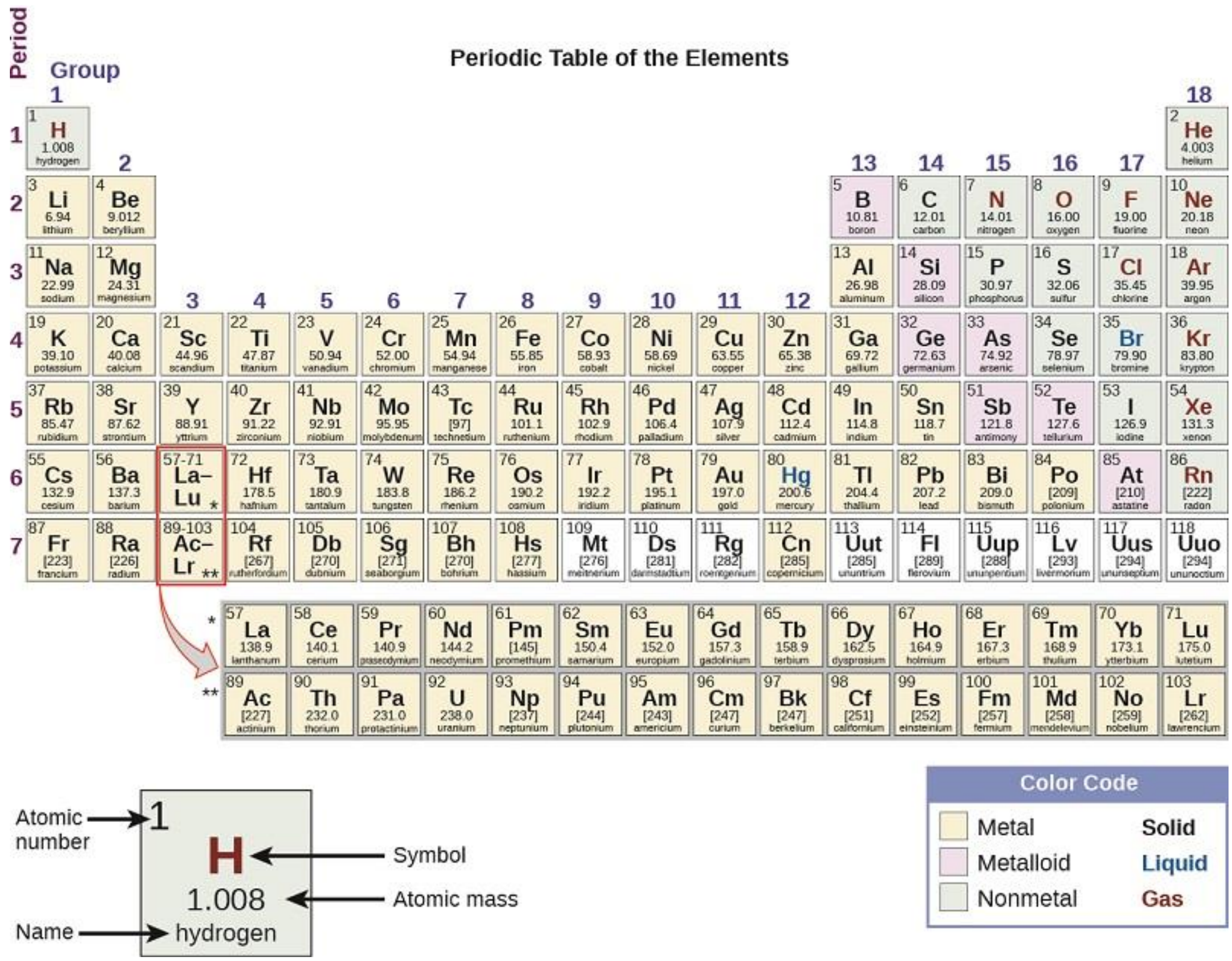
- Exhibit properties of both metals and non-metals.
- Found along the "stair-step" line in the periodic table (e.g., Si, Br).



1.2 The Periodic Table

The periodic table is a systematic arrangement of chemical elements organized by their atomic number, electron configuration, and recurring chemical properties. It is a fundamental tool in chemistry, providing a clear framework for understanding the relationships between elements and predicting their behavior.

The idea of arranging the elements into a periodic table had beenconsidered by many chemists, but either the data to support the ideawere insufficient or the classification scheme was incomplete.Mendeleev and Meyer organized the elements in order of atomic weight and then identified families of elements with similar properties.By arranging these families in rows or columns, and by considering similarities in chemical behavior as well as atomic weight,Mendeleev found vacancies in the table and was not able to predict the properties of several elements (Gallium, Scandium, Germanium, Polonium) that had not yet been discovered.


Periodic Table of the Elements
Period
Group
Atomic number
Symbol
Atomic mass
Name
1
H
1.008
hydrogen
Color Code
Metal
Metalloid
Nonmetal
Solid
Liquid
Gas

1.3 Structure of the Periodic Table

❖ Groups (Columns):

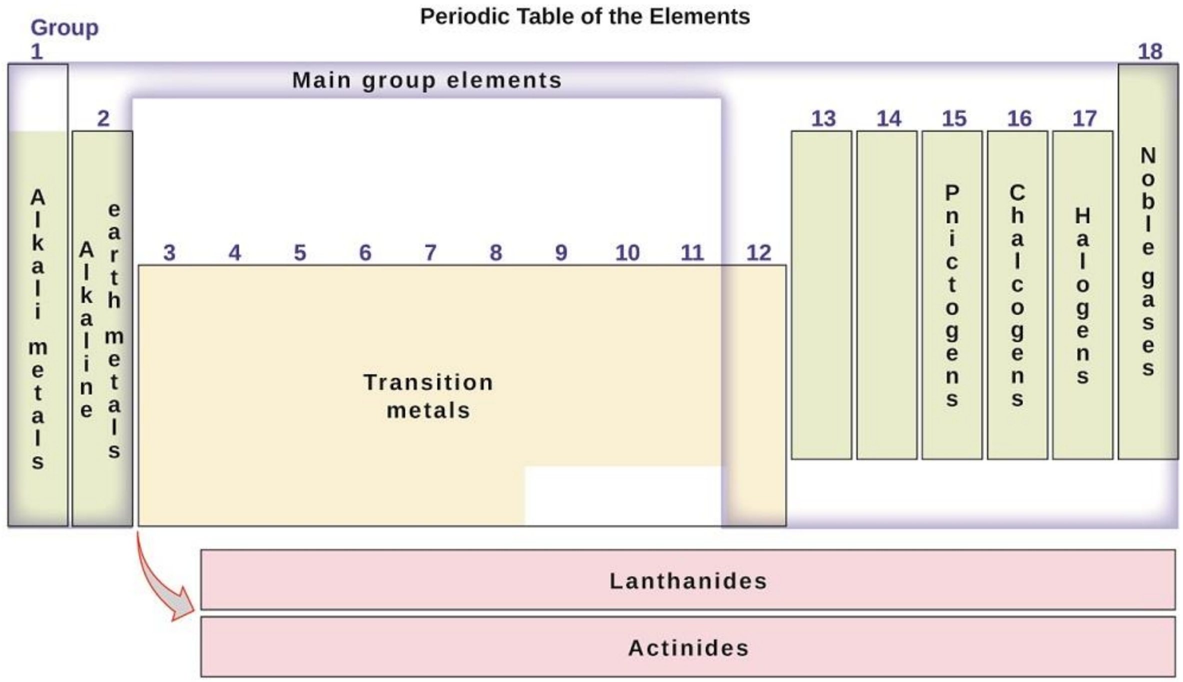
- There are 18 vertical columns called groups.
- Elements in the same group share similar chemical properties because they have the same number of valence electrons.
- Examples:
  - Group 1: Alkali metals (e.g., Lithium - Li).
  - Group 17: Halogens (e.g., Fluorine - F).
  - Group 18: Noble gases (e.g., Helium - He).

❖ Periods (Rows):

- There are 7 horizontal rows called periods.
- The period number corresponds to the number of electron shells in the elements of that row.

❖ Blocks:

- The table is divided into four main blocks based on the electron configuration of the elements:
  - **s-block**: Groups 1-2.
  - **p-block**: Groups 13-18.
  - **d-block**: Transition metals.
  - **f-block**: Lanthanides and actinides.



1.4 Electron Configuration

Electron configuration refers to the arrangement of electrons in an atom's orbitals around its nucleus. It determines the chemical and physical properties of an element. The electrons are distributed in energy levels or shells, which are further divided into subshells (s, p, d, and f).

Examples:

H_1: $1S^1$

Li_3: $1S^2$ $2S^1$

Na_{11}: $1S^2$ $2S^2$ $2P^6$ $3S^1$

K_{19}: $1S^2$ $2S^2$ $2P^6$ $3S^2$ $3P^6$ $4S^1$

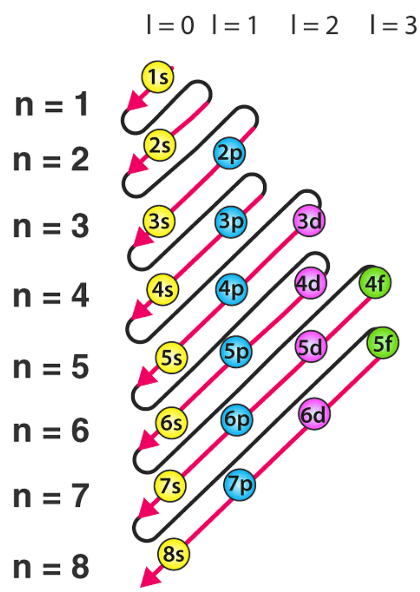
Rh_{37}: $1S^2$ $2S^2$ $2P^6$ $3S^2$ $3P^6$ $4S^2$ $3d^{10}4P^6$ $5S^1$

Cs_{55}: $1S^2$ $2S^2$ $2P^6$ $3S^2$ $3P^6$ $4S^2$ $3d^{10}4P^6$ $5S^2$ $4d^{10}5P^6$ $6S^1$

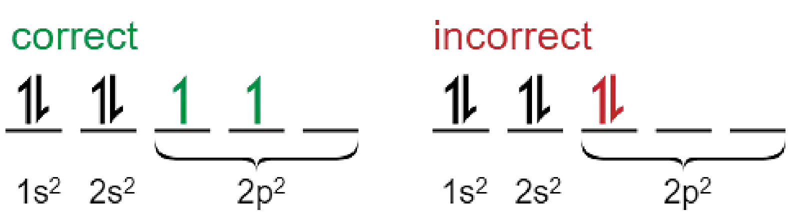
Fr_{87}: $1S^2$ $2S^2$ $2P^6$ $3S^2$ $3P^6$ $4S^2$ $3d^{10}4P^6$ $5S^2$ $4d^{10}5P^6$ $6S^2$ $5d^{10}4f^{14}6P^6$ $7S^1$

1.5 Principles Governing Electron Configuration

1. **Aufbau Principle**:
   - Electrons fill the lowest energy orbitals first before moving to higher energy levels.
   - Orbital filling order: 1s,2s,2p,3s,3p,4s,3d,4p,5s,…



2. **Pauli Exclusion Principle**:
   - Each orbital can hold a maximum of 2 electrons with opposite spins.
3. **Hund's Rule**:
   - In orbitals of equal energy (like the three p-orbitals), electrons fill each orbital singly before pairing up.

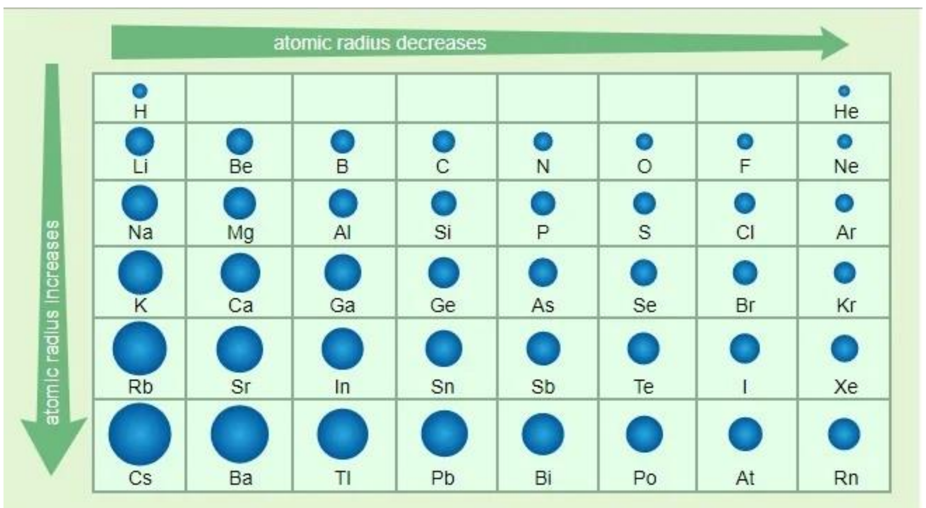


1.6 The Periodic table properties

1.6.1 Atomic Radius

Definition: The atomic radius is the distance from the nucleus to the outermost electron, or it can be described as half the distance between the centers of two adjacent atoms of the same element in a molecule.

- Decreases across a period (left to right) due to increasing nuclear charge.
- Increases down a group as more electron shells are added.



1.6.2 Ionization Energy

Definition: The ionization energy, EI, of an atom/ion is the minimum energy, which is required to remove an electron of an atom. The unit of ionization energy is kJ/mol.

- Increases across a period because atoms hold their electrons more tightly.
- Decreases down a group as electrons are farther from the nucleus.

$$M_{(g)} + \text{Energy} \longrightarrow M^{+}_{(g)} + e^{-}$$

1.6.3 Electronegativity

Definition: The electronegativity, χ, describes the ability of an atom to attract electrons towards.

- Increases across a period as the tendency to attract electrons in a bond strengthens.
- Decreases down a group due to increased distance from the nucleus.

Problem: Put in order of largest to smallest: F, Ar, Sr, and Cs.

Solution: Cs > Sr >Ar > F

1.7 Shielding

Each electron act as a shell for another electron and reducing the attraction between the nucleus and further electrons.

Slater's Rules: In 1930, J. C. Slater proposed a set of empirical rules to semiquantify the concept of effective nuclear charge. He proposed a formula that related

How can we calculate the effective charge of the nucleus?

$$Z_{eff} = Z - S$$

1. The electrons are written in groups as follows:

1s | 2s 2p | 3s 3p | 3d | 4s 4p | 4d | 4f | 5s 5p | 5d |....

2. All electrons in orbitals of greater principal quantum number

(At n+1) contribute zero.

3. for ns or np valence electrons:

a- Electrons in the same ns, np group (same principal quantum number) contributes (0.35).

b- Electrons in the (n-1) principal group contribute (0.85).

c- Electrons in the (n-2) or lower groups contribute (1.00).

4- For nd and nf valence electrons:

a- Electrons in the same nd and nf group contribute (0.35).

b- Electrons in the groups to the left contribute (1.00).

Example: to calculate the effective nuclear charge on one of the 2p

Electrons in the oxygen atom ($1S^2S^2P^4$), we first find the screening (or

Shielding) constant:

$S= (2 \times 0.85) + (5 \times 0.35) = 3.45$

$Zeff = Z – S$

$= 8 - 3.45$

$= 4.55$