# The periodic classification of elements

## Introduction

The study of the electronic structure of atoms allows us to understand in more depth the periodic classification of the elements also called Mendeleev's periodic classification.

In the 19th century, chemists tried to find analogies between the chemical species discovered at the time. Then, they tried to classify  them, to group called  also “families” according to their chemical properties.

## I. Principle of current classification

The current presentation of the periodic classification derives from that of *Mendeleev. However, he did not know the laws governing the* distribution of electrons around the nucleus, that is to say the electronic structure of atoms. We were able to notice that the representation of the electronic structures of atoms revealed certain similarities between the elements, which should make it possible to group some of them into “families”.

It therefore appears that we can define, from knowledge of the distribution of electrons around the nucleus, a periodicity appearing in Mendeleev's table. The fundamental difference between the current classification and that of Mendeleev is that the elements are no longer classified by increasing mass number but by order of increasing atomic number Z.

## II. Description of the Periodic Table of Elements

There are several ways to present the periodic table. We will adopt the presentation below:

Horizontal lines called periods in which the elements are arranged from left to right in increasing order of their atomic number Z.

Vertical columns which correspond to "families" or chemical groups, the elements defined by a column have an identical electronic configuration of their outer layer.

## 1.Periods

Each period corresponds to the filling of a layer, there are 7 periods corresponding to the filling of 7 layers.

**1st period**: The first period corresponds to the filling of layer K, it contains 02 external configuration elements $1s^1$ and $1s^2$.

**2nd period**: The second period corresponds to the filling of layer L, it contains 08 external configuration elements $2s^1$, $2s^2$, $2s^2 2p^1$ up to $2p^6$.

**3rd period**: The third period corresponds to the filling of layer M, it contains 08 elements of external configurations $3s^1$, $3s^2$, $3s^2 3p^1$ up to $3p^6$.

**4th period**: The fourth period corresponds to the filling of layer N, it contains 18 external configuration elements $4s^1$,$4s^2$,$4s^2 3d^1$ up to $3d^{10}$,$4s^2 3d^{10} 3p^1$ up to $3p^6$.

**5th period**: The fifth period corresponds to the filling of layer 0, it contains 18 elements of external configurations $5s^1$, $5s^2$, $5s^2 4d^1$ up to $4d^{10}$, $5s^2 4d^{10} 5p^1$ up to $5p^6$.

**6th period**: The sixth period corresponds to the filling of layer P, it contains 32 elements of external configurations $6s^1$, $6s^2$, $6s^2 4f^1$ up to $4f^{14}$,$6s^2 4f^{14} 5d^1$ up to $5d^{10}$ and ends with $6s^2 5d^{10} 4f^{14} 6p^1$ up to $6p^6$.

**7th period**: The seventh period corresponds to the filling of the Q layer, it contains 32 elements of external configurations $7s^1$, $7s^2$, $7s^25f^1$ up to $5f^{14}$,$7s^25f^{14}6d^1$ up to $6d^{10}$,$7S^25f^{14}6d^{10}7p^1$ up to $7p^6$.

**Noticed :**

1/ 4f elements follow Lanthanum. They are called Lanthanides.

2/ 5f elements follow actinium. They are called actinides.

3/ Lanthanides (Z = 57 to 71), actinides (Z = 89 to 103) are represented outside the table in order to limit the expansion of the periods.

## 2. Groups

## Group A:

1) The letter A or B makes it possible to better specify certain chemical analogies between columns defined by the same Roman numeral; for example the elements of column $I_A$ while having as $I_B$ a single electron in the s orbital of the last $ns^1$ layer have partly different chemical properties.

2) Column $VIII_A$ was subsequently added at the time of the discovery of rare gases also called inert gases, the only chemical elements to exist under normal conditions, as simple bodies in atomic form.

| Group | External electronic structure | Family |
|---|---|---|
| $I_A$ | $ns^1$ | Alkali metal ($Na^+$, $K^+$) |
| $II_A$ | $ns^2$ | Alkaline earth metal ($Mg^{+2}$, $Ca^{+2}$) |
| $III_A$ | $ns^2np^1$ | Boron family |

| | | |
|---|---|---|
| $IV_A$ | $ns^2np^2$ | Carbon family |
| $V_A$ | $ns^2np^3$ | Nitrogen family |
| $VI_A$ | $ns^2np^4$ | Oxygen family |
| $VII_A$ | $ns^2np^5$ | Halogen family |
| $VIII_A$ | $ns^2np^6$ | Noble gas family |

## Group B:

Elements or transition metals : These are elements whose external sublayer is not saturated , it is of the $ns^2(n-1)d^x$ type . ( x varies from 1 to 10).

| Group | External electronic structure | kind |
|---|---|---|
| $III_B$ | $ns^2(n-1)d^1$ | |
| $IV_B$ | $ns^2(n-1)d^2$ | |
| $V_B$ | $ns^2(n-1)d^3$ | |
| $VI_B$ | $ns^2(n-1)d^4$ | |
| $VII_B$ | $ns^2(n-1)d^5$ | |
| $VIII_B$ | $ns^2(n-1)d^6$, $ns^2(n-1)d^7$, $ns^2(n-1)d^8$ | Group of triads having similar physicochemical |
| $I_B$ | $ns^1(n-1)d^{10}$ | These groups are not considered transitional elements because their outer sublayer d is saturated |
| IIB | $ns^2(n-1)d^{10}$ | |

## 3. Blocks

The periodic table is divided into four blocks: s block, p block, d block and f block.

The s block: all the elements of groups IA and IIA.

The p block: all elements of groups IIIA up to VIIIA.

The d block : corresponds to the elements of groups IB to VIIIB.

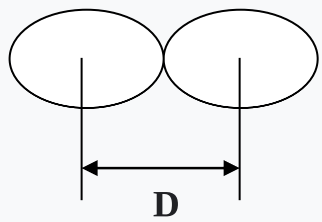
The f Block : contains the elements of the two rows outside the periodic table table.

## III. Periodic laws:

### 1. Atomic radius AR( R ).

The atomic radius(AR) of an element is defined as half the distance between two neighboring atoms of this element taken under standard conditions.

R=D/2




AR decreases going through a period from left to right and increases going down a group.

## 2. Ionization potential (Ip)

The ionization potential (Ip) is the energy that must be supplied to a gaseous atom X(g) to remove an electron from it.

$$X(g)(\text{ ionization potential}) \longrightarrow X^+ + e$$

Ip corresponds to the first ionization potential. There is, of course, a second ionization potential, denoted $Ip_2$, if a second electron is extracted.

Ip increases going through a period from left to right and decreases going down a group from top to bottom.

## 3. Electronic affinity (Ea)

The electron affinity (Ea) of an element is the energy released by its atom when it captures an electron. Ea is positive when the electronic attachment reaction is exothermic.

$$X(g) + e \longrightarrow X^{-}(g) + \text{energy (Ea)}$$

Ea Increases when crossing a period from left to right but varies very little when going down a group. As with the ionization potential, there is a second electron affinity when $X^-$ captures a second electron, ……etc.

## 4. Electronegativity (χ)

The electronegativity (χ of an element is the tendency of that element to attract an electron.

The notions of ionization potential and electron affinity relate to a single atom. On the other hand, the notion of electronegativity will be used more later because it occurs when the atom is associated with other atoms.

**Noticed :**

1/ χ increases when crossing a period from left to right and decreases when going down a group of the periodic table.

2/ Elements at the bottom and left of the periodic table tend to easily give up their valence electrons to a partner when forming a chemical bond. They are said to be electropositive.

3/ Elements at the top and right of the periodic table tend to easily capture valence electrons from a partner when forming a chemical bond. They are said to be electronegative.

The difference in electronegativity between bonded atoms A and B:

$$\chi\,(A\text{-}B) = \chi(A) - \chi(B)$$

is therefore a direct measure of the electronic distribution of the valence electrons which ensure the chemical bond. This difference is the criterion which makes it possible to classify chemical bonds.

## V. Metals and non-metals:

There are two main classes of elements in the periodic table, metals and non-metals:

• Metals: the outermost s and p orbitals generally contain fewer than 4 electrons.

• Non-metals: the number of external electrons s and p is equal to or greater than 4.

• In chemical reactions, non-metals tend to capture electrons to acquire the stable configuration of noble gases.

**Example:**

$$S + 2e \longrightarrow S^{2-}$$

• In the other case, metals easily lose their external electrons to acquire the stable configuration of the noble gases which precede them.

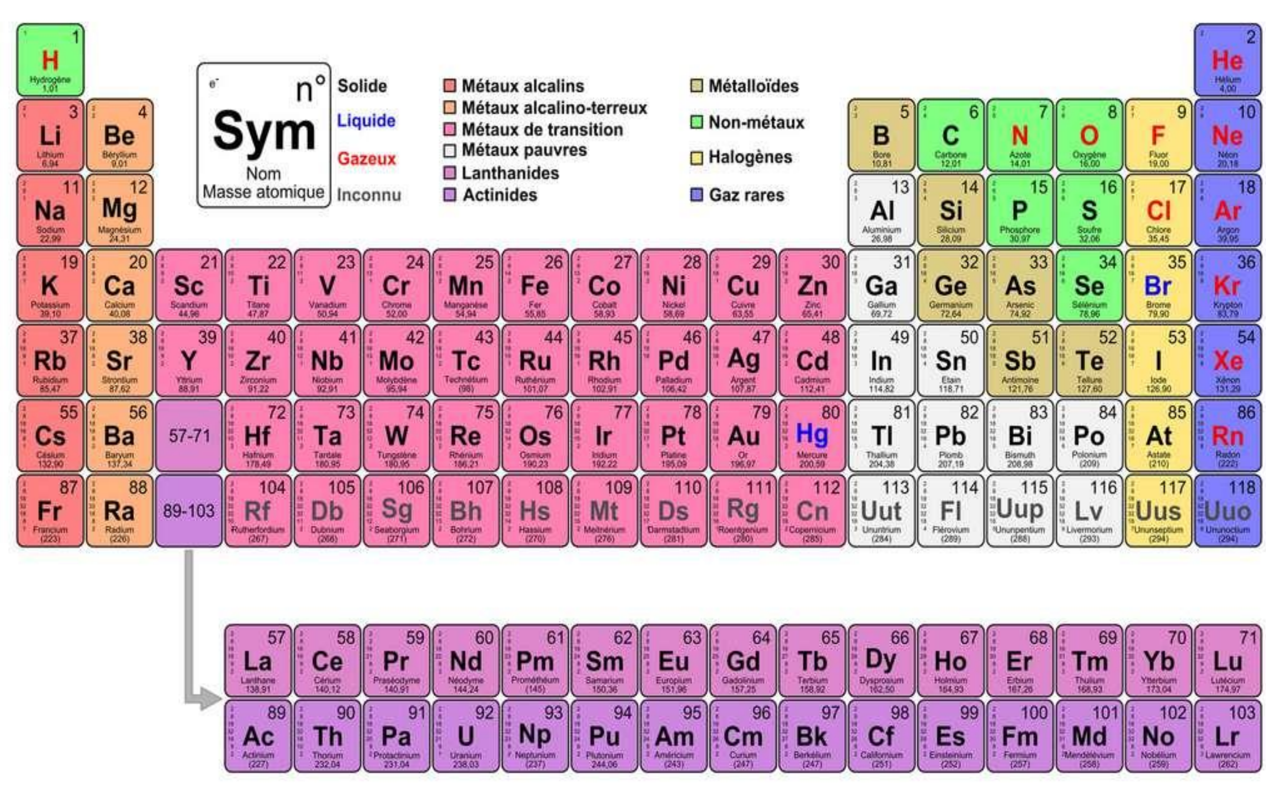
**Example:**

$$Ca \longrightarrow Ca^{+2} + 2e.$$

• In the scale of electronegativities, non-metals will be placed on the side of high electronegativities and metals on the side of low electronegativities.

• At the boundary between these two classes are the intermediate elements which exhibit the character of both metals and non-metals. Hydrogen, the first element of the periodic table, has only one electron. Like the metals of the first column it can easily lose this electron: $H \longrightarrow H^+ + 1é$, to have the stable configuration of a rare gas, like the non-metals of group VIIA it can also gain an electron: $H + 1e \longrightarrow H^-$.

## Annex 1 :




**Periodic table of elements**

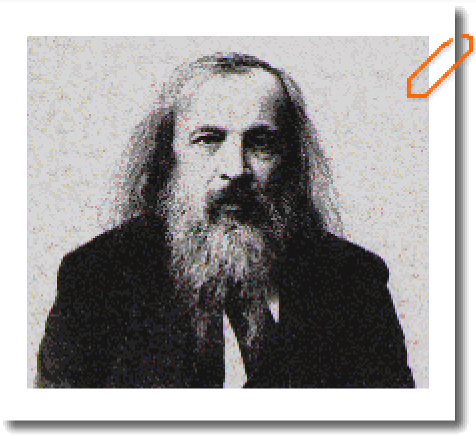
# Annex 2 :

## Who is Dimitri Mendeleev?

Dimitri Mendeleev, a Russian chemist, was the first to propose in 1869 the most elaborate and complete classification of the 66 chemical elements known at the time.

## The classification ?

He arranged the elements in ascending order of their atomic mass by going down the line so that atoms with similar properties were one below the other, thus forming a family.



mendeleiev (1834 - 1907)