MOHAMED KHIDER UNIVERSITY OF BISKRA.

FACULTY OF EXACT SCIENCES AND NATURAL AND LIFE SCIENCES

DEPARTMENT OF BIOLOGY

COURSE TITLE: General Chemistry I

CHAPTER III: Part 3

Level: 1st year LMD

Dr: Ismail DAOUD

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1.4. Periodic classification

1.4.1. Group (Column), Period (Line)

1.4.2. Evolution of physical properties within the periodic table: radius atomic, ionization energy, electron affinity….

1.4. Periodic classification of elements

Mendeleev's classification (1869) initially based on the classification of elements by increasing atomic mass; the modern classification is based on the classification of elements by increasing atomic number Z, therefore based on the electronic structure of atoms.

- We have in the periodic table:

- 4 blocks (s, p, d, f).
- 7 lines (horizontal) called "periods or shells"
- 18 columns (vertical) called "families or groups".

1.4.1. Group, Period and Blocks:

a. The period (Line):

There are 7 periods (3 short periods and 4 long periods).

The elements of the same period have the same value of the principal quantum number "n".

Note that after having written the electronic structure of an element, the highest principal quantum number "n" will tell us about the period of this element.

For example:

$_{26}Fe$: $1s^2 /2s^2\ 2p^6/3s^2\ 3p^6 /3d^6 4s^2$, the period: 4.

Note:

Most of the elements in these two families are radioactive, so Klechkowski's rule is not applicable to them.

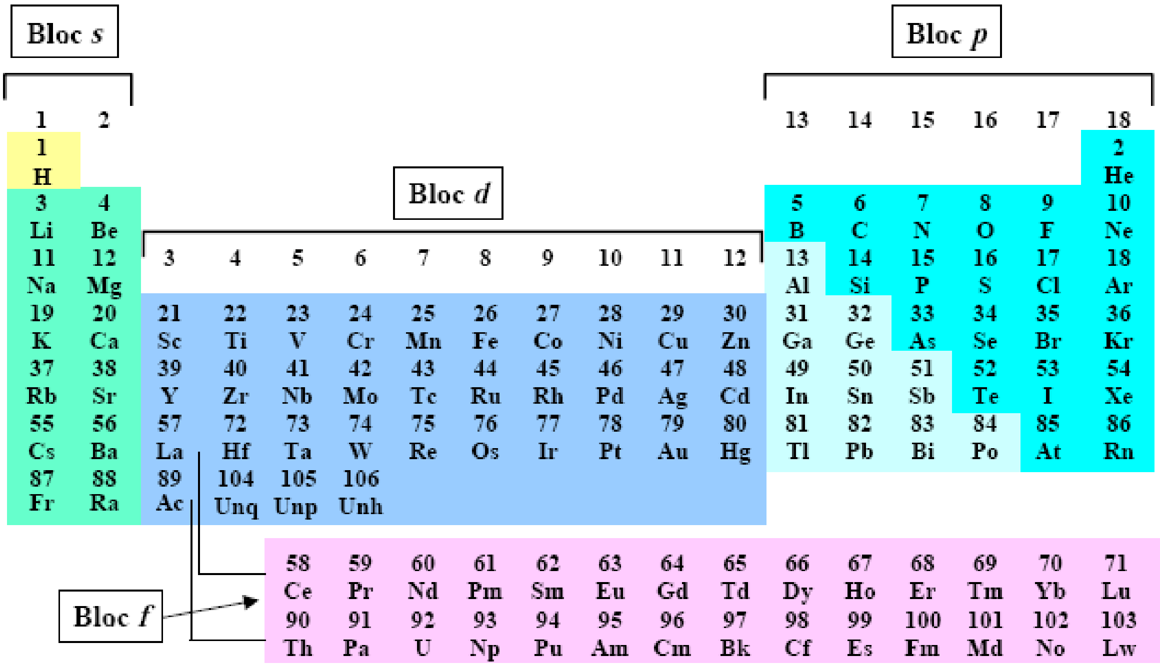
b. The group (Column):

Elements belonging to the same column generally have the same external electronic structure, therefore often similar chemical or physical properties (be careful: do not generalize!).

a. Blocks:

There are 4 blocks in the periodic table: (s, p, d, f).

Periodic table:



1.4.2. Procedure for determining group and subgroup A and B:

Using groups A and B (numbers written in Roman numerals: I, II, etc.).

The elements of blocks s and p belong to group A

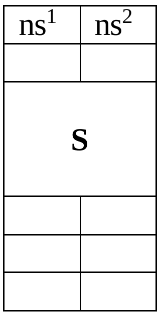
The elements of blocks d and f belong to group B.

As a reminder, some useful Roman numerals: I(1), II(2), III(3), IV(4), V(5), VI(6), VII(7), VIII(8), IX(9) and X(10).

a. Procedure for determining group and subgroup A:

All you have to do the sum of electrons in the last shell (valence shell, peripheral shell).

Block « S » :



2 Column (Group 1 and 2) ⇒ because subshell S has two electrons.

1^{rst} Column (Group): ns^1 (n= 1,…,7)

2^{nd} Column (Group): ns^2 (n= 1,…,7)

Block S: block of metals except hydrogen

Example :

- $_{37}Rb$: [$_{36}Kr$] $5s^{\mathbf{1}}$:

=> $_{37}Rb$ belongs to: **I A**

Block: **S**

Group: **I** (because it has 1 valence electron)

Subgroup: **A** (because it belongs to block S)

Period: n=5 (line 5)

Block « P » :

6 Column (Group 13 -18) ⇒ because subshell P has six electrons.

1rst Column (Group): ns^2np^1 ⇒ **IIIA**

2nd Column (Group): ns^2np^2 ⇒ **IVA**

3rd Column (Group): ns^2np^3 ⇒ **VA**

4th Column (Group): ns^2np^4 ⇒ **VIA**

5th Column (Group): ns^2np^5 ⇒ **VIIA**

6th Column (Group): ns^2np^6 ⇒ **VIIIA**

ns^2np^1	ns^2np^2	ns^2np^3	ns^2np^4	ns^2np^5	ns^2np^6
P					

Block P: block of non-metals.

Note: $_2$He: $1s^2$ is classified in column 18 because it has the same properties as rare gases.

Example :

- $_{33}$As : $1s^2$/ …………….,/$4s^2 4p^3$

=> Rb belongs to: **VA**

Block: **P**

Group: **V** (because it has (2+3) = 5 valence electron)

Subgroup: **A** (because it belongs to block P)

Period: n=4 (line 4)

b. Procedure for determining group and subgroup B:

For the elements belonging to the group and subgroup, the valence shell will be of the form:

$$ns^X\ (n\text{-}1)\mathbf{d}^y \quad \text{or} \quad (n\text{-}1)\mathbf{d}^y\ ns^X$$

The sum (x+y) of the electrons will tell us about the group of the element:

Case 1:

When: 3 ≤ (x+y) ≤ 7 => The corresponding elements will belong to groups: **IIIB**, **IVB**, **VB**, **VIB** and **VIIB**.

3rst Column (Group): $ns^2(n\text{-}1)d^1$ ⇒ **IIIB**

4nd Column (Group): $ns^2(n\text{-}1)d^2$ ⇒ **IVB**

5rd Column (Group): $ns^2(n\text{-}1)d^3$ ⇒ **VB**

6th Column (Group): $ns^2(n\text{-}1)d^4$ ⇒ $ns^1(n\text{-}1)d^5$ ⇒ **VIB**

7^{th} Column (Group): $ns^2(n\text{-}1)d^5$ ⇒ **VIIB**

Example:

$_{40}Zr$: $1s^2$, …., $/5s^2\ 4d^2$;

=> $_{40}Zr$ belongs to: **IVB**

Block: **d**

Group: **IV** (because it has (x+y=2+2) = 4 valence electron)

Subgroup: **B** (because it belongs to block d)

Period: n=5 (line 5)

Case 2:

When: $8 \leq (x+y) \leq 10$ => The corresponding elements will belong to group **VIIIB (1, 2 and 3)**.

If x+y= 8 ⇒ **8^{th} Column** (Group): $ns^2(n\text{-}1)d^6$ ⇒ **VIIIB (1)**

If x+y= 9 ⇒ **9^{th} Column** (Group): $ns^2(n\text{-}1)d^7$ ⇒ **VIIIB (2)**

If x+y= 10 ⇒ **10^{th} Column** (Group): $ns^2(n\text{-}1)d^8$ ⇒ **VIIIB (3)**

Example:

$_{45}Rh$: $1s^2$, ….., $/5s^2\ 4d^7$;

=> $_{45}Rh$ belongs to: **VIII B(2)**

Block: **d**

Group: **VIII** (because it has (x+y=2+7 = 9) 9 valence electrons)

Subgroup: **B** (because it belongs to block d)

Period: n=5 (line 5)

Case 3:

- When: Quand : (x+y) > **10** ⇒ The corresponding elements:

11^{th} Column (Group): $(n\text{-}1)\ d^{10}\ ns^1$ => will belong to group **IB**

12^{th} Column (Group): $(n\text{-}1)\ d^{10}\ ns^2$ => will belong to group **IIB**

Example:

$_{29}Cu$: $1s^2\ /2s^2\ 2p^6\ /3s^2\ 3p^6\ /3d^9\ 4s^2$ ⇒ $_{29}Cu$: $[_{18}Ar]\ 3d^9\ 4s^2$ ⇒ $_{29}Cu$: $[_{18}Ar]\ 3d^{10}\ 4s^1$

=> $_{29}Cu$: belongs to: **I B**

Block: **d**

Group: **I** (because it has (x+y=10+1 = 11) 11 valence electrons); it is necessary to count the electrons of subshell S because the subshell d is saturated

Subgroup: **B** (because it belongs to block d)

Period: n=4 (line 4)

Block d: block of transition metals.

1.4.3. The main families (Columns)

a. S block Families

Column 1: Alkaline metals (except hydrogen because it is a special case), Simple bodies: metals (monoatomic).

The external electronic structure is: ns^1

They give monovalent cations: Na^+, K^+…

Column 2: Alkaline-earth metals: Simple bodies: metals (diatomics)

The external electronic structure is: ns^2

They give bivalent cations: Mg^{2+}, Ca^{2+} …

b. P block Families

Column 13: the boron family

The external electronic structure of these elements is: ns^2 np^1

Column 14: the carbon family

The external electronic structure is: ns^2np^2

They form mainly covalence bonds.

Column 15: the nitrogen family

The external electronic structure is: ns^2np^3

They give mainly covalence bonds

Column 16: the oxygen family or chalcogens

Their external electronic structure is: ns^2np^4

They give bivalent anions: O^{2-}, S^{2-} ...

Column 17: halogens

Their external electronic structure is: ns^2np^5

They give monovalent anions: F^-, Cl^-, Br^- ...

Column 18: rare gases (noble gases or inert gases).

The external electronic structure is: ns^2np^6, except for He ($1s^2$).

The rare gas configuration is the saturation of the outer electronic shell

c. d block Families

Columns 3 to 12: transition metals

Their external electronic structure is: $(n-1)d^x$, ns^2 (ns^1 or ns^0) with $1 \leq x \leq 10$.

They give cations with multiple valences: Fe^{2+}, Fe^{3+}, Cu^+, Cu^{2+} ...

1.4.5. Evolution of physical periodicities within the periodic table

The elements of the periodic table are divided according to their physicochemical properties.

a. The atomic radius:

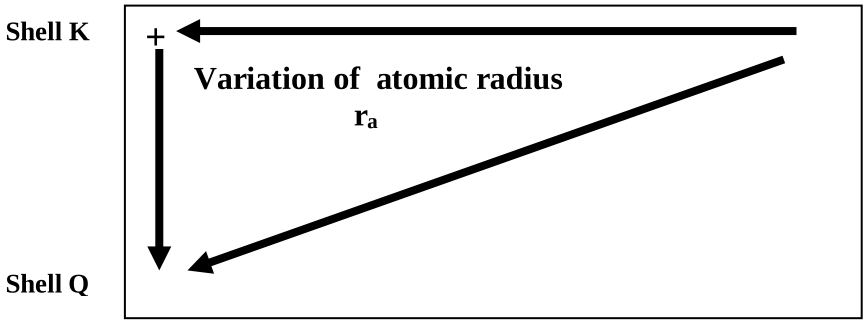
The radius of the atom decreases (↓) from left to right in the same period, because Z (charge of the nucleus) => the force of attraction (nucleus-electron of the internal shells) increases.

The radius increases (↑) when we go from shell K to shell Q (going down in the same column, the number of shell increases) => the force of peripheral nucleus-electron attraction decreases.

Example:

The same period (n=2): $_{11}Na$, $_{15}P$, $_{18}Ar$ ($_{11}Na > _{15}P > _{18}Ar$)

The same group (IIA): $_{4}Be$, $_{20}Ca$, $_{56}Ba$ ($_{4}Be < _{20}Ca < _{56}Ba$)



b. Ionization energy (Ei)

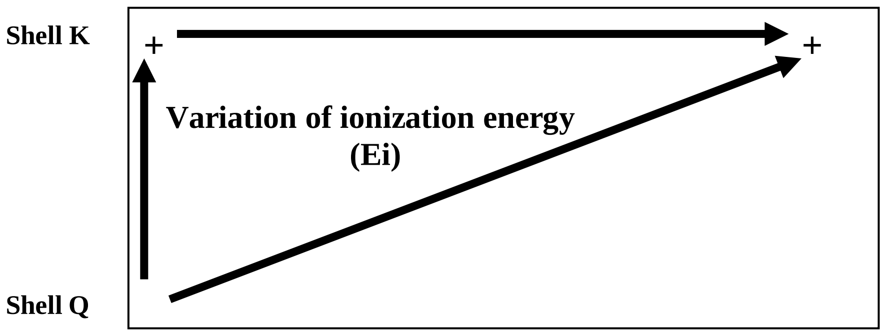
This is the energy necessary to remove one or more electrons from an atom A:

$$A + \mathbf{Ei} \longrightarrow 1\,e^- + A^+$$

To remove an electron from an atom, it is necessary to provide energy greater than the force of attraction which binds this electron to the nucleus.

The higher the force of attraction (↑) ⇒ the smaller r (↓), the more energy must be provided to remove this electron, the greater Ei (↑).

The ionization energy increases (↑) from left to right along the same period, it increases (↑) when we go up from the Q shell towards the K shell.



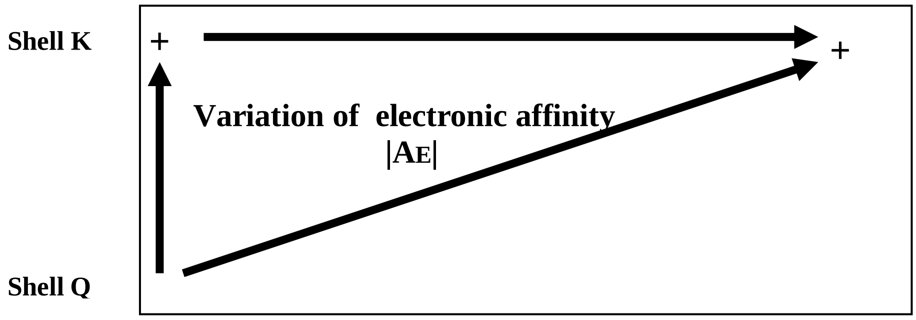
c. ***Electronic Affinity (AE)***

This is the energy released when an electron is captured by an atom:

$$A + 1e^- \longrightarrow A^- + \mathbf{AE}$$

Ionization energy = Electronic affinity in absolute value.

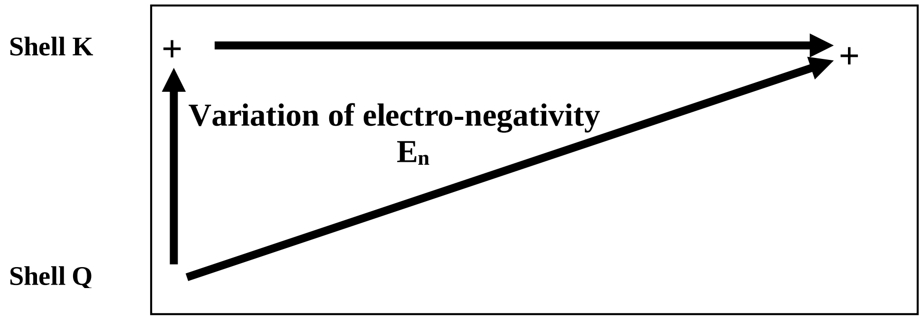
The affinity taken in absolute value varies in the same way as the ionization energy. This energy is negative because the atom releases it.



d. Electro-negativity (En)

Electro-negativity is the ability of an atom to attract one or more electrons. In the period, electro-negativity increases with Z. In a group, it decreases as Z increases.

Overall, the electro-negativity increases in the oblique direction going from Cesium (Cs) to Fluorine (F).



Summary:

The same period, when Z ↑ → r_a ↓, Ei ↑, |AE| ↑, En ↑

The same group, when Z ↑ → r_a ↑, Ei ↓, |AE| ↓, En ↓