

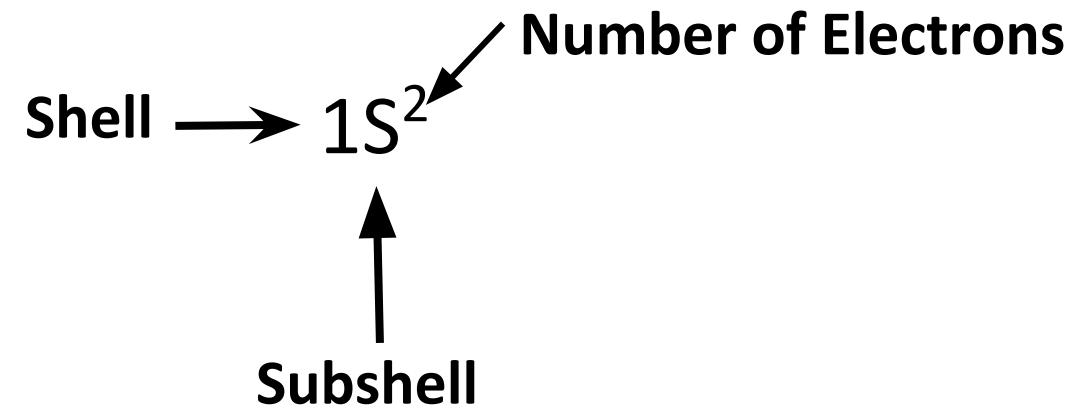
CHAPTER V

ELECTRONIC CONFIGURATIONS AND PERIODIC PROPERTIES OF ELEMENTS

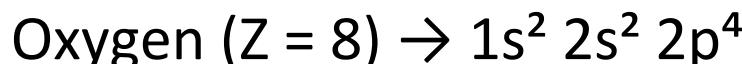
I/ Electronic configuration of the elements of the periodic table

I.1/ The Electronic Configuration of Representative Elements

Electronic configuration shows how electrons are arranged in an atom. It tells us where the electrons are — in which energy levels and orbitals.



Example



I.2/The Main Principles of Electronic Configuration

The electronic configuration follows three main principles:

✓ Energy Levels of Subshells and the Filling of Orbitals

According to this principle, electrons fill orbitals starting with the lowest energy and moving to higher ones. The same rule applies inside each subshell. This way, the atom keeps its lowest total energy.

Experiments show that orbitals are filled in the following order of increasing energy (with some small exceptions):

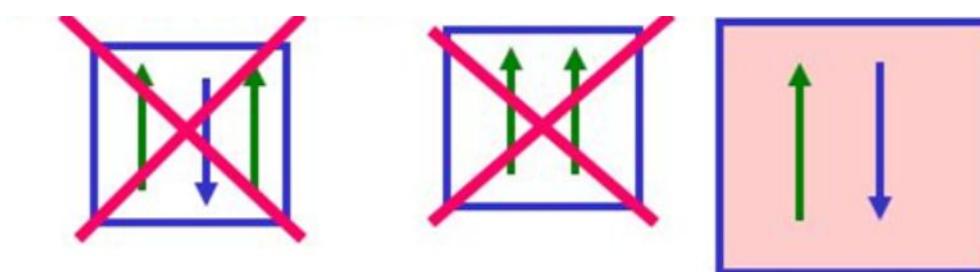
1s → 2s → 2p → 3s → 3p → 4s → 3d → 4p → 5s → 4d → 5p → 6s → 4f → 5d → 6p → 7s → 5f → 6d → 7p

✓ The Pauli Exclusion Principle

The Pauli Exclusion Principle states that no two electrons in the same atom can have the same set of four quantum numbers.

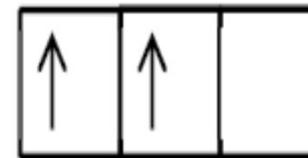
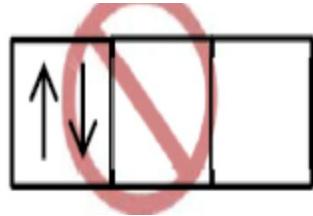
It follows that an atomic orbital can contain no more than two electrons, and these two electrons must have opposite spins.

It is customary to represent orbitals by quantum boxes, which are squares in which electrons are symbolized by arrows (\uparrow or \downarrow). The upward arrow (\uparrow) arbitrarily represents the spin value $+1/2$.



✓ Hund's Rule

Hund's rule states that electrons occupy degenerate orbitals singly first and with parallel spins before pairing up.



I.3/ Definition of the Valence Shell

The valence shell is the outermost electron shell of an atom.

It contains the valence electrons, which are the electrons involved in chemical bonding and reactions.

Example Oxygen ($Z = 8$) $\rightarrow 1s^2 2s^2 2p^4$

In the atom of oxygen ($Z = 8$), the valence shell is the second shell ($n = 2$), which contains six electrons.

I.4/ Electronic configurations of periodic table elements

Each element in the periodic table has a unique electronic configuration. It shows how the electrons are arranged in the different shells and subshells around the nucleus.

The electronic configuration helps us understand the position of the element in the periodic table and explains its chemical properties.

Elements in the same group have similar outer electron configurations, so they show similar chemical behavior.

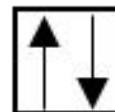
I.4.a/Electronic configuration of s- and p-block elements

✓ Group IA Elements (1)

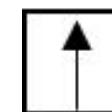
Example : Li ($Z = 3$) : $1s^2 2s^1$

Group IA elements : ns^1 (Paramagnetic element).

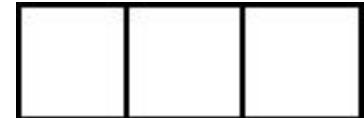
The Group IA belongs to the s-block.



$1s^2$



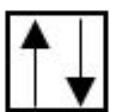
$2s^1$



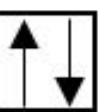
✓ Group IIA Elements (2)

Example: Be ($Z = 4$) : $1s^2 2s^2$

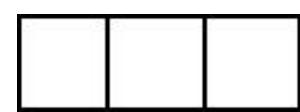
Group IIA elements : ns^2 (Diamagnetic element).



$1s^2$



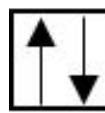
$2s^2$



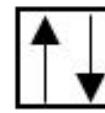
The Group IIA belongs to the s-block.

✓ Group IIIA Elements (13)

Example : B ($Z = 5$) : $1s^2 2s^2 2p^1$



$1s^2$



$2s^2$



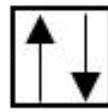
$2p^1$

Group IIIA elements : $ns^2 np^1$ (Paramagnetic element).

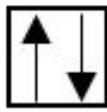
The Group IIIA belongs to the p-block.

✓ Group VIA Elements (14)

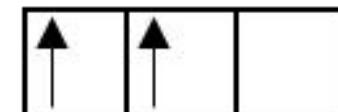
Example : C ($Z = 6$) : $1s^2 2s^2 2p^2$



$1s^2$



$2s^2$



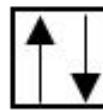
$2p^2$

Group IVA elements : $ns^2 np^2$ (Paramagnetic element).

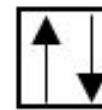
The Group IVA belongs to the p-block.

✓ The Group VA Elements (15)

Example : N (Z = 7) : $1s^2 2s^2 2p^3$



$1s^2$



$2s^2$

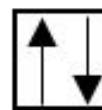


Group VA elements : $ns^2 np^3$ (Paramagnetic element).

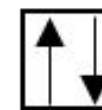
The Group VA belongs to the p-block.

✓ The Group VIA Elements (16)

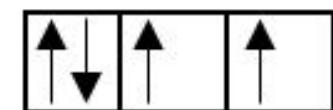
Example : O (Z = 8) : $1s^2 2s^2 2p^6$



$1s^2$



$2s^1$

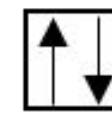


Group VIA elements : $ns^2 np^6$ (Paramagnetic element).

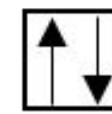
The Group VIA belongs to the p-block.

✓ The Group VIIA Elements (17)

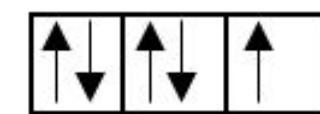
Example: F (Z = 9) : $1s^2 2s^2 2p^5$



$1s^2$



$2s^1$

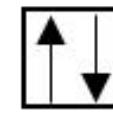


Group VIIA elements : $ns^2 np^5$ (Paramagnetic element).

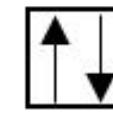
The Group VIIA belongs to the p-block.

✓ The Group VIIIA Elements (18)

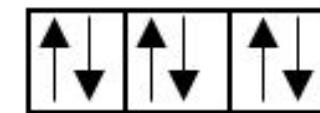
Example : Ne (Z = 10) : $1s^2 2s^2 2p^6$



$1s^2$



$2s^1$



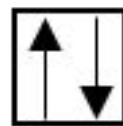
Group VIIIA elements : $ns^2 np^6$ (Diamagnetic element).

The Group VIIIA belongs to the p-block.

I.4.b/ The electronic configuration of transition elements

✓ Group IIIB

Example : Sc ($Z = 21$) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$



$4s^2$



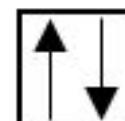
$3d^1$

The elements of group IIIB: $ns^2 (n-1)d^1$ (Paramagnetic element).

Group IIIB belongs to the D block.

✓ Group IVB

Example : Ti ($Z = 22$) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$



$4s^2$



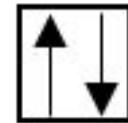
$3d^2$

The elements of group IVB: $ns^2 (n-1)d^2$ (Paramagnetic element).

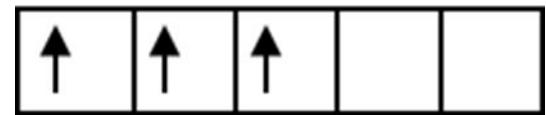
Group IVB belongs to the D block.

Group VB

✓ Example : V ($Z = 23$) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$



$4s^2$



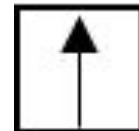
$3d^3$

The elements of group VB: $ns^2 (n-1)d^3$ (Paramagnetic element).

Group VB belongs to the D block.

✓ Group VIB

Example : Cr ($Z = 24$) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$



$4s^1$



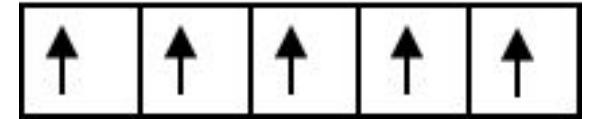
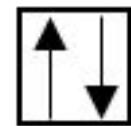
$3d^5$

The elements of group VIB: $ns1 (n-1)d^5$ (Paramagnetic element).

Group VIB belongs to the D block.

✓ Group VIIIB

Example : Mn ($Z = 25$) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$



$4s^2$

$3d^5$

The elements of group VIIIB: $ns^2 (n-1)d^5$ (Paramagnetic element).

Group VIIIB belongs to the D block.

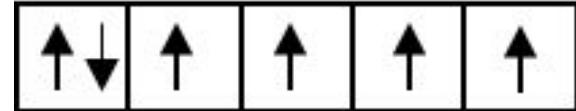
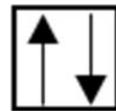
✓ Group VIIIB

Example :

Fe ($Z = 26$) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

Co ($Z = 27$) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$

Ni ($Z = 28$) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$



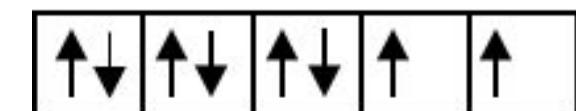
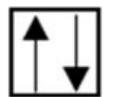
$4s^2$

$3d^6$



$4s^2$

$3d^7$



$4s^2$

$3d^8$

$ns^2 (n-1)d^6$ (Paramagnetic element).

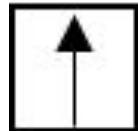
The elements of group VIIIB*: $ns^2 (n-1)d^7$ (Paramagnetic element).

$ns^2 (n-1)d^8$ (Paramagnetic element).

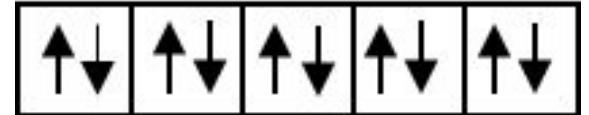
Group VIIIB belongs to the D block.

✓ Group IB

Example : Cu (Z =29) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$



$4s^1$



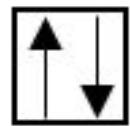
$3d^{10}$

The elements of group IB: $ns^2 (n-1)d^{10}$ (Paramagnetic element).

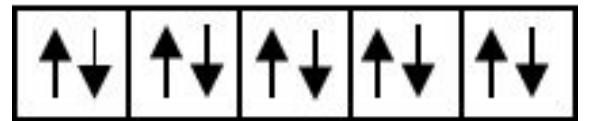
Group IB belongs to the D block.

✓ Group IIB

Example : Zn (Z =30) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$



$4s^2$



$3d^{10}$

The elements of group IIB: $ns^2 (n-1)d^{10}$ (Diamagnetic element).

Group IIB belongs to the D block.

II/ The Periodic Table and the Properties of Elements

II.1/The Periodic Table

The classification proposed by Dmitri Ivanovich Mendeleev

- ✓ In a period, the elements have the same value of n (the principal quantum number) for their valence shell.
 - ✓ In a group, the elements have the same valence configuration.

Note

Helium belongs to the S block but is classified in the P block because it has the same chemical properties as the elements in the last column.

Periodic Table of Elements																		
I		II																
1	H	II																
2	Li	Be																
3	Na	Mg																
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Tb	Te	I	Xe
6	55 Cs	56 Ba	La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	13 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo
	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu			
	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr			

The periodic table contains 7 periods and 18 columns (the f block is set apart).

- ✓ IA and IIA → S block: ns¹ and ns².
- ✓ IIIA, IVA, VA, VIA, VIIA, and VIIIA → P block: ns² np^x.
- ✓ IB, IIB, IIIB, IVB, VB, VIB, VIIB, and VIIIB → D block: (n-1)d^x ns².
- ✓ 4f: Lanthanides (14 elements). 5f: Actinides (14 elements). → F block: (n-2)f^x (n-1)d^y ns².

A detailed periodic table of elements showing atomic number, symbol, name, and average atomic mass for each element. The table includes groups 1 through 18 and the noble gases He, Ne, Ar, Kr, Xe, and Rn. It also includes the lanthanide and actinide series at the bottom. A legend identifies the color coding for different element categories: Alkali Metals (yellow), Alkaline Earth Metals (orange), Transition Metals (blue), Other Metals (dark blue), Non-metals (pink), Halogens (light blue), Noble Gases (purple), Lanthanides (red), and Actinides (green). The table is framed by a black border.

GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
PERIOD 1	H Hydrogen 1.008	Be Beryllium 9.012											Pt Platinum 195.1					He Helium 4.003
2	Li Lithium 6.94	Mg Magnesium 24.31											B Boron 10.81	C Carbon 12.01	N Nitrogen 14.01	O Oxygen 16.00	F Fluorine 19.00	Ne Neon 20.18
3	Na Sodium 22.99	Mg Magnesium 24.31	Sc Scandium 44.96	Ti Titanium 47.88	V Vanadium 50.94	Cr Chromium 52.00	Mn Manganese 54.94	Fe Iron 55.85	Co Cobalt 58.93	Ni Nickel 58.69	Cu Copper 63.55	Zn Zinc 65.39	Ga Gallium 69.72	Ge Germanium 72.61	As Arsenic 74.94	Se Selenium 78.96	Br Bromine 79.90	Kr Krypton 83.80
4	K Potassium 39.09	Ca Calcium 40.08	Sc Scandium 44.96	Ti Titanium 47.88	V Vanadium 50.94	Cr Chromium 52.00	Mn Manganese 54.94	Fe Iron 55.85	Co Cobalt 58.93	Ni Nickel 58.69	Cu Copper 63.55	Zn Zinc 65.39	Ga Gallium 69.72	Ge Germanium 72.61	As Arsenic 74.94	Se Selenium 78.96	Br Bromine 79.90	Kr Krypton 83.80
5	Rb Rubidium 85.47	Sr Strontium 87.62	Y Yttrium 88.91	Zr Zirconium 91.23	Nb Niobium 92.91	Mo Molybdenum 95.96	Tc Technetium 98.00	Ru Ruthenium 101.1	Rh Rhodium 102.9	Pd Palladium 106.4	Ag Silver 107.89	Cd Cadmium 112.4	In Indium 114.8	Sn Tin 118.7	As Antimony 121.8	Te Tellurium 127.6	I Iodine 126.9	Xe Xenon 131.3
6	Cs Cesium 132.9	Ba Barium 137.3	57-71 Lanthanides	Hf Hafnium 178.5	Ta Tantalum 180.9	W Tungsten 183.9	Re Rhenium 186.3	Os Osmium 190.2	Ir Iridium 192.2	Pt Platinum 195.1	Au Gold 197.0	Hg Mercury 200.5	Tl Thallium 204.38	Pb Lead 207.2	Bi Bismuth 209.0	Po Polonium 209.0	At Astatine 210.0	Rn Radon (222)
7	Fr Francium (223)	Ra Radium (226)	89-103 Actinides	Rf Rutherfordium (260)	Db Dubnium (264)	Sg Seaborgium (272)	Bh Bohrium (270)	Hs Hassium (277)	Mt Meitnerium (278)	Ds Darmstadtium (280)	Rg Roentgenium (281)	Cn Copernicium (285)	Nh Nihonium (284)	Fl Florium (285)	Mc Moscovium (286)	Lv Livermorium (294)	Ts Tennessine (294)	Og Oganesson (294)
			57 La Lanthanum 138.9	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.9	61 Pm Promethium 147.0	62 Sm Samarium 150.4	63 Eu Europium 151.9	64 Gd Gadolinium 157.9	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.2	69 Tm Thulium 168.9	70 Yb Ytterbium 173.6	71 Lu Lutetium 175.0	
			59 Ac Actinium (227)	60 Th Thorium (232)	61 Pa Protactinium (231.0)	62 U Uranium (238.0)	63 Np Neptunium (239)	64 Pu Plutonium (244)	65 Am Americium (243)	66 Cm Curium (247)	67 Bk Berkelium (249)	68 Cf Californium (250)	69 Es Einsteinium (257)	70 Fm Fermium (257)	71 Md Mendelevium (258)	72 No Nobelium (259)	73 Lr Lawrencium (259)	

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II.2/ The families of elements

- ✓ **Alkali metals** (Group IA or 1): Very reactive, especially with water. Belong to the **S** block.
Examples: Lithium (Li), Sodium (Na), Potassium (K)
- ✓ **Alkaline earth metals** (Group IIA or 2) : Less reactive than alkali metals. Belong to the **S** block
Examples: Magnesium (Mg), Calcium (Ca), Barium (Ba).
- ✓ **Halogens** (Group VIIA or 17): Very reactive, form salts with metals. Belong to the **p** block
Examples: Fluorine (F), Chlorine (Cl), Iodine (I)
- ✓ **Noble gases** (Group VIIIA or 18): Chemically inert (do not react easily).Belong to the **p** block.
Examples: Helium (He), Neon (Ne), Argon (Ar)

✓ **Transition metals** (Groups IIIB to IIB or 3 to 12): Good conductors of heat and electricity.

Belong to the **d** block.

Examples: Iron (Fe), Copper (Cu), Zinc (Zn)

✓ **Lanthanides**: from Lanthanum (La) to Lutetium (Lu) → **4f**

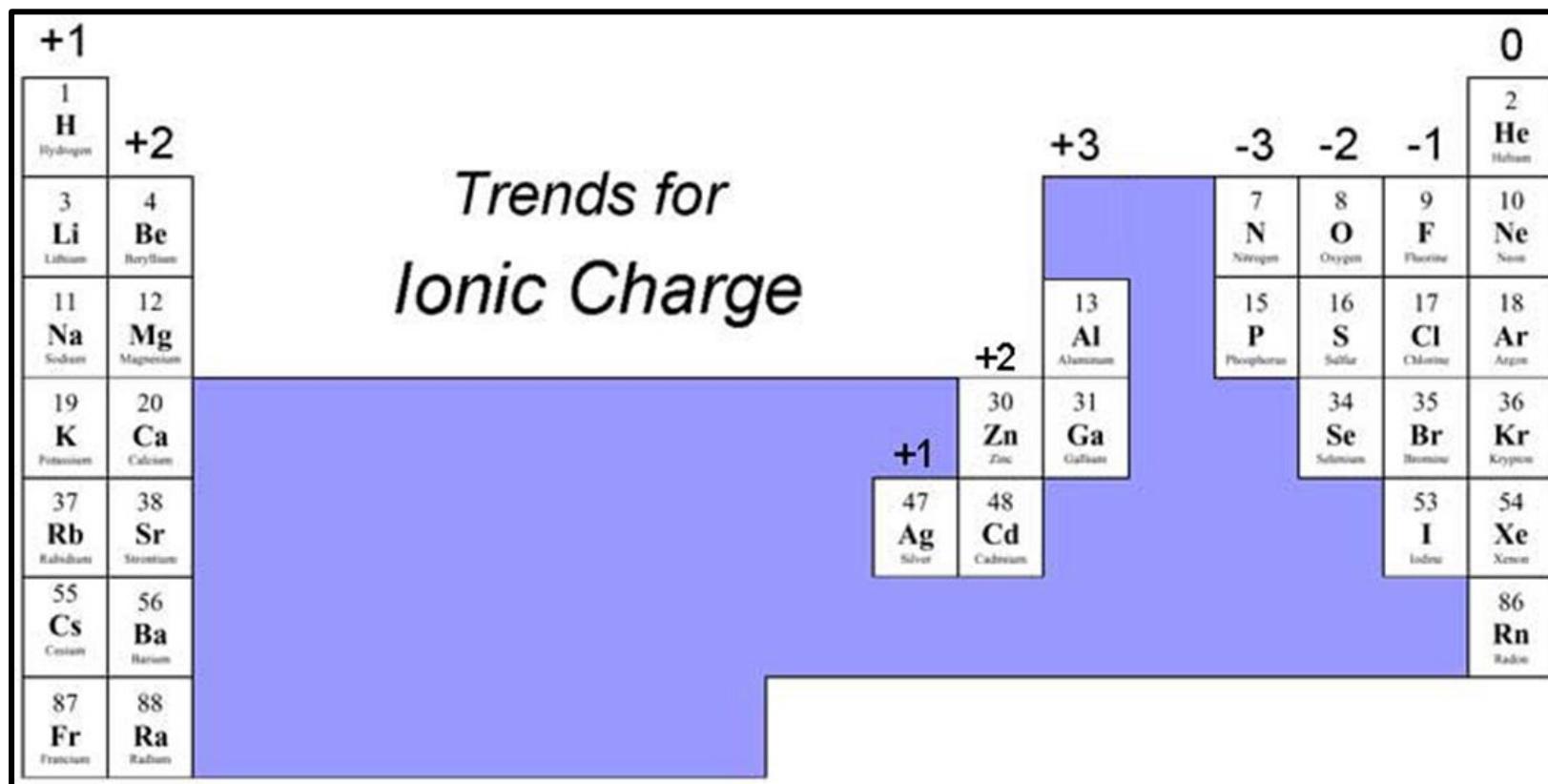
✓ **Actinides**: from Actinium (Ac) to Lawrencium (Lr) → **5f**

Metals often used in industry and technology.

II.3/ The charge of monoatomic ions

All the elements in the same family form ions with the same charge.

Elements gain or lose electrons to obtain the (stable) electronic configuration of the nearest noble gas in the periodic table.



II.4/ Trends of covalent radius across the periodic table

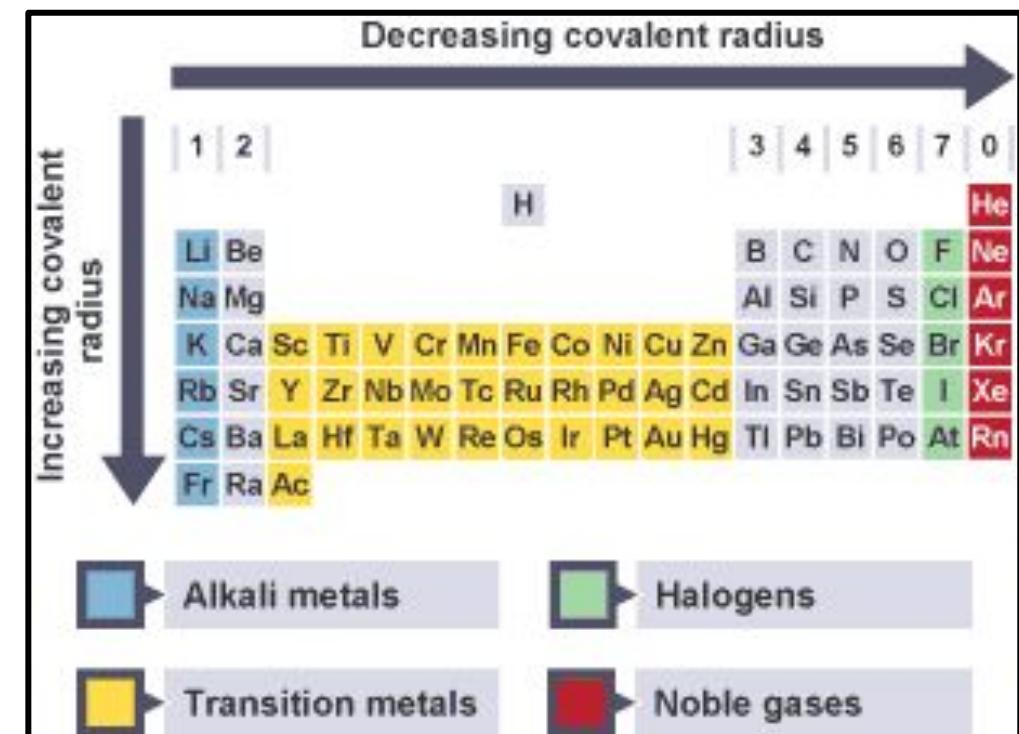
The covalent radius is half the distance between the nuclei of two identical atoms joined by a covalent bond.

The radius decreases when we move from left to right in a period. It decreases because the nuclear charge increases, and the electrons are more attracted to the nucleus.

The radius increases when we move from top to bottom in a group because when we go down the table, extra electron shells are added.

Note

Cations are always smaller than their parent (neutral) atoms because they have one less electron, while anions are larger because one electron is added to them.

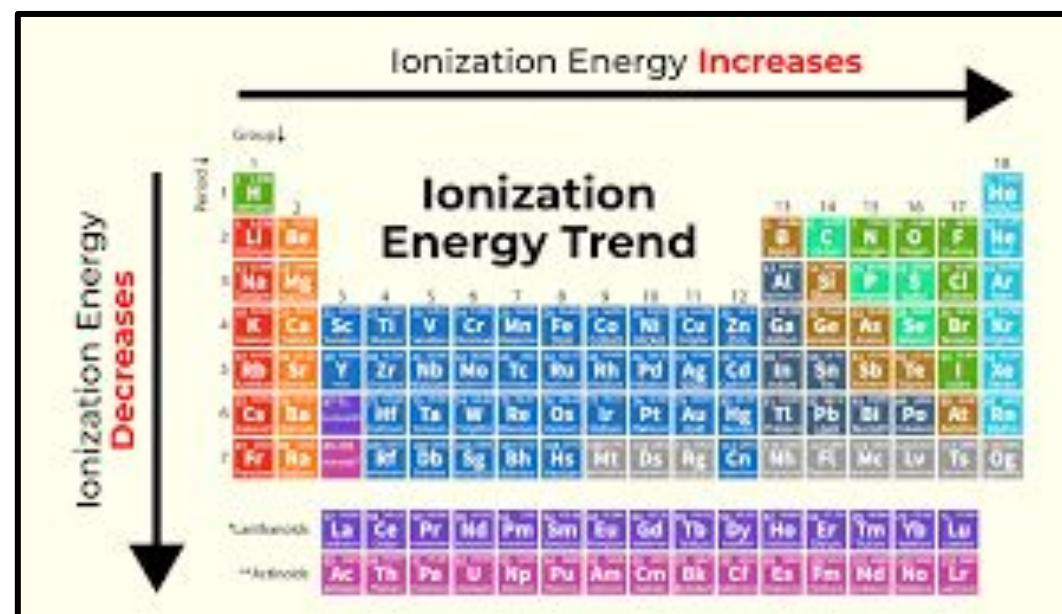


II.4/Trends of ionization energy across the periodic table

Ionization energy is the energy needed to remove one electron from an atom in its gaseous state.

The ionization energy increases from left to right across the table because the atomic radius are smaller, so the electrons are more strongly attracted to the nucleus.

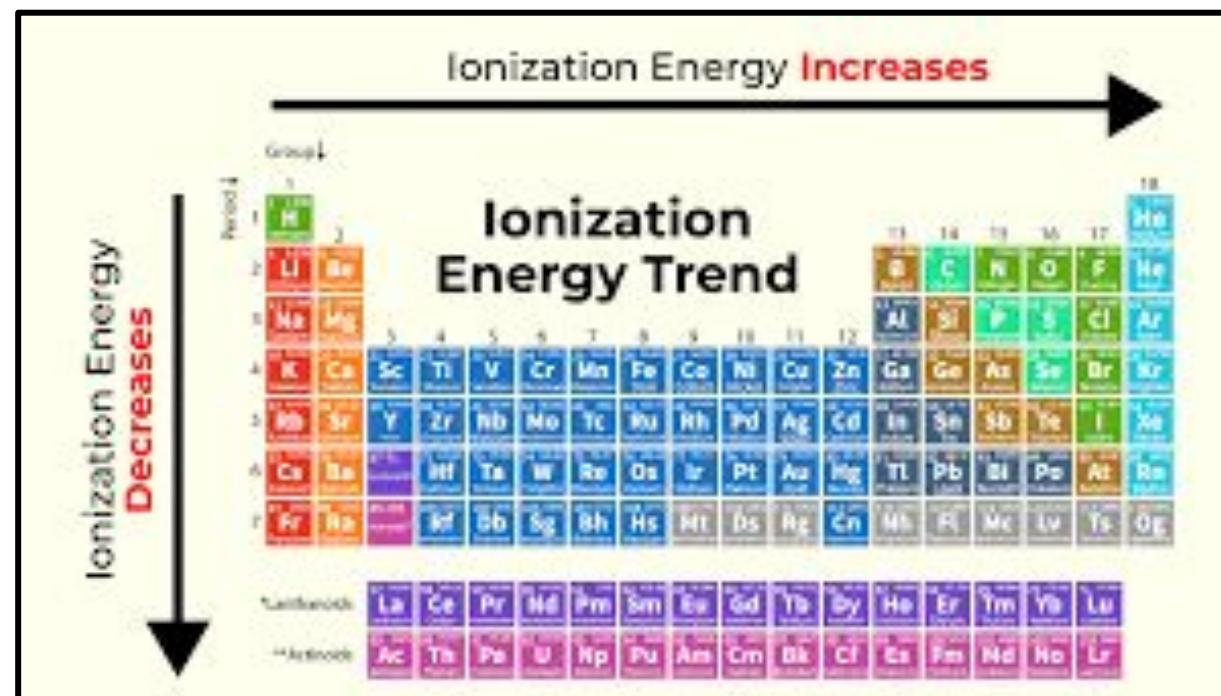
From top to bottom in a group, the ionization energy decreases because the electrons are in shells farther and farther from the nucleus.



The lowest ionization energy is that of the elements in group IA, because when these elements lose one electron, they reach the stable configuration of a noble gas.

The noble gases ($ns^2 np^6$) (He, Ne, Ar, Kr, Xe, Rn) have high ionization energies. This is normal because the process involves breaking a pair of electrons.

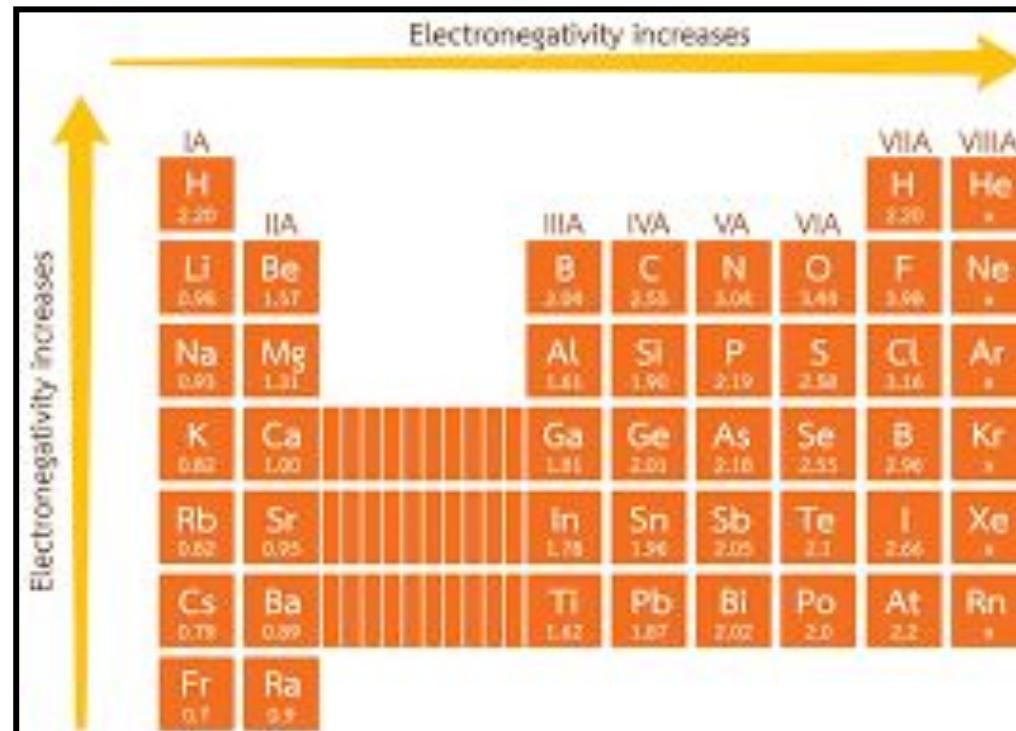
The ionization energy increases when more electrons are removed. This is because the attraction force of the nucleus is stronger in cations.



II.5/ / Trends of electronegativity (χ) across the periodic table

Electronegativity is the ability of an atom to attract the electrons in a chemical bond.

Electronegativity increases from left to right and from bottom to top in the periodic table.



In summary

- ✓ The covalent radius **decreases** from left to right and **increases** from top to bottom.
- ✓ The ionization energy **increases** from left to right and **decreases** from top to bottom.
- ✓ **Cations** are smaller than their parent atoms, while **anions** are larger.
- ✓ **Electronegativity** increases from left to right and from bottom to top.
- ✓ **Noble gases** have very high ionization energies because their electron shells are full.

