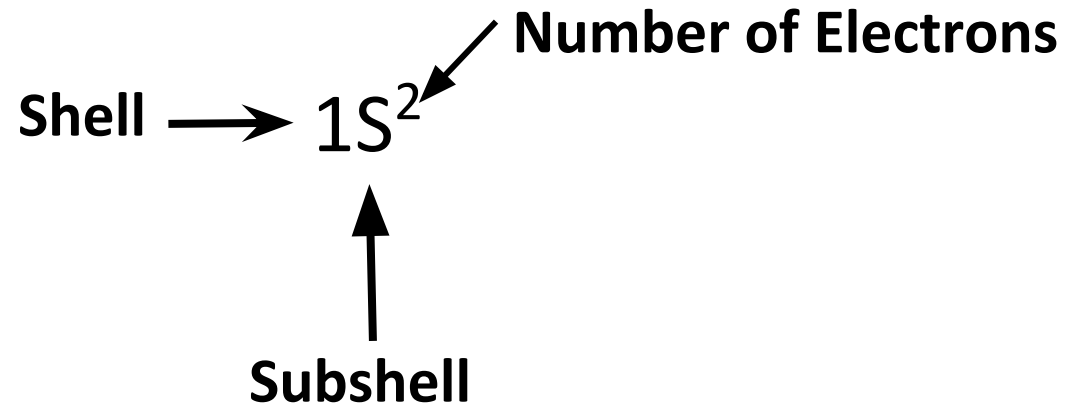


CHAPTER V
ELECTRONIC CONFIGURATIONS AND PERIODIC
PROPERTIES OF ELEMENTS

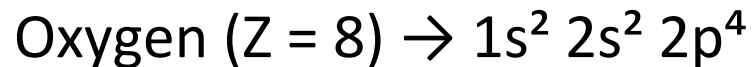
I/ Electronic configuration of the elements of the periodic table

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):

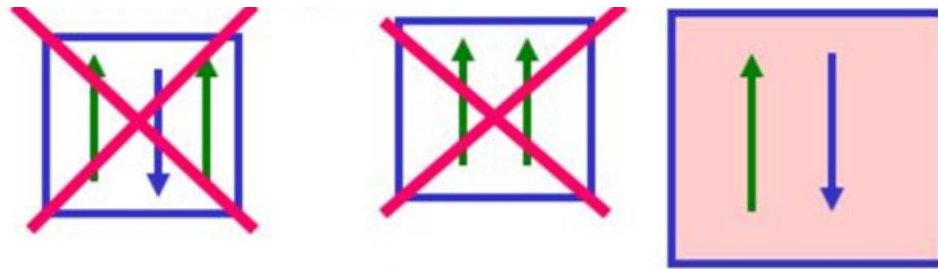
$1s \rightarrow 2s \rightarrow 2p \rightarrow 3s \rightarrow 3p \rightarrow 4s \rightarrow 3d \rightarrow 4p \rightarrow 5s \rightarrow 4d \rightarrow 5p \rightarrow 6s \rightarrow 4f \rightarrow 5d \rightarrow 6p \rightarrow 7s \rightarrow 5f \rightarrow 6d \rightarrow 7p$

✓ 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.

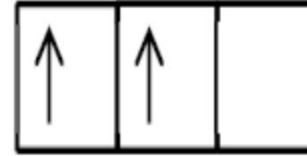
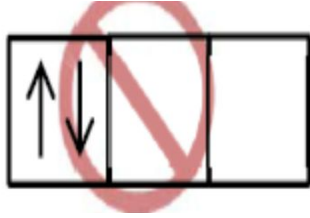
It follows that an atomic orbital can contain no more than two electrons, and these two electrons must have opposite spins.

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.



1.3/ 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.

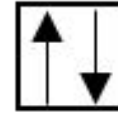
I.4.a/Electronic configuration of s- and p-block elements

✓ Group IA Elements (1)

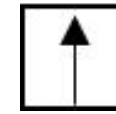
Example : Li ($Z = 3$) : $1s^2 2s^1$

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

The Group IA belongs to the s-block.



$1s^2$



$2s^1$

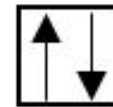


✓ Group IIA Elements (2)

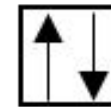
Example: Be ($Z = 4$) : $1s^2 2s^2$

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

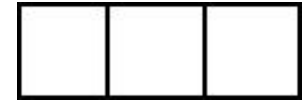
The Group IIA belongs to the s-block.



$1s^2$

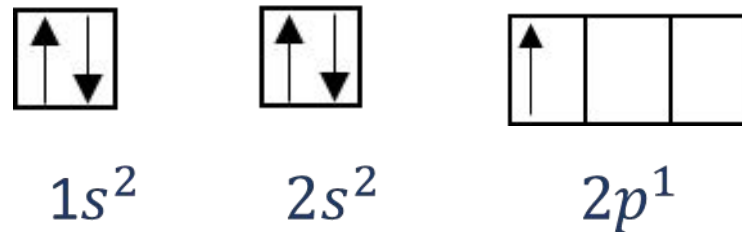


$2s^2$



✓ Group IIIA Elements (13)

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



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

The Group IIIA belongs to the p-block.

✓ Group IVA Elements (14)

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

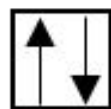


Group IVA elements : $ns^2 np^2$ (Paramagnetic element).

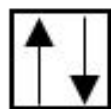
The Group IVA belongs to the p-block.

✓ The Group VA Elements (15)

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



$1s^2$



$2s^2$

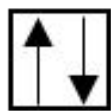


Group VA elements : $ns^2 np^3$ (Paramagnetic element).

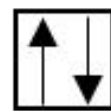
The Group VA belongs to the p-block.

✓ The Group VIA Elements (16)

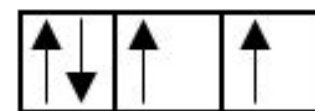
Example : O (Z = 8) : $1s^2 2s^2 2p^6$



$1s^2$



$2s^2$



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

The Group VIA belongs to the p-block.

✓ The Group VIIA Elements (17)

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



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

The Group VIIA belongs to the p-block.

✓ The Group VIIIA Elements (18)

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



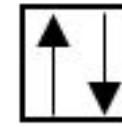
Group VIIIA elements : $ns^2 np^6$ (Diamagnetic element).

The Group VIIIA belongs to the p-block.

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

✓ Group IIIB

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



$4s^2$



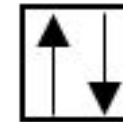
$3d^1$

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) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$



$4s^2$



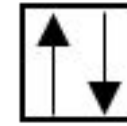
$3d^2$

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) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$



$4s^2$



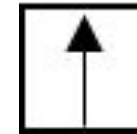
$3d^3$

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) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$



$4s^1$



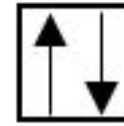
$3d^5$

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

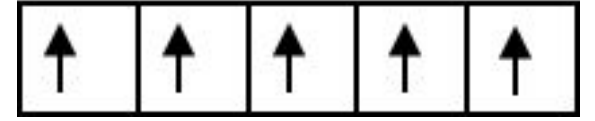
Group VIB belongs to the D block.

✓ Group VIIB

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



$4s^2$



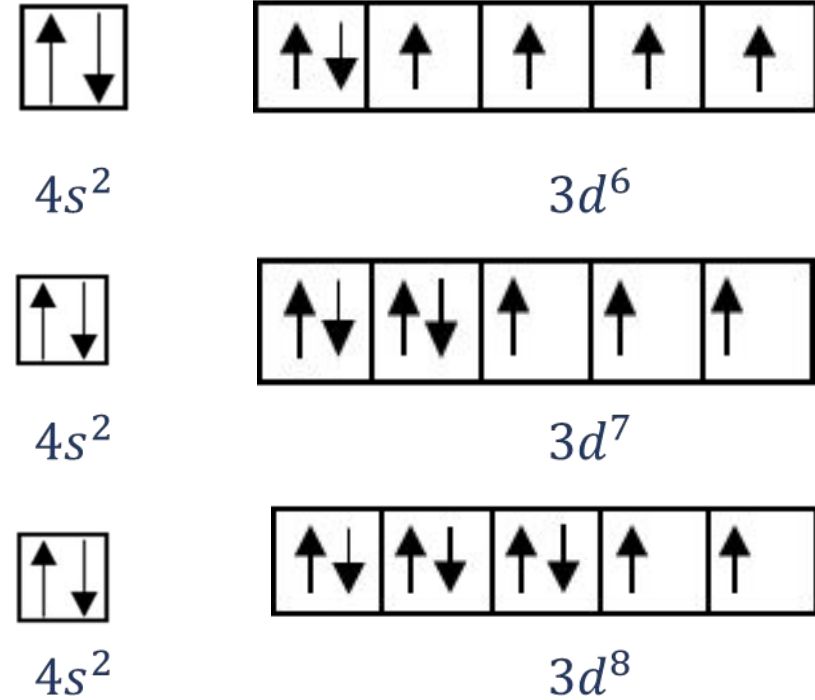
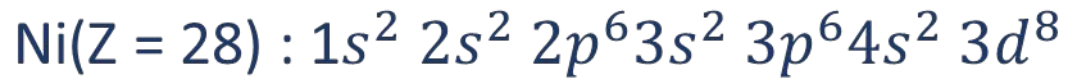
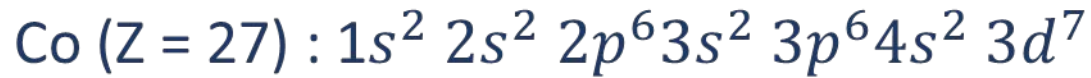
$3d^5$

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

Group VIIB belongs to the D block.

✓ Group VIIIB

Example :



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

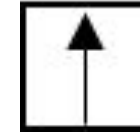
The elements of group VIIB*: $ns^2 (n-1)d^7$ (Paramagnetic element).

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

Group VIIIB belongs to the D block.

✓ Group IB

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



$4s^1$



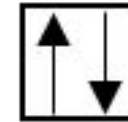
$3d^{10}$

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

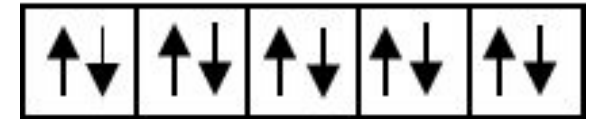
Group IB belongs to the D block.

✓ 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.

The diagram shows a standard periodic table with the following labels:

- Vertical Axis (Left):** Labeled "Period".
- Horizontal Axis (Top):** Labeled "Group".

A red rectangular box highlights the element Nitrogen (N), which is located at Group V and Period 2.

A green rectangular box highlights the entire Period 6, spanning from Group I to Group VIII.

The periodic table includes elements from Hydrogen (H) to Oganesson (Og). The lanthanide and actinide series are shown separately below the main body of the table.

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

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

GROUP	1	2											13	14	15	16	17	18	
PERIOD 1	H Hydrogen 1.008																	He Helium 4.003	
2	Li Lithium 6.94	Be Beryllium 9.012											B Boron 10.81	C Carbon 12.01	N Nitrogen 14.01	O Oxygen 16.00	F Fluorine 18.99	Ne Neon 20.18	
3	Na Sodium 22.99	Mg Magnesium 24.31											Al Aluminum 26.98	Si Silicon 28.09	P Phosphorus 30.97	S Sulfur 32.06	Cl Chlorine 35.45	Ar Argon 39.95	
4	K Potassium 39.10	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 65.38	Ga Gallium 69.72	Ge Germanium 72.64	As Arsenic 74.92	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 91.22	Nb Niobium 92.91	Mo Molybdenum 95.94	Tc Technetium (98)	Ru Ruthenium 101.1	Rh Rhodium 102.9	Pd Palladium 106.4	Ag Silver 107.9	Cd Cadmium 112.4	In Indium 114.8	Sn Tin 118.7	Sb 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 183.8	Re Rhenium 186.2	Os Osmium 190.2	Ir Iridium 192.2	Pt Platinum 195.1	Au Gold 197.0	Hg Mercury 200.6	Tl Thallium 204.4	Pb Lead 207.2	Bi Bismuth 209.0	Po Polonium (209)	At Astatine (210)	Rn Radon (222)
7	Fr Francium (223)	Ra Radium (226)	89-103 Actinides		Rf Rutherfordium (261)	Db Dubnium (262)	Sg Seaborgium (266)	Bh Bohrium (264)	Hs Hassium (277)	Mt Meitnerium (268)	Ds Darmstadtium (271)	Rg Roentgenium (272)	Cn Copernicium (285)	Nh Nihonium (286)	Fl Flerovium (289)	Mc Moscovium (290)	Lv Livermorium (293)	Ts Tennessine (294)	Og Oganesson (294)

Alkali Metals

Alkaline Earth Metals

Transition Metals

Other Metals

Metalloids

Non-metals

Halogens

Noble Gases

Lanthanides

Actinides

78

Pt

Atomic Number

Symbol

Name

Average Atomic Mass

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La Lanthanum 138.9	Ce Cerium 140.1	Pr Praseodymium 140.9	Nd Neodymium 144.2	Pm Promethium (145)	Sm Samarium 150.4	Eu Europium 152.0	Gd Gadolinium 157.3	Tb Terbium 158.9	Dy Dysprosium 162.5	Ho Holmium 164.9	Er Erbium 167.3	Tm Thulium 168.9	Yb Ytterbium 173.0	Lu Lutetium 175.0
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac Actinium (227)	Th Thorium 232.0	Pa Protactinium 231.0	U Uranium 238.0	Np Neptunium (237)	Pu Plutonium (244)	Am Americium (243)	Cm Curium (247)	Bk Berkelium (247)	Cf Californium (251)	Es Einsteinium (252)	Fm Fermium (257)	Md Mendelevium (258)	No Nobelium (259)	Lr Lawrencium (262)

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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.

+1												0		
1 H Hydrogen	+2										2 He Helium			
3 Li Lithium	4 Be Beryllium									7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon	
11 Na Sodium	12 Mg Magnesium									13 Al Aluminum	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon
19 K Potassium	20 Ca Calcium									30 Zn Zinc	31 Ga Gallium	34 Se Selenium	35 Br Bromine	36 Kr Krypton
37 Rb Rubidium	38 Sr Strontium									47 Ag Silver	48 Cd Cadmium	53 I Iodine	54 Xe Xenon	
55 Cs Cesium	56 Ba Barium													
87 Fr Francium	88 Ra Radium													

Trends for Ionic Charge

+3

+2

+1

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

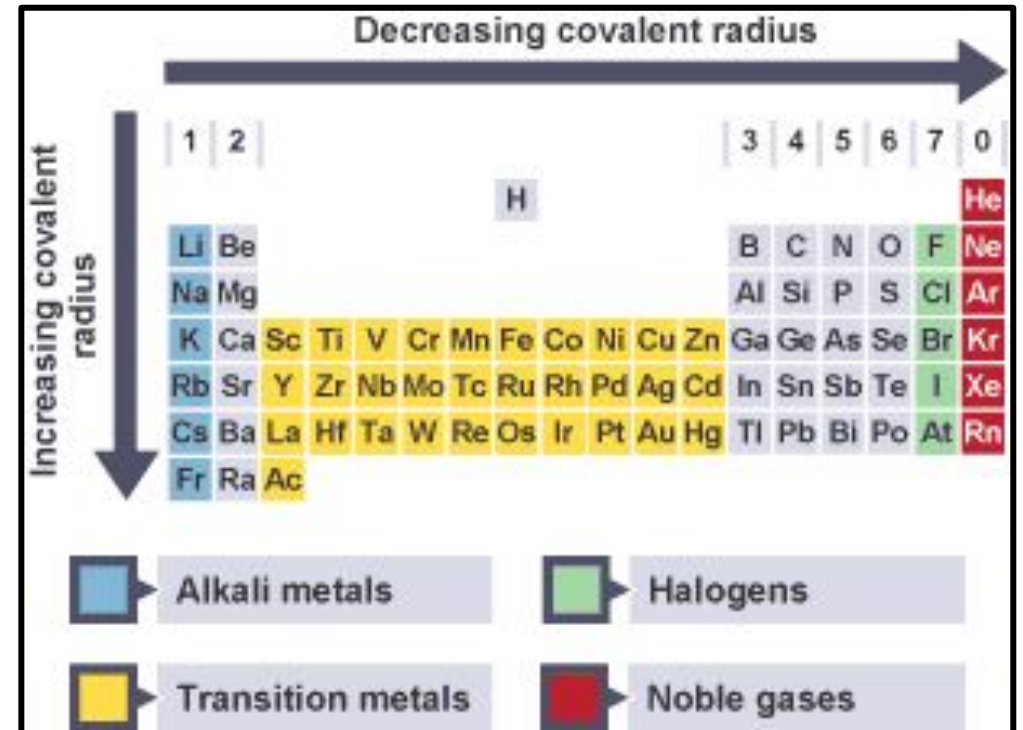
The covalent radius is half the distance between the nuclei of two identical atoms joined by a covalent bond.

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.

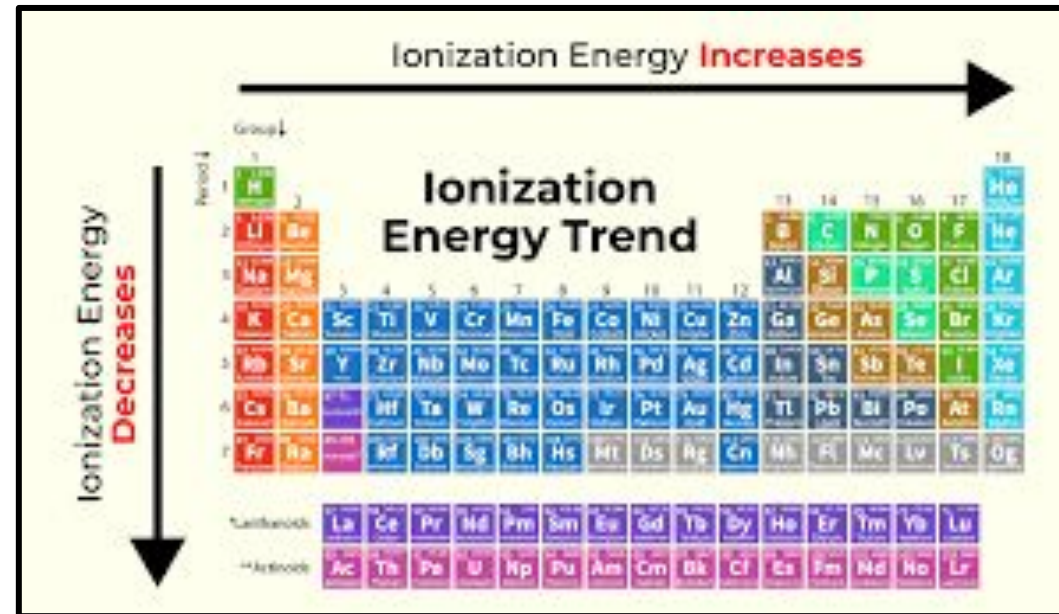


II.4/Trends of ionization energy across the periodic table

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.

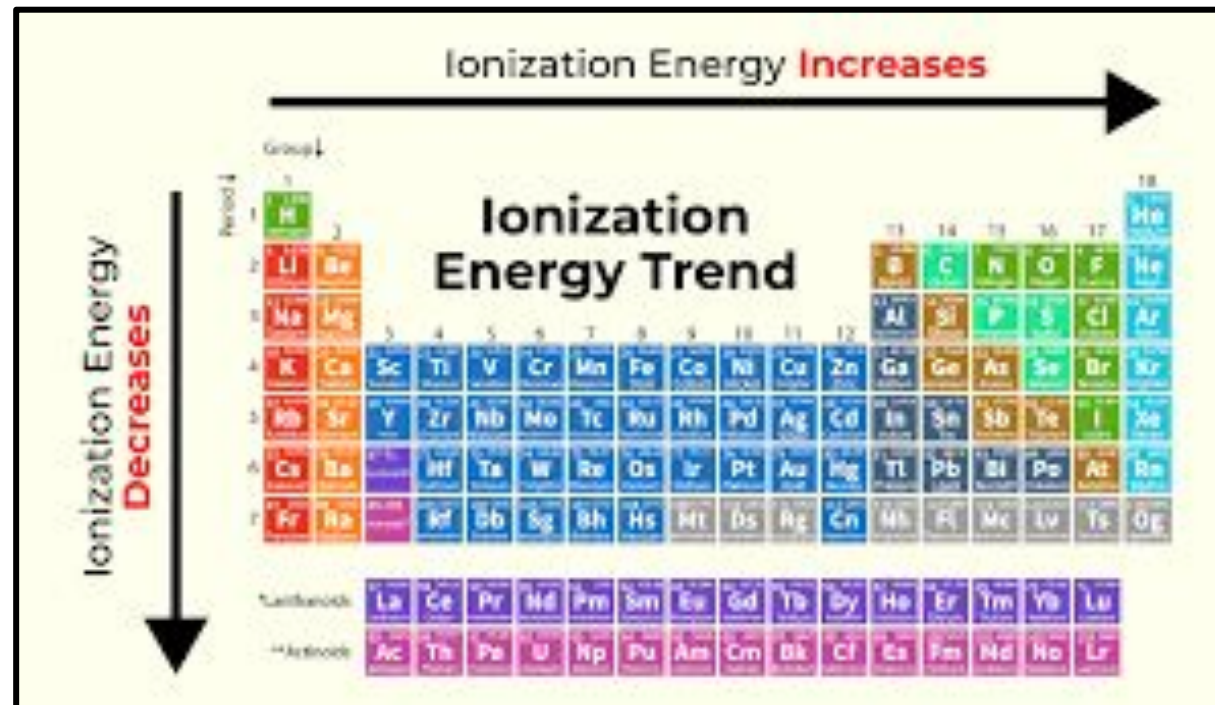
From top to bottom in a group, the ionization energy decreases because the electrons are in shells farther and farther from the nucleus.



The lowest ionization energy is that of the elements in group 1A, 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.

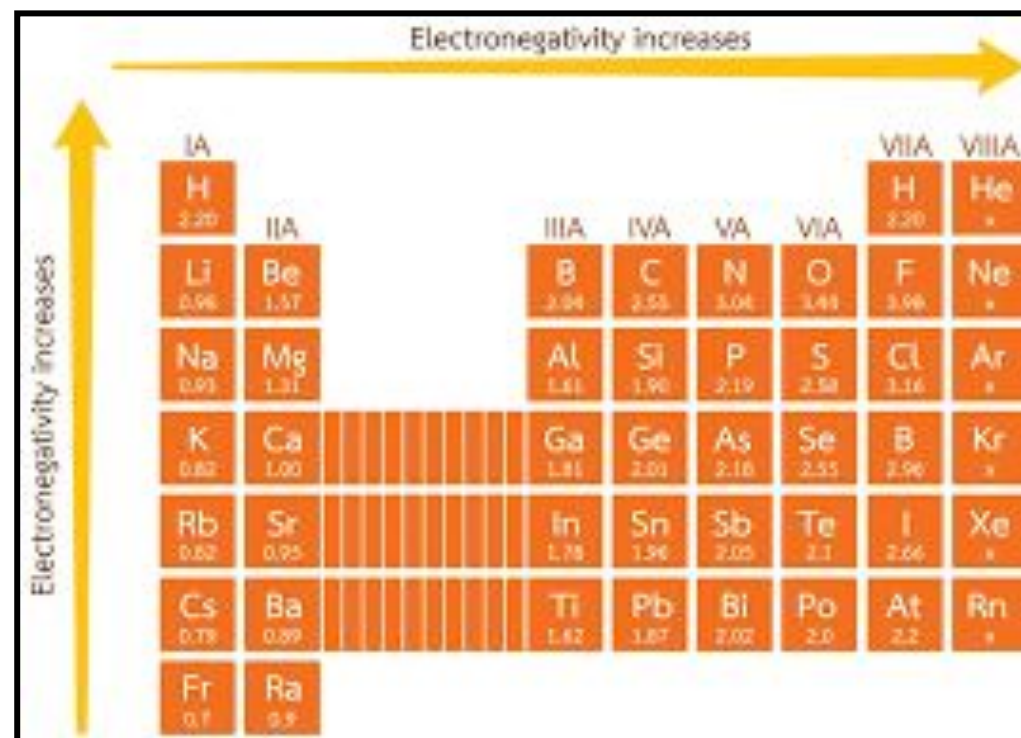
The ionization energy increases when more electrons are removed. This is because the attraction force of the nucleus is stronger in cations.



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.

The periodic table is annotated with three arrows indicating trends:

- Atomic Size Increases:** Indicated by a red arrow pointing left from the right side of the table.
- Electronegativity Increases:** Indicated by a black arrow pointing right from the left side of the table.
- Ionization Energy Increases:** Indicated by a blue arrow pointing right from the left side of the table.

Additionally, on the left side of the table:

- A red arrow pointing down is labeled **Atomic Size Increases**.
- A black arrow pointing up is labeled **Electronegativity Increases**.
- A blue arrow pointing up is labeled **Ionization Energy Increases**.

1 H 1.008 HYDROGEN																	2 He 4.003 HELIUM
3 Li 6.941 LITHIUM	4 Be 9.012 BERYLLIUM											5 B 10.811 BORON	6 C 12.011 CARBON	7 N 14.007 NITROGEN	8 O 15.999 OXYGEN	9 F 18.998 FLUORINE	10 Ne 20.180 NEON
11 Na 22.990 SODIUM	12 Mg 24.305 MAGNESIUM											13 Al 26.982 ALUMINUM	14 Si 28.086 SILICON	15 P 30.974 PHOSPHORUS	16 S 32.065 SULFUR	17 Cl 35.453 CHLORINE	18 Ar 39.948 ARGON
19 K 39.098 POTASSIUM	20 Ca 40.078 CALCIUM	21 Sc 44.956 SCANDIUM	22 Ti 47.88 TITANIUM	23 V 50.942 VANADIUM	24 Cr 51.996 CHROMIUM	25 Mn 54.938 MANGANESE	26 Fe 55.845 IRON	27 Co 58.933 COBALT	28 Ni 58.693 NICKEL	29 Cu 63.546 COPPER	30 Zn 65.38 ZINC	31 Ga 69.723 GALLIUM	32 Ge 72.64 GERMANIUM	33 As 74.922 ARSENIC	34 Se 78.96 SELENIUM	35 Br 79.904 BROMINE	36 Kr 83.80 KRYPTON
37 Rb 85.468 RUBIDIUM	38 Sr 87.62 STRONTIUM	39 Y 88.906 YTTRIUM	40 Zr 91.224 ZIRCONIUM	41 Nb 92.906 NIOBNIUM	42 Mo 95.94 MOLYBDENUM	43 Tc 98 TECHNETIUM	44 Ru 101.07 RHODIUM	45 Rh 101.07 RHODIUM	46 Pd 106.36 PALLADIUM	47 Ag 107.868 SILVER	48 Cd 112.411 CADMIUM	49 In 114.818 INDIUM	50 Sn 118.710 TIN	51 Sb 121.757 ANTIMONY	52 Te 127.6 TELLURIUM	53 I 126.905 IODINE	54 Xe 131.29 XENON
55 Cs 132.905 CAESIUM	56 Ba 137.327 BARIUM	57-71 La-Lu LANTHANIDES	72 Hf 178.49 HAFNIUM	73 Ta 180.948 TANTALUM	74 W 183.84 WOLYBIUM	75 Re 186.207 RHENIUM	76 Os 190.23 OSMIUM	77 Ir 192.222 IRIDIUM	78 Pt 195.084 PLATINUM	79 Au 196.967 GOLD	80 Hg 200.59 MERCURY	81 Tl 204.38 THALLIUM	82 Pb 207.2 LEAD	83 Bi 208.98 BISMUTH	84 Po 209 POLONIUM	85 At 210 ASTATINE	86 Rn 222 RADON
87 Fr 223 FRANCIUM	88 Ra 226 RADIUM	89-103 Ac-Lr ACTINIDES	104 Rf 261 RUFORNIUM	105 Db 262 DUBNIUM	106 Sg 266 SEABORGIUM	107 Bh 264 BOHRIUM	108 Hs 277 HASSIUM	109 Mt 268 MEITNERIUM	110 Ds 271 DARMSTADTIUM	111 Rg 272 ROSGOLDIUM	112 Cn 285 COGNITIONIUM	113 Uut 284 UNUNTRIUM	114 Uuq 289 UNUNQUADIUM	115 Uus 288 UNUNPENTIUM	116 Uuh 292 UNUNHEXADIUM	117 Uus 294 UNUNSEPTIUM	118 Uuo 294 UNUNOCTIUM
LANTHANIDES			57 La 138.905 LANTHANUM	58 Ce 140.12 CELESIUM	59 Pr 140.908 PRASEODYMIUM	60 Nd 144.24 NEODYMIUM	61 Pm 144.913 PROMETHIUM	62 Sm 150.36 SAMARIUM	63 Eu 151.964 EUROPEUM	64 Gd 157.25 GADOLINIUM	65 Tb 158.925 TERBIUM	66 Dy 162.50 DYSPROSIUM	67 Ho 164.930 HOLEMIUM	68 Er 167.259 ERBIUM	69 Tm 168.930 TERMIUM	70 Yb 173.054 YTERBIUM	71 Lu 174.967 LUTETIUM
ACTINIDES			89 Ac 227.033 ACTINIUM	90 Th 232.038 THORIUM	91 Pa 231.036 PROACTINIUM	92 U 238.029 URANIUM	93 Np 237.048 NEPTUNIUM	94 Pu 244.064 PLUTONIUM	95 Am 243.061 AMERICIUM	96 Cm 247.070 CURIUM	97 Bk 247.070 BERKELIUM	98 Cf 251.08 CALIFORNIUM	99 Es 252.083 EINSTEINIUM	100 Fm 257.10 FERMIUM	101 Md 258.10 MEISSNERIUM	102 No 259.10 NIOBELIUM	103 Lr 260.10 LAWRENCIUM