Science-X

I.C.S.E.

1 Periodic Table, Periodic Properties & Variations of Properties

Topics

1.1 INTRODUCTION

- Elements are the pure substances made up of one type of atoms
- All matter is made up of atoms
- Right now there are 118 elements: 94 natural and 24 synthetic produced in nuclear reactions (IUPAC)
- Classification of elements:
  - Dobereiner Triads: Similar triads $_{20}Ca^{40}$, $_{38}Sr^{88}$, $_{56}Ba^{137}$ and $_{17}Cl^{35}$, $_{35}Br^{80}$, $_{53}I^{127}$
  - Newlands Octaves: starting from any element, every 8^{th} element is similar to the 1^{st} one like Sa, Re, Ga, Ma, Pa, Da, Ni, again start from Pa, Da,…………
  - Mendeleev's Periodic Table: based on the law that
    " *The properties of elements are the periodic functions of their* ***atomic masses***."
  - Moseley's Modern Periodic Table: based on the law that
    " *The properties of elements are the periodic functions of their* ***atomic number***."
  - Neils Bohr: Long form of Modern Periodic Table

ATOMIC NUMBER: **(pure number)**

The Number Of ELECTRONS or PROTONS in an atom

ATOMIC MASS: (Unit: a.m.u.)

Approx. equivalent to the sum of number of PROTONS and NEUTRONS in the nucleus of an atom

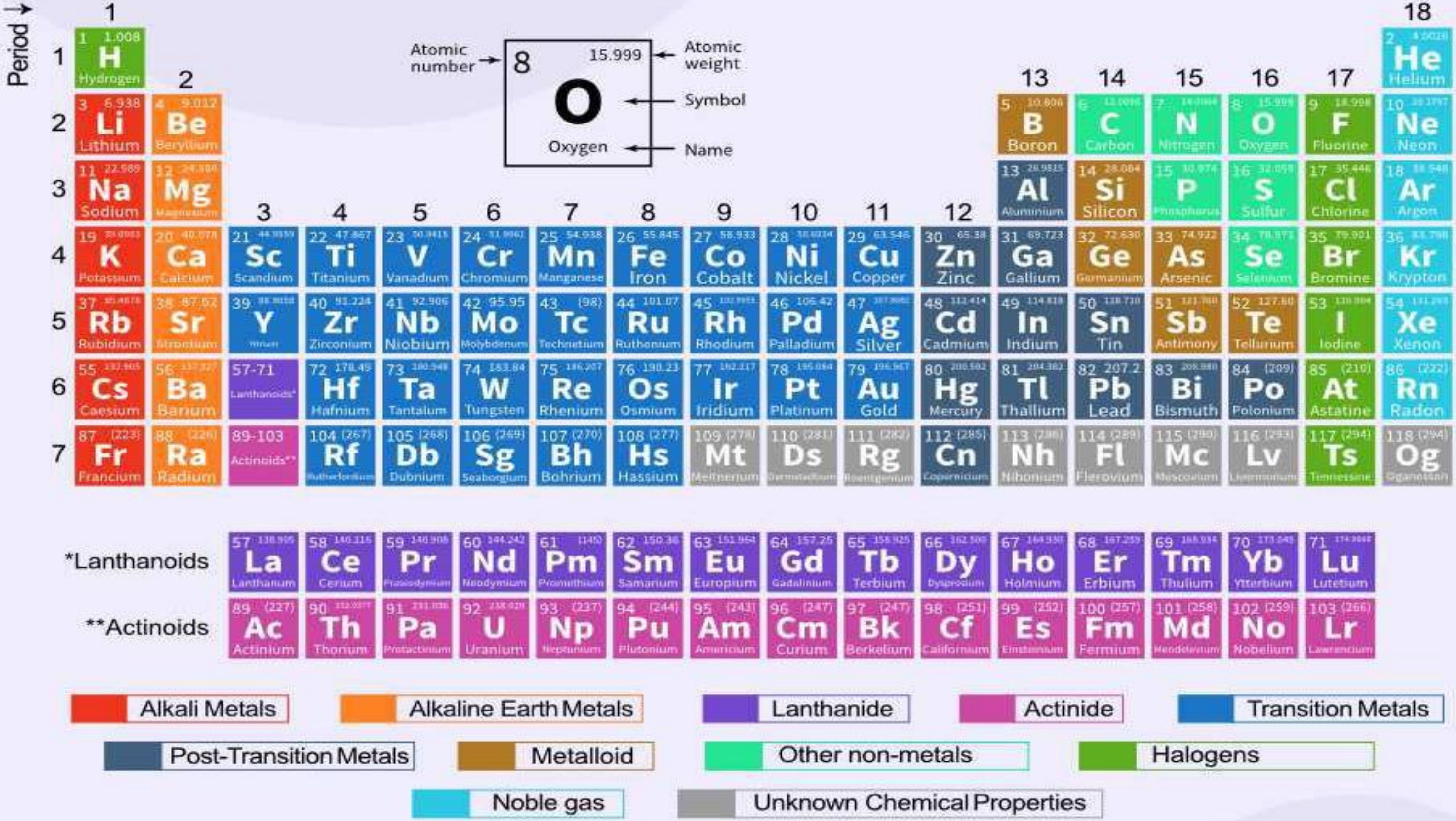
MASS NUMBER: (pure number)

the sum of number of PROTONS and NEUTRONS in the nucleus of an atom

PERIODIC TABLE:

The tabular arrangement of elements in PERIODS (horizontal row) and GROUPS (vertical columns)

LONG FORM MODERN PERIODIC TABLE



1.2 SALIENT FEATURES OF MODERN PERIODIC TABLE

Total Number of Periods (rows) : 7

Total Number of Columns (groups) : 18

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1.3 PERIODICITY

The properties of elements that appear at regular intervals are known as **Periodic properties** and the phenomenon is known as **Periodicity**

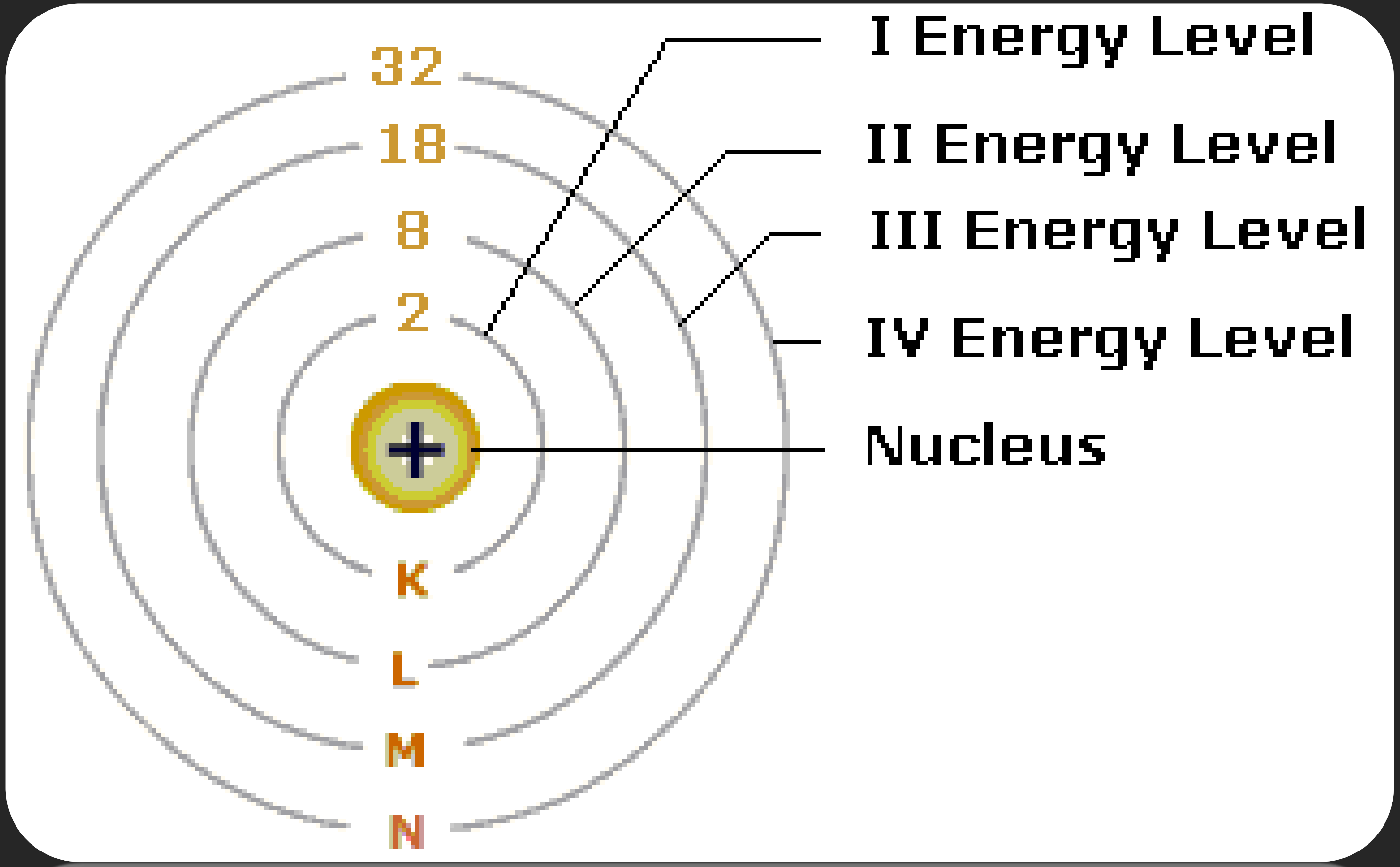
Cause of periodicty

The cause of periodicity is the re-occurence of similar electronic configuration after certain intervals

** In a particular group the elements have similar properties due to similar electronic configuration*

1.4 SHELLS (ORBITS) & VALENCY

Orbits: The certain definite circular paths in which electrons revolve around the nucleus of an atom are known as Orbits or Shells



Number of shells = period

According to Bohr's model of an atom, the maximum number of electrons that can be in an orbit or shell is calculated using the formula $2n^2$ where n is the orbit number.

Number of electrons in an orbit = $2n^2$

Where n = number of the orbit

Examples,

Orbit Number	Total Electrons ($2n^2$)
1	2
2	8
3	18
4	32

VALENCY

Valency is the combining capacity of an atom. It is the number of electrons that an atom can share, donate or accept

Valency of elements of a particular group remains the same due to their similar electronic configuration

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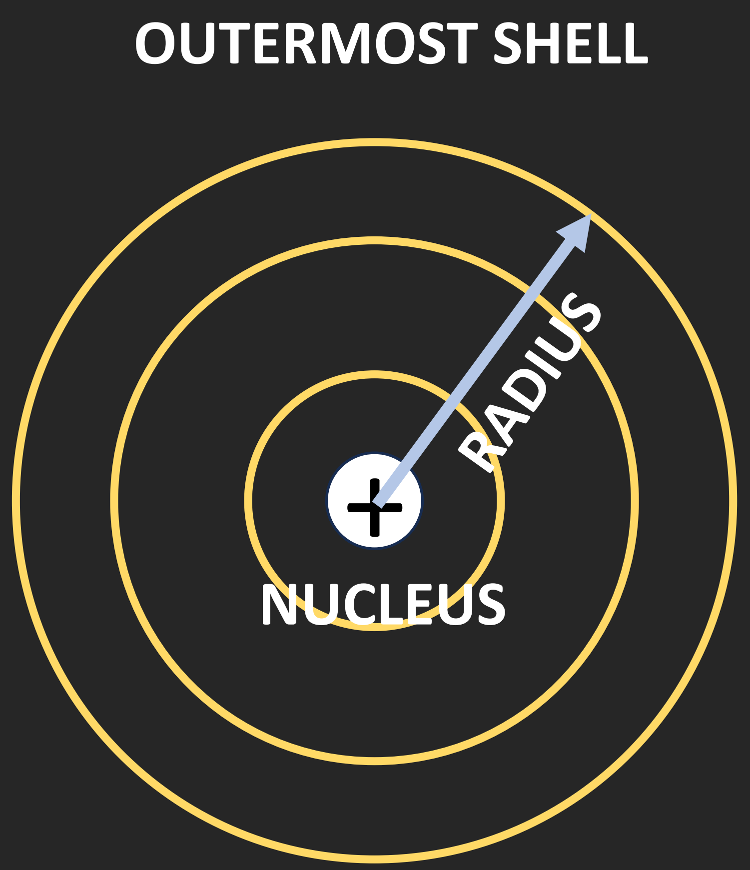
Valency of elements of a particular group remains the same due to their similar electronic configuration

1.5 PERIODIC PROPERTIES

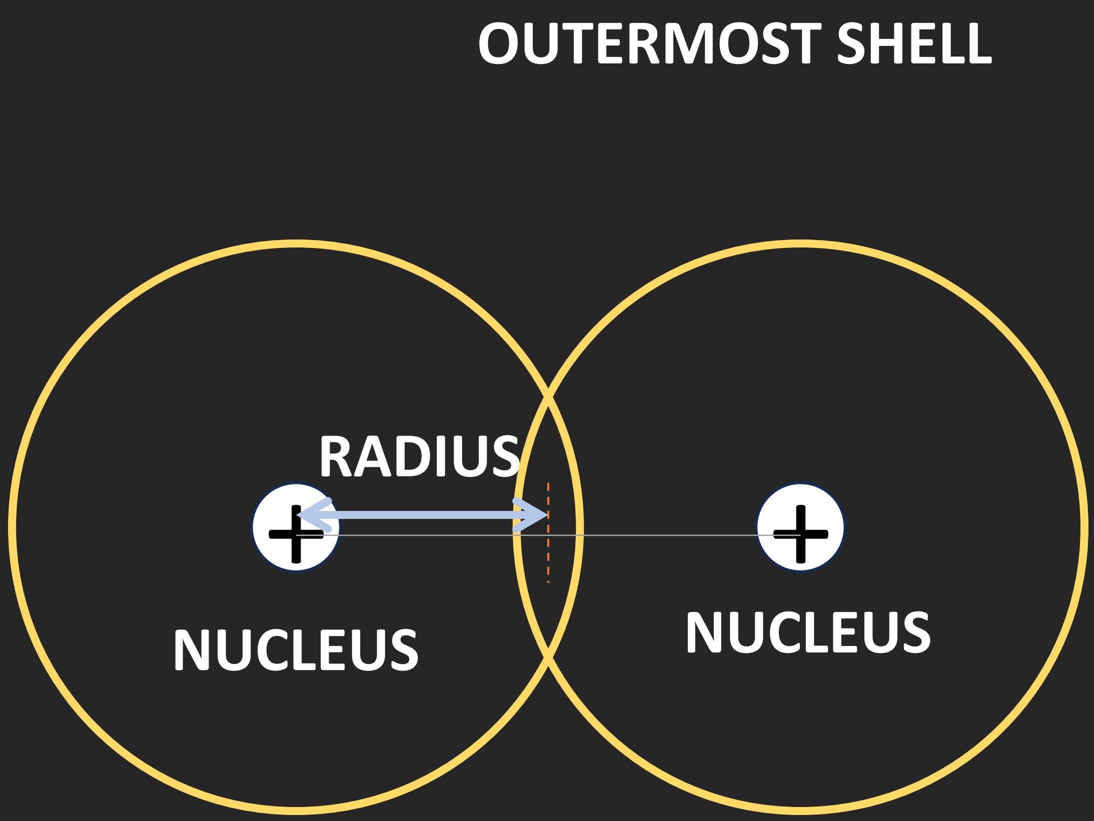
to be continued...

1.5.1 ATOMIC SIZE (ATOMIC RADIUS)

The distance between the centre of the nucleus and the outermost shell is kwn as Atomic size or Atomic radius.



Atomic radius can also be defined as the half of the internuclear distance between two bonded atoms in a molecule



- **The size of the atom increases as the number of shells increase**
- **The size of the atom decreases as the nucleus charge increases**

Trends in Atomic Size

Down a group: atomic size increases as the number of shells increases

Fl	64pm
Cl	99pm
Br	114pm
I	133pm
At	140pm

Across a period: atomic size decreases from L to R in a period

Example:

Li	Be	B	C	N	O	Fl	Ne
3	4	5	6	7	8	9	10
152pm	112pm	88pm	77pm	70pm	66pm	64pm	112pm

Exception: Atomic size of Noble gases is bigger than the halogens of the same period.

Reason: The outmost shell is complete in the atoms of the Noble gases. Due to the crowding of the electrons in the outermost shell, a repulsive force between the electrons increases the size of the atom and also the nuclear charge has less effect on the outmost electrons due to the shielding effect. The size of the atoms of Noble gases is not more than the Alkali metals in the same period.

- Cation is always **smaller** than the parent atom

$$Na - e^{-} \rightarrow Na^{+}$$

2, 8, 1 → 2,8

As the number of electrons decreases and the effective nuclear charge increases resulting into smaller size of cation

- Anion is always bigger than the parent atom

$$Cl + e^{-} \rightarrow Cl^{-}$$

2, 8, 7 → 2,8, 8

As the number of electrons increases and the effective nuclear charge (pull) decreases resulting into bigger size of anion

- **Size of Iso-electronic ions: size decreases as the nuclear charge increases as the resultant pull on the electrons increases,**

Iso-electronic ion	Mg^{2+}	Na^{+}	F^{-}	O^{2-}
No. of electrons	10	10	10	10
No. of Protons	12	11	9	8
Size in Å	0.65	0.95	1.26	1.42

1.5.2 METALLIC CHARACTER

The elements whose atoms have a tendency to lose electrons and make a positive ion (cation) are known as Metals.

Examples,

$$Na - e^- \rightarrow Na^+$$

2, 8, 1 → 2, 8

$$Mg - 2e^- \rightarrow Mg^{2+}$$

2, 8, 2 → 2, 8

Exception: H forms H^+ ion but it is a non-metal

Trends in Metallic character

Down a group: metallic character increases as we go down a group

Across a period: metallic character decreases as we move across a period.

1.5.3 NON-METALLIC CHARACTER

The elements whose atoms have a tendency to gain electrons and to complete their octet to get stabilized and make a negative ion are known as Non-metals

The Non-metallic character depends on two factors as follows,

(i) Atomic size: smaller the size more is the non-metallic character

(ii) Nuclear charge: more the nuclear charge more is the non-metallic character

Trends in Non-metallic character

Down a group: non-metallic character decreases as we go down a group

Across a period: metallic character increases as we move across a period.

Chemical Reactivity

The chemical reactivity depends on the tendency to lose or gain electrons by an atom

Therefore, greater the tendency to lose or gain electrons, greater is the reactivity

Trends in Chemical Reactivity

Across a period: on moving from L to R in a period, the chemical reactivity first decaresaes then increases

Example: 3rd period:

Na	Mg	Al	Si	P	S	Cl
Most reactive Metal			Least reactive			Most reactive Non-metal

Down a group: The chemical reactivity of metals increases dowen a group because the tendency to lose electrons increases down a group. The most reactive metal is at the bottom of group 1

Trends in Chemical Reactivity

Down a group:

Metals: The chemical reactivity of metals increases down a group because the tendency to lose electrons increases down a group. The most reactive metal is at the bottom of group 1 i.e. Francium (Fr)

Non-metals: The chemical reactivity of non-metals decreases down a group because the tendency to gain electrons deacreases down a group. The most reactive non-metal is at the top of group 17 i.e. Fluorine (F).

Gradation in Physical Properties

Down a group:

Metals: The M.P and B.P of metals decrease down a group

Metals	M.P. (°C)	B.P. (°C)
Li	180.5	1347
Na	94.5	883
K	63.5	774

Non-metals: The M.P and B.P of non-metals increase down a group

Non-metals	M.P. (°C)	B.P. (°C)	Physical state
F	-219.6	-187	Gas
Cl	-101	-34.6	Gas
Br	-7.2	+58.8	Liquid
I	+113.6	+183	Solid

Density : increases down a group

Across a period:

The M.P and B.P. increase from L to R in a particular period upto group-14 and then decrease.

Density: increase from L to R in a particular period and then slight decrease

1.5.4 IONIZATION POTENTIAL OR IONIZATION ENERGY OR IONIZATION ENTHALPY (I.E.)

The energy required to remove an electron from a gaseous isolated atonm to make a positive ion is known as Ionization Energy or Ionization Enthalpy (I.E.)

$$M(g) + I.E. \rightarrow M^{+} + e^{-}$$

Units of I.E. : electron volts per atom (e/V/atom

I.E. depends on

(i) Atomic size: IE is inversely proportional to atomic size
(ii) Nuclear Charge : IE is directly proportional to nuclear charge

Terends in IONIZATION ENERGY

Across a Period: increase due to increased nuclear charge

Down a group: decrease due to increase in the atomic size

1.5.5 ELECTRON AFFINITY (E.A.) OR ELECTRON GAIN ENTHALPY

The energy released while making a negative ion from a gaseous isolated atom by adding an electron

$$X (g) + e^- \rightarrow X^- + E.A$$

Units of I.E. : electron volts per atom (e/V/atom)

E.A. depends on

(i) **Atomic size: EA is inversely proportional to atomic size**
(ii) **Nuclear Charge :EA is directly proportional to nuclear charge**

Terends in ELECTRON AFFINITY

Across a Period: increase due to increased nuclear charge

Down a group: decrease due to increase in the atomic size

1.5.6 ELECTRONEGATIVITY (E.N.)

The tendency of an atom in a molecule to attract the shared pair of electrons towards itself is known as Electronegativity

$$X\ (g) + e^- \rightarrow X^- + E.A$$

Units of E.N. : E.N. is a dimensionless quantity because it is just a tendency But there are many scales to measure EN. The most widely used scale of EN was given by Linus Pauling (1932)

E.N. depends on

(i) Atomic size: EN is inversely proportional to atomic size
(ii) Nuclear Charge :EN is directly proportional to nuclear charge

Terends in ELECTRONEGATIVITY (E.N.)

Across a Period: increase due to increased nuclear charge

Down a group: decrease due to increase in the atomic size

1.6 COMPARISON OF ALKALI METALS & HALOGENS

	Alkali Metals (Group-1)	Halogens (Group-17)
Occurrence	Combined state	Combined state
Physical state	Shining, Soft, Li is hardest	Non-metals, gaseous, poisonous, diatomic molecules
Valence electron, Conduction nature	1 Valence shell electron	7 Valence shell electron
M.P. & B.P.	Decrease down a group	Increase down a group
Atomic Size	Largest size in a period	Smallest size in a period
I.E.	Lowest	Highest
E.A.	Lowest	Highest
E.N.	Lowest	Highest
Reactivity	Reactive metals	Reactive non-metals
Rxn with Water & Acids	Vigorous rnx producing H, reactivity increases down a group	No rxn with dilute acids and water
Reducing/Oxidizing agents formation	Strong Reducing agents	Strong Oxidizing agents

QUIZ

Tomorrow


Our office