# Periodic Table, Periodic Properties and Variations of Properties

## Class X, Chapter-1

1. **Modern Periodic Law:** The physical and chemical properties of the elements are the periodic function of their atomic number.

2. **Structural features of long form of periodic table:**

- Blocks: The periodic table is divided into four main blocks(s, p, d, f) depending upon the sub shell to which the differentiating electron enters into.

| Group | Special name of groups | Block | |
|---|---|---|---|
| 1 | Alkali metals | s(1,2) | Representative elements |
| 2 | Alkaline earths | | |
| 3 to 12 | | d(3 to 12) | Transition elements |
| 13 | | p(13 to 18) | Representative elements |
| 14 | | | |
| 15 | Pnictogens | | |
| 16 | Chalcogens | | |
| 17 | Halogens | | |
| 18 | Noble gases | | |

The two horizontal rows placed at the bottom of the periodic table is f block elements. They are also called inner transition elements.

| Period | Elements | Total number of elements | |
|---|---|---|---|
| 1 | H and He | 2 | Shortest period |
| 2,3 | Li to Ne, Na to Ar | 8 | Short period |
| 4,5 | K to Kr, Rb to Xe | 18 | Long period |
| 6 | Cs to Rn | 32 | Longest period |
| 7 | Fr to ... | 19 | Incomplete period |

- Elements of third period are called typical elements.
- **Diagonal relationship:** Certain elements of second period exhibit similarity in properties with the elements in third period diagonally placed right.

| | Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| $2^{nd}$ Period | Li → | Be → | B → | C |
| $3^{rd}$ Period | Na | Mg | Al | Si |

This is called diagonal relationship. This is due to identical ionic radii and polarizing power (Charge /size ratio). Elements of second period are known as bridge elements.

- **Anomalous behaviour of first elements of a group :** The first element of a group exhibits difference in its properties in certain respects from the rest of the elements of its group. This is due to its small size, high electronegativity and non-availability of d-electrons. This anomalous behaviour is shown by the elements of the second period(Li to F)

- **Periodicity of properties and its cause:** Repetition of the properties of elements after certain intervals is called periodicity. The basic cause of periodicity is the periodic repetition of outer electronic configuration of the elements at regular intervals of 2,8,8,18,18,32.

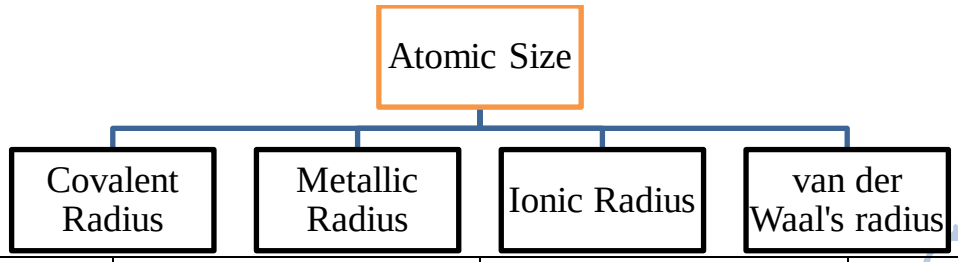
3. **Periodic properties:** The properties which are directly or indirectly related to their electronic configuration and show gradual change when we move from left to right in a period or from top to bottom in a group are called periodic properties.

i) Atomic volume, atomic size, melting point, boiling point and density are important physical properties.

ii) Electronic configuration, ionisation energy, electron affinity, electronegativity, metallic character, nature of oxides, oxidation state , reducing character are chemical properties.

iii) Specific heat, refractive index are not periodic properties.

A. **Atomic Size:** The distance between the centres of nucleus of atom to its outermost shell of electrons.




| | | | |
|---|---|---|---|
| Half of the distance between two successive nuclei of two covalently bonded like atoms in a molecule | Half of the distance between two successive nuclei of two adjacent metal atoms in the metallic closed packed crystal lattice. | The distance of the outer most shell of an anion or cation from its nucleus. | Half of the distance between the nuclei of two non bonded isolated atoms or two adjacent atoms belonging to two neighbouring molecules of an element in the solid state. |

Van der waals,s radius> metallic > covalent

- Factors influencing atomic radii:
  - i. Number of shells: With the increase in the number of shells, atomic size increases.
  - ii. Nuclear charge: With the increase in nuclear charges, atomic size decreases.
- Variation of atomic radii:
  - i. Across the period atomic radius (Covalent) decreases
  - ii. Down a group atomic radius increases.
  - iii. This decrease and increasing order is valid till group 17. For group 18, van der Waal radius is taken into consideration , thus all of a sudden the atomic size increases from group 17 to 18
  - iv. In period 2, Ne>Li>Be>B>C>O>F>N
  - v. In period 3, Ar>Na>Mg>Al>Si>P>S>Cl
  - vi. The size of the transition elements hardly changes.
  - vii. Atomic size of anion > cation
  - viii. For isoelectronic species, ionic radii decrease with the increase in the magnitude of the nuclear charge. $Al^{3+}<Mg^{2+}<Na^{+}<F^{-}<O^{2-}<N^{3-}$

B. **Ionisation potential of Ionisation energy or ionisation enthalpy:** The minimum amount of energy required to remove the most loosely bound electron from an isolated gaseous atom to produce a gaseous cation is called ionisation enthalpy or energy.
Since it is the minimum potential difference (in a discharge tube) required to remove the most loosely bound electron , it is also called ionisation potential.

- I.E is expressed in eV/atom or kcal/mol, kJ/mol. The I.E have a positive value.
- Variation of I.E:
  - i. I.E increases across the period from left to right. I.E decreases from froup 2 to 3 and 15 to 16.
  - ii. I.E decreases in a group from top to bottom.
  - iii. In second period: Li<B<*Be*<C<O<*N*<F<Ne
  - iv. In third period: Na< Al< *Mg*< Si< S < *P*< Cl < Ar
  - v. He possess the highest I.E, Cs possess the lowest.

vi. Metals have low I.E, non-metals have high I.E.

- Factors influencing I.E:
  i. Atomic size: With the increase in atomic size, I.E decreases.
  ii. Nuclear charge: With the increase in nuclear charge, I.E increases.

C. **Electron affinity or electron gain enthalpy**: The amount of energy released while converting a neutral gaseous isolated atom into a gaseous anion.

- E.A is expressed in eV/atom or kcal/mol, kJ/mol.
- Factors influencing E.A:
  iii. Atomic size: With the decrease in atomic size, E.A increases.
  iv. Nuclear charge: With the increase in nuclear charge, E.A increases.
- Variation of E.A:
  i. Electron gain enthalpy can be negative as well as positive.
  ii. Across the period the value become more negative( E.A increases)
  iii. Down a group the value become less negative (E.A decreases)
  iv. E.A of Be, Mg, N and noble gases are positive.
  v. For group 17, I<Br<F<Cl
  vi. Exceptions: S>O, Cl>F
  vii. Ne possess the most positive E.A, Cl possess the most negative E.A
  viii. E.A of noble gases is positive due to completely filled subshells.
  ix. Among the inert gases, He possesses the lowest value.
  x. Normally no two elements have the same value of E.A .(Except Ar and Kr)
  xi. E.A of gaseous anions is always positive.
  xii. More the value of E.A, more is the oxidising power.

D. **Electronegativity:** Electronegativity of an element is the tendency of its atom in a molecule to attract the shared pair of electrons towards itself in a covalent bond.

- E.N is a dimensionless quantity as it is only a tendency. Pauling scale is used to measure E.N
- F possesses the highest E.N value and Cs possesses the lowest.
- Factors influencing E.N:
  v. Atomic size: With the decrease in atomic size, E.N increases.
  vi. Nuclear charge: With the increase in nuclear charge, E.N increases.
- Variation of E.A:
  E.N increases across a period and decreases down a group. Among halogens, I<Br<Cl<F
- Application of E.N:
  i. With the increase in E.N, non-metallic character of elements increases.
  ii. If the electronegative difference between two atoms is-
    a) Greater than 1.7, bond is ionic.
    b) Less than 1.7, bond is covalent.
    c) 1.7, bond is 50% ionic.
    d) Zero, bond is 100% covalent
  iii. Metalloids have E.N close to 2.0

| E.A | E.N |
|---|---|
| 1. It is energy released by an isolated gaseous atom. | 1. It is the tendency of an atom to attract the shared pair of electrons. |
| 2. It can be experimentally measured. | 2. It cannot be experimentally measured |
| 3. It is expressed in kJ/mol or eV/atom | 3.It is a dimensionless quantity. |
| 4. E.A of an atom is constant | 4. E.N of an atom is not constant. |

E. **Metallic character:** It is the ability of the elements to lose the valence electrons in order to attain the electronic configuration of the nearest noble gas.

- Factors influencing Metallic character:
  - i. Atomic size: With the increase in the atomic size, metallic nature increases.
  - ii. Nuclear charge: With the increase in the nuclear charge, metallic nature decreases.
- Variation of metallic properties:
  - i. Across the period, metallic nature decreases.
  - ii. Down a group, metallic nature increases.
- Application:
  - i. Higher the metallic nature, stronger the reducing agent it is.
  - ii. Higher the metallic nature, more basic the oxide of it will form.

F. **Non-metallic character:** It is the ability of the elements to gain electrons in order to attain the electronic configuration of the nearest noble gas.

- Factors influencing Non-Metallic character:
  - iii. Atomic size: With the increase in the atomic size, non-metallic nature decreases.
  - iv. Nuclear charge: With the increase in the nuclear charge, non-metallic nature increases.
- Variation of metallic properties:
  - iii. Across the period, non-metallic nature increases.
  - iv. Down a group, non-metallic nature decreases.
- Application:
  - iii. Higher the non-metallic nature, stronger the oxidising agent it is.
  - iv. Higher the non-metallic nature, more acidic the oxide of it will form.

| Group | 1 | 2 | 3 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|
| Valence electrons | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Valency | 1 | 2 | 3 | 4 | 3 | 2 | 1 | 0 |
| Electron loss/ gain | L | L | L | Share | G | G | G | - |
| Metal/Non-metallic nature | M | M | M | NM | NM | NM | NM | Noble gases |
| Reducing/ Oxidising agent | R | R | R | R | O | O | O | - |

G. **Nature of oxides:** Metallic oxides are basic in nature while non metallic oxides are acidic in nature.

- Variation of the nature of oxide:
  - i. Across the period, gradually the basic nature of the oxides decreases and acidic nature of the oxides increases.
  - ii. Down a group, oxides become more and more basic.

H. Extra points:

i. For metals ,m.p and b.p in general, decreases down the group(Group 1,2)

ii. For non-metals , m.p and b.p in general, increases down the group(Group 17,18)

iii. Atomic size, metallic nature and reducing nature decreases across a period. The rest increases across the period. The reverse takes place down the group.

iv. Chemical reactivity is highest at the two extremes of a period and lowest at the centre. The reactivity at the extreme left is due to low I.P and extreme right is due to hig E.A and E.N.

v. Less I.P → More metallic → Good reducing agent→More basic its oxide is.

vi. More E.N and E.A → More non-metallic→ Good oxidising agent→More acidic its oxide is.

vii. $Li_2O$ and $Na_2O$ are strong basic. LiOH and NaOH are strong alkalis.

viii. BeO is amphoteric, MgO and CaO are basic. $Mg(OH)_2$ and $Ca(OH)_2$ are alkaline.

ix. CO is neutral, $CO_2$ is acidic, $SiO_2$ is acidic, $H_2CO_3$ and $H_2SiO_3$ are weakly acidic.

x. $N_2O$ , NO are neutral. $N_2O_3$, $NO_2$, $N_2O_5$ are acidic. $N_2O_3$ forms $HNO_2$ (nitrous acid) $NO_2$ forms $HNO_2$ and $HNO_3$, $N_2O_5$ forms $HNO_3$.

xi. $P_4O_6$ and $P_4O_{10}$ are acidic. They form $H_3PO_3$(phosphorous acid) and $H_3PO_4$ (phosphoric acid)respectively.

xii. $SO_2$ and $SO_3$ are acidic. They form $H_2SO_3$ and $H_2SO_4$ respectively.

xiii. $Cl_2O_7$ is acidic. It forms $HClO_4$(Perchloric acid).

xiv. LiH, NaH $CaH_2$ are basic, $AlH_3$ weakly basic, $CH_4$, $SiH_4$ are neutral, $NH_3$, $PH_3$ are basic, $H_2O$ is neutral, $H_2S$ and $H_2Se$ are acidic, HF, HCl, HBr,HI are acidic.

xv. For alkali metals:

| | | | | | |
|---|---|---|---|---|---|
| Atomic Size | Li<Na<K<Rb<Cs | | | | |
| Ionic Size | $Li^+<Na^+<K^+<Rb^+<Cs^+$ | | | | |
| Atomic Volume | Li<Na<K<Rb<Cs | | | | |
| Density | Li<K<Na<Rb<Cs | | | | |
| M.P, B.P, I.P | Li>Na>K>Rb>Cs | | | | |
| Reducing power | Li<Na<K<Rb<Cs | | | | |
| Colour imparted in Bunsen flame | Li | Na | K | Rb | Cs |
| | Crimson red | Golden Yellow | Pale violet | Violet | Violet |