CLASS 11 CHEMISTRY

CHAPTER 3 – CLASSIFICATION OF ELEMENTS AND PERIODICITY IN PROPERTIES

Comprehensive and Analytical Notes (Part III)

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1. Evolution of Periodic Table – Analytical View

Early chemists classified elements based on properties like valency, atomic mass, and reactivity.
However, inconsistencies led to the search for a scientific basis.

Scientist	Year	Contribution	Limitations
Dobereiner	1829	Law of Triads: Mean atomic mass rule	Limited triads only
Newlands	1866	Law of Octaves: Every 8th element similar	Failed beyond calcium
Mendeleev	1869	Periodic Law: Properties are periodic functions of atomic mass	Could not explain isotopes, misplaced elements
Moseley	1913	Atomic number as the basis	Led to modern periodic table

Key advancement: Moseley proved that atomic number (Z), not mass, determines the identity and properties of an element.

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2. Structure of the Modern Periodic Table

Total Elements: 118

Periods: 7

Groups: 18

Blocks: s, p, d, f

Series:

1st period – very short (2 elements)

2nd and 3rd – short (8 each)

4th and 5th – long (18 each)

6th – very long (32 elements including lanthanides)

7th – incomplete, includes actinides

Periodic law:
“The physical and chemical properties of elements are periodic functions of their atomic numbers.”

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3. Division of Elements into Blocks

Block	Groups	Outer Configuration	Example	General Character
s-block	1–2	$ns^{1–2}$	Na ($3s^1$)	Highly reactive metals
p-block	13–18	ns^2 np^{1} –	O ($2s^2$ 2p t)	Metals, nonmetals, metalloids
d-block	3–12	$(n – 1)d^{1}$ – ns^{1}p – ²	Fe (3d 4s^2)	Transition metals, variable valency
f-block	Lanth./Act.	$(n – 2)f^{1}$ – $(n – 1)d$ ns^2 – ¹	Ce ($4f^1$ $5d^1$ $6s^2$)	Inner transition metals

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4. Relationship Between Atomic Number and Configuration

Each element’s position depends on its outer electronic configuration.
The group is determined by valence electrons, and period by the principal quantum number (n) of the valence shell.

Example:

Na (Z = 11) !’ $1s^2$ $2s^2$ 2p $3s^1$!’ Period 3, Group 1.

Cl (Z = 17) !’ $1s^2$ $2s^2$ 2 p $3s^2$ 3 p ü Period 3, Group 17.

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5. Origin of Periodic Trends (Quantitative View)

(a) Effective Nuclear Charge (Zeff)

Zeff = Z – S (Slater’s screening constant).
Zeff increases across a period !’ stronger pull on electrons !’ smaller atomic size.

(b) Shielding Effect

Inner shell electrons shield outer electrons from the nucleus.
Order of shielding power: s > p > d > f.
Greater shielding !’ weaker attraction !’ larger radius.

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6. Detailed Discussion of Periodic Trends

(i) Atomic Radius

Types:

Covalent radius (half distance between two atoms in a covalent molecule).

Metallic radius (half distance between two metal nuclei).

van der Waals radius (half distance between non-bonded atoms).

Trends:

Decreases across a period.

Increases down a group.

Anomalies:

Transition elements show slight variation due to d-electron contraction.

Lanthanide contraction affects post-lanthanide elements.

(ii) Ionization Enthalpy (IE)

Definition: Energy required to remove an electron from a gaseous atom.
Successive ionization enthalpies increase:
I E • < I E ‚ < I E ƒ < I E „...

Factors Affecting IE:

Atomic size (!‘size !’ !“ IE)

Nuclear charge (!‘charge !’ !‘ IE)

Shielding (!‘shielding !’ !“ IE)

Electronic configuration (stable configurations !’ higher IE)

Irregularities:

Be > B (2p electron easier to remove)

N > O (O has paired electrons !’ repulsion)

(iii) Electron Gain Enthalpy (EGE)

Definition: Energy change when an electron is added to a neutral gaseous atom.
More negative EGE !’ easier to add electron.

Trends:

Across period !’ more negative.

Down group !’ less negative.

Exceptions:

F < Cl due to small size of F (electron–electron repulsion).

Noble gases have positive EGE (no tendency to gain electrons).

(iv) Electronegativity

Ability of an atom to attract shared electrons.
Scale: Pauling’s scale (relative).
Trends:

Increases across a period.

Decreases down a group.
Order: F (4.0) > O (3.5) > N (3.0) > C (2.5) > H (2.1).

(v) Oxidation States

Main group elements !’ fixed oxidation states.

Transition elements !’ variable oxidation states due to participation of (n–1)d and ns electrons.
Example: Fe^{2}z and Fe^{3}z; Mn^{2}z to Mnwz.

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7. Periodicity of Chemical Reactivity

s-block: Reactivity increases down the group (e.g., Li < Na < K < Rb < Cs).
p-block: Reactivity decreases down the group (F > Cl > Br > I).
Transition elements: Moderate reactivity due to incomplete d subshells.

Key Relation:
Metallic character " Reactivity for metals
Non-metallic character " Reactivity for non-metals

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8. Variation in Metallic and Non-Metallic Character

Across a period:
Metallic !“ ,Non-metallic !‘ .
Down a group:
Metallic !‘ ,Non-metallic !“ .

Example (Period 3):
Na (metal) !’ Mg (metal) !’ Al (metallic) !’ Si (metalloid) !’ P !’ S !’ Cl !’ Ar (non-metals).

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9. Nature of Oxides and Hydrides

Element Oxide Nature Example

Na Basic   N a , O
Mg Basic MgO
Al Amphoteric   A l , O ƒ
Si Weakly acidic   S i O ,
P, S, Cl Acidic   P „ O • €S, O ƒ Ç l , O ‡

Hydrides show similar variation: ionic !’ covalent !’ molecular across a period.

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10. Anomalous Behaviour of Elements

First element of each group differs significantly due to:

1. Small size

2. High ionization enthalpy

3. High electronegativity

4. Absence of d-orbitals

Examples:
Li differs from Na, Be from Mg, B from Al.

Diagonal Relationship:
Li !” Mg, Be !” Al, B !” Si.

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11. Periodicity of Valence and Valency

Valence electrons determine valency.

Across a period: increases from 1 to 4 then decreases to 0.

Down a group: remains same.

Example (Period 2):
Li (1), Be (2), B (3), C (4), N (3), O (2), F (1), Ne (0).

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12. Concept of Isoelectronic Ions

Same number of electrons !' size " 1/Z.
Example:
O ² { (Z=8, e { = 1 0), F { (Z=9, e { = 1 0), N a z (Z=11, e { = 1 0) .
Order of size: O ² { > F { > N a z .

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13. Anomalies in Periodic Properties

Property	Normal Trend	Exception	Reason
IE	!' across a period	Be>B, N>O	Subshell stability
EGE	More negative across	F<Cl	Small size of F
Electronegativity	!' across	None major	—
Radius	!" across	Transition elements	d-electron contraction

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14. Periodicity in Thermodynamic Properties

Property	Trend	Explanation
Ionization enthalpy	!' across	Higher Zeff
Electron affinity	More negative	Greater tendency to gain e {
Lattice energy	!' with ionic charge	q • q , / r relation
Hydration enthalpy	More negative for small cations	Stronger ion-dipole interactions

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15. Relationship Between Atomic Radius and Other Properties

Ionization energy " 1/radius

Electron affinity " 1/radius

Electronegativity " 1/radius

Thus, understanding atomic radius explains most periodic behavior.

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16. Concept of Periodicity in Bonding

Elements in the same group form compounds of similar formula:
NaCl, KCl, RbCl — all Group 1 halides.
B e C l , M g C l , C a C l , — Group 2 halides.
Similarity arises from constant valence electron configuration.

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17. Role of Periodicity in Predicting New Elements

Mendeleev predicted elements like Eka-silicon (Germanium) and Eka-aluminium (Gallium) before discovery.
Modern table continues to guide discovery of superheavy elements (Z > 100).

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18. Applications of Modern Periodic Table

1. Predicting nature and formula of compounds.

2. Classifying new elements.

3. Estimating ionization enthalpy and electron affinity.

4. Understanding chemical bonding and valency.

5. Correlating atomic and physical properties.

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19. Practice Questions (Mixed Type)

Objective

1. Which element has the highest electronegativity?

2. Which of the following has the largest atomic size: N, O, F, C?

3. Which element forms amphoteric oxide: Na, Mg, Al, Si?

4. Which element has maximum metallic character in Period 2?

Short Answer

1. Define diagonal relationship.

2. Why is fluorine less electron-affine than chlorine?

3. Why do transition metals show variable valency?

Long Answer

1. Discuss the periodic variation of atomic and ionic radii.

2. Explain how ionization enthalpy provides evidence for periodicity.

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20. Summary Points for Quick Revision

Periodicity arises due to repetition of valence-shell configuration.

Atomic number is the fundamental property of elements.

Across a period !’ Zeff !‘ !’ size !“ !’ IE !‘ !’ metallic character !“ .

Down a group !’ size !‘ !’ IE !“ !’ metallic character !‘ .

Periodic trends explain bonding, reactivity, and physical nature.