📚 MATH LOVE INSTITUTE

Class 11 Chemistry - Chapter 3

📊 CLASSIFICATION OF ELEMENTS AND PERIODICITY IN PROPERTIES

Session: 2025-26 | CBSE Curriculum

Complete Study Material with Theory, Periodic Trends, MCQs & Case Studies

Indore, Madhya Pradesh

📖 CHAPTER INTRODUCTION

🎯 Why This Chapter is THE Foundation of Chemistry:

"The Periodic Table is arguably the most important concept in chemistry, both in principle and in practice." - Glenn T. Seaborg

This chapter explains:

- ✓ How 118 elements are systematically organized
- ✓ Why elements in same group behave similarly
- ✓ How properties change across periods and down groups
- ✓ Connection between electronic configuration and chemical properties
- ✓ Prediction of element properties without experiments!

Board Exam Weightage: 6-8 marks | JEE: 2-3 questions | NEET: 2-3 questions

💡 Learning Strategy for This Chapter:

1. **History First:** Understand Dobereiner → Newlands → Mendeleev → Modern Periodic Law
2. **Master Periodic Table Structure:** Periods, groups, blocks (s, p, d, f)
3. **Learn Periodic Trends:** Atomic radius, ionization enthalpy, electronegativity, etc.
4. **Connect Structure to Properties:** Electronic configuration determines everything!
5. **Practice Graphs:** Trends are asked as graphs in boards/JEE/NEET

🎯 WHY CLASSIFY ELEMENTS?

The Problem:

In 1800: Only **31 elements** known

By 1865: **63 elements** identified

Today: **118 elements** discovered!

Imagine studying chemistry of 118 elements + their millions of compounds individually - IMPOSSIBLE!

The Solution: CLASSIFICATION!

- ✓ Group similar elements together
- ✓ Study properties of groups instead of individual elements
- ✓ **Predict properties** of undiscovered elements
- ✓ Rationalize known chemical facts

📜 HISTORICAL DEVELOPMENT OF PERIODIC TABLE

1️⃣ Döbereiner's Triads (1829)

🧑‍🔬 Johann Döbereiner - First Attempt at Classification

Observation: Groups of three elements (triads) with similar properties

Key Feature: Atomic weight of middle element ≈ average of other two

Triad 1	Atomic Weight	Triad 2	Atomic Weight	Triad 3	Atomic Weight
Li	7	Ca	40	Cl	35.5
Na	**23**	**Sr**	**88**	**Br**	**80**
K	39	Ba	137	I	127

Example: For Li, Na, K: (7 + 39)/2 = 23 (actual Na = 23) ✓

❌ **Limitation:** Worked only for few elements, dismissed as coincidence

2️⃣ Newlands' Law of Octaves (1865)

🎵 John Alexander Newlands - Musical Pattern in Elements!

Law of Octaves: "When elements arranged by increasing atomic weight, every 8th element has similar properties to the first (like music octaves)"

Element	Li	Be	B	C	N	O	F
At. Wt.	7	9	11	12	14	16	19
Element	Na	Mg	Al	Si	P	S	Cl
At. Wt.	23	24	27	29	31	32	35.5

Li and Na (8th element) have similar properties! ✓

❌ **Limitation:** Worked only up to Calcium, not for heavier elements

However: Newlands was awarded Davy Medal in 1887 for his work!

3️⃣ Mendeleev's Periodic Table (1869) - THE BREAKTHROUGH!

👑 Dmitri Mendeleev - Father of Periodic Table

📋 Mendeleev's Periodic Law:

"The properties of elements are a periodic function of their atomic weights."

Key Features of Mendeleev's Table:

- ✓ Arranged elements in horizontal rows (periods) and vertical columns (groups)
- ✓ Elements with similar properties placed in same group
- ✓ Used empirical formulas of compounds (hydrides, oxides) for classification
- ✓ **Left gaps** for undiscovered elements!
- ✓ **Corrected** atomic weights of some elements
- ✓ Sometimes ignored atomic weight order to keep similar elements together

🎯 Mendeleev's BOLD Predictions:

Mendeleev predicted properties of **undiscovered elements** and called them:

- **Eka-boron** (later discovered as Scandium)
- **Eka-aluminium** (later discovered as Gallium)
- **Eka-silicon** (later discovered as Germanium)

Example: Eka-aluminium (Gallium) Predictions:

Property	Mendeleev's Prediction (1871)	Actual Gallium (Discovered 1875)
Atomic weight	68	70
Density (g/cm^3)	5.9	5.94
Melting point	Low	302.93 K (very low!)
Formula of oxide	E_2O_3	Ga_2O_3
Formula of chloride	ECl_3	$GaCl_3$

Amazing accuracy made Mendeleev famous!

📝 Example: Iodine-Tellurium Pair

Problem: Atomic weight of I (127) < Te (128)

But: I has similar properties to F, Cl, Br (halogens)

Mendeleev's Solution: Ignored atomic weight order, placed I after Te in halogen group

Result: Mendeleev was RIGHT! (Later explained by atomic number concept)

❌ Limitations of Mendeleev's Periodic Table:

1. **Position of Hydrogen:** Should it be with alkali metals (Group 1) or halogens (Group 17)? Both placements problematic
2. **Anomalous Pairs:** Higher atomic weight elements placed before lower (e.g., Ar-K, Co-Ni, Te-I)
3. **Isotopes:** Where to place isotopes with same properties but different atomic weights?
4. **Lanthanoids & Actinoids:** 14 elements each - all placed in same slot!
5. **Why properties repeat periodically?** No explanation given

⚡ MODERN PERIODIC LAW (1913) - MOSELEY'S DISCOVERY

🧑‍🔬 Henry Moseley - The Game Changer

Discovery (1913): Studied X-ray spectra of elements

Key Finding: Plot of $\sqrt{v}$ (where v = X-ray frequency) vs Atomic Number (Z) gave a STRAIGHT LINE

But: Plot of $\sqrt{v}$ vs Atomic Mass was NOT linear

Conclusion: Atomic Number is more fundamental than Atomic Mass!

⚡ MODERN PERIODIC LAW:

"The physical and chemical properties of elements are periodic functions of their ATOMIC NUMBERS."

Key Point: Atomic Number = Number of Protons = Number of Electrons (in neutral atom)

Electronic Configuration determines Properties!

💡 Why Modern Periodic Law is Better:

- ✓ **Resolves anomalies:** Ar (Z=18) comes before K (Z=19), Te (Z=52) before I (Z=53) - correct order!
- ✓ **Isotopes explained:** Same Z → same position (isotopes have same electrons)
- ✓ **Hydrogen position:** Z=1, unique position justified
- ✓ **Explains periodicity:** Periodic repetition of electronic configuration

📊 MODERN PERIODIC TABLE - STRUCTURE

🎯 Basic Structure:

- **Horizontal Rows:** 7 Periods (rows)
- **Vertical Columns:** 18 Groups (columns)
- **Period Number =** Principal quantum number (n) of valence shell
- **Group Number =** Number of valence electrons (for s and p block)

Group Numbering:

Old System: IA, IIA, ..., VIIA, VIII, IB, ..., VIIB, 0 (Zero group)

IUPAC System (Current): 1, 2, 3, ..., 18

Old	IA	IIA	IIIA	IVA	VA	VIA	VIIA	0
New	1	2	13	14	15	16	17	18

📋 Period-wise Element Distribution:

Period	n value	Number of Elements	Orbitals Filled
1st	1	2	1s
2nd	2	8	2s, 2p
3rd	3	8	3s, 3p
4th	4	18	4s, 3d, 4p
5th	5	18	5s, 4d, 5p
6th	6	32	6s, 4f, 5d, 6p
7th	7	32 (incomplete)	7s, 5f, 6d, 7p

Formula: Maximum elements in period = $2n^2$ (but follows orbital filling order)

🔤 NOMENCLATURE OF ELEMENTS WITH Z > 100

🎯 The Problem:

Elements with very high atomic numbers are:

- ✓ Extremely unstable (milliseconds half-life)
- ✓ Man-made (synthesized in labs)
- ✓ Only few atoms produced
- ✓ Multiple labs claim discovery → naming disputes!

IUPAC Solution: Systematic Nomenclature

Until permanent name decided, use **temporary systematic name** based on atomic number

📐 IUPAC Naming Rules:

Digit	Name	Abbreviation
0	nil	n
1	un	u
2	bi	b
3	tri	t
4	quad	q
5	pent	p
6	hex	h
7	sept	s
8	oct	o
9	enn	e

Method: Write atomic number → Replace each digit with name → Add "ium"

Symbol: First letter of each root (capitalized)

📝 Examples:

Element 104:

1-0-4 → un-nil-quad → **Unnilquadium (Unq)**

Official name: **Rutherfordium (Rf)**

Element 118:

1-1-8 → un-un-oct → **Ununoctium (Uuo)**

Official name: **Oganesson (Og)**

Element 120 (not yet discovered):

1-2-0 → un-bi-nil → **Unbinilium (Ubn)**

📋 Some Important Named Elements (Z > 100):

Z	Systematic Name	Official Name	Symbol
101	Unnilunium	Mendelevium	Md
104	Unnilquadium	Rutherfordium	Rf
106	Unnilhexium	Seaborgium	Sg
107	Unnilseptium	Bohrium	Bh
112	Ununbium	Copernicium	Cn
118	Ununoctium	Oganesson	Og

🎯 CLASSIFICATION INTO BLOCKS: s, p, d, f

💡 Block = Type of orbital being filled with last electron

Elements are divided into 4 blocks based on which subshell receives the last electron:

- **s-block:** Last electron enters s-orbital
- **p-block:** Last electron enters p-orbital
- **d-block:** Last electron enters d-orbital
- **f-block:** Last electron enters f-orbital

1️⃣ s-BLOCK ELEMENTS

📍 Position:

- **Groups:** 1 and 2
- **Elements:** Group 1 (alkali metals): Li, Na, K, Rb, Cs, Fr
- Group 2 (alkaline earth metals): Be, Mg, Ca, Sr, Ba, Ra

Electronic Configuration:

- Group 1: ns^1 (1 electron in outermost s-orbital)
- Group 2: ns^2 (2 electrons in outermost s-orbital)

Properties:

- ✓ All are **metals**
- ✓ Highly reactive (especially Group 1)
- ✓ Low ionization enthalpies
- ✓ Form ionic compounds (except Li, Be which are more covalent)
- ✓ Reactivity increases down the group
- ✓ Group 1: Form +1 ions; Group 2: Form +2 ions

2️⃣ p-BLOCK ELEMENTS

📍 Position:

- **Groups:** 13, 14, 15, 16, 17, 18
- **Elements:** From B to Ne, Al to Ar, Ga to Kr, etc.

Electronic Configuration:

General: $ns^2\ np^{1-6}$

- Group 13: $ns^2\ np^1$
- Group 14: $ns^2\ np^2$
- Group 15: $ns^2\ np^3$
- Group 16: $ns^2\ np^4$
- Group 17: $ns^2\ np^5$
- Group 18: $ns^2\ np^6$

Properties:

- ✓ Include **metals, non-metals, AND metalloids**
- ✓ Show wide variety of properties
- ✓ Group 18 (Noble gases): Most stable, inert
- ✓ Group 17 (Halogens): Highly reactive non-metals
- ✓ Metallic character decreases across period (left to right)
- ✓ Non-metallic character increases across period

Note: Helium (He) has $1s^2$ configuration (s-block) but placed in p-block with noble gases due to similar properties

3️⃣ d-BLOCK ELEMENTS (Transition Elements)

📍 Position:

- **Groups:** 3 to 12
- **Elements:** Sc to Zn, Y to Cd, La to Hg, Ac to Cn

Electronic Configuration:

General: $(n-1)d^{1-10}\ ns^{0-2}$

- Example: Sc (Z=21): [Ar] $3d^1\ 4s^2$
- Exception: Cu (Z=29): [Ar] $3d^{10}\ 4s^1$ (not $3d^9\ 4s^2$)
- Exception: Cr (Z=24): [Ar] $3d^5\ 4s^1$ (not $3d^4\ 4s^2$)

Properties:

- ✓ All are **metals**
- ✓ Form **colored compounds**
- ✓ Show **variable oxidation states**
- ✓ Exhibit **paramagnetism**
- ✓ Used as **catalysts** (Fe, Ni, Pt, etc.)
- ✓ Form complex compounds
- ✓ High melting and boiling points

Why "Transition"? Form bridge between reactive s-block metals and less active p-block elements

Note: Zn, Cd, Hg have $(n-1)d^{10}\ ns^2$ configuration - don't show typical transition metal properties

4️⃣ f-BLOCK ELEMENTS (Inner Transition Elements)

📍 Position:

Placed separately at bottom of periodic table in two series:

- **Lanthanoids (4f series):** Ce (Z=58) to Lu (Z=71) - 14 elements
- **Actinoids (5f series):** Th (Z=90) to Lr (Z=103) - 14 elements

Electronic Configuration:

General: $(n-2)f^{1-14}\ (n-1)d^{0-1}\ ns^2$

- Lanthanoids: $4f^{1-14}\ 5d^{0-1}\ 6s^2$
- Actinoids: $5f^{1-14}\ 6d^{0-1}\ 7s^2$

Properties:

- ✓ All are **metals**
- ✓ Show similar properties within each series
- ✓ **Lanthanoids:** Silvery-white, reactive, similar chemical properties
- ✓ **Actinoids:** All radioactive, many man-made (transuranium elements)
- ✓ Lanthanoids show limited oxidation states (mostly +3)
- ✓ Actinoids show multiple oxidation states

Why separate? To maintain compact structure of periodic table

⚛️ METALS, NON-METALS, AND METALLOIDS

🔨 METALS (>78% of elements)

Location: Left and center of periodic table

Physical Properties:

- ✓ Solid at room temperature (except Hg - liquid)
- ✓ Lustrous (shiny)
- ✓ Good conductors of heat and electricity
- ✓ Malleable (can be hammered into sheets)
- ✓ Ductile (can be drawn into wires)
- ✓ High density (usually)
- ✓ High melting and boiling points (usually)

Chemical Properties:

- ✓ Low ionization enthalpies (easy to lose electrons)
- ✓ Form positive ions (cations)
- ✓ Form basic oxides (e.g., Na_2O, CaO)
- ✓ Electropositive character

Examples: Na, K, Ca, Al, Fe, Cu, Zn, Ag, Au

NON-METALS (<20 elements)

Location: Top-right corner of periodic table

Physical Properties:

- ✓ Solids, liquids, or gases at room temperature
- ✓ Dull (not lustrous) - except iodine, graphite
- ✓ Poor conductors (insulators) - except graphite
- ✓ Brittle in solid state (not malleable/ductile)
- ✓ Low melting and boiling points (usually)

Chemical Properties:

- ✓ High ionization enthalpies
- ✓ High electron gain enthalpies (easy to gain electrons)
- ✓ Form negative ions (anions)
- ✓ Form acidic oxides (e.g., SO_3, Cl_2O_7)
- ✓ Electronegative character

Examples: H, C, N, O, P, S, Cl, Br, I, noble gases

⚡ METALLOIDS / SEMI-METALS (~7 elements)

Location: Border between metals and non-metals (zigzag line)

Properties:

- ✓ Show properties of BOTH metals and non-metals
- ✓ Semiconductors (conduct electricity under certain conditions)
- ✓ Used in electronics industry

Elements: B, Si, Ge, As, Sb, Te, (Po)

Most Important: Silicon (Si) - used in computer chips!

💡 Periodic Trends:

- **Across a Period (left to right):** Metallic character DECREASES, Non-metallic character INCREASES
- **Down a Group:** Metallic character INCREASES, Non-metallic character DECREASES

Why? Related to ionization enthalpy and electron gain enthalpy!

📊 PERIODIC TRENDS IN PHYSICAL PROPERTIES

1️⃣ ATOMIC RADIUS

What is Atomic Radius?

Problem: Atoms don't have sharp boundaries (electron cloud)

Solution: Measure distance between nuclei in bonded atoms

Types:

1. Covalent Radius: Half of distance between two identical atoms bonded by single covalent bond

Example: Cl-Cl bond length = 198 pm → Covalent radius of Cl = 99 pm

2. Metallic Radius: Half of distance between two adjacent metal atoms in metallic crystal

Example: Cu-Cu distance in solid copper = 256 pm → Metallic radius = 128 pm

📐 TRENDS IN ATOMIC RADIUS:

1. Across a Period (left to right): DECREASES

Li (152 pm) > Be (111 pm) > B (88 pm) > C (77 pm) > N (74 pm) > O (66 pm) > F (64 pm)

2. Down a Group: INCREASES

Li (152 pm) < Na (186 pm) < K (231 pm) < Rb (244 pm) < Cs (262 pm)

💡 Explanation of Trends:

Across a Period (Decrease):

- ✓ Electrons added to SAME shell
- ✓ Nuclear charge INCREASES
- ✓ Shielding effect remains approximately SAME
- ✓ **Result:** Increased nuclear attraction → electrons pulled closer → size DECREASES

Down a Group (Increase):

- ✓ New shell added (n increases)
- ✓ Nuclear charge increases BUT
- ✓ Shielding effect INCREASES (more inner electrons)
- ✓ **Result:** Valence electrons farther from nucleus → size INCREASES

2️⃣ IONIC RADIUS

Ionic Radius = Size of ion in ionic crystal

Key Concepts:

1. Cation (positive ion): Formed by loss of electron(s)

- ✓ **Smaller** than parent atom
- ✓ Reason: Fewer electrons, same nuclear charge
- ✓ Example: Na (186 pm) → Na^{+} (95 pm)

2. Anion (negative ion): Formed by gain of electron(s)

- ✓ **Larger** than parent atom
- ✓ Reason: More electrons, increased repulsion, same nuclear charge
- ✓ Example: F (64 pm) → F^{-} (136 pm)

📝 Isoelectronic Species:

Definition: Species with same number of electrons

Example: O^{2-}, F^{-}, Na^{+}, Mg^{2+}, Al^{3+} (all have 10 electrons)

Size Comparison:

Species	Electrons	Protons (Z)	Ionic Radius (pm)
O^{2-}	10	8	140
F^{-}	10	9	136
Na^{+}	10	11	95
Mg^{2+}	10	12	65
Al^{3+}	10	13	50

Trend: $O^{2-} > F^{-} > Na^{+} > Mg^{2+} > Al^{3+}$

Rule: For isoelectronic species, size DECREASES with increasing nuclear charge

3️⃣ IONIZATION ENTHALPY ($\Delta_i H$)

Definition:

Ionization Enthalpy: Energy required to remove the most loosely bound electron from an isolated gaseous atom in its ground state

$X(g) \rightarrow X^{+}(g) + e^{-}$ $\Delta_i H_1$ (First ionization enthalpy)

$X^{+}(g) \rightarrow X^{2+}(g) + e^{-}$ $\Delta_i H_2$ (Second ionization enthalpy)

Units: kJ/mol

Always POSITIVE (energy always required to remove electron)

Important Points:

- ✓ $\Delta_i H_1 < \Delta_i H_2 < \Delta_i H_3$ (successive ionization enthalpies increase)
- ✓ Removing electron from cation (positive ion) requires more energy
- ✓ Measure of how tightly electron is held by nucleus
- ✓ Lower $\Delta_i H$ → easier to lose electron → more metallic
- ✓ Higher $\Delta_i H$ → difficult to lose electron → more non-metallic

📐 TRENDS IN IONIZATION ENTHALPY:

1. Across a Period (left to right): INCREASES

Li (520) < Be (899) < B (801) < C (1086) < N (1402) < O (1314) < F (1681) < Ne (2080) kJ/mol

2. Down a Group: DECREASES

Li (520) > Na (496) > K (419) > Rb (403) > Cs (374) kJ/mol

💡 Explanation:

Across a Period (Increase):

- ✓ Atomic size DECREASES
- ✓ Nuclear charge INCREASES
- ✓ **Result:** Stronger attraction → more energy needed to remove electron

Down a Group (Decrease):

- ✓ Atomic size INCREASES
- ✓ Shielding effect INCREASES
- ✓ **Result:** Weaker attraction → less energy needed to remove electron

⚠️ Exceptions/Anomalies:

1. Be > B (Beryllium has higher $\Delta_i H$ than Boron)

Be: $1s^2\ 2s^2$ (electron removed from 2s - closer to nucleus)

B: $1s^2\ 2s^2\ 2p^1$ (electron removed from 2p - farther, more shielded)

Result: Easier to remove 2p electron from B

2. N > O (Nitrogen has higher $\Delta_i H$ than Oxygen)

N: $1s^2\ 2s^2\ 2p^3$ (each 2p orbital has 1 electron - stable half-filled)

O: $1s^2\ 2s^2\ 2p^4$ (one 2p orbital has 2 electrons - electron-electron repulsion)

Result: Easier to remove paired electron from O due to repulsion

📝 Example: Why is second IE of Na much higher than first?

Na: $1s^2\ 2s^2\ 2p^6\ 3s^1$

$\Delta_i H_1$ ($Na \rightarrow Na^+$): Remove $3s^1$ electron = 496 kJ/mol

Na^+: $1s^2\ 2s^2\ 2p^6$ (stable noble gas configuration)

$\Delta_i H_2$ ($Na^+ \rightarrow Na^{2+}$): Must remove electron from stable $2p^6$ = 4562 kJ/mol!

$\Delta_i H_2$ >> $\Delta_i H_1$ because breaking noble gas configuration requires enormous energy

4️⃣ ELECTRON GAIN ENTHALPY ($\Delta_{e^-}H$)

Definition:

Electron Gain Enthalpy: Energy change when an electron is added to an isolated gaseous atom in its ground state

$$X(g) + e^- \rightarrow X^-(g) \quad \Delta_{e^-}H$$

Units: kJ/mol

Usually NEGATIVE (energy released when electron added)

Important Points:

- ✓ More negative $\Delta_{e^-}H$ → greater tendency to gain electron → more non-metallic
- ✓ Halogens have most negative $\Delta_{e^-}H$ (want to complete octet)
- ✓ Noble gases have POSITIVE $\Delta_{e^-}H$ (don't want extra electron)
- ✓ Opposite of ionization enthalpy (IE removes e^-, EGE adds e^-)

Sign Convention:

Negative $\Delta_{e^-}H$: Energy released (exothermic) - favorable

Positive $\Delta_{e^-}H$: Energy absorbed (endothermic) - unfavorable

📐 TRENDS:

1. Across a Period: Becomes MORE NEGATIVE (left to right)

Group 1 → Group 17: Δ_e-.H becomes more negative

Example: Na (-53) → Cl (-349) kJ/mol

2. Down a Group: Becomes LESS NEGATIVE

F (-328) → Cl (-349) → Br (-325) → I (-295) kJ/mol

💡 Explanation:

Across a Period (More Negative):

- ✓ Atomic size DECREASES
- ✓ Nuclear charge INCREASES
- ✓ **Result:** Stronger attraction for incoming electron → more energy released

Down a Group (Less Negative):

- ✓ Atomic size INCREASES
- ✓ **Result:** Incoming electron farther from nucleus → less energy released

⚠️ Important Exception:

F < Cl (Fluorine has LESS negative Δ_e-.H than Chlorine!)

F: Very small size → High electron-electron repulsion when adding electron to 2p orbital

Cl: Larger 3p orbital → Less repulsion, more space for incoming electron

Result: Δ_e-.H (Cl) = -349 kJ/mol is MORE negative than Δ_e-.H (F) = -328 kJ/mol

Similarly: O < S (oxygen less negative than sulfur)

📝 Example: Why do noble gases have positive Δ_e-.H?

Ne: $1s^2\ 2s^2\ 2p^6$ (complete octet, stable)

Adding electron: $Ne + e^- \rightarrow Ne^-$ (electron must go to 3s orbital)

New configuration: $1s^2\ 2s^2\ 2p^6\ 3s^1$ (UNSTABLE, repulsion with complete shell)

Result: Energy must be SUPPLIED (positive Δ_e-.H = +116 kJ/mol)

Conclusion: Noble gases DON'T want extra electrons!

5 ELECTRONEGATIVITY (χ)

Definition:

Electronegativity: Ability of an atom in a molecule to attract shared electrons toward itself

Key Points:

- NOT a measurable quantity (unlike IE or EGE)
- Qualitative measure
- Most common scale: **Pauling Scale** (0.7 to 4.0)
- Fluorine = 4.0 (highest, most electronegative)
- Caesium = 0.7 (lowest, most electropositive)

Important Electronegativities (Pauling Scale):

Element	χ	Element	χ	Element	χ
F	4.0	N	3.0	C	2.5
O	3.5	Cl	3.0	H	2.1
Br	2.8	I	2.5	P	2.1

Order: F > O > N = Cl > Br > I ≈ C > S > P ≈ H

📐 TRENDS:

1. Across a Period (left to right): INCREASES

Li (1.0) < Be (1.5) < B (2.0) < C (2.5) < N (3.0) < O (3.5) < F (4.0)

2. Down a Group: DECREASES

F (4.0) > Cl (3.0) > Br (2.8) > I (2.5)

💡 Explanation:

- ✓ Electronegativity ∝ 1/(Atomic radius)
- ✓ Smaller atom → electrons closer → stronger attraction → higher χ
- ✓ **Across period:** Size decreases → χ increases
- ✓ **Down group:** Size increases → χ decreases

Relationship with Other Properties:

- ✓ High χ → High ionization enthalpy → Non-metallic character
- ✓ Low χ → Low ionization enthalpy → Metallic character

📝 Example: Bond polarity

In HCl:

$\chi(H) = 2.1$, $\chi(Cl) = 3.0$

Difference = 3.0 - 2.1 = 0.9

Result: Cl is more electronegative → shared electrons closer to Cl

Bond is **polar covalent**: $H^{+}\delta$ - $Cl^{-}\delta$

In NaCl:

$\chi(Na) = 0.9$, $\chi(Cl) = 3.0$

Difference = 3.0 - 0.9 = 2.1 (very large)

Result: Electron completely transferred from Na to Cl

Bond is **ionic**: $Na^{+}Cl^{-}$

📈 SUMMARY OF PERIODIC TRENDS

🎯 All Trends at a Glance:

Property	Across Period (→)	Down Group (↓)
Atomic Radius	DECREASES	INCREASES
Ionic Radius	DECREASES	INCREASES
Ionization Enthalpy	INCREASES	DECREASES
Electron Gain Enthalpy	MORE NEGATIVE	LESS NEGATIVE
Electronegativity	INCREASES	DECREASES
Metallic Character	DECREASES	INCREASES
Non-metallic Character	INCREASES	DECREASES

💡 Memory Trick for Trends:

Think of Fluorine (top right):

- ✓ SMALLEST atomic radius
- ✓ HIGHEST ionization enthalpy
- ✓ HIGHEST electronegativity (4.0)
- ✓ MOST non-metallic

Think of Francium (bottom left):

- ✓ LARGEST atomic radius
- ✓ LOWEST ionization enthalpy
- ✓ LOWEST electronegativity
- ✓ MOST metallic

🧪 PERIODIC TRENDS IN CHEMICAL PROPERTIES

1️⃣ Valence and Oxidation States

Valence:

Definition: Combining capacity of element

For main group elements:

- Valence = Number of valence electrons OR
- Valence = 8 - (Number of valence electrons)

Group	1	2	13	14	15	16	17	18
Valence e^-	1	2	3	4	5	6	7	8
Valence	1	2	3	4	3,5	2,6	1,7	0,8

📝 Examples of Hydrides and Oxides:

Group	1	2	13	14	15	16	17
Hydride	NaH	CaH_2	AlH_3	CH_4	NH_3	H_2O	HCl
Oxide	Na_2O	CaO	Al_2O_3	CO_2	N_2O_5	SO_3	Cl_2O_7

2 Nature of Oxides

Trend Across a Period:

Basic → Amphoteric → Acidic

Element	Oxide	Nature	Reaction with Water
Na	Na_2O	**Basic**	$Na_2O + H_2O \rightarrow 2NaOH$ (base)
Mg	MgO	**Basic**	$MgO + H_2O \rightarrow Mg(OH)_2$
Al	Al_2O_3	**Amphoteric**	Reacts with both acids and bases
Si	SiO_2	**Weakly Acidic**	Reacts with strong bases
P	P_4O_{10}	**Acidic**	$P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$
S	SO_3	**Acidic**	$SO_3 + H_2O \rightarrow H_2SO_4$
Cl	Cl_2O_7	**Strongly Acidic**	$Cl_2O_7 + H_2O \rightarrow 2HClO_4$

💡 Rule:

- **Metallic oxides:** BASIC (react with acids)
- **Non-metallic oxides:** ACIDIC (react with bases)
- **Metalloid oxides:** AMPHOTERIC (react with both)

Why this trend?

- ✓ **Left side (metals):** Low electronegativity → form ionic oxides → basic
- ✓ **Right side (non-metals):** High electronegativity → form covalent oxides → acidic

3️⃣ Chemical Reactivity

Pattern in Periodic Table:

Reactivity is HIGHEST at both extremes, LOWEST in middle

Across a Period:

- **Group 1 (Li, Na, K):** Very reactive metals (low IE, easy to lose e^-)
- **Middle (C, Si):** Less reactive
- **Group 17 (F, Cl, Br):** Very reactive non-metals (high EGE, easy to gain e^-)
- **Group 18 (He, Ne, Ar):** Least reactive (noble gases, complete octet)

Down a Group:

- **Metals (Group 1, 2):** Reactivity INCREASES (IE decreases)
- **Non-metals (Group 17):** Reactivity DECREASES (EGE becomes less negative)

📝 Examples:

Alkali Metals + Water:

$2Na + 2H_2O \rightarrow 2NaOH + H_2\uparrow$ (vigorous reaction)

Reactivity: Li < Na < K < Rb < Cs (increases down group)

Halogens + Hydrogen:

$H_2 + Cl_2 \rightarrow 2HCl$

Reactivity: F > Cl > Br > I (decreases down group)

F_2 reacts explosively, Cl_2 reacts vigorously, I_2 reacts slowly

✅ PRACTICE MCQs (CBSE Pattern)

Q1. Modern periodic law states that properties of elements are periodic function of their:

(a) Atomic mass

(b) Atomic number

(c) Atomic volume

(d) Atomic density

Q2. Which of the following is correct order of atomic radii?

(a) F > Cl > Br > I

(b) I > Br > Cl > F

(c) Cl > F > Br > I

(d) Br > Cl > I > F

Q3. The correct order of ionization enthalpy is:

(a) Li < Na < K < Rb

(b) K < Na < Li < Rb

(c) Na < Li < K < Rb

(d) Rb < K < Na < Li

Q4. Which element has the highest electronegativity?

(a) Oxygen

(b) Fluorine

(c) Nitrogen

(d) Chlorine

Q5. Lanthanoids belong to which block?

(a) s-block

(b) p-block

(c) d-block

(d) f-block

Q6. Element with atomic number 118 belongs to:

(a) Group 17

(b) Group 18

(c) Group 1

(d) Group 2

Q7. Which has largest size among isoelectronic species?

(a) F^-

(b) Na^+

(c) Mg^{2+}

(d) Al^{3+}

Q8. Electronic configuration of Group 17 elements is:

(a) $ns^2\ np^4$

(b) $ns^2\ np^5$

(c) $ns^2\ np^6$

(d) ns^1

Q9. Which oxide is amphoteric?

(a) Na_2O

(b) Al_2O_3

(c) SO_3

(d) Cl_2O_7

Q10. Metallic character down a group:

(a) Increases

(b) Decreases

(c) Remains same

(d) First increases then decreases

Q11. Mendeleev arranged elements based on:

(a) Atomic number

(b) Atomic weight

(c) Electron configuration

(d) Valency

Q12. Number of elements in 5th period is:

(a) 8

(b) 18

(c) 32

(d) 2

Q13. Which has highest electron gain enthalpy (most negative)?

(a) F

(b) Cl

(c) Br

(d) I

Q14. d-block elements are also called:

(a) Alkali metals

(b) Transition elements

(c) Inner transition elements

(d) Noble gases

Q15. Which is a metalloid?

(a) Al

(b) Si

(c) P

(d) S

Q16. Cation is smaller than parent atom because:

(a) It gains electrons

(b) It loses electrons

(c) Nuclear charge increases

(d) Shielding increases

Q17. Element with Z=114 belongs to:

(a) 6th period, Group 14

(b) 7th period, Group 14

(c) 6th period, Group 4

(d) 7th period, Group 4

Q18. Which has highest ionization enthalpy?

(a) Li

(b) Na

(c) K

(d) Cs

Q19. Noble gases belong to:

(a) Group 17

(b) Group 18

(c) Group 1

(d) Group 2

Q20. Across a period, atomic radius:

(a) Increases

(b) Decreases

(c) Remains same

(d) First decreases then increases

✅ ANSWER KEY:

1.(b) 2.(b) 3.(d) 4.(b) 5.(d) 6.(b) 7.(a) 8.(b) 9.(b) 10.(a)

11.(b) 12.(b) 13.(b) 14.(b) 15.(b) 16.(b) 17.(b) 18.(a) 19.(b) 20.(b)

📚 CASE-BASED QUESTIONS (New CBSE Pattern)

Case Study 1: Periodic Trends

Passage:

The physical and chemical properties of elements vary periodically with their atomic numbers. Across a period, atomic size generally decreases while ionization enthalpy increases. This is because as we move from left to right, nuclear charge increases while electrons are added to the same shell. Down a group, atomic size increases because new shells are added, and ionization enthalpy decreases due to increased shielding effect.

Q1. Atomic radius decreases across a period because:

(a) Nuclear charge decreases

(b) Shielding effect increases

(c) Nuclear charge increases, electrons in same shell

(d) New shell is added

Q2. Ionization enthalpy decreases down a group because:

(a) Atomic size decreases

(b) Shielding effect increases

(c) Nuclear charge decreases

(d) Electrons enter same shell

Q3. Which element has smallest atomic radius in Period 3?

(a) Na

(b) Mg

(c) Cl

(d) Ar

Q4. Electronegativity across period:

(a) Increases

(b) Decreases

(c) Remains constant

(d) First increases then decreases

Answers: 1.(c) 2.(b) 3.(c) 4.(a)

Case Study 2: Classification into Blocks

Passage:

Elements are classified into s, p, d, and f blocks based on which orbital receives the last electron. s-block elements (Groups 1 and 2) are highly reactive metals. p-block elements (Groups 13-18) include metals, non-metals, and metalloids. d-block elements (Groups 3-12) are transition metals showing variable oxidation states and colored compounds. f-block elements are lanthanoids and actinoids placed separately at the bottom.

Q1. Electronic configuration ns^2 np^3 belongs to:

(a) Group 13

(b) Group 14

(c) Group 15

(d) Group 16

Q2. Transition elements show variable oxidation states because:

(a) They have d-electrons

(b) They have s-electrons only

(c) They are non-metals

(d) They are gases

Q3. Number of elements in f-block (each series):

(a) 10

(b) 14

(c) 18

(d) 8

Q4. Alkali metals belong to:

(a) s-block

(b) p-block

(c) d-block

(d) f-block

Answers: 1.(c) 2.(a) 3.(b) 4.(a)

Case Study 3: Chemical Reactivity

Passage:

Chemical reactivity of elements depends on their ability to lose or gain electrons. Alkali metals (Group 1) are highly reactive because they have low ionization enthalpies and readily lose one electron. Halogens (Group 17) are highly reactive non-metals with high electron gain enthalpies, readily gaining one electron. Noble gases (Group 18) are least reactive with complete octet. Across a period, metallic character decreases while non-metallic character increases.

Q1. Which alkali metal is most reactive?

(a) Li

(b) Na

(c) K

(d) Cs

Q2. Which halogen is most reactive?

(a) F

(b) Cl

(c) Br

(d) I

Q3. Noble gases are unreactive because:

(a) They are gases

(b) They have complete octet

(c) They are non-metals

(d) They have high atomic mass

Q4. Across a period, metallic character:

(a) Increases

(b) Decreases

(c) Remains same

(d) First decreases then increases

Answers: 1.(d) 2.(a) 3.(b) 4.(b)

🎯 EXAM STRATEGY & IMPORTANT POINTS

📋 Topic-wise Weightage:

1. **HIGH PRIORITY (Must Score 100%):**
   - Periodic trends (atomic radius, IE, EGE, electronegativity) - graphs!
   - Block classification (s, p, d, f)
   - Mendeleev vs Modern Periodic Law
   - Nature of oxides
2. **MEDIUM PRIORITY:**
   - Historical development (Dobereiner, Newlands)
   - IUPAC nomenclature (Z > 100)
   - Isoelectronic species
   - Chemical reactivity patterns
3. **LOW PRIORITY:**
   - Exact dates and names
   - Detailed history

⚠️ Last Minute Checklist (1 Day Before Exam):

- ✅ Modern Periodic Law (by heart!)
- ✅ All periodic trends - direction across period and down group
- ✅ Exceptions: Be > B, N > O, F < Cl
- ✅ Block classification and electronic configurations
- ✅ s-block: ns^{1-2}, p-block: $ns^2\ np^{1-6}$, d-block: $(n-1)d^{1-10}\ ns^{0-2}$, f-block: $(n-2)f^{1-14}$
- ✅ Number of elements in each period: 2, 8, 8, 18, 18, 32, 32
- ✅ IUPAC nomenclature table
- ✅ Cation < atom < anion (size comparison)
- ✅ Nature of oxides: Basic → Amphoteric → Acidic
- ✅ Isoelectronic species concept
- ✅ Electronegativity: F (4.0) highest

🎯 Exam Writing Tips:

1. **Trends Questions:** Always explain with reason (nuclear charge, shielding, size)
2. **Graphs:** Practice sketching trend graphs (very common in boards!)
3. **Comparisons:** Use correct symbols (>, <, =) with element names
4. **Electronic Configurations:** Write in noble gas notation to save time
5. **Definitions:** Write word-to-word from NCERT (Modern Periodic Law especially)
6. **Examples:** Give specific examples with symbols (Na_2O, Cl_2O_7, etc.)
7. **Historical:** Just write key points, don't elaborate unless asked

📝 Quick Revision Points:

Concept	Key Point
Modern Periodic Law	**Properties are periodic function of atomic number**
Period number	**= Principal quantum number (n) of valence shell**
Max elements in period	**= $2n^2$ (but follows filling order)**
Atomic radius trend	**Decreases →, Increases ↓**
IE trend	**Increases →, Decreases ↓**
EGE trend	**More negative →, Less negative ↓**
Electronegativity	**F = 4.0 (highest)**
Isoelectronic size	**Decreases with increasing Z**
s-block	**Groups 1, 2 (alkali, alkaline earth)**
d-block	**Groups 3-12 (transition elements)**

📚 Study Material Information

This comprehensive study material on **Classification of Elements and Periodicity in Properties** has been meticulously prepared following the latest CBSE curriculum and examination pattern for Class 11 Chemistry (2025-26 session). The content includes detailed coverage of need for classification, historical development (Dobereiner's triads, Newlands' octaves, Mendeleev's periodic table), Modern Periodic Law and present form of periodic table, nomenclature of elements with Z > 100 (IUPAC system), classification into s, p, d, f blocks with properties, metals, non-metals and metalloids, complete coverage of periodic trends (atomic radius, ionic radius, ionization enthalpy, electron gain enthalpy, electronegativity), periodic trends in chemical properties (valence, oxidation states, nature of oxides, chemical reactivity), 20 CBSE-pattern MCQs with answer key, 3 complete case studies with questions, solved examples and problems, trend graphs and diagrams, exceptions and anomalies explained, memory tricks and shortcuts, and complete exam preparation strategy.

Key Features of This Material:

- ✅ Complete Chapter 3 coverage following NCERT 2025-26
- ✅ Historical development with all important scientists
- ✅ Modern Periodic Law and its significance
- ✅ Complete periodic table structure (118 elements)
- ✅ IUPAC nomenclature for elements with Z > 100
- ✅ All four blocks (s, p, d, f) with properties
- ✅ Complete periodic trends with explanations
- ✅ All exceptions clearly explained (Be > B, N > O, F < Cl)
- ✅ Isoelectronic species concept with examples
- ✅ Nature of oxides (basic, acidic, amphoteric)
- ✅ Chemical reactivity patterns across period and down group
- ✅ 20 MCQs + 3 case studies (latest CBSE pattern)
- ✅ Solved examples for each concept
- ✅ Trend graphs (very important for boards!)
- ✅ Memory tricks for easy learning
- ✅ Common mistakes to avoid
- ✅ Last-minute checklist and exam strategy
- ✅ Quick revision tables and comparison charts

🎯 Why This Chapter is Extremely Important:

Classification of Elements and Periodicity is the **backbone of inorganic chemistry!** This chapter helps you understand:

- ✓ Why elements behave the way they do
- ✓ Prediction of properties without experiments
- ✓ Connection between electronic configuration and properties
- ✓ Foundation for ALL chemistry topics ahead
- ✓ Direct questions in JEE/NEET every year
- ✓ Understanding chemical bonding (next chapter)
- ✓ s-block, p-block, d-block, f-block chemistry (Class 11 & 12)

Master periodic trends = Chemistry becomes 50% easier!

Content is based on NCERT syllabus and CBSE guidelines for 2025-26.

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Disclaimer: This material is prepared as a comprehensive study aid for Class 11 students. While every effort has been made to ensure accuracy and alignment with CBSE curriculum, students are advised to refer to their NCERT textbooks and official CBSE guidelines for examination preparation. This material covers Chapter 3: Classification of Elements and Periodicity in Properties from Class 11 Chemistry NCERT textbook (Reprint 2025-26). All periodic trends, values, and concepts are as per latest NCERT edition. Special emphasis on understanding trends rather than just memorization.

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