Periodic Table for JEE Main Preparation

Comprehensive Guide for Classes X-XII

In-Depth Theory, Pattern Exercises, and Solutions

Prepared for JEE Main Aspirants

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Chapter Synopsis

This booklet provides an exhaustive study guide for the "Periodic Table" chapter, a cornerstone for JEE Main preparation. Designed for Classes X-XII, it includes:

- **Theory with Illustrations**: Comprehensive explanations of periodic trends, electronic configurations, and chemical properties with diagrams.
- **JEE-Level Concepts**: Detailed coverage of high-weightage topics like ionization energy, electronegativity, and anomalies.
- **Solved Examples**: Step-by-step solutions to diverse problems.
- **Pattern-Based Exercises**: Extensive exercises focusing on trend prediction and property comparison, with solutions immediately below.
- **Question Types**: MCQs, Assertion-Reason, and Integer-Type questions.
- **Summary and Formula Sheet**: Comprehensive revision aid.

This 50+ page booklet ensures thorough preparation with enhanced content and pattern recognition for JEE Main.

1 Theory with Illustrations

1.1 Historical Development

Dmitri Mendeleev (1869) organized elements by increasing atomic mass, predicting properties of undiscovered elements. Modern periodic table uses atomic number, following Moseley's work (1913).

1.2 Structure of the Periodic Table

The periodic table is divided into:

- **Periods**: 7 horizontal rows (based on principal quantum number).
- **Groups**: 18 vertical columns (similar valence electrons).
- **Blocks**: s, p, d, f (based on orbital filling).

Periodic Table Layout

1	H									He	2
3	Li									Be	4
11											
19											
37											

1.3 Electronic Configuration

Electronic configurations determine element properties. Rules:

- **Aufbau Principle**: Orbitals fill in order of increasing energy (e.g., 1s, 2s, 2p, 3s).
- **Pauli Exclusion Principle**: Maximum two electrons per orbital with opposite spins.
- **Hund's Rule**: Electrons fill degenerate orbitals singly before pairing.

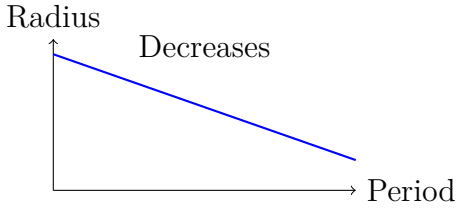
Example: Oxygen ($Z = 8$): $1s^2 2s^2 2p^4$.

↓1s Filled 1s Orbital

1.4 Periodic Trends

1.4.1 Atomic Radius

Atomic radius decreases across a period (increasing Z_{eff}) and increases down a group (additional shells).



1.4.2 Ionization Energy

Ionization energy (IE) is the energy to remove an electron. It increases across a period (higher Z_{eff}) and decreases down a group (larger radius). Anomalies: N > O (half-filled stability).

1.4.3 Electronegativity

Electronegativity measures electron attraction in bonds. It increases across a period and decreases down a group. Fluorine (3.98) is the most electronegative.

1.4.4 Electron Affinity

Electron affinity (EA) is the energy change when adding an electron. It becomes more negative across a period. Exception: Cl > F (small size of F causes repulsion).

1.4.5 Metallic Character

Metallic character decreases across a period (non-metals dominate) and increases down a group (lower IE).

1.5 Classification of Elements

- **s-block**: Groups 1, 2 (highly reactive metals).

- **p-block**: Groups 13–18 (metals, non-metals, metalloids).
- **d-block**: Transition metals (variable oxidation states).
- **f-block**: Lanthanides and actinides (inner transition metals).

1.6 Chemical Properties

Group trends reflect valence electrons:

- Group 1: Highly reactive, form +1 ions.
- Group 17: Form -1 ions, high EA.
- Noble gases: Inert due to stable configurations.

2 Important JEE-Level Concepts

- **Trend Predictions**: Comparing IE, EA, radius, and electronegativity.
- **Anomalies**: Half-filled (N, Cr) and fully-filled (Be, Cu) stability.
- **Configurations**: Exceptions (e.g., Cr : $[Ar]3d^5 4s^1$).
- **Reactivity**: Group 1 and 17 trends.
- **Effective Nuclear Charge**: Z_{eff} drives trends.
- **Periodic Anomalies**: Second period elements (e.g., Li, Be) show unique behavior.

3 Solved Examples

3.1 Example 1: Atomic Radius

Problem: Arrange Na, Mg, Al in order of increasing atomic radius.

Solution: Across period 3, radius decreases due to increasing Z_{eff}.

$$\text{Al} < \text{Mg} < \text{Na}$$

Answer: Al < Mg < Na.

3.2 Example 2: Ionization Energy Anomaly

Problem: Explain why N has higher IE than O.

Solution: N ($1s^2 2s^2 2p^3$) has a half-filled 2p subshell, more stable than O ($1s^2 2s^2 2p^4$).
Answer: Half-filled stability.

3.3 Example 3: Electronic Configuration

Problem: Write the configuration of Cu ($Z = 29$).

Solution: Expected: $[Ar]3d^9 4s^2$. Actual: $[Ar]3d^{10} 4s^1$ (fully-filled 3d). **Answer**: $[Ar]3d^{10} 4s^1$.

3.4 Example 4: Electronegativity

Problem: Arrange C, N, O in order of increasing electronegativity.

Solution: Electronegativity increases across period 2.

$$\text{C} < \text{N} < \text{O}$$

Answer: C < N < O.

3.5 Example 5: Reactivity

Problem: Compare reactivity of K and Cs.

Solution: Down group 1, reactivity increases due to lower IE.

$$\text{K} < \text{Cs}$$

Answer: Cs > K.

4 Pattern-Based Exercises

4.1 Exercise 1: Atomic Radius Trend

Problem: Arrange Li, Be, B in order of increasing atomic radius.

Solution: Across period 2, radius decreases.

$$\text{B} < \text{Be} < \text{Li}$$

Answer: B < Be < Li.

4.2 Exercise 2: Ionization Energy Comparison

Problem: Compare the first IE of F and Cl.

Solution: F (period 2) has higher IE than Cl (period 3) due to smaller size.

$$\text{F} > \text{Cl}$$

Answer: F > Cl.

4.3 Exercise 3: Electronegativity Trend

Problem: Arrange O, S, Se in order of decreasing electronegativity.

Solution: Down group 16, electronegativity decreases.

$$\text{O} > \text{S} > \text{Se}$$

Answer: O > S > Se.

4.4 Exercise 4: Electronic Configuration

Problem: Predict the configuration of Cr ($Z = 24$).

Solution: Expected: $[Ar]3d^4 4s^2$. Actual: $[Ar]3d^5 4s^1$ (half-filled stability). **Answer**: $[Ar]3d^5 4s^1$.

4.5 Exercise 5: Reactivity Trend

Problem: Arrange Na, K, Rb in order of increasing reactivity.

Solution: Down group 1, reactivity increases.

$$\text{Na} < \text{K} < \text{Rb}$$

Answer: Na < K < Rb.

4.6 Exercise 6: IE Anomaly

Problem: Why is the IE of Be higher than B?

Solution: Be ($1s^2 2s^2$) has a fully-filled 2s subshell, more stable than B ($1s^2 2s^2 2p^1$). **Answer**: Fully-filled stability.

4.7 Exercise 7: Electron Affinity

Problem: Compare EA of Cl and Br.

Solution: Cl has more negative EA due to smaller size.

$$\text{Cl} > \text{Br}$$

Answer: Cl > Br.

4.8 Exercise 8: Block Identification

Problem: Identify the block of Ti ($Z = 22$).

Solution: Ti: $[Ar]3d^2 4s^2$. d-block. **Answer**: d-block.

4.9 Exercise 9: Periodic Position

Problem: Find the period and group of Cl ($Z = 17$).

Solution: Cl: $[Ne]3s^2 3p^5$. Period 3, group 17. **Answer**: Period 3, Group 17.

4.10 Exercise 10: Valency Trend

Problem: Predict the valency of Si, P, S.

Solution: Based on valence electrons: Si: 4, P: 5, S: 6. **Answer**: Si: 4, P: 5, S: 6.

4.11 Exercise 11: Radius Down Group

Problem: Arrange F, Cl, Br in order of increasing radius.

Solution: Down group 17, radius increases.

$$\text{F} < \text{Cl} < \text{Br}$$

Answer: F < Cl < Br.

4.12 Exercise 12: IE Across Period

Problem: Arrange Al, Si, P in order of increasing IE.

Solution: IE increases across period 3.

$$\text{Al} < \text{Si} < \text{P}$$

Answer: Al < Si < P.

4.13 Exercise 13: Electronegativity Comparison

Problem: Compare electronegativity of N and P.

Solution: N is more electronegative due to smaller size.

$$\text{N} > \text{P}$$

Answer: N > P.

4.14 Exercise 14: Configuration Exception

Problem: Write the configuration of Mo ($Z = 42$).

Solution: Expected: $[Kr]4d^4 5s^2$. Actual: $[Kr]4d^5 5s^1$. **Answer**: $[Kr]4d^5 5s^1$.

4.15 Exercise 15: Metallic Character

Problem: Arrange Si, P, S in order of increasing metallic character.

Solution: Metallic character decreases across a period.

$$\text{S} < \text{P} < \text{Si}$$

Answer: S < P < Si.

4.16 Exercise 16: IE Anomaly

Problem: Why is the IE of Mg higher than Al?

Solution: Mg ($3s^2$) has a fully-filled subshell, more stable than Al ($ $3s^2 3p^1$$).**Answer** : $Fully - filled stability.$

4.17 Exercise 17: EA Trend

Problem: Arrange O, F, Cl in order of increasing EA (more negative).

Solution: Cl has the most negative EA due to optimal size.

$$\text{O} < \text{F} < \text{Cl}$$

Answer: O < F < Cl.

4.18 Exercise 18: Block Identification

Problem: Identify the block of La ($Z = 57$).

Solution: La: $[Xe]5d^1 6s^2$. d-block (lanthanide precursor). **Answer**: d-block.

4.19 Exercise 19: Periodic Position

Problem: Find the period and group of Ca ($ Z = 20 $).

Solution: Ca: $[Ar]4s^2$. Period 4, group 2. **Answer**: Period 4, Group 2.

4.20 Exercise 20: Valency Prediction

Problem: Predict the valency of Ge, As, Se.

Solution: Ge: 4, As: 5, Se: 6. **Answer**: Ge: 4, As: 5, Se: 6.

4.21 Exercise 21: Radius Across Period

Problem: Arrange C, N, O in order of decreasing radius.

Solution: Radius decreases across period 2.

$$\text{C} > \text{N} > \text{O}$$

Answer: C > N > O.

4.22 Exercise 22: IE Down Group

Problem: Arrange Li, Na, K in order of increasing IE.

Solution: IE decreases down group 1.

$$\text{K} < \text{Na} < \text{Li}$$

Answer: K < Na < Li.

4.23 Exercise 23: Electronegativity Trend

Problem: Arrange B, Al, Ga in order of decreasing electronegativity.

Solution: Down group 13, electronegativity generally decreases, but Ga > Al due to d-block contraction.

$$\text{B} > \text{Ga} > \text{Al}$$

Answer: B > Ga > Al.

4.24 Exercise 24: Configuration Anomaly

Problem: Write the configuration of Pd ($ Z = 46 $).

Solution: Expected: $[Kr]4d^8 5s^2$. Actual: $[Kr]4d^{10}$. **Answer**: $[Kr]4d^{10}$.

4.25 Exercise 25: Reactivity Comparison

Problem: Compare reactivity of Br and I.

Solution: Br is more reactive due to higher EA.

$$\text{Br} > \text{I}$$

Answer: Br > I.

4.26 Exercise 26: IE Trend

Problem: Arrange S, Cl, Ar in order of increasing IE.

Solution: IE increases across period 3.

$$\text{S} < \text{Cl} < \text{Ar}$$

Answer: S < Cl < Ar.

4.27 Exercise 27: EA Anomaly

Problem: Why is the EA of Cl more negative than F?

Solution: F's small size causes electron repulsion, making Cl's EA more negative. **Answer**: Electron repulsion in F.

4.28 Exercise 28: Group Reactivity

Problem: Arrange Mg, Ca, Sr in order of increasing reactivity.

Solution: Down group 2, reactivity increases.

$$\text{Mg} < \text{Ca} < \text{Sr}$$

Answer: Mg < Ca < Sr.

4.29 Exercise 29: Block Identification

Problem: Identify the block of Pr ($ Z = 59 $).

Solution: Pr: $[Xe]4f^3 6s^2$. f-block. **Answer**: f-block.

4.30 Exercise 30: Valency Trend

Problem: Predict the valency of C, N, O.

Solution: C: 4, N: 5, O: 6. **Answer**: C: 4, N: 5, O: 6.

5 Additional Pattern Exercises

5.1 Exercise 31: Radius Comparison

Problem: Arrange Ga, Ge, As in order of increasing radius.

Solution: Across period 4, radius decreases.

$$\text{As} < \text{Ge} < \text{Ga}$$

Answer: As < Ge < Ga.

5.2 Exercise 32: IE Trend

Problem: Arrange B, C, N in order of decreasing IE.

Solution: N has highest IE due to half-filled stability.

$$\text{N} > \text{C} > \text{B}$$

Answer: N > C > B.

5.3 Exercise 33: Electronegativity

Problem: Compare electronegativity of O and Cl.

Solution: O (3.44) > Cl (3.16).

$$\text{O} > \text{Cl}$$

Answer: O > Cl.

5.4 Exercise 34: Configuration

Problem: Write the configuration of Ag ($ Z = 47 $).

Solution: Expected: $[Kr]4d^9 5s^2$. Actual: $[Kr]4d^{10}5s^1$. **Answer**: $[Kr]4d^{10}5s^1$.

5.5 Exercise 35: Reactivity

Problem: Arrange Cl, Br, I in order of decreasing reactivity.

Solution: Down group 17, reactivity decreases.

$$\text{Cl} > \text{Br} > \text{I}$$

Answer: Cl > Br > I.

5.6 Exercise 36: Metallic Character

Problem: Arrange Al, Si, P in order of increasing metallic character.

Solution: Metallic character decreases across period 3.

$$\text{P} < \text{Si} < \text{Al}$$

Answer: P < Si < Al.

5.7 Exercise 37: IE Anomaly

Problem: Why is the IE of S lower than P?

Solution: P ($ 3p^3$)$has a half-filled subshell, more stable than$ S ($ 3p^4$). **Answer** : $Half-filled stability.$

5.8 Exercise 38: EA Trend

Problem: Arrange N, O, F in order of increasing EA.

Solution: N has low EA due to stability, F < O due to repulsion.

$$\mathrm{N} < \mathrm{F} < \mathrm{O}$$

Answer: N < F < O.

5.9 Exercise 39: Block Identification

Problem: Identify the block of Fe ($ Z = 26 $).

Solution: Fe: $[Ar]3d^6 4s^2$. d-block. **Answer**: d-block.

5.10 Exercise 40: Periodic Position

Problem: Find the period and group of I ($Z = 53$).

Solution: I: $[Kr]4d^{10}5s^2 5p^5$. Period 5, group 17. **Answer**: Period 5, Group 17.

6 Multiple Choice Questions

1. The element with the lowest IE in group 1 is:
   (a) Li
   (b) Na
   (c) K
   (d) Cs

   Answer: (d) Cs
2. The most electronegative element in period 3 is:
   (a) Na
   (b) Cl
   (c) Ar
   (d) S

   Answer: (b) Cl
3. The block of Gd ($Z = 64$) is:

(a) s-block

(b) p-block

(c) d-block

(d) f-block

Answer: (d) f-block

4. The element with a half-filled 3p subshell is:

(a) Si

(b) P

(c) S

(d) Cl

Answer: (b) P

7 Assertion-Reason Questions

1. **Assertion**: F has higher IE than Cl.
Reason: F is smaller than Cl.
Answer: Both true, Reason explains Assertion.

2. **Assertion**: Electronegativity increases down a group.
Reason: Atomic radius increases down a group.
Answer: Assertion false, Reason true.

3. **Assertion**: Cr has configuration $[Ar]3d^5 4s^1$.
Reason: Half-filled orbitals are more stable.
Answer: Both true, Reason explains Assertion.

8 Integer-Type Questions

1. The number of valence electrons in Sb ($Z = 51$) is: **Answer**: 5
2. The period number of Xe ($ Z = 54 $) is: **Answer**: 5
3. The group number of Ba ($Z = 56$) is: **Answer**: 2
4. The number of d-electrons in Fe ($Z = 26$) is: **Answer**: 6

9 Advanced Concepts for JEE Main

9.1 Effective Nuclear Charge

$$Z_{\text{eff}} = Z - \sigma$$

Higher Z_{eff} increases IE and electronegativity.

9.2 Periodic Anomalies

- Second period: Li, Be show diagonal relationships with Mg, Al.
- d-block: Cr, Cu exhibit configuration anomalies.
- EA: Cl > F due to size effects.

9.3 Chemical Reactivity

- Group 1: Reactivity increases down due to lower IE.
- Group 17: Reactivity decreases down due to lower EA.

10 Additional Solved Examples

10.1 Example 6: Metallic Character

Problem: Arrange Al, Si, P in order of increasing metallic character.

Solution: Metallic character decreases across period 3.

$$\text{P} < \text{Si} < \text{Al}$$

Answer: P < Si < Al.

10.2 Example 7: Configuration Anomaly

Problem: Why does Pd have configuration $[Kr]4d^{10}$?

Solution: Fully-filled 4d subshell is more stable than partially-filled 5s. **Answer**: Stability of fully-filled subshell.

11 Final Pattern Exercises

11.1 Exercise 41: Radius Trend

Problem: Arrange In, Sn, Sb in order of increasing radius.

Solution: Across period 5, radius decreases.

$$\text{Sb} < \text{Sn} < \text{In}$$

Answer: Sb < Sn < In.

11.2 Exercise 42: IE Comparison

Problem: Compare IE of Se and Br.

Solution: Br has higher IE due to smaller size.

$$\text{Br} > \text{Se}$$

Answer: Br > Se.

11.3 Exercise 43: Electronegativity

Problem: Arrange $\mathrm{N}, \mathrm{O}, \mathrm{F}$ in order of increasing electronegativity.

Solution: Electronegativity increases across period 2.

$$\mathrm{N} < \mathrm{O} < \mathrm{F}$$

Answer: $\mathrm{N} < \mathrm{O} < \mathrm{F}$.

11.4 Exercise 44: Configuration

Problem: Write the configuration of Au ($Z = 79$).

Solution: $[Xe]4f^{14}5d^{10}6s^1$. **Answer**: $[Xe]4f^{14}5d^{10}6s^1$.

11.5 Exercise 45: Reactivity

Problem: Arrange $\mathrm{Li}, \mathrm{Na}, \mathrm{K}$ in order of increasing reactivity.

Solution: Down group 1, reactivity increases.

$$\mathrm{Li} < \mathrm{Na} < \mathrm{K}$$

Answer: $\mathrm{Li} < \mathrm{Na} < \mathrm{K}$.

12 Summary and Formula Sheet

12.1 Summary

The periodic table is key to understanding element properties. Highlights:

- Trends in radius, IE, EA, and electronegativity.
- Anomalies due to orbital stability.
- Reactivity and chemical behavior by group.
- JEE Main focuses on pattern prediction.

12.2 Formula Sheet

- $Z_{\text{eff}} = Z - \sigma$
- Valence Electrons: Group number (s/p-block).
- IE: Increases across period, decreases down group.
- Radius: Decreases across period, increases down group.
- Electronegativity: Increases across period, decreases down group.

13 Conceptual Questions for Revision

1. Discuss the role of Z_{eff} in periodic trends.
2. Explain diagonal relationships with examples.
3. Analyze the impact of orbital stability on IE.

14 Final Practice Set

14.1 Exercise 46: Radius

Problem: Arrange $\text{Te}, \text{I}, \text{Xe}$ in order of decreasing radius. **Solution**: $\text{Te} > \text{I} > \text{Xe}$.

14.2 Exercise 47: IE

Problem: Compare IE of As and Se. **Solution**: $\text{Se} > \text{As}$.

14.3 Exercise 48: Electronegativity

Problem: Arrange $\text{Si}, \text{P}, \text{S}$ in order of increasing electronegativity. **Solution**: $\text{Si} < \text{P} < \text{S}$.