

## Concept QuickStart – Position in the Periodic Table

**Unit: Unit 4: The d- and f- Block Elements**

**Subject: For CBSE Class 12 Chemistry**

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### SECTION 1: UNDERSTANDING THE CONCEPT

Success in Class 12 Chemistry requires a strategic grasp of the Periodic Table's "territorial" layout. The d- and f-block elements occupy the central and bottom regions, respectively. This placement is never arbitrary; it is a spatial map of the **Aufbau Principle** in action. While s- and p-block elements involve filling the outermost shells, the d- and f-blocks focus on "backfilling" inner electron levels. This internal filling is the physical foundation for their "transitional" nature. Positioned as a bridge between the highly electropositive s-block metals and the electronegative p-block non-metals, these elements exhibit unique trends in atomic size, reactivity, and metallic character that are dictated entirely by their coordinates in the table.

#### 1.1 What Is the Position in the Periodic Table? (Core Idea and Anchor Definition)

- **Zero-Level Explanation:** Imagine the Periodic Table as a large architectural structure. The s-block and p-block are the two main high-rise towers on the left and right. The d-block is the wide, multi-lane bridge connecting them. The f-block is a **separate panel**—essentially a specialized "basement extension"—that technically fits inside the bridge but is pulled out to the bottom to keep the table's width manageable.
- **The Particle Perspective:** At the orbital level, the position is defined by the progressive filling of  $(n-1)d$  and  $(n-2)f$  orbitals. This reflects an increasing nuclear charge where electrons are added to "inner" subshells. Crucially, the **poor shielding effect** of d-electrons means they do not effectively block the nucleus's pull on outer electrons. This "inner-filling" mechanic is why these elements sit in the middle and bottom layers rather than the periphery.
- **Anchor Definition:** The d-block occupies the large middle section of the periodic table (Groups 3–12), while the f-block consists of two series (Lanthanoids and Actinoids) placed in a separate panel at the bottom.
- **Misunderstanding Correction:** Students often label every "middle" element as a transition metal. However, **Group 12 (Zn, Cd, Hg, and Cn)** elements are d-block members but are not technically "transition metals" because they have completely filled d-orbitals in both their ground and common ionic states.

#### 1.2 Why This Position Matters

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- **Chemical Significance:** The placement between the s- and p-blocks creates a gradient of properties. For instance, as you move across the d-block "bridge," the elements transition from highly reactive metals to less reactive ones. Their position determines their ability to show multiple oxidation states and form complex ions.
- **Board Exam Focus:** CBSE examiners frequently focus on "boundary elements." You must be able to justify why Scandium (Group 3) is a transition metal while Zinc (Group 12) is not, based solely on their orbital occupancy at that specific position.

### 1.3 Why This Concept Exists

- **Problem Solving:** The current arrangement solves the classification problem of "inner-shell fillers." By grouping elements that fill d and f subshells, we can predict shared characteristics like colored ions, catalytic activity, and paramagnetic behavior that don't occur in the s or p blocks.
- **Real-World Context:** Position dictates utility. Industrial "workhorse" metals like Iron (d-block) are found in the central bridge, whereas specialized "energy" metals like Uranium (f-block) are found in the bottom panel.

### 1.4 Analogies and Mental Image

- **The Primary Analogy:** The d-block is a **transition bridge** spanning a river.
- **Analogy Mapping:**
  - **The Banks:** The s-block (reactive metals) and p-block (non-metals/metals) are the two shores.
  - **The Bridge Span:** The d-block represents the gradual change in properties as you "cross" from one side of the table to the other.
  - **The Support Tiers:** The four series (3d, 4d, 5d, 6d) are the layers of the bridge's construction.
- **The Mind's Eye:** Picture a bookshelf. You've placed books on the outer edges (s and p). Now, you are "backfilling" the gaps behind the front row. This is the d-block filling the penultimate (second-to-last) layer. The f-block is like a separate drawer—a **separate panel**—pulled out from the Group 3 slot to prevent the shelf from becoming ten feet wide.
- **Concluding Phrase:** This is what the position of these blocks looks like in your mind's eye.

### 1.5 Everyday Context and Applications

- **Observable Phenomenon:** The immense density of middle-block elements like Gold (Au) or Platinum (Pt) is a result of their position. The filling of d-orbitals leads to

stronger interatomic metallic bonding compared to s-block metals (like Sodium), which are so soft they can be cut with a knife.

- **Technology Application:** Modern nuclear energy is powered by the f-block. Specifically, the elements **Th (Thorium)**, **Pa (Protactinium)**, and **U (Uranium)** are sourced from the bottom panel due to their heavy, complex nuclei.
- **Counterintuitive Example:**

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## SECTION 2: WHAT THE TEXTBOOK SAYS (NCERT)

Precise language is the key to scoring in CBSE. NCERT differentiates elements not just by where they sit, but by the "completeness" of their orbitals at that position.

### 2.1 NCERT Key Statements

- **Groups and Periods:** The d-block includes Groups 3 to 12 across the 4th, 5th, 6th, and 7th periods.
- **IUPAC Definition:** Transition metals are defined as metals having an incomplete d-subshell in their neutral atom or in their common ions.
- **Group 12 Exclusion:** Zinc (Zn), Cadmium (Cd), Mercury (Hg), and **Copernicium (Cn)** are not regarded as transition metals because they have a full  $(n-1)d^{10} ns^2$  configuration.
- **Electronic Configuration:** The general configuration is  $(n-1)d^{1-10} ns^{1-2}$ .
- **The Energy Gap Exceptions:** Due to the very small energy difference between  $(n-1)d$  and  $ns$  orbitals, and the stability of half-filled/full-filled subshells, note these specific configurations:
  - **Chromium (Cr):**  $3d^5 4s^1$  (not  $3d^4 4s^2$ )
  - **Copper (Cu):**  $3d^{10} 4s^1$  (not  $3d^9 4s^2$ )
  - **Palladium (Pd):**  $4d^{10} 5s^0$  (a unique exception)

### 2.2 NCERT Examples and Distinctions

- **The 3d Series Example:** Running from Scandium (Z=21) to Zinc (Z=30), this is the first row of the d-block and the primary focus of Class 12 studies.
- **Key Distinctions:**
  - **d-Series:** 3d (Sc–Zn), 4d (Y–Cd), 5d (La & Hf–Hg), and 6d (Ac & Rf–Cn).
  - **f-Series:** Known as "Inner Transition Metals," they consist of Lanthanoids (4f filling, Ce–Lu) and Actinoids (5f filling, Th–Lr).

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## SECTION 3: CLARITY AND MEMORY

### 3.1 Key Clarity Lines

1. **Scandium vs. Zinc:** Sc is a transition metal ( $3d^1$ ), but Zn is not ( $3d^{10}$ ) because transition status requires an *incomplete* d-orbital.
2. **The Shielding Rule:** d-electrons provide **poor shielding**, which is why atomic radii decrease as you move across a series.
3. **The "Penultimate" Rule:** The d-block fills the (n-1) shell; the f-block is "inner transition" because it fills the (n-2) shell.
4. **Lanthanoid Contraction:** This causes the 4d and 5d series to have almost identical radii. **Example: Zr (160 pm) and Hf (159 pm).**
5. **Group 12 Members:** Zn, Cd, Hg, and Cn are the "end members" of the d-series but are technically non-transition elements.

### 3.2 How to Remember the Position

- **3d Series Mnemonic (Sc to Zn):** "**Science Titter Vivace Creates Mnemonics: Fearless Council Nights Cure Zn**" (Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn)
- **Memorable Phrase:** "*The f-block is the Group 3 Guest.*" Remind yourself that all f-block elements are technically "parked" in Group 3, even though they sit in the bottom separate panel.
- **Physical Gesture:**
  - **The Bridge:** Hold your hands wide and flat in front of you. This is the **d-block bridge** spanning Groups 3 to 12.
  - **The Basement:** Drop your hands to your lap. This is the **f-block separate panel** at the bottom.
- **Extreme Association:** Think of Group 12 (Zn, Cd, Hg, Cn) as the "**Full-House Metals.**" Every room (orbital) is already packed with two people (electrons). Because they have "no room" for more, they can't participate in the "transition" behavior of their neighbors.

**This is what the position of these blocks looks like in your mind's eye.**