

Transition Metal Chemistry

Transition metals as d-block elements

For the elements up to Ca the 3d orbitals are higher in energy than the 4s orbital. Therefore, after argon (element 18), the 4s orbital is filled: Ca has electron configuration [Ar] 4s².

From scandium on, the 3d orbitals are filled, until they have ten electrons at zinc.

The term "d-block elements" refers to those elements in which this d-subshell is filling (Sc–Zn), but the term "transition elements" is used for d-block elements which form one or more stable ions with a partially-filled d-subshell.

A transition element is a d-block element that forms one or more stable ions that have incomplete d-orbitals.

This excludes Sc and Zn, since their only common oxidation states are Sc³⁺ (3d⁰) and Zn²⁺ (3d¹⁰).

This distinction is made because the main features of the chemistry of the transition elements depend largely on this partially filled d-subshell.

Electron configurations of the d-block elements and their simple ions.

You will be expected to use your Periodic Table to deduce the electronic configurations of atoms and ions.

Remember that:

- (i) the stability of the half-filled sub-shell means that d⁵ and d¹⁰ configurations are particularly stable e.g. Cr is 1s² 2s² 2p⁶ 3s² 3p⁶ 4s¹ 3d⁵ (not 4s² 3d⁴);
Cu is 1s² 2s² 2p⁶ 3s² 3p⁶ 4s¹ 3d¹⁰ (not 4s² 3d⁹);
- (ii) in ions the 4s electrons are always lost before 3d electrons: Fe²⁺ is 1s² 2s² 2p⁶ 3s² 3p⁶ 3d⁶.

| Element | Symbol | Electronic structure of atom | Common ion(s) | Electronic structure of ion |
|-----------|--------|--------------------------------------|--------------------------------------|---|
| Scandium | Sc | (Ar)3d ¹ 4s ² | Sc ³⁺ | (Ar) |
| Titanium | Ti | (Ar)3d ² 4s ² | Ti ⁴⁺ Ti ³⁺ | (Ar) (Ar)3d ¹ |
| Vanadium | V | (Ar)3d ³ 4s ² | V ³⁺ | (Ar)3d ³ |
| Chromium | Cr | (Ar)3d ⁵ 4s ¹ | Cr ³⁺ | (Ar)3d ³ |
| Manganese | Mn | (Ar)3d ⁵ 4s ² | Mn ²⁺ | (Ar)3d ⁵ |
| Iron | Fe | (Ar)3d ⁶ 4s ² | Fe ²⁺ Fe ³⁺ | (Ar)3d ⁶ (Ar)3d ⁵ |
| Cobalt | Co | (Ar)3d ⁷ 4s ² | Co ²⁺ | (Ar)3d ⁷ |
| Nickel | Ni | (Ar)3d ⁸ 4s ² | Ni ²⁺ | (Ar)3d ⁸ |
| Copper | Cu | (Ar)3d ¹⁰ 4s ¹ | Cu ⁺ Cu ²⁺ | (Ar)3d ¹⁰ (Ar)3d ⁹ |
| Zinc | Zn | (Ar)3d ¹⁰ 4s ² | Zn ²⁺ | (Ar)3d ¹⁰ |

Note Fe³⁺ is more stable than Fe²⁺ as it has an electron configuration without electron repulsion in the partially filled d sub-shell.

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Table of Contents Transition Metal Chemistry Volume 5

1. Understanding the eBook Transition Metal Chemistry Volume 5
 - The Rise of Digital Reading Transition Metal Chemistry Volume 5
 - Advantages of eBooks Over Traditional Books
2. Identifying Transition Metal Chemistry Volume 5
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Transition Metal Chemistry Volume 5
 - User-Friendly Interface
4. Exploring eBook Recommendations from Transition Metal Chemistry Volume 5
 - Personalized Recommendations
 - Transition Metal Chemistry Volume 5 User Reviews and Ratings
 - Transition Metal Chemistry Volume 5 and Bestseller Lists
5. Accessing Transition Metal Chemistry Volume 5 Free and Paid eBooks

- Transition Metal Chemistry Volume 5 Public Domain eBooks
 - Transition Metal Chemistry Volume 5 eBook Subscription Services
 - Transition Metal Chemistry Volume 5 Budget-Friendly Options
6. Navigating Transition Metal Chemistry Volume 5 eBook Formats
- ePub, PDF, MOBI, and More
 - Transition Metal Chemistry Volume 5 Compatibility with Devices
 - Transition Metal Chemistry Volume 5 Enhanced eBook Features
7. Enhancing Your Reading Experience
- Adjustable Fonts and Text Sizes of Transition Metal Chemistry Volume 5
 - Highlighting and Note-Taking Transition Metal Chemistry Volume 5
 - Interactive Elements Transition Metal Chemistry Volume 5
8. Staying Engaged with Transition Metal Chemistry Volume 5
- Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Transition Metal Chemistry Volume 5
9. Balancing eBooks and Physical Books Transition Metal Chemistry Volume 5
- Benefits of a Digital Library
 - Creating a Diverse Reading Collection Transition Metal Chemistry Volume 5
10. Overcoming Reading Challenges
- Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Transition Metal Chemistry Volume 5
- Setting Reading Goals Transition Metal Chemistry Volume 5
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Transition Metal Chemistry Volume 5
- Fact-Checking eBook Content of Transition Metal Chemistry Volume 5
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
- Utilizing eBooks for Skill Development

- Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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