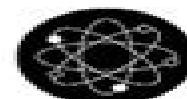


Chem Factsheet



January 2003

Number 46

Transition Metals 2 - Compounds and Reactions

To succeed in this topic you need to:

- Understand the principle of oxidation numbers.
- Understand types of bonding and molecular shapes.
- Understand the basics of Transition Metals (covered in Factsheet 38)

After working through this Factsheet you will:

- Have more experience of transition metal compounds;
- Recall the reactions of transition metal ions with hydroxides and ammonia;
- Recall the oxidation states of vanadium, and how they can be interconverted.

The following simple test tube reactions illustrate the behaviour of transition metal ions.

Addition of aqueous alkali to transition metal ions

Practical 1 – Addition of sodium hydroxide solution

Dilute sodium hydroxide solution is added dropwise to aqueous transition metal ions. Initially a precipitate is looked for, then the sodium hydroxide is added to excess to find out if the precipitate will eventually re-dissolve.

Ion	Addition of NaOH (aq)	Excess NaOH (aq)
Cr^{3+}	Green ppt	Green solution
Mn^{2+}	Buff ppt, darkens in air	Precipitate does not dissolve
Fe^{2+}	Pale green ppt, browns on surface	Precipitate does not dissolve
Fe^{3+}	Red brown ppt	Precipitate does not dissolve
Co^{2+}	Blue ppt, turns brown in air	Precipitate does not dissolve
Ni^{2+}	Pale green	Precipitate does not dissolve
Cu^{2+}	Pale blue ppt	Precipitate does not dissolve
Zn^{2+}	White ppt	Colourless solution

The equations for these reactions are similar; each of the transition metal ions should be written as the hexa-aqua ion, except for zinc which forms a tetra-aqua ion. In each case the precipitates formed are the simple hydroxide compounds.

For example:



and for zinc,



The reaction mechanism for this process is important and often examined. When aqueous transition metal ion react with hydroxide ions the reaction mechanism is **deprotonation**.



Notice how a H^{+} ion (a proton) is removed from the aqua ligand leaving a hydroxide ion. Note that this is **not** a ligand exchange.

As can be seen from the results, few transition metal ions react in excess sodium hydroxide.

Most metal hydroxides are basic, so the metal hydroxide precipitates formed in these reactions do not react in excess sodium hydroxide, itself a strong base.

However, some metal hydroxides (e.g. $\text{Cr}(\text{OH})_3$) are **amphoteric**, so will react with NaOH.



Practical 2 – Addition of ammonia solution

Dilute ammonia solution is added dropwise to aqueous transition metal ions. Initially a precipitate is looked for, then the ammonia solution is added to excess to find out if the precipitate will eventually re-dissolve.

Ion	Addition of NH_3 (aq)	Addition of excess NH_3 (aq)
Cr^{3+}	Green ppt	Precipitate does not dissolve
Mn^{2+}	Buff ppt, darkens in air	Precipitate does not dissolve
Fe^{2+}	Pale green ppt, browns on surface	Precipitate does not dissolve
Fe^{3+}	Red brown ppt	Precipitate does not dissolve
Co^{2+}	Blue ppt, turns brown in air	Precipitate does not dissolve
Ni^{2+}	Pale green	Blue solution
Cu^{2+}	Pale blue ppt	Deep blue solution
Zn^{2+}	White ppt	Colourless solution

On adding aqueous ammonia solution, it is hydroxide (OH^{-}) ions, which are again introduced and react with the transition metal ions.



The precipitates which form are therefore the metal hydroxides again, just as when sodium hydroxide was the aqueous alkali added.

It is when the ammonia solution is added to excess that the reactions vary when comparing results to practical 1.

Ammonia is a **weak** base, too weak to react with the amphoteric metal hydroxides (e.g. $\text{Cr}(\text{OH})_3$).

Transition Metals Chen Quest 21

Horst Rogalla, Peter H. Kes

A red circular graphic with a gradient, appearing as a semi-circle or a partial circle, located to the right of the authors' names.

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Chueh, 2018-11-23 This book gives a comprehensive overview of recent advances in developing nanowires for building various kinds of electronic devices Specifically the applications of nanowires in detectors sensors circuits energy storage and conversion etc are reviewed in detail by the experts in this field Growth methods of different kinds of nanowires are also covered when discussing the electronic applications Through discussing these cutting edge researches the future directions of nanowire electronics are identified **100 Years of Superconductivity** Horst Rogalla, Peter H. Kes, 2011-11-11 Even a

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Physics of Spin-Orbit-Coupled Oxides Gang Cao, Lance DeLong, 2021 This book reviews recent experimental and theoretical evidence that the physical and structural properties of transition metal oxides may decisively be influenced by strong spin orbit interactions that compete with comparable Coulomb magnetic exchange and crystalline electric field interactions

Lanthanides Peng Cheng, 2023-08-17 Lanthanides Fundamentals and Applications provides the fundamentals new research promising applications and future outlooks of lanthanide compounds and lanthanide based materials The book begins with an introduction including key concepts oxidation states and sources extraction and separation of the lanthanides followed by spectroscopic and magnetic properties and metals crystals and compounds Organometallic compounds coordination compounds molecular magnetic materials and luminescent materials are covered before a discussion of specific lanthanide applications Spintronics bioimaging photoelectric materials catalysis and nuclear applications are discussed This comprehensive resource is ideal for researchers and students studying inorganic and materials chemistry in both academia and industry Includes comprehensive and in depth coverage of lanthanides Features the most current research progress on lanthanides Covers a combination view of fundamental research and specific applications of the lanthanides including spintronics bioimaging and additives for photoelectric materials

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Reinhardt, Richard F. Reidy, 2011-04-12 Provides an In depth discussion of surface conditioning for semiconductor applications The Handbook of Cleaning for Semiconductor Manufacturing Fundamentals and Applications provides an in depth discussion of surface conditioning for semiconductor applications The fundamental physics and chemistry associated with wet processing is reviewed as well as surface and colloidal aspects of cleaning and etching Topics covered in this new

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Rare Earth and Transition Metal Doping of Semiconductor Materials Volkmar Dierolf, Ian Ferguson, John M Zavada, 2016-01-23 Rare Earth and Transition Metal Doping of Semiconductor Material explores traditional semiconductor devices that are based on control of the electron's electric charge This book looks at the semiconductor materials used for spintronics applications in particular focusing on wide band gap semiconductors doped with transition metals and rare earths These materials are of particular commercial interest because their spin can be controlled at room temperature a clear opposition to the most previous research on Gallium Arsenide which allowed for control of spins at supercold temperatures Part One of the book explains the theory of magnetism in semiconductors while Part Two covers the growth of semiconductors for spintronics Finally Part Three looks at the characterization and properties of semiconductors for spintronics with Part Four exploring the devices and the future direction of spintronics Examines materials which are of commercial interest for producing smaller faster and more power efficient computers and other devices Analyzes the theory behind magnetism in semiconductors and the growth of semiconductors for spintronics Details the properties of semiconductors for spintronics

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Proceedings of the 9th International Conference on Mechanical Manufacturing Technology and Material Engineering Jiang Guo, Alam Md. Mahbub, Ying-Ren Chien, 2025-04-28 This book offers a comprehensive examination of the latest advancements in mechanical manufacturing technology and material engineering as presented at the 9th International Conference on Mechanical Manufacturing Technology and Material Engineering MMTME 2024 It delves into the forefront of research in areas like intelligent manufacturing process and structure optimization intelligent mechanical design and simulation analysis The book is structured to highlight significant innovations that are poised to redefine manufacturing processes enhance material performance and drive sustainability in production Each chapter provides in depth analysis of emerging technologies and their practical applications backed by recent case studies and expert insights Key topics such as the integration of AI and IoT in manufacturing advancements in 3D and 4D printing technologies and the development of new sustainable materials are explored These are critical for pushing the boundaries of what is possible in manufacturing and materials science today This book is significant as it not only encapsulates state of the art research but also provides a vision for future directions in the field It sets out to solve problems related to efficiency cost effectiveness and environmental impact in manufacturing offering new perspectives and solutions to researchers and professionals The target audience includes academic researchers industry professionals and engineers in the fields of mechanical manufacturing and material engineering

Advancing VLSI through Machine Learning Abhishek Narayan Tripathi, Jagana Bihari Padhy, Indrasen Singh, Shubham Tayal, Ghanshyam Singh, 2025-03-31 This book explores the synergy between very large scale integration VLSI and machine learning ML and its applications across various domains It investigates how ML techniques can enhance the design and testing of VLSI circuits improve power efficiency optimize layouts and enable novel architectures This book bridges the gap between VLSI and ML showcasing the potential of this integration in creating innovative electronic systems advancing computing capabilities and paving the way for a new era of intelligent devices and technologies Additionally it covers how VLSI technologies can accelerate ML algorithms enabling more efficient and powerful data processing and inference engines It explores both hardware and software aspects covering topics like hardware accelerators custom hardware for specific ML tasks and ML driven optimization techniques for chip design and testing This book will be helpful for academicians researchers postgraduate students and those working in ML driven VLSI

Polymers from Renewable Resources George Z. Papageorgiou, 2019-01-10 This book is a printed edition of the Special Issue Polymers from Renewable Resources that was published in Polymers

National Library of Medicine Current Catalog National Library of Medicine (U.S.), 1971

Greater China's Quest for Innovation Henry S.

Rowen, Marguerite Gong Hancock, William F. Miller, 2008 Governments in Greater China Mainland Taiwan Hong Kong and Singapore are striving to create higher value added and homegrown products services and technologies No longer satisfied with China's role as the world's factory the Chinese government calls its effort Independent Innovation Likewise Taiwanese firms are endeavoring to become global architects of many products and Hong Kong and Singapore are rising to similar challenges This book addresses topics at the heart of these efforts What specific actions are Greater China's governments taking to advance their respective competencies How do foreign firms bring technologies to them How adequate are the pools of talent and how are they changing What do patent and publication data tell us about trends in science and technology Why are China's research institutes being reorganized What has made a small set of hightech regions so productive The authors leading scholars and business people from Greater China the United States and Europe offer valuable insights into the region's transition from workshop of the world to wellspring of innovation Enantioselection in Asymmetric Catalysis

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Table of Contents Transition Metals Chen Quest 21

1. Understanding the eBook Transition Metals Chen Quest 21
 - The Rise of Digital Reading Transition Metals Chen Quest 21
 - Advantages of eBooks Over Traditional Books
2. Identifying Transition Metals Chen Quest 21
 - 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 Metals Chen Quest 21
 - User-Friendly Interface
4. Exploring eBook Recommendations from Transition Metals Chen Quest 21
 - Personalized Recommendations
 - Transition Metals Chen Quest 21 User Reviews and Ratings
 - Transition Metals Chen Quest 21 and Bestseller Lists
5. Accessing Transition Metals Chen Quest 21 Free and Paid eBooks

- Transition Metals Chen Quest 21 Public Domain eBooks
- Transition Metals Chen Quest 21 eBook Subscription Services
- Transition Metals Chen Quest 21 Budget-Friendly Options
- 6. Navigating Transition Metals Chen Quest 21 eBook Formats
 - ePub, PDF, MOBI, and More
 - Transition Metals Chen Quest 21 Compatibility with Devices
 - Transition Metals Chen Quest 21 Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Transition Metals Chen Quest 21
 - Highlighting and Note-Taking Transition Metals Chen Quest 21
 - Interactive Elements Transition Metals Chen Quest 21
- 8. Staying Engaged with Transition Metals Chen Quest 21
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Transition Metals Chen Quest 21
- 9. Balancing eBooks and Physical Books Transition Metals Chen Quest 21
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Transition Metals Chen Quest 21
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Transition Metals Chen Quest 21
 - Setting Reading Goals Transition Metals Chen Quest 21
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Transition Metals Chen Quest 21
 - Fact-Checking eBook Content of Transition Metals Chen Quest 21
 - 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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