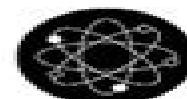


# Chem Factsheet



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)
$\text{Cr}^{3+}$	Green ppt	Green solution
$\text{Mn}^{2+}$	Buff ppt, darkens in air	Precipitate does not dissolve
$\text{Fe}^{2+}$	Pale green ppt, browns on surface	Precipitate does not dissolve
$\text{Fe}^{3+}$	Red brown ppt	Precipitate does not dissolve
$\text{Co}^{2+}$	Blue ppt, turns brown in air	Precipitate does not dissolve
$\text{Ni}^{2+}$	Pale green	Precipitate does not dissolve
$\text{Cu}^{2+}$	Pale blue ppt	Precipitate does not dissolve
$\text{Zn}^{2+}$	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  $\text{H}^{+}$  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 $\text{NH}_3$ (aq)	Addition of excess $\text{NH}_3$ (aq)
$\text{Cr}^{3+}$	Green ppt	Precipitate does not dissolve
$\text{Mn}^{2+}$	Buff ppt, darkens in air	Precipitate does not dissolve
$\text{Fe}^{2+}$	Pale green ppt, browns on surface	Precipitate does not dissolve
$\text{Fe}^{3+}$	Red brown ppt	Precipitate does not dissolve
$\text{Co}^{2+}$	Blue ppt, turns brown in air	Precipitate does not dissolve
$\text{Ni}^{2+}$	Pale green	Blue solution
$\text{Cu}^{2+}$	Pale blue ppt	Deep blue solution
$\text{Zn}^{2+}$	White ppt	Colourless solution

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



The precipitates which forms 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

**Vinayak Pachkawade, Koushik Guha**



## **Transition Metals Chen Quest 21:**

*Micro-Resonators: The Quest for Superior Performance* Reza Abdolvand, 2019-02-15 This book is a printed edition of the Special Issue Micro Resonators The Quest for Superior Performance that was published in Micromachines **Micro- and Nano-Systems in 21st-Century** Vinayak Pachkawade, Koushik Guha, 2025-08-16 This book covers the principles operation and applications of the modern micro nano devices being developed to address global twenty first century challenges The subject of this book is Micro Nano Systems in the twenty first century The major areas of applications cover medical diagnostics 5G 6G communication inertial space geography and resource exploration defense aviation etc This book provides the readers with a comprehensive outlook on the topics to help understand the physical scientific principles and techniques being applied to the design and development of devices sensors and actuators using Micro Nano System Technology MST The book addresses fabrication technologies such as CMOS MEMS Piezoelectric and other special MEMS processes where novel transducers are being designed and developed for ultrasound energy harvesting data storage computing inertial fluidics optomechanical etc The book serves as a tutorial guide to graduate students researchers engineers other large technical audiences and also the general public to understand these topics in a systematic and more thorough way by providing a range of illustrations comparative charts tables equations analysis and plots graphs In a nutshell the book is designed to provide a didactic approach to explaining scientific facts and figures in more lucid ways The students will get the engineering and scientific know how of modern micro and nano system technology a range of transduction principles and potential applied application areas Readers will understand through first hand equations principles of operations solved examples notes several illustrations and graphs how to design and develop a range of applications in microsystem technology

**Environmental Toxicology** J Rose, 2003-09-02 Because our chemical environment affects our physical and mental well being it is a matter of increasing concern and is therefore attracting much research effort This timely collection of essays highlights current developments in the field of environmental toxicology Chapters analyze the carcinogenic mutagenic genotoxic and neurotoxic effects of both anthropogenic and natural toxins in the soil air and water around us as well as in our workplace and diet The book also examines the effects of toxins on other organisms as well as the techniques policies and management strategies employed in studying and controlling environmental pollutants It will be an essential reference to a variety of personnel in environmental studies and public health Nanowire Electronics Guozhen Shen, Yu-Lun

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

hundred years after its discovery superconductivity continues to bring us new surprises from superconducting magnets used in MRI to quantum detectors in electronics 100 Years of Superconductivity presents a comprehensive collection of topics on nearly all the subdisciplines of superconductivity Tracing the historical developments in superconductivity

***Homogeneous Catalysis Concepts and Basics*** Mohammad Reza Rahimpour, Mohammad Amin Makarem, Tayebah Roostaie, Maryam Meshksar, 2024-08-15 Homogeneous Hydrogenation and Metathesis Reactions a volume in the Advances in Catalysis series covers hydrogenation and metathesis reactions in two separate sections The first section is devoted to homogeneous hydrogenation reactions and related processes including hydrogenation of alkenes esters olefins etc In the second section the metathesis reactions of olefins alkenes and alkynes are presented In addition the industrial application of homogeneous metathesis reactions is investigated Includes thermodynamic and kinetic studies of homogeneous catalysts Describes transition metal ligand and solvent role in homogeneous catalysts Explains preparation characterization deactivation and regeneration of homogeneous catalysts Presents homogeneous catalysts by clusters carbenes fixed metal complexes and liquid liquid multiphase catalysts

***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

***Colloidal Gold Nanorods*** Nikhil Ranjan Jana, 2023-01-09 This book covers the synthesis and applications of colloidal gold nanorods including their properties approaches for various chemical synthesis and different gold nanorod based nanocomposites with their properties and application potentials Furthermore it covers the surface chemistry and functionalization of gold nanorods for numerous biomedical applications Various applications of gold nanorods including optical probes dark field contrast agents photothermal therapy agents and plasmonic photocatalyst are covered along with the toxicological aspects Features Covers all aspects of gold nanorods along with selected protocols Focuses on synthetic chemistry optical property and

functionalization approach of colloidal gold nanorods Describes standard synthetic methods and advantages of gold nanorods in biomedical applications Includes authentic and reproducible experimental procedures Discusses applications like redox catalysts catalyst promoters delivery carriers solar cell materials and so forth This book aims at graduate students and researchers interested in nanotechnology and gold nanoparticles      **Towards New Milestones in Our Quest to Go**

**Beyond the Standard Model** Antonino Zichichi, 2007 This volume is a collection of lectures given by distinguished physicists from around the world covering the most recent advances in theoretical physics and the latest results from current experimental facilities Following one of the principal aims of the School to encourage and promote young physicists to achieve recognition at an international level the students who distinguished themselves for the excellence of their research were given the opportunity to publish their presentations in this volume      **Metal Response in Cupriavidus**

**metallidurans** Max Mergeay, Rob Van Houdt, 2015-07-09 This book is the first volume of a two volume set summarizing 40 years of key research findings directly related to metal resistant Cupriavidus Ralstonia Betaproteobacteria In this first volume the historical and geographical context of these bacteria which are mostly found in industrial and polluted environments linked to zinc and other non ferrous metallurgy is sketched to illustrate the interactions between bacteria and human activities and the possible evolutionary consequences on bacterial genomes especially as far as the association of metal resistance genes with mobile genetic elements is concerned A detailed description of the response and underlying genetic determinants of type strain Cupriavidus metallidurans CH34 to a variety of metals is provided With high level resistance to cadmium chromate cobalt copper mercury nickel lead and zinc mediated by well known genes for detoxification carried by its megaplasms pMOL28 and pMOL30 This description is complemented with the genomic context of the metal response genes in C metallidurans CH34 with a focus on its mobilome including insertion sequence elements transposons integrative and conjugative elements and genomic islands In addition in the second volume structural and catalytic data from bacterial primary and secondary transporters P ATPases tripartite chemiosmotic cation proton efflux systems cation diffusion facilitators Major Facilitator Superfamily and some minor categories are outlined and detailed for the corresponding C metallidurans proteins The available three dimensional structures of C metallidurans proteins are reviewed in detail including RND and membrane fusion proteins from tripartite chemiosmotic cation proton efflux systems sigma and anti sigma regulatory proteins of the cnr efflux system resistance to cobalt and nickel and various periplasmic proteins mainly involved in the response to copper and mercury      **Handbook for Cleaning for Semiconductor Manufacturing** Karen A.

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

reference include Front end line FEOL and back end of line BEOL cleaning applications such as high k metal gate post etch cleaning and pore sealing high dose implant stripping and cleaning and germanium and silicon passivation Formulation development practices methodology and a new directions are presented including chemicals used for preventing corrosion of copper lines cleaning aluminium lines reclaiming wafers and water bonding as well as the filtering and recirculating of chemicals including reuse and recycling Wetting cleaning and drying of features such as high aspect ratio features and hydrophilic surface states especially how to dry without watermarks the abilities to wet hydrophobic surfaces and to remove liquid from deep features The chemical reactions and mechanisms of silicon dioxide etching with hydrofluoric acid particle removal with ammonium hydroxide hydrogen peroxide mixture and metal removal with hydrochloric acid The Handbook of Cleaning for Semiconductor Manufacturing Fundamentals and Applications is a valuable resource for any engineer or manager associated with using or supplying cleaning and contamination free technologies for semiconductor manufacturing Engineers working for semiconductor manufacturing capital equipment chemicals or other industries that assures cleanliness of chemicals material and equipment in the manufacturing area will also find this handbook an indispensable reference

*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

**Advanced Technologies for Rechargeable Batteries** Prasanth Raghavan, Akhila Das, Jabeen Fatima M. J., 2024-08-22 This volume focuses on alkaline metal ion redox flow and metal sulfur batteries and provides details about the various kinds of advanced rechargeable batteries It explains magnesium ion batteries sodium ion batteries metal sulfur batteries and redox flow batteries with an introduction to rechargeable batteries and major upcoming batteries magnesium sodium ion batteries Various kinds of redox flow batteries from introduction extending to the recent progress in redox flow batteries have been extensively discussed Features Covers recent battery technologies in detail from chemistry to advances in post lithium ion batteries Reviews magnesium ion batteries sodium ion batteries metal sulfur

batteries and redox flow batteries Explains various metal sulfur batteries Explores different types of redox flow batteries for large scale energy storage application Provides authoritative coverage of scientific contents via global contributing experts This book is aimed at graduate students researchers and professionals in materials science chemical and electrical engineering and electrochemistry

*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

Ilya D. Gridnev, Pavel A. Dub, 2016-11-03 The field of asymmetric catalysis is currently one of the hottest areas in chemistry This unique book focuses on the mechanism of enantioselectivity in asymmetric catalysis rather than asymmetric catalysis from the synthetic view It describes reliable experimentally and computationally supported mechanisms and discusses the danger of so called plausible or accepted mechanisms leading to wrong conclusions It draws parallels to enzymatic catalysis in biochemistry and examines in detail the physico chemical aspects of enantioselective catalysis



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