



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 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

Guozhen Shen, Yu-Lun Chueh



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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

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 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

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

Homogeneous Catalysis Concepts and Basics Mohammad Reza Rahimpour,Mohammad Amin Makarem,Tayebeh 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

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

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

Advances in Organometallic Chemistry, 2019-05-04 Advances in Organometallic Chemistry Volume 71 contains authoritative review articles on researchers in the field of organometallic chemistry This longstanding serial is known for its comprehensive coverage of topics in organometallic synthesis reactions mechanisms homogeneous catalysis and more It is ideal for a wide range of researchers involved in organometallic chemistry including synthetic protocols mechanistic studies and practical applications New chapters cover Titanium in Catalysis Applications in Amine and N Heterocycle Synthesis Gold alkynyl complexes for biomedical applications Catalytic Nonreductive Valorization of Carbon Dioxide into Fine Chemicals Transition metal catalyzed CO₂ hydrogenation in the presence of ionic liquids and much more Contains contributions from leading authorities in the field of organometallic chemistry Covers topics in organometallic synthesis reactions mechanisms homogeneous catalysis and more Informs and updates readers on the latest developments in the field Carefully edited to provide easy to read material

Small Molecule Drug Discovery Andrea Trabocchi, Elena Lenci, 2019-11-23 Small Molecule Drug Discovery Methods Molecules and Applications presents the methods used to identify bioactive small molecules synthetic strategies and techniques to produce novel chemical entities and small molecule libraries chemoinformatics to characterize and enumerate chemical libraries and screening methods including biophysical techniques virtual screening and phenotypic screening The second part of the book gives an overview of privileged cyclic small molecules and major classes of natural product derived small molecules including carbohydrate derived compounds peptides and peptidomimetics and alkaloid inspired compounds The last section comprises an exciting collection of selected case studies on drug discovery enabled by small molecules in the fields of cancer research CNS diseases and infectious diseases The discovery of novel molecular entities capable of specific interactions represents a significant challenge in early drug discovery Small molecules are low molecular weight organic compounds that include natural products and metabolites as well as drugs and other xenobiotics When the biological target is well defined and understood the rational design of small molecule ligands is possible Alternatively small molecule libraries are being used for unbiased assays for complex diseases where a target is unknown or multiple factors contribute to a disease pathology Outlines modern concepts and synthetic strategies underlying the building of small molecules and their chemical libraries useful for drug discovery Provides modern biophysical methods to screening small molecule libraries including high throughput screening small molecule microarrays phenotypic screening and chemical genetics Presents the most advanced chemoinformatics tools to characterize the

structural features of small molecule libraries in terms of chemical diversity and complexity also including the application of virtual screening approaches Gives an overview of structural features and classification of natural product derived small molecules including carbohydrate derivatives peptides and peptidomimetics and alkaloid inspired small molecules

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

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

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 megaplasmids 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

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

Spintronics Handbook, Second Edition: Spin Transport and Magnetism Evgeny Y. Tsymbal,Igor Žutić,2019-05-20 The second edition offers an update on the single most comprehensive survey of the two intertwined fields of spintronics and magnetism covering the diverse array of materials and structures including silicon organic semiconductors carbon nanotubes graphene and engineered nanostructures It focuses on seminal pioneering work together with the latest in cutting edge advances notably extended discussion of two dimensional materials beyond graphene topological insulators skyrmions and molecular spintronics The main sections cover physical phenomena spin dependent tunneling control of spin and magnetism in semiconductors and spin based applications

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

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

Advances in Quantum Chemical Topology Beyond QTAIM Juan I. Rodriguez,Fernando Cortés-Guzmán,James S.M. Anderson,2022-12-06 Advances in Quantum Chemical Topology Beyond QTAIM provides a complete overview of the field starting with traditional methods and then covering key steps to the latest

state of the art extensions of QTAIM The book supports researchers by compiling and reviewing key methods comparing different algorithms and providing computational results to show the efficacy of the approaches Beginning with an introduction to quantum chemistry QTAIM and key extensions the book goes on to discuss interacting quantum atoms and related energy properties explores partitioning methods and compares algorithms for QTAIM Partitioning schemes are then compared in more detail before applications are explored and future developments discussed Drawing together the knowledge of key authorities in the area this book provides a comprehensive pedagogical guide to this insightful theory for all those interested in modelling exploring and understanding molecular properties Provides a contemporary review of the extensions and application of QTAIM methods Compiles all extensions of QTAIM in one place for easy reference Includes a chapter with an Introduction to Quantum Chemistry Presents complex information at a level accessible to those engaged in theoretical computational chemistry

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

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