

Lab 8: Chemical Reactions of Copper

Introduction

Elemental copper reacts with concentrated nitric acid (HNO_3) to form copper(II) nitrate ($\text{Cu}(\text{NO}_3)_2$). The addition of sodium hydroxide to a copper(II) nitrate solution precipitates copper(II) hydroxide, $\text{Cu}(\text{OH})_2$. When copper(II) hydroxide is heated, it forms copper(II) oxide, CuO . Addition of sulfuric acid to copper(II) oxide produces copper sulfate, CuSO_4 . Reduction of copper(II) sulfate with zinc gives you back the elemental copper.

This series of reactions involves four important types of chemical reactions:

- i) reduction/oxidation (redox)
- ii) acid/base
- iii) precipitation
- iv) decomposition

The driving forces behind these reactions are briefly described as follows:

Redox:

Electron transfer occurs from species that are "electron rich" and have low reduction potentials (hence are reducing agents) to species that are "electron poor" and have higher reduction potentials (hence are oxidizing agents). At the start of this experiment, elemental copper (the oxidant) reduces nitric acid (the reductant) and forms $\text{Cu}^{2+}_{\text{aq}}$ ions. Later, Cu^{2+} ions in turn serve as an oxidizing agent when combined with Zn metal, a stronger reducing agent. A general description of the trend in

reduction potentials of d block elements is that reduction potential normally increases going across the period (with some exceptions). On the other hand, reduction potential decreases going down the group for metals near the right hand side, and increases going down the group for metals on the left hand side of the periodic table. There are fluctuations going down the group for metals near the middle of the block

| Half reaction | E° (V) |
|---|---------------|
| $\text{NO}_3^- + 4\text{H}^+ + 3\text{e}^- \rightarrow \text{NO} + 2\text{H}_2\text{O}$ | +0.96 |
| $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$ | +0.337 |
| $\text{Cu}^+ + \text{e}^- \rightarrow \text{Cu}$ | +0.153 |
| $\text{Cu}^+ + \text{e}^- \rightarrow \text{Cu}$ | +0.521 |
| $\text{Zn}^{2+} + 2\text{e}^- \rightarrow \text{Zn}$ | -0.763 |

Precipitation of ionic solid:

Charged species are unstable in nature in the sense that they seek opposite charges. This may be termed charge neutralization. In chemistry, charged ions can interact with oppositely charged ions and form an ionic solid. The cations and anions are held together by the resulting **lattice energy**. Charged ions can also be surrounded by polar molecules such as water molecules and thus have their charges counteracted. This involves **solvation energy**. Precipitates form when lattice energies of solids are larger than the solvation energies of the ions. This holds true for ionic transition metal compounds the same as for any other ionic compound.

Decomposition:

Many substances can be heated to bring about chemical changes. In ionic compounds, thermal instability is often brought about by mismatch of cation and anion radii compatibility and by polarization of anion by cations of high charge density. Often, gaseous byproducts are driven off. In many instances a redox reaction actually takes place. One type of decomposition involves dehydration of metal hydroxides to form a metal oxide. Metal oxides are sometimes considered base anhydrides; this means that the metal oxide can produce the metal hydroxide if it is made to react with water. Copper hydroxide is sufficiently unstable that it decomposes to CuO upon heating.

Acid/Base:

According to the Bronsted Lowry definition, acids are H^+ donors and bases are H^+ acceptors; therefore, acid/base reactions are hydrogen ion (proton) transfer reactions. Metal oxides are typically basic in nature. Transition metal oxides acidity/basicity vary depending on their structure and composition. In this case, the CuO in this experiment is basic in nature, hence will react with sulfuric acid H^+ ions to form water, H_2O and salt.

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Ruth Ann Murphy



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Environmental Chemistry in the Lab Ruth Ann Murphy, 2022-08-31 Environmental Chemistry in the Lab presents a comprehensive approach to modern environmental chemistry laboratory instruction together with a complete experimental experience The laboratory experiments have an introduction for the students to read a pre lab for them to complete before coming to the lab a data sheet to complete during the lab and a post lab which would give them an opportunity to reinforce their understanding of the experiment completed Instructor resources include a list of all equipment and supplies needed for 24 students a lab preparation guide an answer key to all pre lab and post lab questions sample data for remote learners and a suggested rubric for grading the labs Additional features include Tested laboratory exercises with instructor resources for environmental science students Environmental calculations industrial regulation and environmental stewardship Classroom and remote exercises An excellent user friendly and thought provoking presentation which will appeal to students with little or no science background A qualitative approach to the chemistry behind many of our environmental issues today Million Dollar Data: Building Confidence - Vol.1 Stephen DeMeo, 2020-07-31 Global warming our current and greatest challenge is without precedent Among the many consequences that are impacting our society one unanticipated concern involves scientific truth When the President of the United States and others in his administration declare that global warming is fake science it calls into question what real science is and what real school science should be I will argue that real science is quality science one that is based on the rigorous collection of reliable and valid data To collect quality data requires bending over backwards to get things right and this is exactly what makes science so special Truth is made when scientists go this extra yard and devise controlled experiments collect large data sets confirm the data and rationally analyze their results Making scientific truth sounds difficult to do in the science laboratory but in reality there are many straightforward ways that truth can be constructed In the first of two volumes I discuss twelve such ways I call them Confidence Indicators that can allow students to strongly believe in their data and their subsequent results Many of these methods are intuitive and can be used by young students on the late elementary level all the way up to those taking introductory college science courses As in life science is not without doubt In the second volume I introduce the concept of scientific uncertainty and the indicators used to calculate its magnitude I will show that science is about connecting confidence with uncertainty in a specific manner what I refer to as the Confidence Uncertainty Continuum expression This important relationship epitomizes the scientific enterprise as a search for probabilistic rather than absolute truth This two volume set will contain a variety of ways that data quality can be instituted into a science curriculum To support its use many of the examples that I will present involve science teachers as well as student work and feedback from different grade levels and in different scientific disciplines Specific chapters will be devoted to reviewing the academic literature on data quality as well as describing my own personal research on this important but often neglected topic **Exploring General Chemistry in the Laboratory** Colleen F. Craig, Kim N.

Gunnerson,2017-02-01 This laboratory manual is intended for a two semester general chemistry course The procedures are written with the goal of simplifying a complicated and often challenging subject for students by applying concepts to everyday life This lab manual covers topics such as composition of compounds reactivity stoichiometry limiting reactants gas laws calorimetry periodic trends molecular structure spectroscopy kinetics equilibria thermodynamics electrochemistry intermolecular forces solutions and coordination complexes By the end of this course you should have a solid understanding of the basic concepts of chemistry which will give you confidence as you embark on your career in science *Exploring Physical Science in the Laboratory* John T. Salinas ,2019-02-01 This full color manual is designed to satisfy the content needs of either a one or two semester introduction to physical science course populated by nonmajors It provides students with the opportunity to explore and make sense of the world around them to develop their skills and knowledge and to learn to think like scientists The material is written in an accessible way providing clearly written procedures a wide variety of exercises from which instructors can choose and real world examples that keep the content engaging Exploring Physical Science in the Laboratory guides students through the mysteries of the observable world and helps them develop a clear understanding of challenging concepts **Fundamentals of Chemistry in the Laboratory** Ralph A. Burns,1999 *Experiments in General Chemistry* Kenneth W. Whitten,Carl B. Bishop,Kenneth D. Gailey,1992 *The Zinc and Iodine Book* Stephen DeMeo,2019-05-15 This book is for chemistry teachers who are thinking about reinventing their laboratory experiments that they provide to their students More than a collection of experiments it is an example of using a chemical theme to teach chemistry Instead of introducing many different chemicals per experiment as is the norm in most lab manuals this novel resource focuses on two commonly found elements Zinc and Iodine So what is so special about these elements At the heart of this resource is a colorful cyclic reaction between zinc and iodine one that produces a compound that can decompose back to its original elements This unique phenomenon demonstrates that matter not only changes but is also conserved through a chemical reaction Knowing that a compound can be the same but different than the reactants that formed it is to understand the essence of chemical change Complementing this reaction this book contains experimental activities that utilize the zinc and iodine theme to scaffold new concepts such as the properties of matter solid and gas stoichiometry equilibrium kinetics acid base chemistry and electrochemistry This teacher tested resource focuses on a set of safe substances that are appropriate for high school teachers who provide an advanced chemistry placement course and for college instructors teaching a first year chemistry laboratory sequence *Selected Water Resources Abstracts* ,1975-05 Chemistry, an Experimental Science Chemical Education Material Study,1963 Chemistry McGraw-Hill Staff,2001-07 **Illinois Chemistry Teacher** ,2001 Journal of Applied Chemistry ,1872 **Electrochemical and Metallurgical Industry** Eugene Franz Roeber,Howard Coon Parmelee,1920 **Government Reports Announcements & Index** ,1988 Oil, Paint and Drug Reporter and New York Druggists' Price Current ,1917 Vols include the proceedings some summarized some

official stenographic reports of the National Wholesale Druggists Association called 18 1882 Western Wholesale Druggists Association and of other similar organizations *Scientific American* ,1916 Quarterly Cumulative Index to Current Medical Literature. V. 1-12; 1916-26 ,1926 **Toxicology Research Projects Directory** ,1979 An indexed directory of current research project abstracts in toxicology and related fields *A Supplement to the Oxford English Dictionary* R. W. Burchfield,1972 These volumes replace the 1933 Supplement to the OED The vocabulary treated is that which came into use during the publication of the successive sections of the main Dictionary that is between 1884 when the first fascicle of the letter A was published and 1928 when the final section of the Dictionary appeared together with accessions to the English language in Britain and abroad from 1928 to the present day Nearly all the material in the 1933 Supplement has been retained here though in revised form Preface *INIS Atomindex* ,1988

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