A Cycle of Copper Reactions

Purpose:

To demonstrate a series of copper reactions that begins and ends with solid copper. These reactions will demonstrate different types of common reactions as well as multiple oxidation states of copper.

Background:

As shown in previous labs, there are various different types of reactions. This lab will go over some new reaction types as well as some old ones.

Types of reactions:

Single Replacement (single displacement): a reaction where an element exchanges place with another element in a compound. E.g. $2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$

Double Replacement (double displacement): a reaction where two elements exchange places in their respective compounds. E.g. $AgNO_3 + NaCl \rightarrow NaNO_3 + AgCl$

Synthesis (combination): two or more species react to create a more complex compound. E.g. $Zn + I_2 \rightarrow ZnI_2$

Decomposition: the opposite of a synthesis reaction. One compound breaks down into two or more less complex species. E.g. $CaCO_3 \rightarrow CaO + O_2$

Redox (<u>Red</u>uction/<u>Ox</u>idation): A reaction where electrons are exchanged between two species resulting in both changing oxidation states. E.g. $Ni^{2+} + Zn \rightarrow Ni + Zn^{2+}$

Molecular Equation: $Ni(NO_3)_2 + Zn \rightarrow Ni + Zn(NO_3)_2$

Ionic Equation: $Ni^{2+} + 2NO_3^- + Zn \rightarrow Ni + Zn^{2+} + 2NO_3^-$

Net Ionic Equation: $Ni^{2+} + Zn \rightarrow Ni + Zn^{2+}$

Acid/Base: Either H^+ and OH^- reactions, or Brønsted-Lowry [proton (H^+) donators = acid and proton acceptors = base] acid and base reactions. E.g. $NH_3 + HCl \rightarrow NH_4^+ + Cl^-$ HCl is a proton donor (acid) and NH_3 is a proton acceptor (base).

Precipitation: An insoluble solid that results from a reaction. E.g. $AgNO_3(aq) + NaCl(aq) \rightarrow NaNO_3(aq) + AgCl(s)$ AgCl is a precipitate.

Not all of these reactions are mutually exclusive. A single replacement is often a redox reaction. A double replacement reaction could result in a precipitate.

A balanced redox equation needs the same number of electrons transferred from each half reaction. Even electrons must obey the law of conservation of mass. You cannot create or destroy any electrons! Therefore the electrons lost by one half reaction MUST be set equal to the electrons gained by the other half reaction.

The Copper Reactions Lab

Name ______________________________ TA ______________________________ Time ____________

All of the reactions should be done under the small hoods!

You can even do the first reaction in the large hood

Reaction 1; copper metal to copper (II) nitrate

a) Obtain a 0.5 g piece of copper wire and record its exact mass to the maximum accuracy of your scale.

Initial mass of copper wire __________________ number of moles of Cu _________________

b) Place the piece of wire in a 250 beaker and dissolve with 4.0 mL concentrated nitric acid.

After it has all dissolved, dilute to about 100 mL.

What did you observe? ____

Are there any change of state? What are they? _______ _______________________________________

List all the reactants; ____

List all the products; ____

Write the balanced molecular equation ____

Write the Net Ionic equation ____

What type of reaction is this? (Circle your answer(s))

Double replacement Single replacement Decomposition Synthesis Precipitation Acid / base Redox

Reaction 2; copper (II) nitrate to copper (II) hydroxide

a) Stir the copper (II) nitrate solution with a glass rod.
b) Add 30 mL of 3.0 M NaOH to the copper (II) nitrate solution.

What did you observe? ____

Are there any change of state? What are they? _______ _______________________________________

List all the reactants; ____

List all the products; ____

Write the balanced molecular equation ____

Write the Net Ionic equation____

What type of equation is this? (Circle your answer(s))

Double replacement Single replacement Decomposition Synthesis Precipitation Acid / base Redox

Reaction 3; copper (II) hydroxide to copper (II) oxide

a) Heat to boiling while stirring.

What did you observe? ____

Are there any change of state? What are they? _______ ______________________________________

List all the reactants; ____

List all the products; ____

Write the balanced molecular equation ____

Write a Net Ionic equation____

What type of equation is this? (Circle your answer(s))

Double replacement   Single replacement   Decomposition   Synthesis   Precipitation   Acid / base   Redox

Reaction 4; copper (II) oxide to copper (II) sulfate

a) Allow the precipitate to settle and decant off the liquid
b) Wash the precipitate with 100 mL hot distilled water and decant the washing
c) Cool to room temperature
d) Dissolve the precipitate with 15 mL 6.0 M H_2SO_4

What did you observe? ____

Are there any change of state? What are they? _______ ______________________________________

List all the reactants; ____

List all the products; ____

Write the balanced molecular equation ____

Write a Net Ionic equation____

What type of equation is this? (Circle your answer(s))

Double replacement   Single replacement   Decomposition   Synthesis   Precipitation   Acid / base   Redox

Reaction 5; copper (II) sulfate to copper metal

a) Quickly add 2.0 g 30 mesh zinc metal with stirring until the liquid is colorless
b) Decant the solution and dissolve any unreacted zinc with 6 M HCl, warm the solution if needed.
c) Wash the recovered copper with about 5 mL of water a few times then transfer it to your evaporating dish. Then wash the copper once with about 5 mL methanol and dry the sample by heating on a hotplate.
d) After it has cooled transfer the copper to a preweighed beaker and determine the mass recovered.

What did you observe? ____

Are there any change of state? What are they? _______ _______________________________________

List all the reactants; ____

List all the products; ____

Write the balanced molecular equation ____

Write a Net Ionic equation____

What type of equation is this? (Circle your answer(s))

Double replacement   Single replacement   Decomposition   Synthesis   Precipitation   Acid / base   Redox

Copper Cycle Results

Final mass of copper recovered _____________________

Percent recovery _________________

Did your experiment illustrate the law of conservation of mass?

What are potential sources of error if a student has a low percent recovery?

What are potential sources of error if a student has a high percent recovery?

What is the potential consequence if a student didn't have at least a little leftover zinc in reaction 5?