7.1 Virtual Redox Lab

Background

Oxidation and reduction reactions have been known for millennia but were not understood until the 17th century. The terms come from metallurgy. Most metals do not naturally exist in their metallic forms (except gold and silver), but were extracted from rocks and minerals. As such the ores were "reduced" to a small amount of metal from a large amount of ore. It was noted that the metals would react with oxygen and form a new substance and hence were oxidized. We now understand that redox (oxidation-reduction) reactions involve the transfer of electrons. Consider for instance, the reaction between copper ions ($Cu^{2+}_{(aq)}$) and zinc metal ($Zn_{(s)}$) react according to the chemical reaction:

$$Cu^{+2}_{(aq)} + Zn_{(s)} \Rightarrow Cu_{(s)} + Zn^{+2}_{(aq)}$$

Electrons were exchanged in this reaction, making it a redox reaction. To make the electron exchange more apparent, we can break this reaction into "half reactions".

$Zn_{(s)} \Rightarrow Zn^{+2}_{(aq)} + 2\,e^-$ (zinc metal gives up electrons; hence zinc is oxidized)

$Cu^{+2}_{(aq)} + 2\,e^- \Rightarrow Cu_{(s)}$ (copper ion gains electrons; hence Cu^{2+} is reduced)

Another way of looking at the above reaction is to consider what the Cu^{2+} ion is doing to the Zn. Cu^{2+} is causing the Zn to be oxidized, so Cu^{2+} is acting as the oxidizing agent. Conversely, Zn is causing Cu^{2+} to be reduced, so Zn is a reducing agent. Reactions such as that between Zn(s) and $Cu^{2+}_{(aq)}$ only go in one direction. In other words, we **will not** see the following reaction occur:

$$Cu_{(s)} + Zn^{+2}_{(aq)} \rightarrow Cu^{+2}_{(aq)} + Zn_{(s)}$$

In other words, Zn is able to reduce Cu^{2+} but Cu is not able to reduce Zn^{2+}. We can summarize this by saying that Zn is a stronger reducing agent that Cu.

Purpose

The purpose of this lab is to order Cu, Mg, Zn and Pb from strongest to weakest reducing agent.

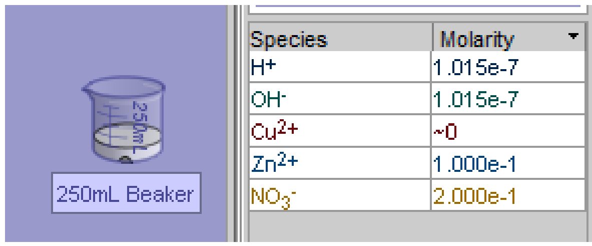
Procedure

All of the materials and equipment you need to carry out the lab can be found at the website below:

http://chemcollective.org/vlab/106

The stockroom contains solutions of Cu^{2+}, Mg^{2+}, Zn^{2+} and Pb^{2+} ions and the corresponding metals (Cu, Mg, Zn, Pb). Your first task is to order Cu, Mg, Zn and Pb from stronger to weakest reducing agent. To do this, you need to obtain a beaker to mix a solid metal with a known solution.

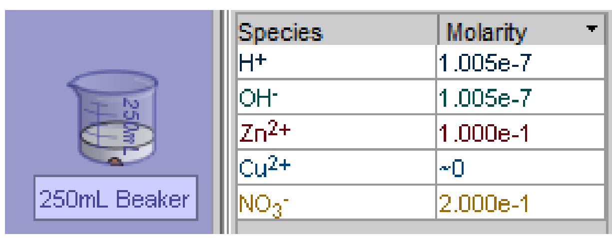
For example, if I wanted to test whether Zn could reduce Cu^{2+}, I would take 10 g of solid zinc and place it in a beaker with 100mL of 0.10M $Cu(NO_3)_2$. Using the concentration of ions (seen on the right side of the webpage), I see the following information:



Species	Molarity
H^+	1.015e-7
OH^-	1.015e-7
Cu^{2+}	~0
Zn^{2+}	1.000e-1
NO_3^-	2.000e-1

You can see that I now have Zn^{2+} ions in my solution, but no Cu^{2+} ions. From this data, I can conclude that Cu^{2+} was reduced (as there are no Cu^{2+} ions present) and Zn^{2+} was oxidized (as there are now Zn^{2+} ions present and I didn't add any to my initial solution). =

By that same logic, if I wanted to test whether Cu could reduce Zn^{2+}, I would take 10 g of solid copper and place it in a beaker with 100mL of 0.10M $Zn(NO_3)_2$. Using the concentration of ions (seen on the right side of the webpage), I see the following information:



Species	Molarity
H^+	1.005e-7
OH^-	1.005e-7
Zn^{2+}	1.000e-1
Cu^{2+}	~0
NO_3^-	2.000e-1

You can see that I do not have Cu^{2+} ions in my solution, but still have Zn^{2+} ions. From this data, I can conclude that Zn^{2+} was not reduced and Cu was not oxidized (as there are not any Cu^{2+} ions present). Thus, Zn is a stronger reducing agent than Cu.

Your task will be to mix all of the solids with all of the solutions to determine if a redox reaction happens. If a reaction happens, write reaction in the data table below. If no reaction occurs, write no reaction (see examples between the copper and zinc). You will then use this data to order Cu, Mg, Zn, and Pb from strongest to weakest reducing agent.

Data:

	$Cu(NO_3)_{2(aq)}$	$Mg(NO_3)_{2(aq)}$	$Zn(NO_3)_{2(aq)}$	$Pb(NO_3)_{2(aq)}$
$Cu_{(s)}$	N/A		No reaction	
$Mg_{(s)}$		N/A		
$Zn_{(s)}$	reaction		N/A	
$Pb_{(s)}$				N/A

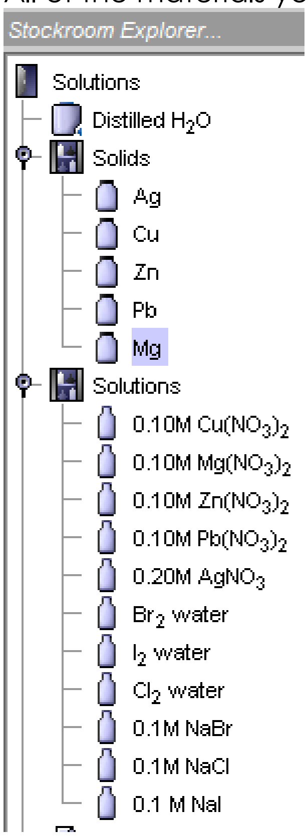
Analysis:

Based on the data you collected above, order Cu, Mg, Zn and Pb from strongest to weakest reducing agent.

Appendix 1: Helpful Hints

A few things that might be helpful to know when using the virtual lab software:

1. Click on this button  for any glassware you need (beaker, flasks, burets, etc.).
2. Click on this button  for any equipment you need (Bunsen burner, etc.).
3. All of the materials you need can be found in the "stockroom"



4. To add material to glassware, place the material on top of the glassware until you see a green (+) sign. Then, type in the amount you want to add to the glassware into the transfer amount and click pour

5. Right click on any glassware, equipment or materials and choose remove from the drop down menu to remove them from your workbench.