

Week 5 • Oxidation-Reduction

TEACHING IDEAS AND RESOURCES

Overview:

Many Oxidation-Reduction Ideas were discussed during Week 3 - Predicting Reactions. I have given just a brief re-statement of some of them. You will need to go back for the fuller discussion.

Laboratory Ideas:

Introduction to Oxidation Reduction:

Aluminum metal is oxidized as copper(II) ions are reduced. We ignore the side reaction of water being turned into H_2 (gas). I also take this opportunity to point out the color change of the copper(II) ion when a little water and more water is added. This is due to complex ion formation. This reaction must use copper(II) chloride. It does not work with copper(II) sulfate (I found out.) You can use copper(II) sulfate if you add some sodium chloride (I've been told). The chloride must help break through the tough aluminum oxide coating on the foil. The handout is given.

Burning Mg:

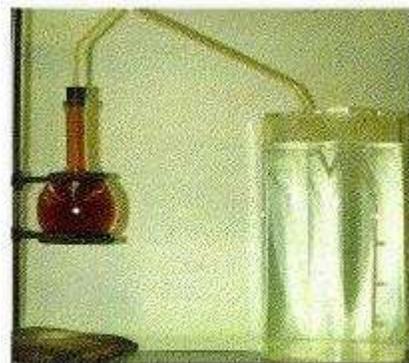
$Mg(s) + O_2(g) \rightarrow MgO$ is an easy introductory redox reaction that can be added in as an anticipatory set or just as a break from lecture. I have never done the quantitative version of this where magnesium is placed in a crucible and heated. Burning steel wool and massing it before and after was suggested in our Discussion Groups.

Nitric Acid Acts on Copper:

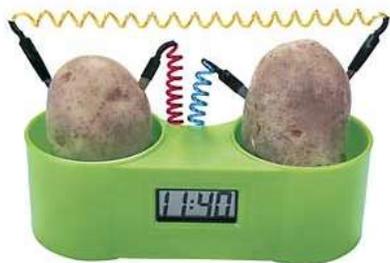


Check out chemmybear.com for a complete write-up on this demonstration. I use this on my first day of summer school (first day of chemistry for my students). The setup is simple.

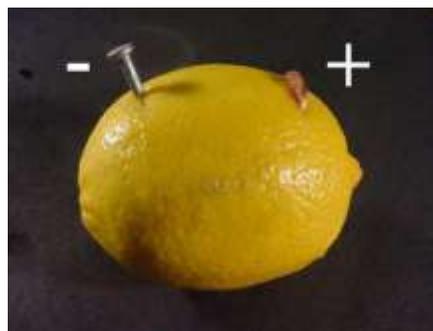
We re-visit this demonstration the week before the AP exam and they are surprised at how much more sophisticated their observations and knowledge about this demonstration have become.



Two-Potato Clock and Lemon Battery:



Here are two takes on the same sort of demonstration. Both are cute and both could be used. The lemon is quick and easy, but you need something to show the electricity created... something that doesn't require much current. A digital meter. I've always thought about using Christmas lights.



Growing Crystals in Gels:

Two of these reactions involve oxidation-reduction reactions. These are the two that look pretty for a week or four, but lose their aesthetic appeal after some time. All of the details are in Week 3.

Activity of Metals Labette:

In this two part lab, I use a 24-well plate with samples of four metals and solutions of the four ions to determine which metal is most active (most likely to be oxidized). One metal reacts with all three solutions, one reacts with two solutions, etc. We make an activity series from this.

The metals are easy to obtain. The solutions are kept in dropper bottles. The results are good, although we discuss as a group the results in case one group gets odd results.

Next, we build simple electrochemical cells with these metals sitting on a drop of their solution on filter paper. This is all done in a Petri dish. The voltages are usually all incorrect, but they come out to correct relative order.

We are not working under standard conditions, but even so, I tell my students that getting those textbook values of E° is more of an art than a science.



Electrolysis Labette:



I have written out a version of this verbal labette. We have a pencil electrolysis apparatus that we build. You can also use a 9-volt battery with the Radio Shack battery connector leads placed directly into the solution. It is much quicker, but the copper leads reacts and disappear into solution. This changes the reactions a little. You can hold the two leads onto mechanical pencil leads or search Google for pencil electrolysis for some other ideas. Here are the various solutions I explore with my students.

In a solution of Na_2SO_4 + universal indicator (see next page)	Students observe that H^+ ions are produced at the positive electrode (oxidation of O^{2-} in water) while OH^- ions are produced at the negative electrode as the H^+ in water is reduced to $\text{H}_2(\text{g})$.
In a solution of KI + phenolphthalein (Shown above)	I use an index card to separate the two electrodes. Brown $\text{I}_2(\text{s})$ forms at the positive electrode and some yellow/orange I_3^- forms in solution. At the negative electrode, H^+ is again reduced to $\text{H}_2(\text{g})$ and the phenolphthalein turns pink due to the OH^- ions.
In a solution of CuCl_2	I haven't tried this one yet... but you should see copper metal formed at the negative electrode and smell chlorine gas formed at the positive electrode. I am wondering whether the $\text{Cl}_2(\text{g})$ will permeate my graphite pencil leads and change the reactions next period. Probably not.

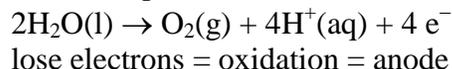
I use a Hoffmann apparatus with Pt° electrodes to show $\text{H}_2(\text{g})$ and $\text{O}_2(\text{g})$ forming in a 2:1 ratio.



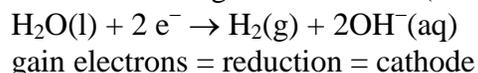
Electrolysis Lab (continued):

Here is a picture of the electrolysis lab done with wires hanging off the top of a 9-volt battery in a solution of sodium sulfate and universal indicator. The colors are clues to the reactions at the electrodes as water is both oxidized and reduced.

Red is acid at the positive electrode (red wire):



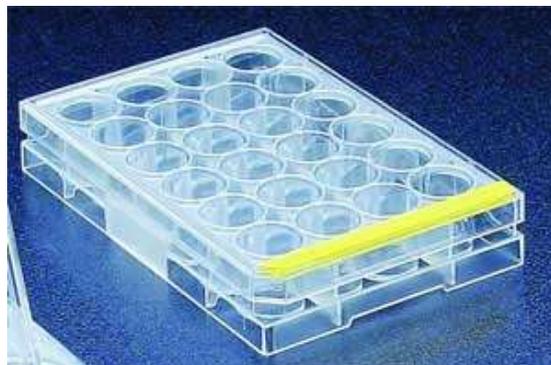
Purple is base as the negative electrode (black wire):



Activity of Metals Labette:

In this two part lab, I use a 24-well plate with samples of four metals and solutions of the four ions to determine which metal is most active (most likely to be oxidized). One metal reacts with all three solutions, one reacts with two solutions, etc. We make an activity series from this.

Next, we build simple electrochemical cells with these metals sitting on a drop of their solution on filter paper. The voltages are all incorrect, but they come out to correct relative order.



Electrochemical Cells:

Sally Ann Vonderbrink's lab manual (sold by Flinn) has a great, involved, lab on this same topic. Using a 24-well plate and the same metals and solutions plus more, you set up tiny electrochemical cells using a tiny strip of filter paper wetted with KNO_3 and a salt bridge. The great part comes with changing the solutions and using the Nernst Equation. You make use $\text{NH}_3(aq)$ to form a complex ion and also make a precipitate. Since these two changes alter the concentrations of the ions, the change in voltage can be used to determine the new concentrations and the equilibrium constants involved. I really understood the Nernst equation better after doing this lab with my students. It is more work than the one above, but there is also more to learn.

Ornament Lab & Oh Chemist's Tree:

I discussed these two in the Written Lecture notes. I especially like the ornament lab because some students, who are not necessarily great chemists, get to shine with their great artistic skills. I am dazzled every year by some of the wonderful, intricate, and creative designs students come up with for their ornaments. We have to go to a hardware store and purchase galvanized iron "flashing" (it comes in rolls) and cut out 3" squares. It can be done with tin snips (keep lots of band aids on hand) but we have found that there is a machine that the metal shop had. Since our metal shop has been turned into a CAD-CAM computer lab, the machine was found at the district's maintenance department. It is like a big paper cutter and we do enough for our 150 students in about an hour.

My Chemistry Christmas Carols:

<http://www.chemmybear.com/groves/tree.html>

<http://www.chemmybear.com/groves/whiteppt.html>