Lab Notes for the Electrochemistry Lab: Everyday Chemistry

I really, thoroughly enjoy electrochemistry … It can seem complicated, but it really is a wonderful area of study. Per the name, electrochemistry can deal with generating an electrical current because of a chemical reaction…. as in a simple galvanic cell or as in the slightly more complicated battery!

A battery is a portable unit, chock-full of chemicals, which, when allowed to react, creates an electrical current designed to do work (run a clock, create light in a flashlight, create an infrared beam in a remote control etc.….)

You know about redox … reduction/oxidation …. The oxidized species loses electrons and the reduced species gains electrons. And, you may remember the classes when we talked about the electron transport system of the cell’s mitochondria.

Well, in a battery, electrons leave one end (the end marked negative [-]) and travel to the end marked positive [+]. One important difference between any old redox reaction, and a battery … is that as the electrons leave the negative end, we force them to travel through wires of a machine … and in doing so, we force them to do some work for us … Then, and only then do are the electrons allowed to get to the positive end of the battery to complete their chemical reaction! Brilliant!

Like the electron transport system, electrons of a battery give up some of their energy as they travel along the system. Oxidizable species (very often metal atoms) give up electrons. Those electrons give up some of their energy, to do work, like creating light, before we allow them to get to the chemicals to be reduced.

So, one side of the battery (the anode) builds up electrons, due to oxidation. The other side (the cathode) has chemicals that can be reduced.

Electrons flow out of the anode, through a wire, doing work, on their way to the cathode, where there are chemicals waiting to be reduced.

Very often, the oxidized species is a metal, while the reduced species is a metal *ion* or *cation* … found at the cathode, end of the battery. See the

similarity in terms between cation and cathode? One is a positive ion the other is the labeled the positive end of a battery, as electrons travel there.

For instance, in the lab we react zinc metal with copper(II) sulfate.

<https://www.physics-and-radio-electronics.com/blog/battery-battery-works/>

 Zn(s) + CuSO4(aq) 🡪 ZnSO4(aq) + Cu(s) … but to really understand the

movement of electrons, let’s look at the charges….

 Zn0(s) + Cu2+(aq)  🡪 Zn2+(aq) + Cu0(s)

You see, the metallic zinc went from 0 to Zn2+ … That’s an oxidation…The original species became more positive.

Well where did those electrons go? They can’t just be lost per the Law of the Conservation of Mass, Energy and Charge!!!

Those electrons travelled to the Cu2+ of the solution, (the other reactant!) and this metal cation was reduced to Cu0 or copper metal.

The reaction occurred between the reactants Zn0 + Cu2+ and these species turned into the products: Zn2+ + Cu0

Now, in the video, you will hear Dr. Selzer refer to a build up of spongy copper metal … That is because he created a simplified battery (a Galvanic cell), which oxidized zinc, reduced copper ion and created an electrical current in doing so!

You will also hear other terms in the video…such as:

1) Tin (Sn) and copper (Cu) ***cannot replace*** zinc (as an ion). This means that tin and zinc ion (Zn2+ of a solution) DO NOT react with each other. “To Replace” is sometimes used instead of “Reacts With)

For instance, “replaced by” means that the metal cation of the solution is reduced to its metallic form, and replaced with the metal cation of the metal being oxidized.

Thus, you might hear that magnesium metal (Mg) ***can replace*** zinc ion … That means that magnesium metal ***can react with*** zinc ion of the solution. (Remember aqueous solutions are mixtures, with the symbol, (aq))

 Mg0(s) + Zn2+(aq) 🡪 Mg2+(aq) + Zn0(aq)

 Notice that the oxidized species (of the anode) is a metallic species, while the reduced species (e.g. Zn2+)

 a metal cation

2) Dr. Selzer also says that ***it appears that the magnesium metal is dissolving*** … That is because as magnesium metal is oxidized it turns into Mg2+ which ***becomes soluble*** in water … Hence, the magnesium metal is being corroded or eaten away by the chemical oxidation reaction …. It is a fine point … We know dissolving is a physical change …. but this is a nuanced issue.

The magnesium metal **is not** dissolving per se …. **but it is being oxidized to a soluble form** (the cation, Mg2+) …. Remember, he says it “appears” to be dissolving. He does NOT say it *is* dissolving … This is the nuance…

In truth there is a chemical reaction occurring…. a redox reaction.

3) Dr Selzer also mentions that the “bright metal darkens”. The darkening of a metal suggests that another metal is being formed over it … **a precipitate if you will**. As the metal cation is reduced, the new metal is forming a dark layer over the metal being oxidized.

Why is it a dark layer? **Well, finely divided metals actually appear dark**. The **crystals of metal being formed are so small, that they act like a light trap**. Instead of reflecting light, they sort of allow light to bounce around from crystal to crystal, never to re-emerge from the layer … Hence, finely divided, newly formed metal crystals appear to be black, or dark … instead of silvery.

**Remember, a bold color change (silvery to black), or the formation of a new solid and a new gas bubbling out…like H2 are visible signs of a chemical reaction.** We have seen this a number of times in our labs … We have seen this in the acid/base lab as well as the analysis of water lab.

**At 16 minutes or so**, you will see that Dr. Selzer, generously re-creates the data tables for you …. So, you can visualize the data and/or record it, should you have your data tables. Recording it may help you answer some of the questions. To help you further, I have recreated the completed 2a.2 Activity Series table for you. It’s on the next page.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Metal Species + Metal Ion | 1M Zn(NO3)2 | 1M Al(NO3)3 | 1M Mg(NO3)2 | 1M CuSO4 | 1M SnCl2 |
| Zn | Not Applicable | No Reaction | No Reaction  | Spongy Copper metal formed  | Black coating of finelydivided Tin metal formed |
| Al | Slight Reaction | Not Applicable | No Reaction | Copper metal formed | Black coating of finelydivided Tin metal formed |
| Mg | Zinc metal formed | Slight Reaction | Not Applicable | Vigorous Reaction; Copper metal formed | Vigorous Reaction; Tin Metal Formed |
| Sn | No Reaction | No Reaction | No Reaction | No Reaction (But should have) | Not Applicable |
| Cu | No Reaction | No Reaction | No Reaction | Not Applicable | No Reaction |

Notice: Zn + Al(NO3)3 🡪 no reaction

or rather …. Zn0 + Al3+ 🡪 no reaction …. Zinc metal does NOT become oxidize in the presence of Al3+

The 0 on an element indicates the pure element … a 0 number of electrons is being used to bond zinc atoms to atoms or ions of a different element … Everything in Zn0 is zinc atoms, bonded to zinc atoms …

Compare this to the reaction with CuSO4

Zn + CuSO4 🡪 ZnSO4 + Cu

or rather …. Zn0 + Cu2+ 🡪 Zn2+ + Cu0 ….Zinc metal becomes oxidized (loses electrons) to Cu2+ ion and

 Cu2+ ion is reduced (gains those electrons) to Cu metal. This

 builds up as “spongy copper metal” on the piece of zinc metal.

Okay, that’s it … Take a look at the video: <https://youtu.be/5-XVcYVWWE8>

It is 26 minutes …. but again, at 16 minutes, Dr. Selzer recreates the data tables for us….