Electrolytic Cells

1. How is an electrolytic cell different to a galvanic cell?

   Electrolytic cells use electrical energy to force non-spontaneous reactions forward. Thus, the cell potential associated with electrolytic cells is negative.

2. What are the units for an Ampere?

$$\text{Ampere (Amp)} = \frac{\text{Coulumb}}{\text{second}}$$

3. What does the term "plating" mean?

   Reduction of a metal ion to a neutral (solid) metal.

4. What is a useful equation for solving electrolysis problems?

$$I = \frac{nF}{t}$$

Where:

I = Amps	$F = 96485 \frac{C}{mol\ e^-}$
n = moles of e^-	t = time (in seconds)

5. How long will it take to plate out 1.0 kg of Al from aqueous AlF_3 with a current of 100.0 A?

   In this problem we are plating Al. This means that we are reducing the Al^{3+}. We can determine the charge on the Al based on the compound, AlF_3. The half reaction for this reduction is:

$$Al^{3+} + 3e^- \rightarrow Al$$

From this reaction we see that there are three moles of electrons required per mole of Al^{3+}.

From the question we are able to determine:

$$I = 100.0A \quad n = 3\ mole^- \quad t = ?$$

Let's rearrange the expression in terms of t, plug in and solve

$$t = \frac{nF}{I} = \frac{(3\ mole^-)\left(96485 \frac{C}{mol\ e^-}\right)}{100.0A} = 2894.6 \frac{s}{mol\ Al}$$

Remember that we have not yet answered the question. We are being asked for the amount of time it would take a 1000g of Al to plate out. We have determined the amount of time that it would take a single mole of Al to plate out.

So we still need to…

$$1000g\ Al \; \frac{mol\ Al}{26.98g} \; \frac{2894.63\ s}{mol\ Al} \; \frac{1\ hr}{3600s} = \boxed{29.8\ hrs}$$

6. What mass of Cr from molten CrO_3 can be produced in 1.0h with a current of 15A?

There is another way that you are able to do these problems – that is by using stoichiometry instead of the formula.

I typically prefer the stoichiometry approach, I find that it is much easier to keep track of the units, but it honestly boils down to your preference.

If you were to take the stoichiometry approach to this question it would look like this:

$$1.0 \text{ hr} \; \frac{3600 \text{ s}}{1 \text{ hr}} \; \frac{15 \text{C}}{\text{s}} \; \frac{\text{mol e}^-}{96485 \text{ C}} \; \frac{1 \text{ mol Cr}}{6 \text{ mol e}^-} \; \frac{52.00 \text{ g Cr}}{\text{mol Cr}} = 4.85 \text{ g Cr}$$

7. An aqueous solution of an unknown salt of ruthenium is electrolyzed by a current of 2.50 A passing for 50.0 min. If 2.618 g Ru is produced at the cathode, what is the charge on the ruthenium ions in the solution?

At this point you can pick whichever method you prefer… I'll use the formula method in this case. First I'll organize the information given to me in the problem:

$$I = 2.50 \frac{\text{C}}{\text{s}} \qquad n = ?$$

$$F = 96485 \frac{\text{C}}{\text{mol e}^-} \qquad t = 50 \text{ min} \frac{60 \text{ sec}}{1 \text{ min}} = 3000\text{s}$$

Next I will plug the data in to the formula (set in terms of moles)

$$n = \frac{It}{F} = \frac{\left(2.50 \frac{\text{C}}{\text{s}}\right)(3000\text{s})}{96485 \frac{\text{C}}{\text{mol e}^-}} = 0.0777 \text{ mol e}^-$$

This number here represents the actual number of electrons transferred to plate the actual number of moles of ruthenium in the sample.

Next I will use the molar mass to determine the number of moles of ruthenium formed.

$$2.618 \text{ g Ru} \frac{1 \text{ mol Ru}}{101.1 \text{ g Ru}} = 0.0259 \text{ mol Ru}$$

Now, we need to see how many moles of electrons are transferred per mole of ruthenium. If we know the number of moles of electrons required we know the charge on the compound.

$$\frac{0.0777 \text{ mol } e^-}{0.0259 \text{ mol Ru}} = 3 \frac{\text{mol } e^-}{\text{mol Ru}}$$

Thus the charge on the ruthenium is :

$$\boxed{Ru^{3+}}$$

1. Electrolysis of an alkaline earth metal chloride using a current of 5.00 A for 748 seconds plates out 0.471 g of metal at the cathode. What is the identity of the alkaline earth metal chloride?

It is important to be able to identify where on the periodic table, the alkaline earth family is located – this will be the key to figuring out the number of electrons transferred. This family is the 2nd column – meaning it is the family that tends to lose 2 electrons. This means that in order to plate the alkaline earth metal ions, 2 electrons would have to be transferred.

Next, it is also helpful to keep in mind that, typically, the identity of a substance will be obtained by determining the molar mass of the substance. Remember that

$$\text{molar mass} = \frac{\text{mass of substance}}{\text{moles of substance}}$$

We have been given the number of grams of the substance – 0.471g. Thus, we only need to determine the number of moles of the alkaline earth metal and we are able to solve.

$$748\ s\ \frac{5.00\ C}{s}\ \frac{mol\ e^-}{96485\ C}\ \frac{1\ mol\ A}{2\ mol\ e^-} = 0.01938\ mol\ A$$

$$\text{Molar Mass} = \frac{g}{mol} = \frac{0.471\ g}{0.01938\ mol} = 24.30\ g\ mol$$

That is the molar mass of **Magnesum.**