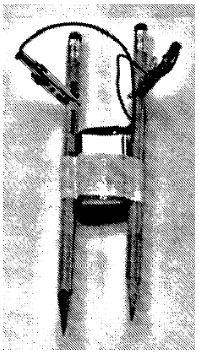
Name ________________________________
Period ___ Date ___/___/___

21 • Electrochemistry

ELECTROLYSIS LABETTE

Introduction:



Electricity can be used to cause a chemical change. We will try this using our pencil electrolysis apparatus. Notice that it is two pencils taped together with a 9-volt battery. The battery top has wires that connect to the graphite of each pencil. Remember, $C_{(graphite)}$ is a conductor due to the extended pi bond (chicken-wire shaped) above and below the sp^2 hybridized carbon atoms. The carbon has another benefit in that they are relatively inert and will not react with the solutions we will use.

Pencil "lead" itself is interesting stuff and you can read more about it here:
`http://pubs.acs.org/cen/whatstuff/stuff/7942sci4.html`

1. Get a clean Petri dish and put in some distilled H_2O. Place the tips of your pencil apparatus into the distilled water and make observations. ____

2. You probably notice that nothing happens because distilled H_2O is a very poor conductor of electricity. Add a pinch of Na_2SO_4 to your water to increase the conductivity. Also, add a few drops of universal indicator. (Don't use the pencil apparatus to mix the solution.) You should see a green color if your water is neutral.

   Place the tips of your pencil apparatus into the distilled water and make observations. __________
   ____

3. At one pencil tip, H^+ ions are being formed. At the other pencil tip, OH^- ions are being formed. We need to explain this observation. Let's consider the negative electrode first.
   Water surrounds the negative electrode and _____ (Na^+ | SO_4^{2-}) ions will be attracted to the negative electrode. The negative electrode is negative because it has ______________ (too many | too few) electrons. It will force a chemical to ________ (gain | lose) electrons which is called _____________ (oxidation | reduction).

Standard Reduction Potential	E° (volts)
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$	+1.23
$SO_4^{2-}(aq) + 4\ H^+(aq) + 2e^- \rightarrow SO_2(g) + 2\ H_2O$	+0.20
$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	-0.828
$Na^+(aq) + e^- \rightarrow Na(s)$	-2.714

This chart shows various reduction reactions with the most likely to be reduced higher in the chart. So, for our two choices of reductions at the negative electrode, write the chemical reaction that occurs:

The color at the negative electrode is __________ due to the presence of _____ ions. Since reduction is occurring at the negative electrode, this is the _________ (anode | cathode).

4. At the positive electrode, H_2O is oxidized. The S in SO_4^{2-} is already in the most oxidized state it can be in, so it does not change. Use the chart to find the oxidation of H_2O. Since this is a chart of reductions, you must look at the equations backwards. Find the reaction in which the H_2O is oxidized.

5. In this situation, water is both oxidized and reduced. Write the two equations and add them together. You will need to double one of the reactions to cancel the e^-'s. Write the net reaction.

   Oxidation:

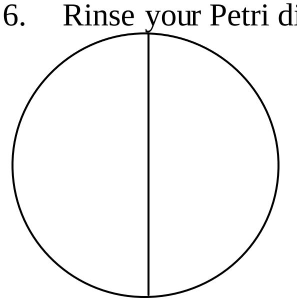
   Reduction:

   Net Reaction:

   Remove the pencil apparatus and mix the solution. Observations: ________________________

   Explain: ____

6. Rinse your Petri dish and again add distilled water. Using a spatula, add a "pinch" of KI to the water and dissolve using a clean glass stirring rod. Add a few drops of phenolphthalein indicator solution. Place a strip of index card down the center of the dish to separate the dish into two areas. (It doesn't have to be at all perfect.)



   Now, touch the pencil apparatus to the solution, one tip on each side of the card. Hold it still and make observations. ____________________________________
   ____

   In this solution, you have K^+, I^-, and H_2O. It is now your task to determine the two possible reactions at the anode. Write the two possible reductions that occur. Use the reduction potential chart to determine which of the two will actually occur.

Reduction	**E°**	**Which will occur?**

Standard Reduction Potential	E° (volts)
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$	+1.23
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
$I_2(s) + 2e^- \rightarrow 2I^-(aq)$	+0.535
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.337
$SO_4^{2-}(aq) + 4\,H^+(aq) + 2e^- \rightarrow SO_2(g) + 2\,H_2O$	+0.20
$2\,H^+(aq) + 2\,e^- \rightarrow H_2(g)$ (reference electrode)	0.00
$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	-0.828
$Na^+(aq) + e^- \rightarrow Na(s)$	-2.714
$K^+(aq) + e^- \rightarrow K(s)$	-2.93

7. It is a little more tricky to determine which **oxidation** will occur at the **anode**.
In this solution, you have K^+, I^-, and H_2O. Determine the two possible **oxidations**. You will consider the reactions on the chart below written in **reverse**. Use the **reduction** potential chart to determine which of the two will actually occur by **changing the sign** of the reduction potentials. You are now listing the **oxidation potentials**. The higher the E° value, the more likely the chemical is to be oxidized.

Oxidation	**E°**	**Which will occur?**

Standard Reduction Potential	E° (volts)
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$	+1.23
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
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$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	-0.828
$Na^+(aq) + e^- \rightarrow Na(s)$	-2.714
$K^+(aq) + e^- \rightarrow K(s)$	-2.93

8. Link your equations with the observations.

Electrode:	**What is observed?**	**Explain (write the equation)**
anode		
cathode		

9. What do you predict would happen with a solution of $CuCl_2$? What reactions would occur? What would you observe? Rinse your Petri dish and try it.