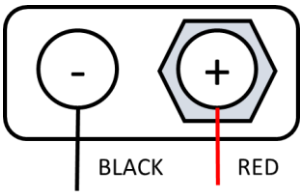
Oxidation and Reduction: an investigation of the electrolysis of copper sulphate solution.

Materials

• Copper nails • Graphite rods • Lego brick electrode holder	• 9V battery connector with soldered clips • Small beaker • Dilute copper sulphate solution (CARE!)

Experiment 1

- Put a small amount of copper sulfate solution in the beaker.
- Attach the clips of the battery holder to two copper nails and place them in the lego brick electrode holder
- Connect the battery holder to the battery.
- Note: the red wire is the positive and is attached to the rose shaped connector.



- Note which electrode is positive and which is negative.
- **KEEP THE BATTERY ATTACHED FOR ABOUT 2 MINUTES NO LONGER!**
- Make a note of your observations in the table.

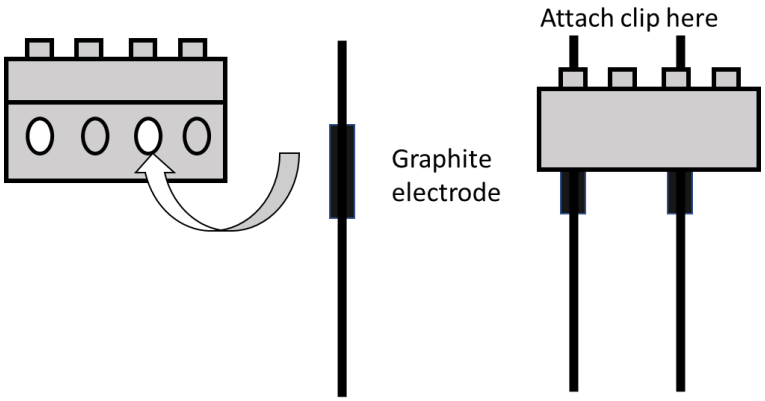
	Cathode (-)	**Anode (+)**
Copper		

- What do you notice about the solution?
- Which species are present in solution?
- Which are oxidation reactions and which are reduction reactions?
- Which electrode is associated with each type of reaction?
- Write out equations for what is happening at each electrode.
- How do you think this process might be useful industrially?

Equations:

Experiment 2

- Repeat the procedure using the graphite electrodes.



- DO NOT remove them from their lego holders: insert the electrode into the brick so that a small part of the graphite sticks out of the top.
- Attach the clip of the battery connector to this part.
- Immerse the electrodes into the copper sulphate solution.
- Make a note of your observations.

	Cathode (-)	**Anode (+)**
Graphite		

- What do you notice about the solution?
- Which species are present in solution?
- Which are oxidation reactions and which are reduction reactions?
- Which electrode is associated with each type of reaction?
- Write out equations for what is happening at each electrode.

Equations:

Notes

Copper sulphate dissociates in solution to give Cu^{2+} and SO_4^{2-} ions but the solution also contains H^+ and OH^- which are in equilibrium with undissociated water molecules. This means that according to the type of electrodes that are used, we can obtain different products from the solution.

Copper Electrodes

Cathode (-)	**Anode (+)**
The negative cathode attracts the positively charged copper ions which receive electrons from the cathode to give the deposit of copper metal. Copper (II) is reduced in this reaction and the mass of the electrode increases. $Cu^{2+} + 2e^- \rightarrow Cu(s)$	The chemistry of the anode is more complex. The positively charged anode attracts the negative ions in solution (SO_4^{2-} and OH^-) but since these are both very stable anions, they will not give up electrons easily to the anode. Instead, the copper of the electrode is the source of the electrons which means that the anode gradually dissolves as the copper goes into solution. This is an oxidation reaction because the copper metal loses electrons. $Cu(s) \rightarrow Cu^{2+} + 2e^-$

Graphite Electrodes

Cathode (-)	**Anode (+)**
The chemistry at the cathode is the same as for the copper electrodes. The negative cathode attracts the positively charged copper ions which receive electrons from the cathode to give the deposit of copper metal. Copper (II) is reduced in this reaction and the mass of the electrode increases. $Cu^{2+} + 2e^- \rightarrow Cu(s)$	The chemistry of the anode is more complex and is different from the case of the copper anode: this is because carbon is very reluctant to donate electrons to the anode. Of the three possible species which can give away electrons to the anode (carbon anode, SO_4^{2-} and OH^-) it is the hydroxyl anion that is the source of the electrons: $4OH^- \rightarrow 4e^- + 2H_2O + O_2(g)$ As you can see, this results in the production of oxygen gas which can be seen as bubbles at the anode.

- How could you test the gas that is produced at the anode?

Electrolysis of water. Distilled water is a poor conductor of electricity therefore we add a small amount of sodium sulphate to allow the current to flow better. The presence of the SO_4^{2-} and the Na^+ do not influence the outcome of this reaction. However, if we use normal salt (NaCl), the chemistry changes and we find that chlorine gas is developed at the anode.

The process of splitting water into hydrogen and oxygen takes a lot of energy.

Cathode (-)	**Anode (+)**
$4H_2O + 4e^- \rightarrow H_2(g) + 4OH^-$	$2H_2O \rightarrow O_2(g) + 4H^+ + 4e^-$

- There is currently a lot interest in ways of splitting water to give hydrogen and oxygen, why?