Electrolysis of copper (ii) sulphate solution essay

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This investigation will examine one of the factors that affect the amount off copper deposited during the electrolysis of copper (II) sulphate solution. Electrolysis is the decomposition of an ionic solution by electricity. The electricity splits ionic chemical compounds into separate components, for example, copper chloride can be split into Cu metal and Cl gas.

Electrolysis is used to extract reactive metals from solutions of their ores. It is an extremely powerful way of splitting a compound using electricity, but it is very expensive and is only used for metals higher up in the reactivity series. These metals only way of extraction is by electrolysis as they are more reactive than carbon. These metals are Potassium, Calcium, Magnesium, Aluminium and sodium. This is a simple diagram of an electrolysis cell:

When the battery is switched on, it creates and electrical current. The positive and negative terminals create a positive and a negative electrode. The current flows through the electrolyte (the molten ore).

The ore has to be melted in order for electricity pass through it. As electricity flows through the molten ore, the compound splits apart and forms ions. These ions are free to move because the ore is a liquid. The ions carry a charge and the negative ions (the non-metal ions) are attracted to the positive anode and the positive ions (the metal ions) are attracted to the negative anode. The metal is always deposited at the cathode and a gas is given off at the anode. If the metal is reactive, it will produce H2 at the cathode (where it is collected) as it reacts with the water present.

We had done a previous experiment investigating the electrolysis of copper (II) sulphate as described below. We first got two pieces of copper and labelled them ‘ C’ and ‘ A’ (cathode and anode). We cleaned the copper with cotton wool and propanone to remove any dirt or grease and we then weighed the electrodes and recorded their masses. The electrodes were then connected to a battery in a simple circuit (as shown below) with a light bulb with the copper (II) sulphate solution as the electrolyte. The negative terminal of the battery was connected to then cathode, and the positive to the anode. The electrolysis was kept going for as long as possible.

When the experiment was over, we disconnected the electrodes carefully, washed them in distilled water and patted them gently dry. The electrodes were reweighed and their masses recorded. It was found that the copper cathode had increased in mass and the copper anode had decreased in mass. The ions present in the solution are Cu2+, SO42-, OH- and H+. This preliminary experiment will help me ensure that I choose the right range of currents for my purposes and gave me an insight into how to carry out the investigation. It will also show me what results to expect from the actual investigation.

Identifying the key factors:

In this experiment, I will choose to vary one factor that may affect the amount of copper deposited at the cathode. These are:

a) the size of current passing through the cell

b) the time for which the current passes through the cell

c) the concentration of the copper sulphate solution

d) the distance the electrodes are apart.

If we vary one or more of the above factors, the amount of copper deposited on the cathode will change. In

a) The larger the current, the larger the amount of copper deposited. This is because by increasing the current, more electrons are passed into the cell and so should increase the amount of copper deposited at the cathode. The rate of Cu2+ combining with e- will speed up as there are more electrons readily accessible to form copper atoms.

b) The longer the time allowed for electrolysis, the more copper will be deposited on the cathode. This is because more electrons can be passed into the cell and should increase the amount of copper collected at the cathode.

c) The higher the concentration of the copper (II) sulphate solution, the more copper will be deposited on the cathode. This is because increasing the concentration increases the number of copper ions, so there are more ions to be converted into copper atoms.

d) The further apart the electrodes are, the less copper will be deposited on the cathode. If the electrodes are closer together, the ions have less distance to move and so the copper can be deposited more quickly.

This diagram demonstrates what is said below

Copper (II) Sulphate is an ionic substance. When in solution, the ions are free to move and can carry an electric charge. Ions are also produced from the water:

H_2O (l) –> H^+(aq) + OH^- (aq)

$CuSO_4$ (aq) –> Cu^{2+}(aq) + SO_4^{2-} (aq)

The copper ions carry a positive charge and are attracted to the cathode. In the electrolysis of copper sulphate a number of things happen at the anode. If it is made from graphite oxygen will be formed and given off. If the anode is made from copper the copper atoms will lose electrons to form copper ions which will then go into solution. The copper ions are then attracted to the cathode where they gain electrons to form copper metal once more. Only copper will be deposited at the cathode. This means that if an impure piece of copper is used as an anode the copper atoms will ionise and the ions will be deposited on the cathode as pure copper. This is therefore a good way to purify copper.

At the cathode, the copper ions become copper atoms as they gain electrons:

$Cu^{2+} + 2e^-$ –> Cu

The copper atoms cling to the cathode and make it heavier, copper is deposited at the cathode.

At the anode, the copper atoms dissolve and become copper ions:

(electricity)

Cu –> Cu2+ + 2e-

The anode becomes lighter as it has lost atoms.

I have chosen to investigate the affect that the size of current has on the electrolysis of the solution. I chose this because it is easy to control as you can use a variable resistor and will give reliable and concise results.

Prediction:

If I increase the size of the current I will increase the amount of copper deposited at the cathode. This is because more electrons are passed through the solution. Therefore if I double the current, I will double the amount of electrons passing through the cell. This, if I double the amount of electrons, I will double the amount of copper deposited at the cathode. This is because 2 electrons are needed in order to make a copper ion a copper atom

(Cu2+ +e- –> Cu (s)) so if I double the number of electrons, I will double the number of available electrons to combine with more copper ions, forming more copper atoms. I think that the gain/loss in mass of the cathode/anode will be directly proportional to current. I think this means that I will get a graph that has a straight line through the origin if the results are accurate.