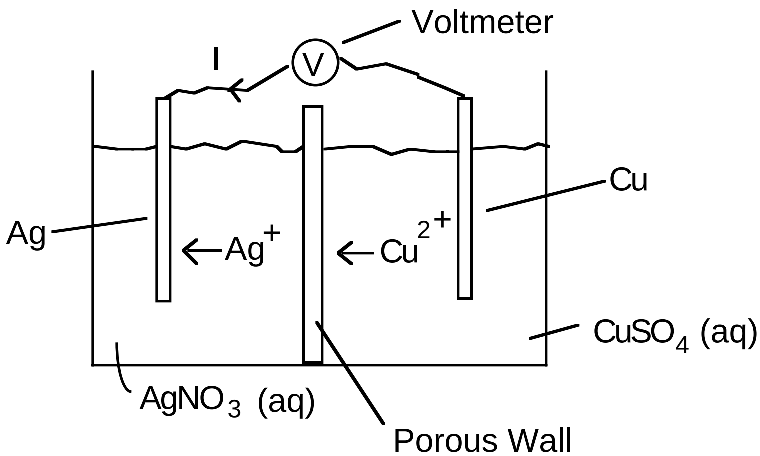
Chem12 Electrochemical Cells : Notes/W.S. - 20

In an electrochemical cell, a redox reaction is used to produce an electric current. An example of an electrochemical cell is shown below.



The above cell consists of two parts. The left side contains a silver electrode in a silver nitrate solution. The right side contains a copper electrode in a copper (II) sulfate solution. The two sides are separated by a porous wall. Copper is the stronger reducing agent and loses electrons to the silver electrode. When both electrodes are connected by a wire, electrons will flow from the copper electrode to the silver electrode. The V represents a voltmeter which measures the energy the electrons have. The V can be replaced by a light-bulb or some other device that consumes energy. Silver ions come out of solution and are deposited on the silver electrode. Its mass increases. At the copper electrode, copper ions go into solution and its mass decreases. The positive copper ions on the right and the nitrate ions on the left migrate towards the porous wall where they form copper (II) nitrate. The circuit can't be complete without the porous wall and the formation of the copper (II) nitrate. This prevents a charge build-up in both half-cells.

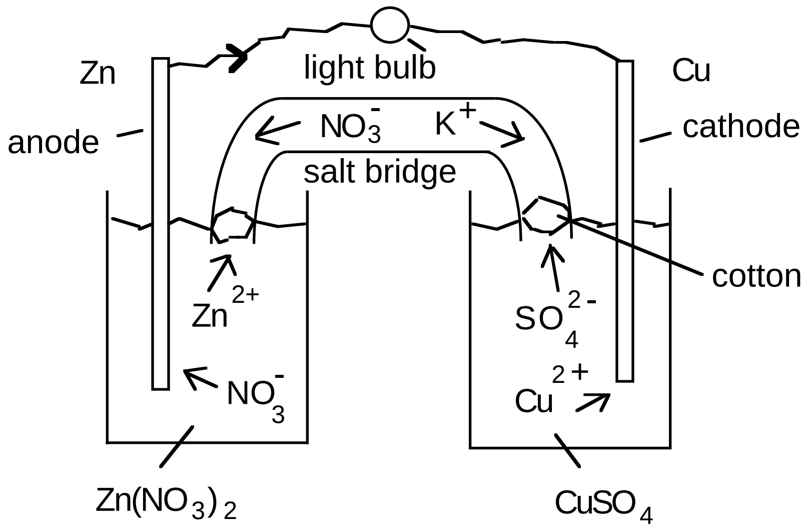
The redox reaction here is : $Cu(s) + 2Ag^+ \rightarrow Cu^{2+} + 2Ag$ + energy

Copper is oxidized. The copper electrode is called the **Anode**. In any electrochemical cell, **oxidation occurs at the anode**. The silver electrode is called the **Cathode**. Reduction occurs at the cathode.

This cell is described in texts as a

Cu/Cu^{2+} || Ag^{+}/Ag cell.

Another type of cell uses a "salt bridge", instead of a porous wall to prevent charge build-up. An example of this type of cell is shown below.



In the cell above Zinc is oxidized. It is the anode. Oxidation occurs at the anode. Reduction occurs at the cathode. So electrons move toward the cathode. The zinc electrode is immersed in a solution containing a salt of zinc such as zinc nitrate. The copper electrode is immersed in a solution of a salt of copper such as copper sulfate. Zinc ions go into solution. The zinc electrode decreases in mass. Copper ions come out of solution and the copper electrode increases in mass. Charge does not build up in both half cells because of the salt bridge. Potassium ions move toward the cathode (they neutralize sulfate ions in the cotton) and nitrate ions move toward the anode (they neutralize the zinc ions in the cotton). The energy produced by the redox reaction is lost in the light bulb. This cell is described in texts as a :

Zn/Zn^{2+} || Cu^{2+}/Cu cell.

- Problems : Draw a diagram of a Ni/Ni^{2+}||Ag^{+}/Ag (silver-nickel) cell.

  1) Label the anode, cathode, and the direction of electron flow. Write the half reactions at each electrode. Write down the balanced overall cell

reaction. Which electrode increases in mass ?
Which electrode decreases in mass ?

2) Answer these problems based on the cell above.

a) Where does oxidation occur?

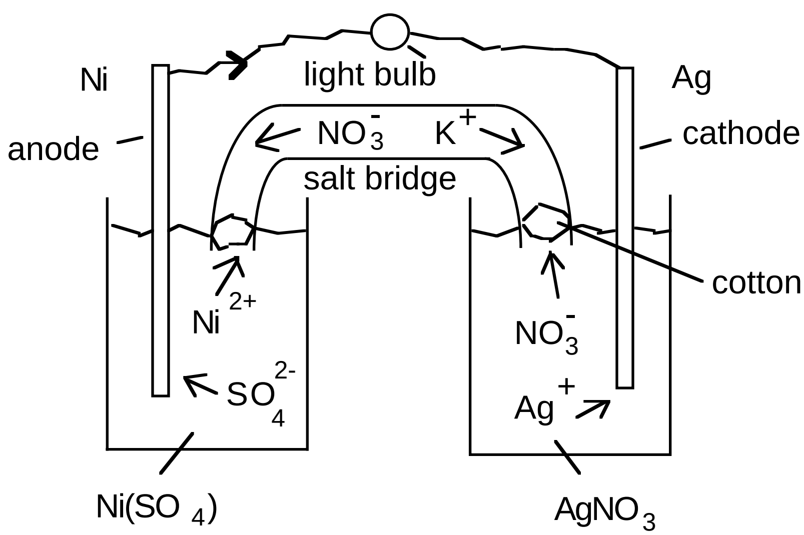
b) Where does reduction occur?

c) To which electrode do positive ions migrate.

d) To which electrode do negative ions migrate ?

e) Give suitable solutions for each half-cell and the salt bridge.

Answers : 1) Ni is the anode, Ag is the cathode, electrons flow from the Ni electrode to the Ag electrode. The half-cell reaction in the Ni cell is : $Ni \rightarrow Ni^{2+} + 2e^-$. The half-cell reaction in the Ag cell is : $Ag^+ + e^- \rightarrow Ag$. The overall reaction is : $2Ag^+ + Ni \rightarrow 2Ag + Ni^{2+}$. The Ag electrode increases in mass. The Ni electrode decreases in mass. See the diagram below.



2)a) Ni, b) Ag, c) Ag, d) Ni, e) Suitable solutions : Ni half-cell, $NiSO_4$, Ag half-cell, $AgNO_3$, salt bridge, KNO_3.