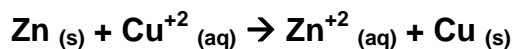
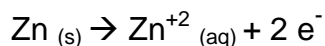


## Sections 19.2 - 19.3: Voltaic Cell

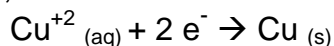
Consider the redox reaction occurring in a Voltaic cell:



Break the redox reaction into an oxidation half-reaction,



and a reduction half-reaction,



Thus, a Voltaic cell consists of two **compartments**, or two beakers, one where the oxidation half-reaction occurs, and the other where the reduction half-reaction occurs.

Assume that:

the oxidation half-reaction occurs in the left beaker.

the reduction half-reaction occurs in the right beaker.

Thus, the half-reactions are:



In this redox reaction, we have solid Zn and Cu. Both Zn and Cu are metals. Hence, they conduct electricity. Substances made of materials that conduct electricity can be used as **electrodes**. Thus, there are two electrodes in a Voltaic cell. In this example, we use strips of Zn and Cu as electrodes.



For a chemical reaction to occur, these electrodes are dipped in aqueous solutions containing  $\text{Zn}^{2+}$  and  $\text{Cu}^{2+}$  ions. These aqueous solutions are **electrolytes**. Recall, electrolytes are solutions that conduct electricity.

One of the electrodes is called the **cathode**, and the other is called the **anode**.



The cathode is always the electrode at which the reduction half-reaction occurs. In this example, Cu is the cathode. Recall, reduction is the gain of electrons. This means that a cathode accepts electrons.

The anode is always the electrode at which the oxidation half-reaction occurs. In this example, Zn is the anode. Recall, oxidation is the loss of electrons. This means that an anode gives out electrons.

To allow the transfer of electrons between the two electrodes, the anode and the cathode are connected to each other with a wire. This is called creating a circuit. Thus, electrons always flow from the anode to the cathode.

There is an excess negative charge at the anode, since this is where the oxidation (i.e. loss of electrons) takes place. For this reason, a negative charge is shown at the anode.

There is a deficit of negative charge at the cathode, since this is where reduction (i.e. gain of electrons) occurs. For this reason, a positive charge is shown at the cathode.

The electrons will flow from the anode to the cathode momentarily because the electrical circuit is not complete. Why?

Consider the oxidation half-cell. The oxidation half-cell contains a  $\text{Zn}^{+2}$  solution. Now, the loss of two  $e^-$  at the Zn electrode is accompanied by the ionization of Zn to  $\text{Zn}^{+2}$ , and the release of this ion into solution. Thus, a net positive charge would develop in solution.

Consider the reduction half-cell. The gain of two  $e^-$  at the Cu electrode is accompanied by the migration of a  $\text{Cu}^{+2}$  ion onto the cathode, and its transformation to Cu metal. Hence, the reduction half-reaction decreases  $[\text{Cu}^{+2}]$  in solution. Thus, a net negative charge would develop in solution.

Overall, this results in a charge build-up, which stops the flow of electrons. To enable the flow of electrons, we use a **salt bridge** to connect the two half-cells. The salt bridge completes the circuit by allowing the ions to flow between the two half-cells. The salt bridge prevents charge build-up, and allows the continuous flow of electrons from the anode to the cathode.

The salt bridge is an inverted U-tube containing a gel. The gel contains a solution of non-reactive ions (e.g.  $\text{Na}^+$  and  $\text{SO}_4^{-2}$  ions). Note: These non-reactive ions can diffuse into and out of the half-cells via the salt bridge, but the solutions cannot.