Outcome 2
Topic 1 – Understanding Voltaic Cells

- You learned in Chapter 13 that a redox reaction involves a transfer of electrons from the reducing agent to the oxidizing agent.

http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animations/ZnCutransfer.html

- In a voltaic cell, electrons pass from the reducing agent to the oxidizing agent through an ***external circuit*** rather than passing directly from one substance to another.

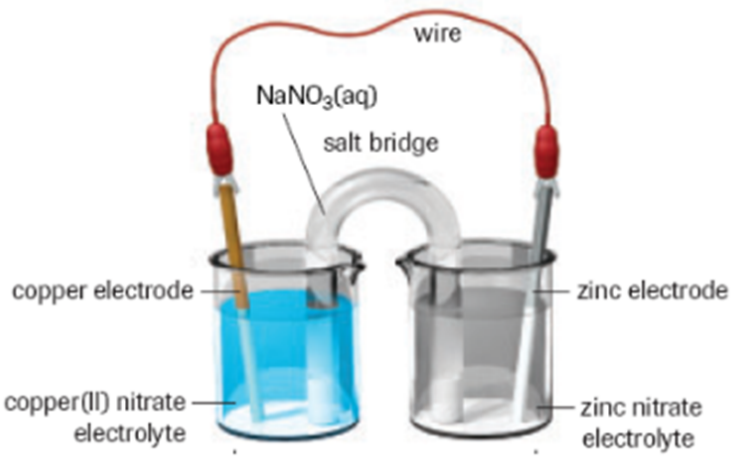
http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/flashfiles/electroChem/voltaicCellEMF.html

http://www.mhhe.com/physsci/chemistry/essentialchemistry/flash/galvan5.swf

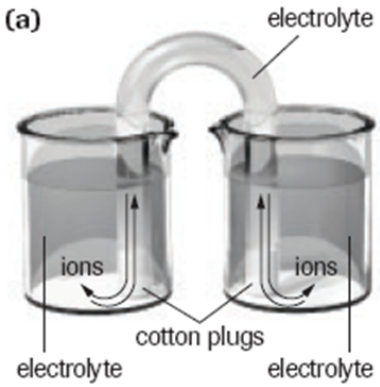
- A voltaic cell is a cell that has **two electrodes** and their **electrolyte**s separated

  - The SRA and SOA are **<u>separated</u>**

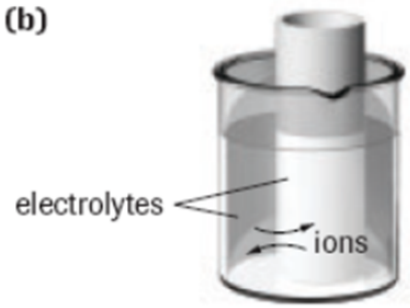
This is not a very practical arrangement, but it helps the study of cells



- A porous boundary separates the two electrolytes, at least for a short time, while still permitting ions to move between the two solutions through tiny openings in the cotton plugs of a salt bridge (**Figure (a)**) or in the walls of a porcelain cup (**Figure (b)**).

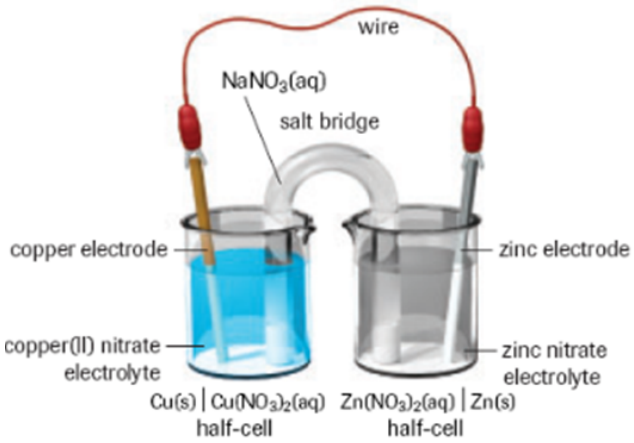


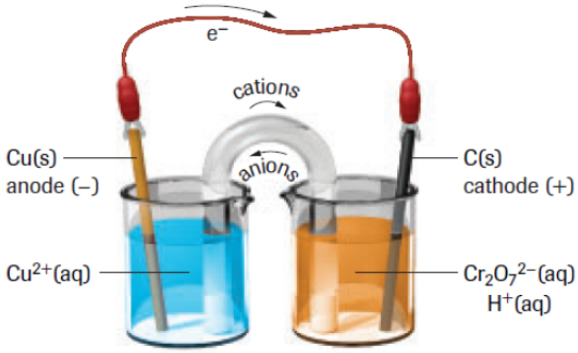
(a) A salt bridge is a U-shaped tube containing an inert (unreactive) aqueous electrolyte such as sodium sulfate.



(b) An unglazed porcelain (porous) cup containing one electrolyte sits in a container of a second electrolyte.

- Each part, called a half-cell, consists of one **electrode** and one **electrolyte**
    - Electrodes may be a **metal** or an **inert** material such as carbon or platinum



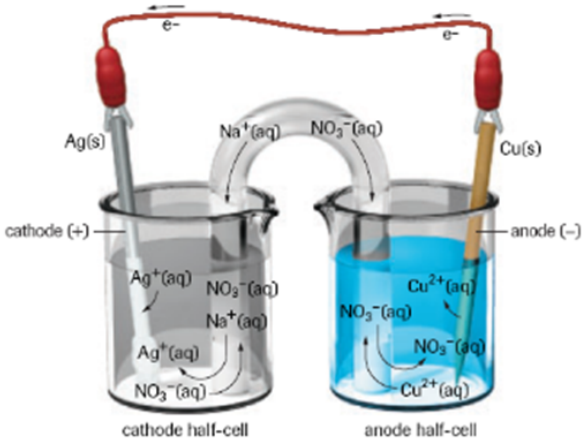


Demonstration - Silver - Copper Voltaic Cell

Table 1 Evidence and Interpretations of the Silver–Copper Cell

Evidence	Interpretation
The copper electrode decreases in size and the intensity of the blue colour of the electrolyte increases.	Oxidation of copper metal is occurring: $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ (blue)
The silver electrode increases in size as long, silver-coloured crystals grow.	Reduction of silver ions is occurring: $Ag^+(aq) + e^- \rightarrow Ag(s)$
A blue colour slowly moves up the U-tube from the copper half-cell to the silver half-cell.	Copper(II) ions (cations) move toward the cathode.
An ammeter shows that the electric current flows along a wire between the copper electrode and the silver electrode.	Electrons move through the wire from the copper electrode to the silver electrode.
A voltmeter indicates that the silver electrode cathode (positive) and the copper electrode is the anode (negative).	Electrons have a tendency to leave the copper half-cell and enter the silver half-cell.

http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/electroChem/voltaicCellEMF.html



Shorthand Cell Notation

- A cell can be represented using an abbreviated ("shorthand") notation

- In this notation, a single line (|) indicates a phase boundary, such as the interface of an electrode and an electrolyte in a half-cell.

A double line (||) represents a physical boundary, such as a porous cup or salt bridge

anode (—) | electrolyte || electrolyte | cathode (+)

Write the shorthand notation for the voltaic cell in the picture above

Theoretical Descriptions of a Voltaic Cell - pg 623-626

- Observation of a voltaic cell as it operates provides evidence to explain what is happening inside the cell

- From our observations we know:
  - The SOA in the cell always undergoes a **reduction** at the **cathode**
  - The SRA in the cell always undergoes an **oxidation** at the **anode**

- Therefore, the **cathode is the electrode where reduction occurs** and the **anode is the electrode where oxidation occurs**.

- This gives us two new acronyms

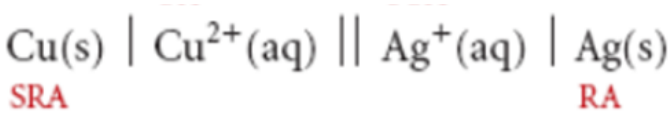
RED CAT and AN OX and/or; **SOAC a GERC** (soak a jerk)

- **anions move toward the anode** and **cations move toward the cathode** as the cell operates. The solutions remain electrically neutral.

- **Electrons released by the oxidation of the SRA at the anode travel through the connecting wire to the cathode where the SOA gains the electrons**

How do I figure out what reaction is going to occur in a voltaic cell?

- Use the shorthand notation as a list of what is present in the cell and identify the OA's and RA's



- Write the reaction for the SOA and SRA and then combine them into a net reaction

http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animations/SHEZnV7.html

http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animations/SHECu.html

Example

1 (a) Write equations for the half-reactions and the overall reaction that occur in the following cell:

anode SRA SOA cathode

$$C(s) \mid Fe^{2+}(aq), Fe^{3+}(aq) \,||\, Cr_2O_7^{2-}(aq), H^+(aq) \mid C(s)$$

ox: $6[Fe^{2+}_{(aq)} \rightarrow Fe^{3+}_{(aq)} + 1e^-]$

red: $14H^+_{(aq)} + Cr_2O_7^{2-} + 6e^- \rightarrow 2Cr^{3+}_{(aq)} + 7H_2O_{(l)}$

net: $6Fe^{2+}_{(s)} + 14H^+_{(s)} + Cr_2O_7^{2-}_{(s)} \rightarrow 6Fe^{3+}_{(s)} + 2Cr^{3+}_{(s)} + 7H_2O_{(s)}$

1 (b) Draw a diagram of the cell, labelling electrodes, electrolytes, the direction of electron flow, and the direction of ion movement.