

Chapter 17: Oxidation and Reduction

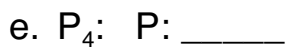
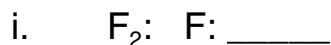
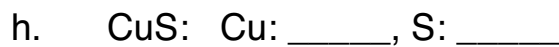
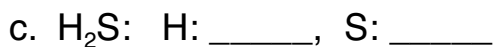
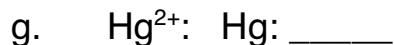
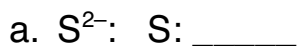
Problems: 1-4, 11-13

17.1 OXIDATION NUMBERS (Ox. #'s) and REDOX REACTIONS

Guidelines for Assigning Oxidation Numbers

1. A metal or a nonmetal in the free state (i.e. by itself) has an ox. # of 0.
 - e.g. the oxidation number for each element in H_2 , O_2 , P_4 , Na, etc. is 0.
2. A monatomic ion has an ox. # equal to its charge.
 - e.g. In Na_3N , the oxidation # of Na in Na^+ is +1 and -3 for N in N^{3-} .
In Al_2O_3 , the oxidation number for Al is +3 and -2 for O.
3. In a compound, the sum of all oxidation numbers must equal 0.

Example: Determine the oxidation number for each element in the following:



17.2 OXIDATION-REDUCTION (REDOX) REACTIONS

In a redox reaction

- One reactant **loses electrons (is oxidized)**, and another reactant **gains electrons (is reduced)**.

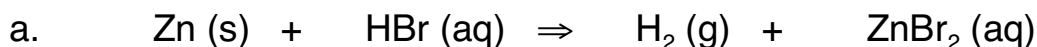
An easy way to remember is “**LEO the lion goes GER.**”

- **LEO (lose electrons=oxidized)**
- **GER (gains electrons=reduced)**

The reactant **oxidized** is the **reducing agent** because it reduced the other.
The reactant **reduced** is the **oxidizing agent** because it oxidized the other.

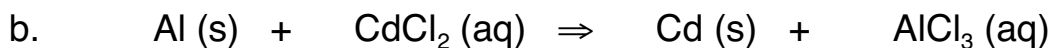
Example: For each of the following redox reactions,

1. Balance the chemical equation.
2. Determine oxidation numbers for each element
3. Diagram the electrons lost and gained.
3. Identify the reactant oxidized and the reactant reduced.
4. Identify the oxidizing agent and the reducing agent.



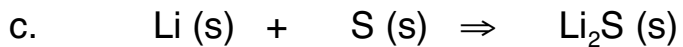
The reactant oxidized is _____, so it is the _____ agent.

The reactant reduced is _____, so it is the _____ agent.



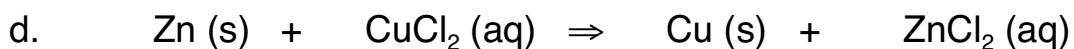
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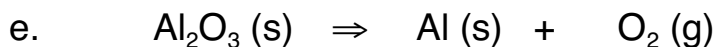
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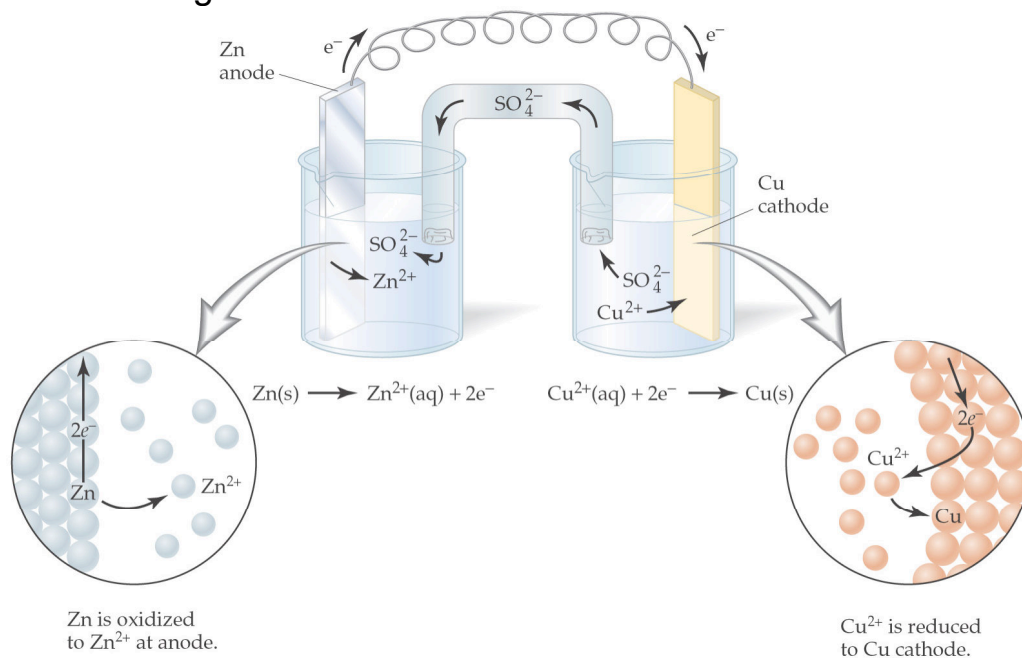
The reactant oxidized is _____, so it is the _____ agent.

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17.6 Voltaic Cells

- Any **spontaneous** redox reaction can be the energy source in a voltaic cell
 - Species reacting must be separated to produce energy.

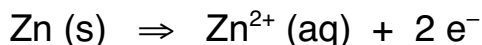
Consider the following voltaic cell:



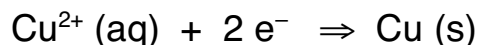
- Two half-cells are prepared by dipping solid metal electrodes into corresponding solutions.
- The **salt bridge** allows ions to flow back and forth to maintain electrical neutrality and prevent a charge build up that stops electrons from flowing.

Let's trace the electron flow:

- At the Zn electrode, electrons are produced by the oxidation half-reaction:



- The electrode where **oxidation** occurs is called the **anode**.
- More Zn²⁺ ions are released into the ZnCl₂ (aq) solution, and electrons are pumped into the external circuit.
- Electrons produced at the anode move through the external circuit to the Cu electrode, where they are consumed in the reduction of Cu²⁺ to solid Cu:



- The electrode where **reduction** occurs is called the **cathode**.

Batteries

electrochemistry: the conversion of chemical energy into electrical energy

For most people, electrochemistry is important because of batteries.

battery: a portable, self-contained electrochemical power source that consists of one or more voltaic cells

- the common 1.5V batteries used in flashlights are single voltaic cells
- higher voltages can be achieved by using multiple voltaic cells in series to make a single battery (e.g. a 12V car battery)
- even greater voltages can be achieved by using a series of batteries
- convention for marking batteries: “+” for cathode, “–” for anode
- As a battery operates, reactants \Rightarrow products, the emf drops to zero
 - **primary cells:** can't be recharged once emf drops
 - **secondary cells:** can be recharged with an external power source once emf drops

Nickel-Cadmium (Nicad), Nickel-Metal-Hydride (NiMH), and Lithium-Ion Batteries

- The growth in high-power-demand portable electronics (laptops, cell phones, etc.) has increased the demand for lightweight, rechargeable batteries
 - More expensive than lead storage battery for amount of electrical energy delivered, but also have longer shelf life
 - e.g. **Nickel-Cadmium** batteries can be recharged but will also eventually lose their ability to be recharged, and because cadmium is a toxic heavy metal, the batteries are heavy and their disposal poses an environmental hazard
 - \Rightarrow **Nickel-Metal-Hydride** batteries that overcome problems with cadmium but still heavy because of nickel
 - \Rightarrow **Lithium Ion** batteries are much lighter!

Alkaline Battery - provides 1.55V at room temperature

- anode: zinc metal in a gel in contact with concentrated KOH, hence the name “alkaline”
- cathode: $\text{MnO}_2(\text{s})$ and graphite rod
- battery is housed in steel to reduce risk of leakage of concentrated KOH