Balancing Redox Equations Using the Half-Cell Method

Key Terminology:

Oxidation: the complete or partial loss of electron	
Reduction: the complete or partial gain of electron	
Oxidizing Agent: a substance that causes another substance to be oxidized and is itself reduced	
Reducing Agent: a substance that causes another substance to be reduced and is itself oxidized	

Standard Table of Half-Reactions (written as reductions)

Have a good look at the table found on page 805 in your text. These are half reactions written as reductions (i.e. all reactants are gaining electrons). These reactions can be run forwards (left to right) or backwards (right to left). If the reaction is run backwards it is now an oxidation since electrons are lost. Please stop and clarify this point before you go on. THESE REACTIONS CAN GO BOTH WAYS!

Please be careful when looking at similar tables. This table can be written upside down or upside down and backwards!! The table may look similar but require different techniques to use properly. We will use this particular table exclusively in this course.

The strongest, most likely reaction is at the top of this table.

$$F_2(g) \rightleftharpoons 2F^{1-} + 2e^{1-}$$

As you have know for some time, F_2 has a dangerous ability to gain electrons rapidly. The reverse of this reaction

$$2F^{1-} + 2e^{1-} \rightleftharpoons F_2(g)$$

and is very unlikely and can only occur under very precise conditions.

The weakest, least likely reaction is at the bottom of this table.

$$Li^{1+} + 1e^{1-} \rightleftharpoons Li(s)$$

Li^{1+} is totally unlikely to gain an electron and become neutral Li(s). It is in fact the reverse reaction that is strong and likely.

$$Li(s) \rightleftharpoons Li^{1+} + 1e^{1-}$$

Lithium dangerously and spontaneously loses electrons. Remember the reaction of Li metal in water?

These reactions are ordered such that the best reductions are at the top (hence strongest oxidizing agents SOA) and the best oxidations (backwards reactions) are at the bottom (hence strongest reducing agents SRA).

Clarify all of these considerations before you go on.

Combining Half Cell Reactions to Make a Redox Reaction

A redox reaction can be created from two half reactions. One of those half reactions will be a reduction (gain electrons), the other will be an oxidation (lose electrons). Half reactions must occur as a redox pair. In other words you cannot have a reduction without an oxidation. The electrons gained in the reduction will come from and balance with the electrons lost in the oxidation.

With the Standard Table of Half Cell Reactions (pg 805) in front of you, hold your left arm out in front of you such that you are pointing to the right. This points the direction of a reduction half reaction (left to right). Now at the same time, hold your right arm out in front of you such that you are pointing to the left. This points the direction of an oxidation half reaction (right to left). By reversing the direction of the oxidation half reaction (represented by the right hand) and adding correct multiples of reduction and oxidation half reactions you can come up with a redox reaction that has a balanced loss and gain of electrons! The electrons will cancel out.

eg reduction of Cu^{2+} with oxidation of Al

reduction half reaction ➜	$Cu^{2+} + 2e^{1-} \rightleftharpoons Cu$
oxidation half reaction ➜	$Al \rightleftharpoons Al^{3+} + 3e^{1-}$
reduction x 3 ➜	$3Cu^{2+} + 6e^{1-} \rightleftharpoons 3Cu$
oxidation x 2 ➜	$2Al \rightleftharpoons 2Al^{3+} + 6e^{1-}$
add half reactions ➜	$3Cu^{2+} + 6e^{1-} + 2Al \rightleftharpoons 3Cu + 2Al^{3+} + 6e^{1-}$
cancel electrons ➜	$3Cu^{2+} + 2Al \rightleftharpoons 3Cu + 2Al^{3+}$

The above result shows cations only. At this level of chemistry, it is not uncommon to write reactions that omit counter ions that are spectator ions. In practice these will often be a soluble anion. The anion associated with both the Cu^{2+} reactant and the resulting Al^{3+} product. NO_3^{1-} is a very likely candidate given its solubility.

The left hand right hand over the table thing, can be used to determine if a reaction is spontaneous or non-spontaneous. For spontaneous reaction to occur, there must be a drop in potential energy (actually Gibb's Free Energy, but that is a long story). The drop in energy will occur if the combination of reduction half reaction and oxidation half reaction provide a more stable location for the electrons involved in the redox transfer. This will occur whenever the reduction half reaction is above the oxidation half reaction as given on the table. Left arm over right arm is spontaneous. If the oxidation reaction is above the reduction reaction (i.e. right over left) then it follows that the reaction is non-spontaneous.   This does not mean that the reaction cannot happen, it means that the reaction will require a significant energy input.