PHS 100- Oxidation/Reduction Summary and Worksheet

Start Simple:

1. Oxidation/Reduction has to do with the transfer of electrons.

2. Reduction- Charge is reduced. The atom/ion that gains electrons is reduced.
   Example: $Ag^{+1}(aq) + 1e^{-} \rightarrow Ag(s)$
   Notice that the charge on silver is reduced from +1 to zero

3. Oxidation- Charge is increased. The atom/ion that loses electrons is oxidized.
   Example: $Fe(s) \rightarrow Fe^{+2}(aq) + 2e^{-}$

LEO the lion says GER!!

Lose Electrons, Oxidation Gain Electrons, Reduction

You do not need to memorize the chemical symbol for each element (or vice-versa). On an exam, if you encounter a symbol or chemical that you do not recognize, please ask me to clarify.

In the above examples, iron was oxidized and silver was reduced. You would not be expected to know the ions that iron or silver are expected to form (because they are transition metals and these do not follow the nice patterns that we saw for the rest of the periodic table).

However, if you see $FeCl_2(aq)$, you should know that this means that the $FeCl_2$ has broken apart into Fe^{2+} ions and 2 Cl^{1-} ions (since the total charge must add up to zero). What ions are present in $Hg(NO_3)$? What ions are present in $Hg(NO_3)_2$? And yes, both of those compounds are possible.

Example Problem #1: You could be given this statement:

"Solid copper (Cu) reacts with Ag^{+1} ions (aqueous) to form solid silver (Ag) and copper ions with a positive 2 charge"

and asked to write oxidation and reduction half reactions as well as the full balanced equation. Let's go through it step by step:

Step 1: Identify the reactants in the equation (given in problem statement).

This is easy.
The problem says "Solid copper (Cu) reacts with Ag^{+1} ions (aqueous)"
We'll arrange this info into a table like this:

Reactants	Products
Cu(s)	
$Ag^{+1}(aq)$	

Step 2: Identify the products in the equation (given in problem statement).

This is also easy. Everything after the words "to form" is going to be a product.
The problem says "…to form solid silver (Ag) and copper ions with a positive 2 charge."

Reactants	**Products**
Cu(s)	$Cu^{+2}(aq)$
$Ag^{+1}(aq)$	Ag(s)

Step 3: Identify the number of protons and electrons in each reactant and product. Fill in the blanks in the statements below and in the table.

The number of protons is equal to the number above the element on the periodic table (fill.

- The number above copper is 29, so it will ALWAYS have ___ protons.
- The number above silver is 47, so it will ALWAYS have ___ protons.

When atoms are neutral (charge=0), they have equal numbers of electrons and protons. Therefore:

- Cu(s) has ___ electrons.
- Ag(s) has ___electrons.

For the ions (ones with non-zero charge), we can figure out how many electrons there are by considering the number of protons and the charge:

- Cu^{+2}(aq) has a charge of +2 so that must mean it has 2 more protons (the positively charged stuff) than it does electrons (the negatively charged stuff). Since it has 29 protons, it must have ___ electrons.
- Ag^{+1}(aq) has a charge of +1 so that must mean it has 1 more proton than it does electrons. Since it has 47 protons, it must have ___ electrons.

Reactants	**Products**
Cu(s) ___ protons ___ electrons	Cu^{+2}(aq) ___ protons ___ electrons
Ag^{+1}(aq) ___ protons ___ electrons	Ag(s) ___ protons ___ electrons

Step 4: Draw two arrows in the table to represent the two half-reactions that are occurring. Then balance the number of electrons on both sides of the equation, as shown in the table:

Reactants		Products		
$Cu(s)$	→	$Cu^{+2}(aq)$	+	$2\ e^-$
___ protons ___ electrons		___ protons ___ electrons		0 protons 2 electrons
$Ag^{+1}(aq)$ + $1\ e^-$	→	$Ag(s)$		
___ protons ___ electrons		0 protons 1 electrons		___ protons ___ electrons

Step 5: Balance the electrons being transferred:

Copper is giving away two, while silver is accepting one:

$Cu(s)$ $Cu^{+2}(aq) + 2\ e^-$
$Ag^{+1}(aq) + 1\ e^-$ $Ag(s)$

If Ag^{+1}only accepts one electron, where will the other electron go? Answer: To another Ag^{+1}. Therefore, we multiply the whole 2nd equation by 2 and add them together:

$Cu(s)$ $Cu^{+2}(aq) + 2\ e^-$
$2 \times \{ Ag^{+1}(aq) + 1\ e^- \}$ $Ag(s) \}$

$Cu(s) + 2Ag^{+1}(aq) + 2\ e^-$ $Cu^{+2}(aq) + 2Ag(s) + 2\ e^-$

There are 2 electrons on both sides of the equation and they cancel out, so we can omit them from the final equation, if we like.

$Cu(s) + 2Ag^{+1}(aq)$ $Cu^{+2}(aq) + 2Ag(s)$

We're done!

Example Problem #2

"In the following oxidation-reduction reaction:

$Cu^{+2}(aq) + Zn(s) \quad Cu(s) + Zn^{+2}(aq)$

which species is gaining electrons and which species is losing electrons?"

Step 1: Using the same type of table as in Example Problem #1, fill in the reactant and product for each half-reaction.

Reactants		Products
$Cu^{+2}(aq)$	→	Cu(s)
Zn(s)	→	$Zn^{+2}(aq)$

Step 2: Fill in the number of protons for each species.

The number of protons is equal to the number above the element on the periodic table:

- The number above copper is 29, so Cu and Cu^{+2} will each have __ protons.
- The number above zinc is 30, so Zn and Zn^{+2} will each have __ protons.

Reactants		Products
$Cu^{+2}(aq)$ 29 protons ___ electrons	→	Cu(s) 29 protons ___ electrons
Zn(s) 30 protons ___ electrons	→	$Zn^{+2}(aq)$ 30 protons ___ electrons

Step 3: Fill in the number of electrons for each species.

When atoms are neutral (charge=0), they have equal numbers of electrons and protons. Therefore:

- Cu(s) has ___ electrons.
- Zn(s) has ___electrons.

For the ions (ones with non-zero charge), we can figure out how many electrons there are by considering the number of protons and the charge:

- $Cu^{+2}(aq)$ has a charge of +2 so that must mean it has 2 more protons (the positively charged stuff) than it does electrons (the negatively charged stuff). Since it has 29 protons, it must have ___ electrons.
- $Zn^{+2}(aq)$ has a charge of +2 so that must mean it has 2 more proton than it does electrons. Since it has 30 protons, it must have 28 electrons.

Reactants		**Products**
$Cu^{+2}(aq)$	→	Cu(s)
29 protons 27 electrons		29 protons 29 electrons
Zn(s)	→	$Zn^{+2}(aq)$
30 protons 30 electrons		30 protons 28 electrons

Step 4: Then balance the number of electrons on both sides of the equation, as shown in the table:

In the 1st reaction (for copper), there are 27 electrons on the left and 29 electrons on the right. Therefore, we must add two electrons to the left part (reactant side) of this equation.

In the 2nd reaction (for zinc), there are 30 electrons on the left and 28 electrons on the right. Therefore, we must add two electrons to the right part (product side) of this equation.

Reactants		**Products**	
$Cu^{+2}(aq)$	$+ 2e^-$ →	$Cu(s)$	
29 protons 27 electrons		29 protons 29 electrons	
$Zn(s)$	→	$Zn^{+2}(aq)$	$+ 2e^-$
30 protons 30 electrons		30 protons 28 electrons	

Final Answer: $Cu^{+2}(aq)$ is gaining 2 electrons, while Zn(s) is losing 2 electrons.

(This seems like a long process, but the steps in this example are all quite short and do not take very much time to do once you understand them. Take shortcuts at your own peril!)

More Help

1. See reaction in the text on p.555 for sodium and chlorine
2. See example in Figure 23.5 on p. 559
3. Exercise 1 on p. 573
4. Go back and try to understand the oxidation/reduction reactions in the chemistry and electrochemistry labs