OXIDATION-REDUCTION REACTIONS involve electron transfer

Terms to Know:

OIL RIG – oxidation is loss, reduction is gain (of electrons)
Oxidation – the loss of electrons, increase in charge
Reduction – the gain of electrons, reduction of charge
Oxidation number – the assigned charge on an atom
Oxidizing agent (OA) – the species that is reduced and thus *causes* oxidation
Reducing agent (RA) – the species that is oxidized and thus *causes* reduction

Rules for Assigning Oxidation States—you know most of this already!

1. The oxidation state of an atom in an element is ZERO including allotropes [i.e. N_2, P_4, S_8].
2. The oxidation state of a monatomic ion is the same as its charge.
3. In its compounds, fluorine is always assigned an oxidation state of -1.
4. Oxygen is usually assigned an oxidation state of -2 in its covalent compounds, such as CO, CO_2, SO_2, and SO_3. Exceptions to this rule include peroxides (compounds containing the O_2^{2-} group), where each oxygen is assigned an oxidation state of -1, as in hydrogen peroxide (H_2O_2), and OF_2 in which oxygen is assigned a +2 oxidation state.
5. In its covalent compounds with nonmetals, hydrogen is assigned an oxidation state of +1. Metal hydrides are an exception; H is at the end of the chemical formula since it has an oxidation state of 1^-.
6. The sum of the oxidation states must be zero for an electrically neutral compound. For a polyatomic ion, the sum of the oxidation states must equal the charge of the ion.

Exercise 16
Assign oxidation states to all atoms in the following.
a. CO_2
b. SF_6
c. NO_3^-

a. oxygen is -2 & carbon is 4
b. fluorine is -6 & sulfer is +6
c. oxygen is -6 & nitrogen is +5

There can be non-integer oxidation states like in Fe_3O_4. There's a -8 for the 4 oxygens divided across 3 iron ions, therefore Fe's charge is $Fe^{8/3+}$

Exercise 17

When powdered aluminum metal is mixed with pulverized iodine crystals and a drop of water is added to help the reaction get started, the resulting reaction produces a great deal of energy. The mixture bursts into flames, and a purple smoke of I_2 vapor is produced from the excess iodine. The equation for the reaction is

$$2Al(s) + 3I_2(s) \rightarrow 2AlI_3(s)$$

For this reaction, identify the atoms that are oxidized and reduced, and specify the oxidizing and reducing agents.

Aluminum is oxidized; Iodine is reduced
Al is the reducing agent; I_2 is the oxidizing agent

Exercise 18

Metallurgy, the process of producing a metal from its ore, always involves oxidation-reduction reactions. In the metallurgy of galena (PbS), the principal lead-containing ore, the first step is the conversion of lead sulfide to its oxide (a process called *roasting*):

$$2PbS(s) + 3O_2(g) \rightarrow 2PbO(s) + 2SO_2(g)$$

The oxide is then treated with carbon monoxide to produce the free metal:

$$PbO(s) + CO(g) \rightarrow Pb(s) + CO_2(g)$$

For each reaction, identify the atoms that are oxidized and reduced, and specify the oxidizing and reducing agents.

First Reaction:
sulfur is oxidized; oxygen is reduced
O_2 is the oxidizing agent; PbS is the reducing agent
Second Reaction:
carbon is oxidized; lead is reduced
PbO is the oxidizing agent; CO is the reducing agent

Balancing Redox Reactions by Half Reaction Method

1. Divide the equation into oxidation and reduction half reactions. [OILRIG]
2. Balance all elements besides hydrogen and oxygen.
3. Balance O's by adding H_2O's to the appropriate side of each equation.
4. Balance H's by adding H^+
5. Balance the charge by adding electrons. [OILRIG again]
6. Multiply the half reactions to make electrons equal for both half-reactions.
7. Cancel out any common terms and recombine the two half reactions.
8. IF BASIC, neutralize any H^+ by adding the SAME NUMBER of OH^- to EACH side of the balanced equation. [This creates some waters that will cancel!]
9. CHECK!!

Sample Problem: Assign oxidation states to all atoms in the following equation, identify the oxidation and reduction half reactions, and the OA and RA.

$MnO_4^-{}_{(aq)} + Fe^{2+}{}_{(aq)} \rightarrow Mn^{+2}{}_{(aq)} + Fe^{3+}{}_{(aq)}$

Sample Problem: Balance the following equation using the half-reaction method.

(acidic) $MnO_4^-{}_{(aq)} + I^-{}_{(aq)} \rightarrow Mn^{+2}{}_{(aq)} + I_{2(aq)}$

(basic) $Ag_{(s)} + CN^- + O_2 \rightarrow Ag(CN)_2^-{}_{(aq)}$

Exercise 19

Potassium dichromate ($K_2Cr_2O_7$) is a bright orange compound that can be reduced to a blue-violet solution of Cr^{3+} ions. Under certain conditions, $K_2Cr_2O_7$ reacts with ethyl alcohol (C_2H_5OH) as follows:

$$H^+(aq) + Cr_2O_7^{2-}(aq) + C_2H_5OH(l) \rightarrow Cr^{3+}(aq) + CO_2(g) + H_2O(l)$$

Balance this equation using the half-reaction method.

Elements balance: 22H, 4Cr, 15O, 2C → 22H, 4Cr, 15O, 2C
Charges balance: +16 + 2(-2) + 0 = +12 → 4(+3) + 0 + 0 = +12

Exercise 20

Silver is sometimes found in nature as large nuggets; more often it is found mixed with other metals and their ores. An aqueous solution containing cyanide ion is often used to extract the silver using the following reaction that occurs in basic solution:

$$Ag(s) + CN^-(aq) + O_2(g) \rightarrow Ag(CN)_2^-(aq)$$

Balance this equation using the half-reaction method.

Elements balance: 8C, 8N, 4Ag, 4O, 4H → 8C, 8N, 4Ag, 4O, 4H
Charges balance: 8(1-) + 0 + 0 + 0 = 8- → 4(1-) + 4(1-) = 8-