Oxidation States and Rules for Assigning Them

The concept of oxidation states (also called oxidation numbers) provides a way to keep track of electrons in "electron transfer" reactions (Redox). It is important to note that electrons are actually transferred in reactions that produce ionic compounds but how about reactions that produce covalent compounds in which electrons are shared? In these cases we assign the shared electrons to more electronegative atoms. In cases of equal sharing electrons are split equally between the atoms often giving each atom a "0" oxidation number. As mentioned above for a covalent bond between two different atoms (and the electrons are thus shared unequally), the shared electrons are assigned completely to the atom that has the stronger attraction for electrons. For example, in the water molecule oxygen has a greater attraction for electrons than does hydrogen (oxygen is more electronegative). Therefore, in assigning the oxidation state of oxygen and hydrogen in H_2O, we assume that the oxygen being more electronegative completes its valence to 8, giving the atom an oxidation number of "-2". This rule gives each of the hydrogens an oxidation number of +1. Note that the summation of all oxidation numbers must equal zero for a compound or equal to the charge of the polyatomic anion or cation.

It is important to realize that **oxidation number** is convenient tool for dealing with chemical reactions. In cases of covalently bonded compounds it is *imagined* that the more electronegative atom attains a complete valence shell by getting electrons from the less electronegative atoms. Of course, for ionic compounds containing monatomic ions, the oxidation states of the ions are equal to the ionic charges.
These considerations lead to a series of rules for assigning oxidation states that are summarized in the following table.

Rules for Assigning Oxidation Numbers

1. The oxidation state of an atom in an element is zero (0). For example, the oxidation state of each atom in the substances Na(*s*), O_2(*g*), N_3(*g*), P_4 (*s*) and Hg(*l*) is 0.

2. The oxidation state of a monatomic ion is the same as its charge. For example, the oxidation state of the Na^+ ion is +1 and of the Cl^- ion is -1.

3. Oxygen is assigned an oxidation state of -2 in its covalent compounds (with less electronegative atoms) such as CO, CO_2, SO_2, and SO_3. An exception to this rule occurs in peroxides (compounds containing the O_2^{2-} group), where each oxygen is assigned an oxidation state of -1. The best-known example of a peroxide is hydrogen peroxide (H_2O_2)

4. In its covalent compounds with nonmetals (more electronegative), hydrogen is assigned an oxidation state of +1. For example, in the compounds HCl, NH_3, H_2O, and CH_4, hydrogen is assigned an oxidation state of +1.

5. In its compounds, fluorine (The most electronegative element) is always assigned an oxidation state of -1.

6. The sum of the oxidation states must be zero for an electrically neutral compound. For an ion, the sum of the oxidation states must equal the charge of the ion. For example, the sum of the oxidation states for the hydrogen and oxygen atoms in water is 0; the sum of the oxidation states for the carbon and oxygen atoms in CO_3^{2-} is -2; and the sum of oxidation states for the nitrogen and hydrogen atoms in NH_4^+ is +1.

Oxidation Number Practice Problems

Note: Before you start this exercise read the handout "Oxidation States and Rules for Assigning Them".

1) find the oxidation number for each atom of the following compounds/ions. Place the name of each compound/ion on the space provided:

______________	______________	______________	______________
K_3PO_4	SO_3	$Ca(NO_3)_2$	SO_2
K__	S__	Ca__	S__
P__	O__	N__	O__
O__		O__	
______________	______________	______________	______________
ClO_4^{-}	CO	N_2O_4	$C_2O_4^{2-}$
Cl__	C__	N__	C__
O__	O__	O__	O__
______________	______________	______________	______________
LiIO	CO_3^{2-}	Na_2SO_3	$Cr_2O_7^{2-}$
Li__	C__	Na__	Cr__
I__	O__	O__	O__
O__		S__	
______________	______________	______________	______________
$KHSO_4$	$KMnO_4$	Cr_2O_3	P_4O_{10}
K__	K__	Cr__	P__
H__	Mn__	O__	O__
S__	O__		
O__			