Jim Hollister/Rolf Unterleitner/
Chemistry 2C Workshop

Learning Skills Center
UC Davis

I. REVIEW OF OXIDATION AND REDUCTION IN ACID OR BASE CONDITIONS

Oxidation State (also known as *oxidation number* or *valence state*), is a quick way of assessing the oxidation or reduction of particular atoms according to a prescribed set of rules. [*Oxidation state* is not the same as *formal charge*, which tries to estimate the real charge distribution of a molecule or ion among its constituent atoms. Formal charge uses information about single bonds, multiple bonds and octet and non-octet structures. *Dipole moment*, the actual distribution of charges in a molecule or ion, must be experimentally measured.]

Empirical Method of Determining Oxidation State (These rules must be memorized and applied **in order**, the first rule has the highest priority, the last has the least priority.)

1) Elements in elemental form are 0 (e.g. Fe(s), O_2(g), etc.)
2) The sum of the oxidation states = the overall charge of the molecule/polyatomic ion. (e.g. ClO_4^-, Cl is +7, O is -2, 7+(4x-2) = -1)
3) All group I metals **and** Ag are +1
4) F is -1
5) All group II metals **and** Zn, Cd are +2
6) H is +1
7) O is -2

Some Definitions

Reduction: The charge (oxidation state) is reduced by gaining electrons. (e.g., in $Fe^{+2} + 2e^- \rightarrow Fe(s)$, the charge goes from +2 to 0 and so the Fe^{+2} is reduced to $Fe_{(s)}$.)

Oxidation: The charge (oxidation state) increases by losing electrons. (eg., $Ag_{(s)} \rightarrow Ag^+ + 1e^-$)

Reducing agent: The reducing agent is the compound which contains the element that is oxidized. When reducing another element or compound, the reducing agent must give electrons away so it becomes oxidized.

Oxidizing agent: The oxidizing agent is the compound which contains the element that is reduced.

Redox Reaction: A balanced chemical reaction consisting of both an oxidation and a reduction. (i.e., the sum of an oxidation 1/2 reaction and a reduction 1/2 reaction.) These are electron transfer reactions.

Balancing Redox Reactions
A six step method:
HEIOHEN

H	El	O	H	E	N
Half rxn's:	Elements:	Oxygen:	Hydrogen:	Electrons:	Number of electrons:
break up into	balance the Elements	balance **O**	balance **H**	add the e^- to	multiply so the Number
Half (1/2) rxn's	except O and H	with H_2O	with H^+	balance charge	of e^- is the same in both

Example: Balance the following reaction in acid: $Cr_2O_7^{-2} + H_2O_2 \rightarrow Cr^{+3} + O_2$

1) **H**: 1/2 rxn's

$Cr_2O_7^{-2}$	→	Cr^{+3}	red (+6 → +3)
H_2O_2	→	O_2	ox (-1 → 0)

2) **El:** elements

$Cr_2O_7^{-2}$	→	**2** Cr^{+3}	red
H_2O_2	→	O_2	ox

3) **O:** oxygen

$Cr_2O_7^{-2}$ → 2 Cr^{+3} + **7 H_2O** red

H_2O_2 → O_2 ox

4) $Cr_2O_7^{-2}$ + **14 H^+** → 2 Cr^{+3} + 7 H_2O red

H_2O_2 → O_2 + **2 H^+** ox

5) **E:** electrons Be sure to use the **net** (total) charge on each sides. Multiply coefficients by charges to get the net.

$Cr_2O_7^{-2}$ + 14 H^+ + **6e^-** → 2 Cr^{+3} + 7 H_2O red

H_2O_2 → **2 e^-** + O_2 + 2 H^+ ox

6) **N:** number

$Cr_2O_7^{-2}$ + 14 H^+ + 6e^- → 2 Cr^{+3} + 7 H_2O red

3 H_2O_2 → **6** e^- + **3** O_2 + **6** H^+ ox

7) Now add them up.

$Cr_2O_7^{-2}$ + 8 H^+ + 3 H_2O_2 → 2 Cr^{+3} + 7 H_2O + 3 O_2

8) Always check that in your answer all electrons cancel and atoms and charges balance! Also check to see if you can divide by a common divisor (see if you have the lowest possible coefficients) and if you can collect terms.

Balancing in Base

The procedure is the same as with acid except that after you add the H^+ to balance the hydrogens, add the **same number of OH^- to both sides and form water on one side**.

Example: Balance the following 1/2 rxn in base: BrO_3^- → BrO_4^-

1) **H**: (The 1/2 rxn is given in this case)

BrO_3^- → BrO_4^-

2) **El:** elements

BrO_3^- → BrO_4^-

Bromines are already balanced.

3) **O:** oxygen

BrO_3^- + H_2O → BrO_4^-

4) **H:** hydrogen (but because its really in base, after adding H^+, then add OH^- to **both** sides.)

BrO_3^- + H_2O + **2 OH^-** → BrO_4^- + **2H^+** + **2 OH^-**

If you put H^+ and OH^- together, they will form water.

BrO_3^- + H_2O + 2 OH^- → BrO_4^- + (**2H^+ + 2 OH^- → 2 H_2O**)

Cancel the waters and continue.

BrO_3^- + 2 OH^- → BrO_4^- + **H_2O**

5) **E:** electrons

BrO_3^- + 2 OH^- → BrO_4^- + H_2O + **2 e^-**