# Homework Assignment
# Balancing Oxidation/Reduction Equations Using the XOHE Method

**Note that the XOHE method is very fast because it requires no calculation of oxidation number, no prior knowledge of what is being oxidized and what is being reduced, and provides the number of electrons transferred, which will be of great use when doing calculations involving electrochemical work. Try it on examples in your book.**

1. Balance the following equations using the XOHE method (described below and in class). Indicate in each case how many moles of electrons (n) are transferred. The four steps of the method include:

| | |
|---|---|
| X | First balance each half-equation for elements other than O and H. |
| O | Next balance each for oxygen using $H_2O$. |
| H | Then balance each for H using $H^+$. |
| E | Finally, balance each for charge using $e^-$. |

Example:

$$Cr_2O_7^{2-} + C_2H_5OH \longrightarrow Cr^{3+} + CO_2$$

| | | | |
|---|---|---|---|
| X | $Cr_2O_7^{2-}$ | $\longrightarrow$ | $2\,Cr^{3+}$ |
| O | $Cr_2O_7^{2-}$ | $\longrightarrow$ | $2\,Cr^{3+} + 7\,H_2O$ |
| H | $14\,H^+ + Cr_2O_7^{2-}$ | $\longrightarrow$ | $2\,Cr^{3+} + 7\,H_2O$ |
| E | $\mathbf{6\,e^- + 14\,H^+ + Cr_2O_7^{2-}}$ | $\longrightarrow$ | $\mathbf{2\,Cr^{3+} + 7\,H_2O}$ |

| | | | |
|---|---|---|---|
| X | $C_2H_5OH$ | $\longrightarrow$ | $2\,CO_2$ |
| O | $3\,H_2O + C_2H_5OH$ | $\longrightarrow$ | $2\,CO_2$ |
| H | $3\,H_2O + C_2H_5OH$ | $\longrightarrow$ | $2\,CO_2 + 12\,H^+$ |
| E | $\mathbf{3\,H_2O + C_2H_5OH}$ | $\longrightarrow$ | $\mathbf{2\,CO_2 + 12\,H^+ + 12\,e^-}$ |

(In actuality, the two half-equations are written only once each, but modified three times until they each look as shown in bold.) The first half-equation is then doubled to get 12 $e^-$ on each side. So n = 12. Adding the two final half-equations gives the final result:

$$16\,H^+ + 2\,Cr_2O_7^{2-} + C_2H_5OH \longrightarrow 4\,Cr^{3+} + 2\,CO_2 + 11\,H_2O \quad (n = 12)$$

To check your answer yourself, check the balance of all elements as well as the charge in the final equation. **Be sure to indicate n for each final equation.**

a. $CH_4 + O_2 \longrightarrow CO_2 + H_2O$

b. $Zn + H^+ \longrightarrow Zn^{2+} + H_2$

c. $Br^- + MnO_4^- \longrightarrow Br_2 + Mn^{2+}$

d. $Pb + PbO_2 \longrightarrow Pb^{2+}$ (use $Pb^{2+}$ in both halves)

e. $H_2O_2 \longrightarrow O_2 + H_2O$ (use $H_2O_2$ in both halves)

2. Balance the above equations in base. To do this, take your final equation and add to it enough of one or the other of "$H^+ + OH^- \longrightarrow H_2O$" or "$H_2O \longrightarrow H^+ + OH^-$" to cancel out all $H^+$. In (b), (c), and (d), do not leave transition metals with $OH^-$ on the same side of the equation, because they form insoluble hydroxide salts. For example:

$$16\,H^+ + 2\,Cr_2O_7^{2-} + C_2H_5OH \longrightarrow 4\,Cr^{3+} + 2\,CO_2 + 11\,H_2O \quad (n = 12)$$

$$16\,H_2O \longrightarrow 16\,H^+ + 16\,OH^-$$

$$5\,H_2O + 2\,Cr_2O_7^{2-} + C_2H_5OH \longrightarrow 4\,Cr^{3+} + 2\,CO_2 + 16\,OH^- \quad (n = 12)$$

However, $Cr(OH)_3$ is insoluble, so we actually have:

$$5\,H_2O + 2\,Cr_2O_7^{2-} + C_2H_5OH \longrightarrow 4\,Cr(OH)_3 + 2\,CO_2 + 4\,OH^- \quad (n = 12)$$