BALANCING REDOX EQUATIONS

THE STEPS IN ALL EXAMPLES CORRESPOND WITH THOSE GIVEN IN THE TEXT. I PREFACE MY BALANCING BY ASSIGNING OXIDATION #S TO ALL SPECIES. YOU NEED NOT DO THIS, AND "BLINDLY" BALANCE CHARGES ON LEFT AND RIGHT BY ADDING e^-'s AS REACTANTS OR PRODUCTS, HOWEVER IF YOU DO THIS YOU WILL NOT KNOW WHAT IS BEING OXIDIZED/REDUCED UNTIL STEP 4, YOU WILL NOT HAVE AN INTERNAL CHECK EARLY IN YOUR BALANCING TO TELL YOU IF SOMETHING IS AMISS, AND YOU WILL HAVE MORE DIFFICULTY RECOGNIZING DISPROPORTIONATION RXS.

1. $\overset{+7\ -2}{MnO_4^-(aq)} + Fe^{2+}(aq) \xrightarrow{\text{ACID}} Fe^{3+}(aq) + Mn^{2+}(aq)$

i) RED: $MnO_4^- + 5e^- \rightarrow Mn^{2+}$

OX: $Fe^{2+} \rightarrow Fe^{3+} + 1e^-$

1) $MnO_4^- \rightarrow Mn^{2+}$ $\qquad Fe^{2+} \rightarrow Fe^{3+}$

2) $+ 4H_2O$

$+ 8H^+$

* $+ 5e^-$ $\qquad + 1e^-$

3) $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ $\qquad (Fe^{2+} \rightarrow Fe^{3+} + 1e^-)5$

4) $MnO_4^- + 8H^+ + \cancel{5e^-} + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+} + \cancel{5e^-}$

$\therefore$ $\boxed{5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)}$

NOTE: H^+ ON LEFT CONSISTENT WITH THIS TAKING PLACE IN ACIDIC AQUEOUS SOLUTION

* IF EVERYTHING IS ADDED UP AFTER THIS STEP, # ATOMS AND CHARGES BALANCE ON LEFT AND RIGHT OF EACH HALF REACTION

2. $\overset{0}{Zn(s)} + \overset{+4\ -2}{MnO_2(s)} \xrightarrow{\text{BASE}} \overset{+2\ -1}{Zn(OH)_4^{2-}(aq)} + \overset{+3\ -2\ -1}{MnO(OH)(s)}$

i) Ox: $Zn \rightarrow Zn(OH)_4^{2-} + 2e^-$

Red: $MnO_2 + 1e^- \rightarrow MnO(OH)$

1) $Zn \rightarrow Zn(OH)_4^{2-}$ $\qquad MnO_2 \rightarrow MnO(OH)$

2) $+ 4H_2O$

** $+ 4OH^-$ $\qquad +4H^+ \}$ $+4OH^- \}$ $4H_2O$ $\qquad +H^+ \}$ $+OH^- \}$ H_2O $\qquad +OH^-$

$+ 2e^-$ $\qquad +1e^-$

3) $Zn + 4OH^- \rightarrow Zn(OH)_4^{2-} + 2e^-$ $\qquad (MnO_2 + H_2O + 1e^- \rightarrow MnO(OH) + OH^-)2$

4) $Zn + \underset{2}{\cancel{4}}OH^- + 2MnO_2 + 2H_2O + \cancel{2e^-} \rightarrow Zn(OH)_4^{2-} + \cancel{2e^-} + 2MnO(OH) + \cancel{2OH^-}$

$\therefore \boxed{Zn(s) + 2MnO_2(s) + 2OH^-(aq) + 2H_2O(l) \rightarrow Zn(OH)_4^{2-}(aq) + 2MnO(OH)s}$

3. $\overset{+4\ -2}{SO_2(aq)} + \overset{+6\ \ -2}{Cr_2O_7^{2-}(aq)} \xrightarrow{\text{ACID}} Cr^{3+}(aq) + \overset{+6\ -2}{SO_4^{2-}(aq)}$

i) Ox: $SO_2 \rightarrow SO_4^{2-} + 2e^-$

Red: $Cr_2O_7^{2-} + 6e^- \rightarrow 2Cr^{3+}$ (3e⁻ per each Cr^{3+})

1) $SO_2 \rightarrow SO_4^{2-}$ $\qquad Cr_2O_7^{2-} \rightarrow Cr^{3+} \}$ $+Cr^{3+} \}$ Or combine as in red step i)

2) $+ 2H_2O$ $\qquad + 7H_2O$

$+4H^+$ $\qquad +14H^+$

$+2e^-$ $\qquad +6e^-$

3) $(SO_2 + 2H_2O \rightarrow SO_4^{2-} + 4H^+ + 2e^-)3$ $\qquad Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

4) $3SO_2 + \cancel{6H_2O} + Cr_2O_7^{2-} + \underset{2}{\cancel{14}}H^+ + \cancel{6e^-} \rightarrow 3SO_4^{2-} + \cancel{12H^+} + \cancel{6e^-} + 2Cr^{3+} + \underset{1}{\cancel{7}}H_2O$

$\therefore \boxed{3SO_2(aq) + Cr_2O_7^{2-}(aq) + 2H^+(aq) \rightarrow 3SO_4^{2-}(aq) + 2Cr^{3+}(aq) + 1H_2O(l)}$

** H^+ cancelled by adding OH^- since rx is in basic soln - $H^+ + OH^- \equiv H_2O$ - you can also do this at end

4. $\overset{0}{Ag(s)} + CN^-(aq) + \overset{0}{O_2(g)} \xrightarrow{\text{BASE}} \overset{+1}{Ag(CN)_2^-}(aq)$

i) Ox: $Ag \longrightarrow Ag(CN)_2^- + 1e^-$

RED: $O_2 + 4e^- \longrightarrow 2H_2O$ OR $2OH^-$ ($2e^-$ PER EACH H_2O OR OH^- - BALANCING HALF REACTION WILL TELL WHICH FORMS)

1) $Ag \longrightarrow Ag(CN)_2^-$ $\qquad O_2 \longrightarrow$

2) $+2CN^-$ $\qquad +2H_2O$

$+4H^+$ } 2 $4H_2O$ $\qquad +4OH^-$

$+4OH^-$ }

$+1e^-$ $\qquad +4e^-$

$(Ag + 2CN^- \rightarrow Ag(CN)_2^- + 1e^-)\,4$ $\qquad O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

$4Ag + 8CN^- + O_2 + 2H_2O + \cancel{4e^-} \rightarrow 4Ag(CN)_2^- + \cancel{4e^-} + 4OH^-$

$\therefore$ $\boxed{4Ag(s) + 8CN^-(aq) + O_2(g) + 2H_2O(l) \rightarrow 4Ag(CN)_2^-(aq) + 4OH^-(aq)}$

5. $\overset{+1\ +6\ -2}{K_2Cr_2O_7}(aq) + \overset{+1\ -1}{HI}(aq) \xrightarrow{\text{ACID}} \overset{+3\ -1}{CrI_3}(s) + \overset{0}{I_2}(s) + \overset{+1\ -1}{KI}(aq)$

i) Ox: $2HI \rightarrow I_2 + 2e^-$ ($1e^-$ PER EACH HI)

RED: $K_2Cr_2O_7 + 6e^- \rightarrow 2CrI_3$ ($3e^-$ PER EACH CrI_3)

1) $2HI \rightarrow I_2$ $\qquad K_2Cr_2O_7 \rightarrow 2CrI_3$

2) $+6I^- + 2I^- \equiv 8I^-$ $\qquad +2K^+ + 2I^- \equiv 2KI$

$+7H_2O$

$+2H^+$ $\qquad +14H^+$

$+2e^-$ $\qquad +6e^-$

3) $(2HI \rightarrow I_2 + 2H^+ + 2e^-)\,3$ $\qquad K_2Cr_2O_7 + 8I^- + 14H^+ + 6e^- \rightarrow 2CrI_3 + 2KI + 7H_2O$

4) $6HI + K_2Cr_2O_7 + 8I^- + \cancel{14}\,8H^+ + \cancel{6e^-} \rightarrow 3I_2 + \cancel{6H^+} + \cancel{6e^-} + 2CrI_3 + 2KI + 7H_2O$

$8H^+ + 8I^- \equiv 8HI$

$\therefore$ $\boxed{K_2Cr_2O_7(aq) + 14HI(aq) \rightarrow 2CrI_3(s) + 3I_2(s) + 2KI(aq) + 7H_2O(l)}$

6. $\overset{+7\ -2}{MnO_4^-(aq)} + Fe^{2+}(aq) \xrightarrow{\text{BASIC}} \overset{+4\ -2}{MnO_2(s)} + Fe^{3+}(aq)$

i) RED: $MnO_4^- + 3e^- \rightarrow MnO_2$

Ox: $Fe^{2+} \rightarrow Fe^{3+} + 1e^-$

1) $MnO_4^- \rightarrow MnO_2$ $\qquad$ $Fe^{2+} \rightarrow Fe^{3+}$

2) $+2H_2O$

$+4H^+$, $+4OH^-$ $\}$ $4H_2O$ $\qquad$ $+4OH^-$

$+3e^-$ $\qquad$ $+1e^-$

3) $MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$ $\qquad$ $(Fe^{2+} \rightarrow Fe^{3+} + 1e^-)\,3$

4) $MnO_4^- + 2H_2O + 3e^- + 3Fe^{2+} \rightarrow MnO_2 + 4OH^- + 3Fe^{3+} + 3e^-$

$\therefore$ $\boxed{MnO_4^-(aq) + 3Fe^{2+}(aq) + 2H_2O(l) \rightarrow MnO_2(s) + 3Fe^{3+}(aq) + 4OH^-(aq)}$

7. $\overset{+6\ -2}{Cr_2O_7^{2-}(aq)} + \overset{-2\ +1\ -2+1}{C_2H_5OH(l)} \xrightarrow{\text{ACID}} Cr^{3+}(aq) + \overset{+4\ -2}{CO_2(g)}$

i) RED: $Cr_2O_7^{2-} + 6e^- \rightarrow 2Cr^{3+}$ ($3e^-$ PER Cr^{3+})

Ox: $C_2H_5OH \rightarrow 2CO_2 + 12e^-$ ($6e^-$ PER CO_2)

1) $Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$ $\qquad$ $C_2H_5OH \rightarrow 2CO_2$

2) $+7H_2O$ $\qquad$ $+3H_2O$

$+14H^+$ $\qquad$ $+12H^+$

$+6e^-$ $\qquad$ $+12e^-$

3) $(Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O)\,2$ $\qquad$ $C_2H_5OH + 3H_2O \rightarrow 2CO_2 + 12H^+ + 12e^-$

4) $2Cr_2O_7^{2-} + 28H^+ + 12e^- + C_2H_5OH + 3H_2O \rightarrow 4Cr^{3+} + 14H_2O + 2CO_2 + 12H^+ + 12e^-$

(16 H^+ on the left; 11 H_2O on the right)

$\therefore$ $\boxed{2Cr_2O_7^{2-}(aq) + C_2H_5OH(l) + 16H^+(aq) \rightarrow 4Cr^{3+} + 2CO_2(g) + 11H_2O(l)}$

BY NOW YOU MIGHT SEE A SHORTCUT - FOR EACH HALF REACTION JUST BALANCE THE ATOMS & # OF e^-'s AND, IF NEUTRAL OR BASIC, ADD OH^- TO CANCEL H^+ MAKING H_2O