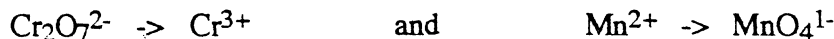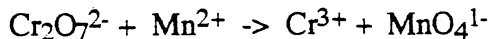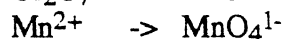# BALANCING REDOX REACTIONS

ACIDIC SOLUTIONS

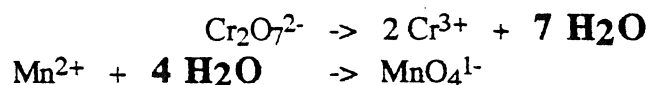1. Divide reaction into half reactions.
    $Cr_2O_7^{2-} + Mn^{2+} \rightarrow Cr^{3+} + MnO_4^{1-}$

    $Cr_2O_7^{2-} \rightarrow Cr^{3+}$ and $Mn^{2+} \rightarrow MnO_4^{1-}$

2. Balance all other elements except for H & O.

    $Cr_2O_7^{2-} \rightarrow \mathbf{2}\ Cr^{3+}$
    $Mn^{2+} \rightarrow MnO_4^{1-}$

3. Balance O by adding H_2O.

    $$Cr_2O_7^{2-} \rightarrow 2\ Cr^{3+} + \mathbf{7\ H_2O}$$
    $$Mn^{2+} + \mathbf{4\ H_2O} \rightarrow MnO_4^{1-}$$
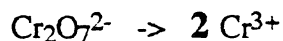
4. Balance H by adding H^+.

    $$Cr_2O_7^{2-} + \mathbf{14\ H^+} \rightarrow 2\ Cr^{3+} + 7\ H_2O$$
    $$Mn^{2+} + 4\ H_2O \rightarrow MnO_4^{1-} + \mathbf{8\ H^+}$$
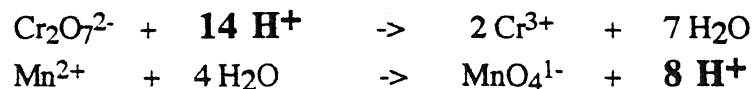
5. Balance charge by adding electrons (e^-) to the side that has more positive charge.

    $$(-2 + +14 = +12) \qquad\qquad (+6 + 0 = +6)$$
    $$Cr_2O_7^{2-} + 14\ H^+ + \mathbf{6\ e^-} \rightarrow 2\ Cr^{3+} + 7\ H_2O$$

    $$(+2 + 0 = +2) \qquad (-1 + +8 = +7)$$
    $$Mn^{2+} + 4\ H_2O \rightarrow MnO_4^{1-} + 8\ H^+ + \mathbf{5\ e^-}$$
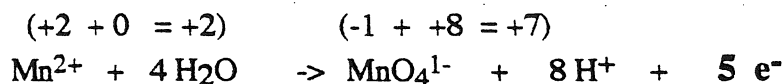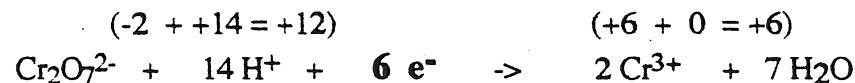
6. Make e^- gain = e^- loss. Multiply first reaction by 5 so (6 x 5 e^- = 30 e^-) and the second reaction by 6 so (5 x 6 e^- = 30 e^-).

    $$5\ Cr_2O_7^{2-} + 70\ H^+ + \mathbf{30\ e^-} \rightarrow 10\ Cr^{3+} + 35\ H_2O$$
    $$6\ Mn^{2+} + 24\ H_2O \rightarrow 6\ MnO_4^{1-} + 48\ H^+ + \mathbf{30\ e^-}$$
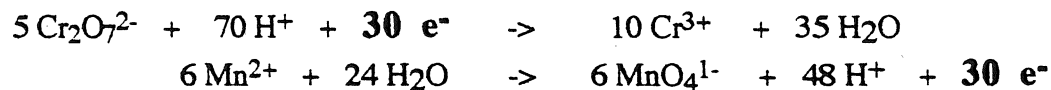
7. Add reactions together and cancel like species on both sides of the reaction.

    $$5\ Cr_2O_7^{2-} + 22\ H^+ + 6\ Mn^{2+} \rightarrow 10\ Cr^{3+} + 11\ H_2O + 6\ MnO_4^{1-}$$
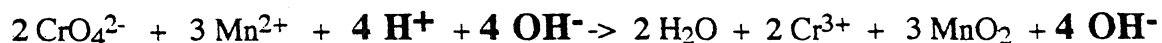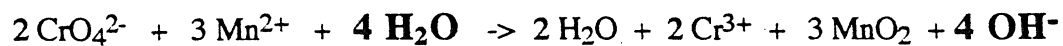
BASIC SOLUTIONS

8. If the reaction SPECIFICALLY states that the reaction occurs in basic solution, FIRST follow steps 1 through 7 for acidic solutions. THEN, convert to basic solutions by adding the same quantity of hydroxide ion (OH^-) to both sides of the reaction to equal the quantity of hydrogen ion present (H^+).

$$2\,CrO_4^{2-} + 3\,Mn^{2+} + \mathbf{4\,H^+} \rightarrow 2\,H_2O + 2\,Cr^{3+} + 3\,MnO_2$$

THUS:
$$2\,CrO_4^{2-} + 3\,Mn^{2+} + \mathbf{4\,H^+} + \mathbf{4\,OH^-} \rightarrow 2\,H_2O + 2\,Cr^{3+} + 3\,MnO_2 + \mathbf{4\,OH^-}$$
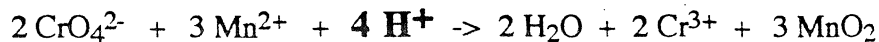
9. Combine the H^+ and OH^- ion together to form water.

$$2\,CrO_4^{2-} + 3\,Mn^{2+} + \mathbf{4\,H_2O} \rightarrow 2\,H_2O + 2\,Cr^{3+} + 3\,MnO_2 + \mathbf{4\,OH^-}$$

10. Cancel out water to obtain final reaction.

$$2\,CrO_4^{2-} + 3\,Mn^{2+} + \mathbf{2\,H_2O} \rightarrow 2\,Cr^{3+} + 3\,MnO_2 + \mathbf{4\,OH^-}$$