Two Methods for Balancing REDOX reactions

A) OXIDATION NUMBER METHOD

Given a chemical reaction $Zn + HCl \rightarrow ZnCl_2 + H_2$

Steps:

1. Assign O.N. to Reactants and Products

$$\overset{0}{Zn} + \overset{+1}{H}\overset{-1}{Cl} \rightarrow \overset{+2}{Zn}\overset{-1}{Cl_2} + \overset{0}{H_2}$$

2. From the ΔO.N., identify the RA and OA.

$$\overset{RA}{Zn} + \overset{OA}{HCl} \rightarrow ZnCl_2 + H_2$$

3. Compute the numbers of electrons lost in oxidation and gained in reduction from ΔO.N.

$$\underbrace{\overset{0}{Zn} + \overset{+1}{H}\overset{-1}{Cl} \rightarrow \overset{+2}{Zn}\overset{-1}{Cl_2}}_{\text{lost 2 e-}} + \overset{0}{H_2}$$

gained 1 e-

4. Multiply one or both of these numbers by appropriate factors to make $e^-_{lost} = e^-_{gained}$, and use the factors as balancing coefficients.

$$\underbrace{\overset{0}{Zn} + \overset{+1}{H}\overset{-1}{Cl} \rightarrow \overset{+2}{Zn}\overset{-1}{Cl_2}}_{\text{lost 2 e-}} + \overset{0}{H_2}$$

(gained 1 e-) x 2

5. Complete the balancing by inspection.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

Exercise: $Ca + AlCl_3 \rightarrow CaCl_2 + Al$

Limitations of Method:

1. time consuming
2. not applicable for oxygen containing reactions

B) HALF REACTION/ ION-ELECTRON METHOD

Given a chemical reaction $I^- + H_2O_2 \rightarrow H_2O + I_2$

Steps:

1. Break the reactions into two half reactions

$$I^- \rightarrow I_2 \qquad H_2O_2 \rightarrow H_2O$$

2. Balance atoms other than O & H.

$$2\,I^- \rightarrow I_2 \qquad H_2O_2 \rightarrow H_2O$$

3. Balance O by adding H_2O and H by H^+ (for acidic media)

$$2\,I^- \rightarrow I_2 \qquad H_2O_2 + 2\,H^+ \rightarrow 2\,H_2O$$

4. Balance the charges by adding e-s to the more positive side

$$2\,I^- \rightarrow I_2 + 2e^-$$
$$H_2O_2 + 2\,H^+ + 2e^- \rightarrow 2\,H_2O$$

5. Multiply the half-reactions by an integer so that $e^-_{lost} = e^-_{gained}$

6. Add the two half reactions and cancel out e-s, H_2O and H^+ if necessary

$$2\,I^- \rightarrow I_2 + \cancel{2e^-}$$
$$H_2O_2 + 2\,H^+ + \cancel{2e^-} \rightarrow 2\,H_2O$$
$$2\,I^- + H_2O_2 + 2\,H^+ \rightarrow I_2 + 2\,H_2O$$

7. If in basic media, add OH^- to both sides to cancel out H^+. H^+ and OH^- will react to form H_2O. Cancel out H_2O if necessary.

$$2\,I^- + H_2O_2 + \underbrace{2\,H^+ + 2\,OH^-}_{\cancel{2\,H_2O}} \rightarrow I_2 + \cancel{2\,H_2O} + 2\,OH^-$$
$$2\,I^- + H_2O_2 \rightarrow I_2 + 2\,OH^-$$

CHECK MBE & CBE

Balance the following reactions using ion-electron method.

1. $Cr_2O_7^{2-} + I^- \rightarrow Cr^{3+} + I_2$ (acidic)

2. $MnO_4^{2-} \rightarrow MnO_4^{1-} + MnO_2$ (acidic)

3. $NH_3 + O_2 \rightarrow NO + H_2O$ (basic)

4. $HNO_3 + H_2S \rightarrow S + NO$ (acidic)

5. $Pb + PbO_2 + H_2SO_4 \rightarrow PbSO_4$ (acidic)

6 $MnO_4^{1-} + SO_2 \rightarrow Mn^{2+} + SO_4^{2-}$ (acidic)