REDOX Lesson 3

Half-Reactions

By separating a redox reaction into two half-reactions, we can get a better understanding of how redox reactions take place.

$$Mg_{(s)} + Cl_{2(g)} \longrightarrow MgCl_{2(s)}$$

$$Cu_{(s)} + 2\ AgNO_{3(aq)} \longrightarrow Cu(NO_3)_{2(aq)} + 2\ Ag_{(s)}$$

Example

Write the half-reactions for the reaction:

$$2\ Al_{(s)} + 6\ HCl_{(aq)} \longrightarrow 2\ AlCl_{3(aq)} + 3\ H_{2(g)}$$

Ion-Electron Method

We can use half-reactions to _____ redox equations. When we do so, we are using the ion-electron method.

1. Write balanced oxidation and reduction _____.
2. Change the coefficients in the balanced half-reactions so that the number of _____ produced in the oxidation half-reaction equals the number of electrons consumed in the reduction half-reaction.
3. Add the two half-reactions to obtain a _____ net ionic equation for the redox reaction.

In acidic solution: To write a balanced half-reaction for the oxidation of ethanol, C_2H_5OH to acetic acid, CH_3CO_2H, in acidic solution, we would follow the steps outlined below.

1. Write the _____ equation:

   $C_2H_5OH \longrightarrow CH_3CO_2H$

2. Balance for species other than oxygen and hydrogen:

   $C_2H_5OH \longrightarrow CH_3CO_2H$ (no change)

3. Balance for oxygen using one _____ molecule for each oxygen you require:

4. Balance for hydrogen using a hydrogen _____ for each hydrogen you require:

5. Balance for charge by adding _____ to either the product or reactant side:

In basic solution: We will use the reduction of the permanganate ion to manganese(IV) oxide in basic solution as an example.

1. Write the skeletal equation:

   $MnO_4^- \longrightarrow MnO_2$

2. Balance for species other than oxygen and hydrogen:

   $MnO_4^- \longrightarrow MnO_2$ (no change)

3. Balance for oxygen atoms by adding one water molecule for each oxygen that you require:

4. Balance for hydrogen atoms by adding one hydrogen ion for every hydrogen atom:

5. For every hydrogen ion add one hydroxide ion to both sides of the equation:

6. Combine hydrogen and hydroxide ions to form water:

7. Balance for charge by adding electrons:

8. Finally, cancel water molecules:

Example

Write a balanced half-reaction for the oxidation of aluminum metal to the aluminate ion (AlO_2^-) in basic solution.

$$Al_{(s)} \longrightarrow AlO_2^-{}_{(aq)}$$

Balancing Half Reactions Assign

Combining Half-Reactions

We can combine the half-reactions for the reduction of iron(III) to iron(II) with the oxidation of hydrogen gas to hydrogen ion:

The Full Ion-Electron Method

A reaction between the purple permanganate ion and iron(II) ion in acid solution to produce the colourless manganese(II) ion and the iron (III) ion.

$$MnO_4^- + Fe^{2+} \longrightarrow Mn^{2+} + Fe^{3+}$$

Example

Use the ion-electron method to write a balanced equation for the reaction between copper metal and concentrated nitric acid to produce copper (II) ions and nitrogen dioxide gas.

See Ion Electron Assign

Name:_____

Balancing Half Reactions

1. Write the oxidation and reduction half-reactions for the preparation of the following ionic compounds:

   a) $2\ Na_{(s)} + Br_{2(l)} \longrightarrow 2\ NaBr_{(s)}$

   b) $Zn_{(s)} + S_{(s)} \longrightarrow ZnS_{(s)}$

   c) $4\ Al_{(s)} + 3\ O_{2(g)} \longrightarrow 2\ Al_2O_{3(s)}$

2. Write net ionic equations and half-reactions for each of the following reactions:

   a) $2\ CrSO_{4(aq)} + Ag_2SO_{4(aq)} \longrightarrow Cr_2(SO_4)_{3(aq)} + 2\ Ag_{(s)}$

   b) $Ca_{(s)} + 2\ H_2O_{(l)} \longrightarrow Ca(OH)_{2(aq)} + H_{2(g)}$

c) $Cl_{2(g)} + 2\ NaI_{(aq)} \longrightarrow 2\ NaCl_{(aq)} + I_{2(s)}$

d) $Mg_{(s)} + 2\ HCl_{(aq)} \longrightarrow MgCl_{2(aq)} + H_{2(g)}$

e) $Zn_{(s)} + 2\ AgNO_{3(aq)} \longrightarrow Zn(NO_3)_{2(aq)} + 2\ Ag_{(s)}$

3. Balance the following half-reactions:

a) $Au^{+}_{(aq)} \longrightarrow Au^{3+}_{(aq)}$

b) $S^{2-}_{(aq)} \longrightarrow S_{(s)}$

c) $Ag_2O_{(s)} + H_2O_{(l)} \longrightarrow Ag_{(s)} + OH^{-}_{(aq)}$

d) $Br_{2(l)} + H_2O_{(l)} \longrightarrow BrO_3^{-}{}_{(aq)} + H^{+}_{(aq)}$

4. Write balanced equations for the following half-reactions in acidic aqueous solution:

   a) the reduction of sulfurous acid, H_2SO_3, to elemental sulfur

   b) the oxidation of formic acid, HCO_2H, to carbon dioxide

   c) the conversion of lead(IV) oxide into lead(II) ions

5. The following half-reactions proceed in basic aqueous solution. Write a balanced reaction equation for each.

   a) the reduction of sulfur dioxide to elemental sulfur

   b) the conversion of methane into carbon dioxide

   c) the oxidation of nickel into nickel(II) oxide

Name:_____

Ion Electron Method

1. Complete and balance the following redox reactions by the ion-electron method.

a) $Ag_{(s)} + Cr_2O_7^{2-}{}_{(aq)} \longrightarrow Ag^{+}{}_{(aq)} + Cr^{3+}{}_{(aq)}$; acidic solution

b) $MnO_4^{-}{}_{(aq)} + NO_2^{-}{}_{(aq)} \longrightarrow MnO_{2(s)} + NO_3^{-}{}_{(aq)}$: basic solution

c) $CH_3OH_{(aq)} + MnO_4^{-}{}_{(aq)} \longrightarrow CO_{2(g)} + Mn^{2+}{}_{(aq)}$; acidic solution

d) $Ce^{4+}{}_{(aq)} + I^{-}{}_{(aq)} \longrightarrow Ce^{3+}{}_{(aq)} + IO_3^{-}{}_{(aq)}$; basic solution

e) $H_2O_{2(aq)} + ClO_3^{-}{}_{(aq)} \longrightarrow O_{2(g)} + Cl_{2(g)}$; acidic solution

f) $NiO_{2(s)} + S_2O_3^{2-}{}_{(aq)} \longrightarrow Ni(OH)_{2(s)} + SO_3^{2-}{}_{(aq)}$; basic solution

2. Balance the reactions by the ion-electron method. Reactions take place in acidic aqueous solutions.

a) $H_2C_2O_4 + IO_3^- \longrightarrow CO_2 + I^-$

b) $NO + Cr_2O_7^{2-} \longrightarrow NO_3^- + Cr^{3+}$

3. Write a balanced equation for the reaction in which zinc metal is oxidized to zinc(II) ion by a dilute acidic solution containing nitrate ion. Dinitrogen monoxide gas is also formed.

4. Balance the reactions by the ion-electron method. Reactions take place in basic aqueous solutions.

a) $MnO_4^- + N_2H_4 \longrightarrow MnO_2 + N_2$

b) $Cr(OH)_3 + IO_3^- \longrightarrow CrO_4^{2-} + I^-$