UNIVERSITY of FLORIDA

Pre-Health Post-Baccalaureate Program Study Guide and Practice Problems

Course: CHM2046

Textbook Chapter: 21.1 (Silberberg 6e)

Topics Covered: Redox Reactions and Electrochemical Cells

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1. Review

Understanding this chapter's material will depend on an in-depth understanding of redox reactions, which were first covered last semester in ch. 4. We will review redox reactions in this study guide, but it would be wise to review ch. 4 if you are having difficulty with this material. Redox reactions will also be incredibly important moving forward into organic chemistry and biochemistry.

2. Oxidation-Reduction Reactions

The mnemonic that you will come back to time and time again for this topic is:

"LEO the lion says GER"

Where "LEO" stands for Loss of Electrons = Oxidation

And "GER" stands for Gain of Electrons = Reduction

The oxidizing agent (the substance that is being reduced) pulls electrons from the substance that is being oxidized.

The reducing agent (the substance that is being oxidized) gives electrons to the substance that is being reduced.

Oxidation and reduction are simultaneous processes. In order for a redox reaction to take place, one substance must be oxidized and the other must be reduced.

When working with oxidation numbers to solve problems, the substance being oxidized (LEO -> loss of electrons) becomes more positive.

Likewise, the substance being reduced (GER -> gaining electrons) becomes more negative.

3. Using Half-Reactions to Solve Redox Problems

Follow the steps below to create half-reactions. It is crucial that you follow the steps in order!

A. Split up the overall reaction into two half-reactions, where the species of one reaction is being oxidized, and the species of the other reaction is being reduced.

B. Balance both reactions, starting with atoms other than oxygen and hydrogen, then moving to oxygen (use water to balance), hydrogen (use protons to balance), and finally charge (use electrons to balance).

C. Multiply the half-reactions by an integer such that the number of electrons lost in the oxidation half-reaction equals the number of electrons gained in the reduction half-reaction.

D. Add the two balanced half-reactions back together.

E. If solution is basic, add one equivalent of hydroxide ions to each side (protons cannot exist in basic solution).

Let's take a look at an example:

Overall reaction:

$$Cr_2O_7^{2-}{}_{(aq)} + I^-{}_{(aq)} \longrightarrow Cr^{3+}{}_{(aq)} + I_{2\,(s)}$$

A:

$$Cr_2O_7^{2-}{}_{(aq)} \rightarrow Cr^{3+}{}_{(aq)}$$

$$I^-{}_{(aq)} \rightarrow I_{2(s)}$$

B:

$$Cr_2O_7^{2-}{}_{(aq)} + 14H^+{}_{(aq)} + 6e^- \rightarrow 2Cr^{3+}{}_{(aq)} + 7H_2O_{(l)}$$

$$2I^-{}_{(aq)} \rightarrow I_{2(s)} + 2e^-$$

C:

$$Cr_2O_7^{2-}{}_{(aq)} + 14H^+{}_{(aq)} + 6e^- \rightarrow 2Cr^{3+}{}_{(aq)} + 7H_2O_{(l)}$$

$$6I^-{}_{(aq)} \rightarrow 3I_{2(s)} + 6e^-$$

D:

$$Cr_2O_7^{2-}{}_{(aq)} + 14H^+{}_{(aq)} + \cancel{6e^-} + 6I^-{}_{(aq)} \rightarrow$$

$$2Cr^{3+}{}_{(aq)} + 7H_2O_{(l)} + 3I_{2(s)} + \cancel{6e^-}$$

What does this tell us? It informs us on how many molar equivalents of water are required for the reaction to happen and how many electrons transfer when this reaction takes place.

Problem:

① Balance the redox reaction below in a basic solution:

$$MnO_4^-{}_{(aq)} + C_2O_4^{2-}{}_{(aq)} \rightarrow MnO_{2(s)} + CO_3^{2-}{}_{(aq)}$$

① Balance the redox reaction below in a basic solution:

$$MnO_4^-{}_{(aq)} + C_2O_4^{2-}{}_{(aq)} \rightarrow MnO_{2\,(s)} + CO_3^{2-}{}_{(aq)}$$

A) $MnO_4^- \rightarrow MnO_2$

$C_2O_4^{2-} \rightarrow CO_3^{2-}$

B) $MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$

$2H_2O + C_2O_4^{2-} \rightarrow 2CO_3^{2-} + 4H^+ + 2e^-$

c) $2MnO_4^- + \cancel{8H^+} + \cancel{6e^-} \rightarrow 2MnO_2 + \cancel{4H_2O}$

$\cancel{6H_2O} + 3C_2O_4^{2-} \rightarrow 6CO_3^{2-} + \cancel{12H^+} + \cancel{6e^-}$

$2H_2O$ $4H^+$

D) $2MnO_4^- + 3C_2O_4^{2-} + 2H_2O \longrightarrow$

$2MnO_2 + 6CO_3^{2-} + 4H^+$

E) $2MnO_4^- + 3C_2O_4^{2-} + \cancel{2H_2O} + 4HO^- \longrightarrow$

$2MnO_2 + 6CO_3^{2-} + (4H^+ + 4HO^-)$

$\hookrightarrow \cancel{4H_2O}$

$2H_2O$

Final: $2MnO_4^- + 3C_2O_4^{2-} + 4HO^- \longrightarrow$

$2MnO_2 + 6CO_3^{2-} + 2H_2O$