CHE 1301

Basic Principles of Modern Chemistry I

Week 12

Hi! Thanks for checking out the weekly resources for Chemistry 1301! This resource covers topics typically taught by professors during the 12th week of classes.

Visit our website, https://baylor.edu/tutoring, to sign up for appointments and check out additional resources for your course! You'll find helpful links with the following titles:

- "Online Study Guide Resources" – The pace of your course may vary slightly from what's shown in this document. If you don't see the topics you're learning right now, use this link to find the weekly resources for the rest of the semester.
- "How to Participate in Group Tutoring" - See if there is a Chemistry 1301 group tutoring session being hosted this semester. These are weekly question/answer sessions taught by our master tutors!
- "View tutoring times for your course" or "Schedule a private 30-minute appointment!"

You can also give us a call at (254)710-4135, or drop in! Our hours are Monday-Thursday 9 am – 8 pm on class days.

KEY WORDS: Displacement Reactions, Redox Reactions, Combustion, Titration Problem-Solving

TOPIC OF THE WEEK: Comparing Types of Reactions

Whenever trying to predict products, you have to look at the reagents (starting materials) and see if any of the forces that are currently holding them together will be overcome by new attractions to different atoms. Depending on the type of reaction, this can look different. As you compare the following types of reactions, try to think about them in these terms.

Precipitate-forming reactions (see Week 11): Ionic compounds are in solution; at the beginning, the attractions between the ions are **weak enough that the water molecules can keep them apart**. But new ions are introduced to each other, and at least two of them are **attracted to each other strongly enough that water can no longer separate them**. They form a solid (they are no longer in solution) called a precipitate.

Double-displacement reactions: two ionic compounds switch cations and anions. A precipitate-forming reaction is the most common type of double-displacement reaction, in which some of the "switching" results in a solid.

$AB + CD \rightarrow AD + CB$

Neutralization (see Week 11): Acids and bases are so named for their tendencies to give protons (acids) and accept protons (bases). In a neutralization reaction, you **start** with **compounds that do these things**, and you **end** up with **compounds that do not** (neutral compounds). How did we get from one place to the other? Well, **the acids gave away their protons**—whatever is left doesn't want to donate another proton. And **the bases accepted protons**—now they no longer need protons.

> **Gas evolution reactions**: One of the products in this special type of neutralization reaction is a gas. This is important because, unless it is contained, the gas will leave. This means that the reaction **cannot be reversible**—because one of the end products is leaving the solution.

Redox reactions (Resources 11-12): Certain compounds "want" to get reduced or oxidized, because they "want" to gain or lose electrons. Which one do they want to do? It depends what will get them closer to having noble gas electron configurations. In **most bonds**, atoms end up with a **different number of electrons than they started with**; they've been **reduced** or **oxidized**. So, in your starting materials, these forces are at play. But, depending on the characteristics of the other starting materials, it might become **more likely (or at least equally likely) for the atoms to be oxidized/reduced a different way.** Most profs will not have you predict products for these, but you do need to be able to identify oxidizing and reducing agents and write reactions based on half reactions (see below).

Single displacement reactions: A free atom (oxidation state zero) or ion (oxidation state=charge) replaces either the cation or anion of an ionic compound. At the end, oxidation states are different (one thing gets oxidized, and another gets reduced). So, a single displacement reaction is a type of redox reaction.

$A + BC \rightarrow B + AC$

Highlight 1: Redox cont.: Half-Reactions

Why do reduction and oxidation always happen together?

Reduction is the gain of electrons, and oxidation is the loss of electrons.

Where do the electrons in reduction come from? They must come from some other compound—and so this other compound will have to lose electrons. And what is the loss of electrons called? Oxidation! So, for one compound to get reduced, another must be oxidized, and vice versa.

Half-reactions show what happens (in terms of electrons) to each compound individually. Let's start by looking at an example of a whole reaction—then, we'll break it into its two half reactions.

$Zn_{(s)} + 2H^{+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + H_{2(g)}$

Starting out, the zinc has an oxidation number of 0, because it's a free atom. At the end, it has an oxidation number of 2 (the charge of the ion). This means that zinc was oxidized—it has a higher oxidation number; it has lost more electrons. See last week's resource to review oxidation number rules!

How many electrons did zinc lose? Well, it started with an oxidation number of zero, and it ended up with 2. **Every time an atom loses an electron, the oxidation number increases by 1.** This is because electrons are negatively charged. Think of oxidation number as the number of electrons lost.

$Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2\ e^{-}$

The opposite is true for the hydrogen. At first, **each one** has a +1 oxidation number, but it ends with zero. This means that **each** hydrogen must have gained an electron. Since there are 2, we'll use 2 electrons.

$2H^{+}_{(aq)} + 2e^{-} \rightarrow H_{2(g)}$

Notice that the electrons are on opposite sides of the equations. This means that, if you added the equations together:

$Zn_{(s)} + 2H^{+}_{(aq)} + 2e^{-} \rightarrow Zn^{2+}_{(aq)} + 2\ e^{-} + H_2^{(g)}$

The electrons would cancel out, and you would get the original equation back!

Now, try going from two half reactions to a whole reaction—see Check Your Understanding.

Highlight 2: Acids and Bases – Titration: Problem-Solving

Here's a link to an article that goes over titrations for weak vs strong acids and bases. It also shows a lot of other ways that a titration problem can be asked—there are a lot of different pieces of information that are required for different kinds of questions!

[7.4: Solving Titration Problems - Chemistry LibreTexts]

Highlight 3: Empirical Formula from a Combustion Reaction: Steps

We've gone over stoichiometry; here's an example of a very key type of stoichiometry problem (combustion). Usually, you'll be given masses of **end products of a combustion reaction** and asked to determine **empirical formula**.

https://www.khanacademy.org/science/ap-chemistry-beta/x2eef969c74e0d802:atomic-structure-and-properties/x2eef969c74e0d802:elemental-composition-of-pure-substances/v/worked-example-determining-empirical-formula-from-combustion-data

The steps can be summarized as follows:

You are trying to find the ratios between the moles of carbon, hydrogen, and any other elements given.

1. Calculate moles of carbon dioxide, moles of water, and moles of any other compounds collected by the combustion apparatus (ex. Nitrogen gas)
2. Use the answers from (1) to calculate moles of carbon, moles of hydrogen, and moles of any other element given (ex. N)
3. Use the answers from (2) to calculate grams of all elements given. Subtract the **sum of their masses** from the **mass of the starting sample**; use this to calculate the mass of oxygen present in the starting sample.
4. Convert the mass of oxygen to moles of oxygen.
5. Divide all mole values by the smallest mole value to get mole ratios.
6. Write the empirical formula. (see Empirical Formulas, Week 8).

Check Your Understanding

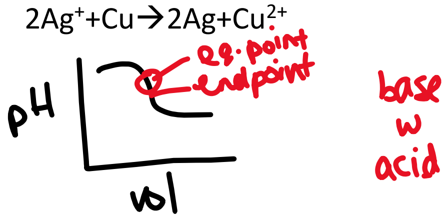
1. Combine the following half reactions:
    a. Ag + + e^- ---> Ag
    b. Cu ---> Cu^{2+} + $2e^-$
2. Identify the equivalence point. Would the endpoint come before or after this? Is this an acid being titrated by base or base being titrated by acid?

3. Starting mass of sample: 0.1005 g. Collected: 0.2829 g CO_2, 0.1159 g H_2O. Find the empirical formula of the compound!

Things You May Struggle With

1. A single displacement reaction is a type of redox reaction. A double displacement reaction is not a redox reaction, and a precipitation reaction is a type of double displacement reaction.
2. Important note: half-reactions do not exist by themselves. The electrons in a reduction reaction must come from another source; that source is the oxidation reaction.
3. **Endpoint** and **equivalence point** are easy to confuse. Equivalence point is when enough acid/base has been added to react with all of the base/acid you started out with. Endpoint is when, now that equivalence has passed, the base/acid being added starts to react with the indicator and change its color.
4. Remember to balance both half-reactions and whole reactions when interconverting!

That's all this week! Please reach out if you have any questions and don't forget to visit the Tutoring Center website for further information at www.baylor.edu/tutoring. Answers to Check Your Learning are below.

1. $2Ag^{+}+Cu \rightarrow 2Ag+Cu^{2+}$
2. 

3. [ChemTeam: Combustion Analysis: Problems 1 - 10]() Problem 3: Menthol C10H20O