

Lab #6- Reactions & Solubility/Studying Chemical Reactions

Objectives

- Classify chemical reactions by type after observing evidence.
- Predict the precipitate in a chemical equation using solubility rules.
- Write balanced chemical equations after observing experimental data and using established solubility rules.

Introduction

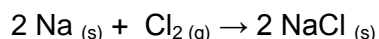
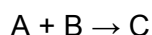
Signs of a Chemical Reaction

Chemical reactions are the process where the chemical composition of the starting material (reactants) is changed (into products). There are several indications that a chemical reaction has taken place. These include a spontaneous **color change**, **precipitation of a solid**, a **change in temperature**, **change in pH**, or **bubbling** (gas evolving). These indicators must be evaluated individually. For example, a soda produces bubbles as the carbon dioxide leaves the beverage. This is not a chemical reaction but rather a loss of a solute. However the decomposition of carbonates, chlorates and peroxides often lead to the production of a gas. Similarly adding a colored solution (such as food coloring or Kool-Aid) to water is not an indicator of a chemical reaction, but the spontaneous color change observed by adding two substances together can be an indication of a chemical reaction. In today's experiment be sure to make observations BEFORE and AFTER reactants are mixed so you can evaluate the four signs of a chemical reaction accurately.

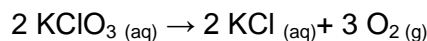
Types of Chemical Reactions

There are five main types of chemical reactions. These are synthesis, decomposition, combustion, single replacement and double replacement.

1. **Synthesis** - A reaction where two reactants combine to form 1 product.

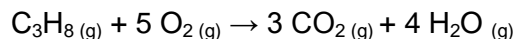


2. **Decomposition**- A reaction where a single reactant separates to form two or more products.

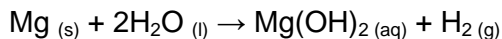
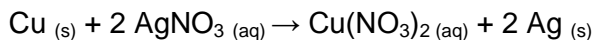
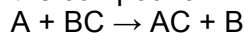


3. **Combustion** - A reaction where a reactant burns in the presence of oxygen to form carbon dioxide and water vapor. Note that here water is usually produced as vapor due to the high amount of heat energy produced in these types of reactions.

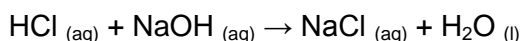
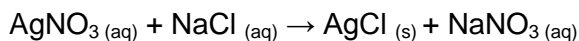
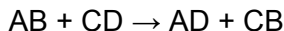




4. **Single Replacement** - A reaction where an element and a compound react. The element replaces a similar element in the compound.



5. **Double Replacement** - A reaction where the elements from two compounds replace one another. (Partners switch).

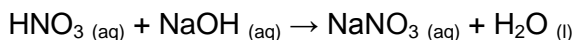
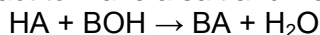


In today's experiment you will deal primarily with decomposition, single replacement and double replacement reactions. However, as you will see below, we can classify these in even more detail.

Reactions in Aqueous Solution

Most reactions take place in water, which allows us to expand these five types of reactions even further. For example, in water a double displacement reaction could also be a neutralization reaction (reaction between an acid and a base) or a precipitation reaction (production of a solid). Since today's lab deals with aqueous solutions, we need to look at the most common reactions in aqueous solutions. These reactions are:

1. **Gas Evolving** – In these reactions there will be spontaneous bubbling that was not occurring prior to the reactants being mixed together. A gas is at least one product. These reactions can also be classified as decomposition, single replacement or double replacement depending on what reactants are added together.
2. **Precipitation** – These double replacement reactions occur when one of the products forms a precipitate (solid). The first indication you have a precipitation reaction is the solution will become cloudy. You can use the solubility rules (see below) to evaluate which product is most likely insoluble.
3. **Oxidation-Reduction (Redox)** – During a redox reaction the oxidation number of one or more elements is changed in the process of the chemical reaction. These reactions can also be classified as synthesis, single replacement or double replacement type of reactions depending on the reactants and products involved. The rules for determining oxidation numbers is included below.
4. **Acid-Base** – Also called neutralization reactions. These double replacement reactions occur when an acid and a base react to make a salt and water.

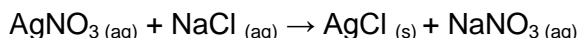


For today's experiment you will classify reactions as one of the main 5 types of chemical

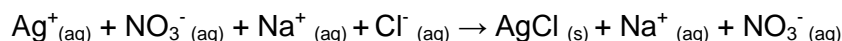
reactions. Then you will further categorize it as a specific type of aqueous reaction. You will use this information and the solubility rules to predict the products of the reactions you observe. Finally you will write the complete, balanced chemical equation including states for chemical reactions seen in lab.

Net Ionic Equations

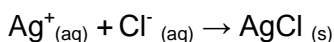
While a chemical reaction describes exactly what happens in the reaction mixture, it is often more useful to include the net-ionic equation. Here **spectator ions** or the ions that are present on both sides of the arrow are excluded. Consider the reaction:



We can rewrite this using the complete ionic equation to show which species are actually present. For example silver nitrate is not present in its molecular state but as ions (as indicated by the subscript aq). Therefore we can write the complete ionic equation as:



The complete ionic equation includes all species that are present in the reaction mixture. However since sodium and nitrate ions are aqueous on both sides and they do not change form, they are not part of the reaction and are called spectator ions. The net ionic equation would eliminate them to write the reaction as:



Net ionic equations are used mostly to simplify the overall reaction occurring for double-replacement reactions.

Information Needed to Help Classify Chemical Reactions:

Solubility Rules

- CH_3COO^- , NO_3^- , NH_4^+ , and Group 1 metal containing compounds are always soluble.
- Cl^- , Br^- , and I^- containing compounds are soluble (unless paired with lead, mercury or silver).
- SO_4^{2-} compounds are soluble (unless sulfate is paired with barium, calcium, mercury or lead).
- Hydroxide compounds are not soluble (unless hydroxide is paired with barium, calcium, ammonium or group 1 metals).
- S^{2-} , CO_3^{2-} , CrO_4^{2-} , and PO_4^{3-} containing compounds are insoluble unless paired with group 1 metals or ammonium.

Oxidation Numbers

- The oxidation number of any element in its native state is 0.
- The oxidation number of oxygen in a compound is usually -2 (except for peroxides in which case oxygen's oxidation number is -1).
- The oxidation number of hydrogen is usually +1 (except in metal hydrides in which case hydrogen has an oxidation number of -1).
- The oxidation number of most elements in compounds is the same as the charge of the ion they would form (exceptions include group 4, and 8—such as C and Xe). Exceptions also include row 3 and down and column 5 and to the right... ie P, S, etc—these exceptions have oxidation numbers that can be several different things and must be solved for).
- The sum of the oxidation numbers for all atoms in a compound MUST add up to be 0.
- The sum of the oxidation numbers for all atoms in an ion MUST add up to be equal to the charge.

Information You May Need to Review

Students who are not comfortable with the material should review the names and formulas for polyatomic ions, names and formulas for chemical compounds and balancing equations.

Materials

- Dropper bottle of FeCl_3
- Dropper bottle of KNO_3
- Dropper bottle of CuCl_2
- Dropper bottle of CuSO_4
- Dropper bottle of $(\text{NH}_4)_2\text{CO}_3$
- Dropper bottle of Na_3PO_4
- Dropper bottle of HCl
- Dropper bottle of NaOH
- Dropper bottle of CH_3COOH
- Dropper bottle of NaHCO_3
- Container of Zn metal
- Container of Al metal
- Spot plate
- Disposable spatula
- Toothpicks
- pH paper.

Safety and Notes

* *It is important to follow the safety guidelines below while performing this lab.*

1. Please use caution with HCl and NaOH as they are corrosive.
2. All solutions are to be placed in the waste beaker and then emptied into the waste container in the hood labelled **111 WASTE** at the end of lab.
3. All containers must be properly labelled according to TCC policy.

Experimental Procedure

Part A: Classifying Aqueous Reactions

1. Acquire a clean spot plate.
2. For each of the following reactions (in each well):
 - a. Be sure to record observations of each solution prior to mixing.
 - b. Add 4 -5 drops of the first solution into the designated spot.
 - c. Add 4-5 drops of the second solution into the designated spot (if a solid is needed use a small piece)
 - d. Use a clean toothpick to mix the solutions together.
 - e. Make observations of the mixture from the moment the chemicals are mixed for ~ 2 minutes.
 - f. If you do NOT see evidence of a chemical reaction, use the dropper bottles to touch add 1 drop of each reactant to a piece of pH paper. Then use a toothpick to swirl the reaction mixture and touch the toothpick to the pH paper. If there is a difference then a reaction occurred. Use this as evidence the same way a precipitate or other information would be used to classify reactions.

Name _____

Date _____

Lab Partner _____

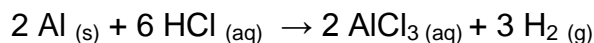
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Pre-Lab Questions

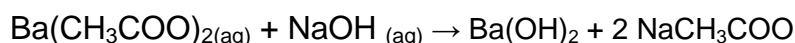
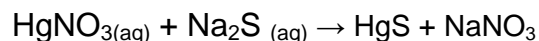
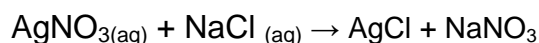
**Students must show their work to receive full credit.*

1. What is the net ionic equation for any strong acid reacting with any strong base?

2. In the following reaction, indicate the oxidation numbers for all elements on BOTH sides of the equation. Which element is being oxidized in this reaction. Which element is being reduced in the reaction?



3. Students perform a reaction specified in the directions. A precipitate forms. Predict (circle) the precipitate in each of the following cases:



Name _____

Date _____

Lab Partner _____

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Experimental Data and Results**Part A: Classifying Aqueous Reactions**

Well/ Spot	Reactant 1	Reactant 2	Reaction Mixture Observations
Example	CuNO_3	Na_2S	Solution became cloudy white: Precipitate formed.
Observations Before Mixing	Blue/green aqueous solution.	Colorless aqueous solution.	
1	HCl	NaOH	
Observations Before Mixing			
2	CH_3COOH	NaOH	
Observations Before Mixing			
3	Na_3PO_4	FeCl_3	
Observations Before Mixing			
4	$(\text{NH}_4)_2\text{CO}_3$	CuCl_2	
Observations Before Mixing			

Name _____ Date _____

Lab Partner _____ Bin # _____

Well/ Spot	Reactant 1	Reactant 2	Reaction Mixture Observations
5 Observations Before Mixing	Al (metal foil)	CuCl ₂	
6 Observations Before Mixing	CH ₃ COOH	NaHCO ₃	
7 Observations Before Mixing	Zn (metal filings)	HCl	
8 Observations Before Mixing	KNO ₃	CuSO ₄	

1. Use your observations above, information in the introduction, and reading to classify the above chemical reactions in the table below.
 - a. First: classify the reaction as a main type: either synthesis, decomposition, combustion, single replacement OR double replacement. If no reaction occurred, say N/A. Record your choice in the space provided.
 - b. Second: classify the reaction as an aqueous redox, acid-base, precipitation AND/OR gas evolving reaction. Record your choice in the space provided. Be sure to include all reaction types if there is more than 1.

Name _____

Date _____

Lab Partner _____

Bin # _____

Reaction Number	Overall Reaction Type	Aqueous Reaction Type
Example	Double-Replacement	Precipitation
1		
2		
3		
4		
5		
6		
7		
8		

Name _____

Date _____

Lab Partner _____

Bin # _____

Post-Lab Questions

1. Write the balanced chemical reaction for reaction 1. Be sure to include the states of matter and correct formulas. If applicable (ie: if you classified it as a precipitation reaction) include the net ionic equation as well.

2. Write the balanced chemical reaction for reaction 3. Be sure to include the states of matter and correct formulas. If applicable (ie: if you classified it as a precipitation reaction) include the net ionic equation as well.

3. Write the balanced chemical reaction for reaction 5. Be sure to include the states of matter and correct formulas. If applicable (ie: if you classified it as a precipitation reaction) include the net ionic equation as well.

4. Write the balanced chemical reaction for reaction 7. Be sure to include the states of matter and correct formulas. If applicable (ie: if you classified it as a precipitation reaction) include the net ionic equation as well.