

## Chem 108: Lab Week 10

Sign in  
Pick up graded papers  
Sit at Lab Drawer Station

## Chemical Reactions

Laboratory Manual:  
Report Form  
pp.46-52 DUE  
Today

Post Lab (Individually  
Submitted): On-line  
Balancing Equations  
DUE Friday

## Exam #2:

Content is through Chemical Reactions,  
Stoichiometry, Net Ionic Equations, and focuses  
on all topics since Exam 1

## Exam #2: Monday November 2<sup>nd</sup>

Includes (GQ) Solutions & Concentrations Guiding Questions

### PhET: Concentration / Calculations Guiding Questions

[http://chemconnections.org/general/chem108/Solutions  
%20Guide.html](http://chemconnections.org/general/chem108/Solutions%20Guide.html)

## Complete Guiding Questions & Submit before Exam 2

Qualitative &  
Quantitative  
Questions  
dealing with 3  
different  
solutions,  
Molarity (M),  
& its  
applications.

Focus on  
first 4  
questions  
for Exam 2.

Understand  
what is a  
solvent and a  
solute; plus  
Molarity (M)

<http://chemconnections.org/general/chem108/Solutions%20Guide.html>

## Aqueous Reactions (Solutions/ Molarity)

### Net Ionic Equations

Dr. Ron Rusay

  
Except where otherwise noted, content on this site is licensed under a Creative Commons Attribution 4.0 International License.

## Aqueous Reactions & Solutions

- ✿ Many reactions are done in a homogeneous liquid or gas phase which generally improves reaction rates.
- ✿ The prime medium for many inorganic reactions is water, which serves as a solvent (the substance present in the larger amount), but does not react itself.
- ✿ The substance(s) dissolved in the solvent is (are) the solute(s). Together they comprise a solution. The reactants would be the solutes.
- ✿ Reaction solutions typically have less solute dissolved than is possible and are “unsaturated”



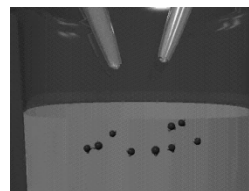
## Aqueous Reactions

✿ There are a few general types:

- 1) **Precipitation:** An insoluble salt forms from the addition of solutions. (Cloudiness is observed. **Solubility governs:**)  
(aq) → (s)
- 2) **Acid-Base (Neutralization):** generally produces a salt, plus heat + water (l):  
(aq) → (l)
- 3) **Oxidation-Reduction (Redox):** there is a change in oxidation numbers between reactants and products

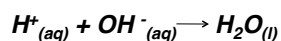
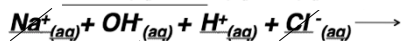
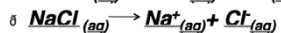
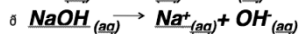
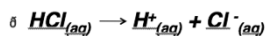
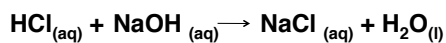


## Aqueous Reactions: Neutralization



## Aqueous Reactions: Neutralization

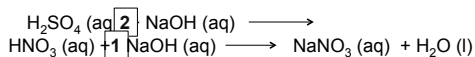
Net Ionic Equations



## QUESTION

In the balanced molecular equation for the neutralization of sulfuric acid,  $\text{H}_2\text{SO}_4$  (aq), with sodium hydroxide, the products in the balanced equation are:

- $\text{NaSO}_4$  (aq) +  $\text{H}_2\text{O}$  (l)
- $\text{NaSO}_3$  (aq) + 2  $\text{H}_2\text{O}$  (l)
- 2  $\text{NaSO}_4$  (aq) +  $\text{H}_2\text{O}$  (l)
- $\text{Na}_2\text{S}$  (aq) + 2  $\text{H}_2\text{O}$  (l)
- $\text{Na}_2\text{SO}_4$  (aq) + 2  $\text{H}_2\text{O}$  (l)



## Answer

In the balanced molecular equation for the neutralization of sulfuric acid,  $\text{H}_2\text{SO}_4(\text{aq})$ , with sodium hydroxide, the products in the balanced equation are:

- A)  $\text{NaSO}_4(\text{aq}) + \text{H}_2\text{O}(\text{l})$   
 B)  $\text{NaSO}_3(\text{aq}) + 2 \text{H}_2\text{O}(\text{l})$   
 C)  $2 \text{NaSO}_4(\text{aq}) + \text{H}_2\text{O}(\text{l})$   
 D)  $\text{Na}_2\text{S}(\text{aq}) + 2 \text{H}_2\text{O}(\text{l})$   
 E)  $\text{Na}_2\text{SO}_4(\text{aq}) + 2 \text{H}_2\text{O}(\text{l})$

How many moles of sodium hydroxide will it take to completely neutralize 1 mole of sulfuric acid  $\text{H}_2\text{SO}_4$ ?

....to neutralize 1 mole of nitric acid  $\text{HNO}_3$ ?

## QUESTION

All balanced net ionic equations when reduced to the smallest common stoichiometric number is the same for the neutralization of all acids: eg. sulfuric acid,  $\text{H}_2\text{SO}_4(\text{aq})$ , nitric acid  $\text{HNO}_3$ , phosphoric acid  $\text{H}_3\text{PO}_4$  and all others.

- A) True  
 B) False  $x \text{H}^+(\text{aq}) + x \text{OH}^-(\text{aq}) \rightarrow x \text{H}_2\text{O}(\text{l})$

## Answer

All balanced net ionic equations when reduced to the smallest common stoichiometric number is the same for the neutralization of all acids: eg. sulfuric acid,  $\text{H}_2\text{SO}_4(\text{aq})$ , nitric acid  $\text{HNO}_3$ , phosphoric acid  $\text{H}_3\text{PO}_4$  and all others.

- A) True  
 B) False  $x \text{H}^+(\text{aq}) + x \text{OH}^-(\text{aq}) \rightarrow x \text{H}_2\text{O}(\text{l})$

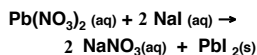
## Aqueous Reactions: Acid-Base



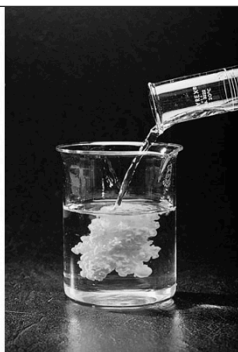
### The Reaction of $\text{Pb}(\text{NO}_3)_2$ and $\text{NaI}$

What type of reaction is it?  
*Double Displacement & Precipitation*

Write a balanced equation for the reaction.



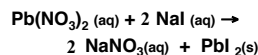
How do you know the state of the products: (s) vs. (aq)?



### The Reaction of $\text{Pb}(\text{NO}_3)_2$ and $\text{NaI}$

What type of reaction is it?  
*Double Displacement & Precipitation*

Write a balanced equation for the reaction.



How do you know the state of the products: (s) and (aq)?



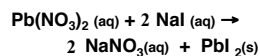
Precipitation Reactions: Solubility Tables  
(aq) *soluble* versus (s) *insoluble*

Simple Rules for the Solubility of Salts in Water

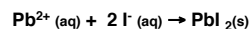
1. Most nitrate ( $\text{NO}_3^-$ ) salts are soluble.
2. Most salts containing the alkali metal ions ( $\text{Li}^+$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cs}^+$ ,  $\text{Rb}^+$ ) and the ammonium ion ( $\text{NH}_4^+$ ) are soluble.
3. Most chloride, bromide, and iodide salts are soluble. Notable exceptions are salts containing the ions  $\text{Ag}^+$ ,  $\text{Pb}^{2+}$ , and  $\text{Hg}_2^{2+}$ .
4. Most sulfate salts are soluble. Notable exceptions are  $\text{BaSO}_4$ ,  $\text{PbSO}_4$ ,  $\text{Hg}_2\text{SO}_4$ , and  $\text{CaSO}_4$ .
5. Most hydroxide salts are only slightly soluble. The important soluble hydroxides are  $\text{NaOH}$  and  $\text{KOH}$ . The compounds  $\text{Ba}(\text{OH})_2$ ,  $\text{Sr}(\text{OH})_2$ , and  $\text{Ca}(\text{OH})_2$  are marginally soluble.
6. Most sulfide ( $\text{S}^{2-}$ ), carbonate ( $\text{CO}_3^{2-}$ ), chromate ( $\text{CrO}_4^{2-}$ ), and phosphate ( $\text{PO}_4^{3-}$ ) salts are only slightly soluble.

The Reaction  
of  $\text{Pb}(\text{NO}_3)_2$   
and  $\text{NaI}$

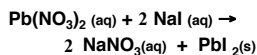
Double Displacement  
& Precipitation



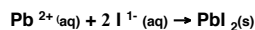
Net Ionic Equation (NIE) &  
state of the products:  
(aq) versus (s)



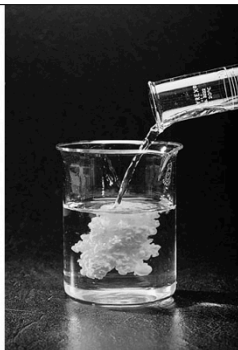
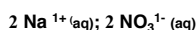
The Reaction  
of  $\text{Pb}(\text{NO}_3)_2$   
and  $\text{NaI}$



Balanced Net Ionic  
equation for the reaction.



What are the spectator ions  
in the reaction?



## QUESTION

Given the insoluble compound  $\text{Al}_2(\text{CO}_3)_3(\text{s})$  predict the ions and coefficients that would be necessary to complete the following net ionic equation:



- A.  $2 \text{AlCl}_3(\text{aq}) + 3 \text{Na}_2\text{CO}_3(\text{aq})$  also include  $6 \text{NaCl}(\text{aq})$  on right  
 B.  $3 \text{Al}^{3+}(\text{aq}) + 2 \text{CO}_3^{2-}(\text{aq})$   
 C.  $2 \text{Al}^{3+}(\text{aq}) + 3 \text{CO}_3^{2-}(\text{aq})$   
 D.  $2 \text{Al}^{3+}(\text{aq}) + 6 \text{Cl}^-(\text{aq}) + 3 \text{CO}_3^{2-}(\text{aq}) + 6 \text{Na}^+(\text{aq})$

## ANSWER

Given the insoluble compound  $\text{Al}_2(\text{CO}_3)_3(\text{s})$  predict the ions and coefficients that would be necessary to complete the following net ionic equation:



- A.  $2 \text{AlCl}_3(\text{aq}) + 3 \text{Na}_2\text{CO}_3(\text{aq})$  also include  $6 \text{NaCl}(\text{aq})$  on right  
 B.  $3 \text{Al}^{3+}(\text{aq}) + 2 \text{CO}_3^{2-}(\text{aq})$   
 C.  $2 \text{Al}^{3+}(\text{aq}) + 3 \text{CO}_3^{2-}(\text{aq})$   
 D.  $2 \text{Al}^{3+}(\text{aq}) + 6 \text{Cl}^-(\text{aq}) + 3 \text{CO}_3^{2-}(\text{aq}) + 6 \text{Na}^+(\text{aq})$

## 7 Solution Problem

Laboratory Manual: Procedure pp. 73-75;

Report Form pp. 76-80;

Aqueous Reactions including

Net Ionic Equations

To Do Today

## 7 Solution Problem

In this experiment, you will react each of the following solutions with each of the others.

0.1 M AgNO<sub>3</sub>    0.1 M FeCl<sub>3</sub>    0.1 M NaCl  
 0.1 M Pb(NO<sub>3</sub>)<sub>2</sub>    0.1 M Ba(NO<sub>3</sub>)<sub>2</sub>    0.1 M Na<sub>2</sub>SO<sub>4</sub>  
 0.1 M KSCN

When you have recorded all your observations in the table provided, you will receive an unknown containing seven numbered vials. Each vial will contain one of the solutions listed above. By reacting each solution with each of the others, you will identify and support the identity of the unknown in each vial.

**Equipment:**  
 From the stockroom:  
 7 clean test tubes  
 From your drawer:  
 7 markers

**Procedure:**  
 Obtain six clean test tubes from the stockroom. Clean them using a cotton swab as a test tube brush and rinse them with deionized water. Use a marker to label the test tubes. The first is one drop of either cation solution in each test tube. Add to each of these about the same amount of one of the other solutions. Mix well. Wash the test tube and repeat your observations in the table provided. Empty the test tubes into your waste beaker and rinse them with deionized water. Clean the test tubes. Perform the same steps of small cation solution into five of the test tubes and mix it with equal amounts of the others, except silver nitrate, which has already been mixed with this solution. Wash the test tubes at least a minute and repeat your observations. Continue this process until each solution has been mixed with each of the others. Empty your waste beaker into the aqueous metal waste container.

Write and balance equations for each reaction. There are twenty-one possibilities. If there is no reaction write NR.

Obtain a set of unknown solutions from your instructor. Record the unknown numbers. Repeat the above procedure with each of the numbered unknown solutions. Report your results in the table provided. Empty your waste beaker into the aqueous metal waste container.

Report the identity of each of the unknown solutions.

### To Do Today

## 7 Solution Problem

**Given:** 7 Unknown Solutions, which comprise the following set in some random order.

0.1 M AgNO<sub>3</sub>    0.1 M Ba(NO<sub>3</sub>)<sub>2</sub>    0.1 M FeCl<sub>3</sub>    0.1 M NaCl  
 0.1 M KSCN    0.1 M Pb(NO<sub>3</sub>)<sub>2</sub>    0.1 M Na<sub>2</sub>SO<sub>4</sub>

### Objective:

Identify the individual unknowns, which correspond to the seven, based on their respective aqueous double displacement reactions when mixed with each other.

Consider that there is a 7x7 matrix for all combinations, 49 in total. However, the solutions do not react with themselves and it will not matter in which order that they are added: A to B, or B to A. Reducing the total to (N-1)! (6 factorial, i.e. 6+5+4+3+2+1=21 possibilities)

### SOLUBILITY RULES

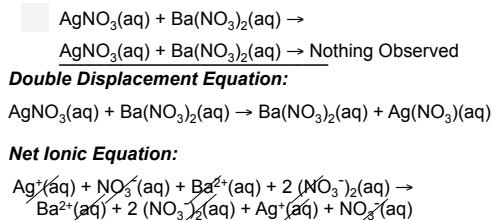
- All ionic compounds containing Na<sup>+</sup>, K<sup>+</sup>, and NH<sub>4</sub><sup>+</sup> are soluble.
- All ionic compounds containing NO<sub>3</sub><sup>-</sup> are soluble.
- All ionic compounds containing C<sub>2</sub>H<sub>3</sub>O<sub>2</sub><sup>-</sup> are soluble except AgC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>.
- All ionic compounds containing Cl<sup>-</sup>, Br<sup>-</sup>, and I<sup>-</sup> are soluble except AgCl, AgBr, AgI, PbCl<sub>2</sub>, PbBr<sub>2</sub>, PbI<sub>2</sub>, Hg<sub>2</sub>Cl<sub>2</sub>, Hg<sub>2</sub>Br<sub>2</sub>, and Hg<sub>2</sub>I<sub>2</sub>. (\*PbCl<sub>2</sub>'s solubility is very dependent on concentration and temperature.)
- All ionic compounds containing F<sup>-</sup> are soluble except MgF<sub>2</sub>, CaF<sub>2</sub>, SrF<sub>2</sub>, BaF<sub>2</sub>, and PbF<sub>2</sub>.
- All ionic compounds containing SO<sub>4</sub><sup>2-</sup> are soluble except BaSO<sub>4</sub>, SrSO<sub>4</sub>, and PbSO<sub>4</sub>. (Ag<sub>2</sub>SO<sub>4</sub> and CaSO<sub>4</sub> are slightly soluble)
- All ionic compounds containing OH<sup>-</sup> are insoluble except NaOH, KOH, and Ba(OH)<sub>2</sub>.
- All ionic compounds containing S<sup>2-</sup> are insoluble except Na<sub>2</sub>S, K<sub>2</sub>S, (NH<sub>4</sub>)<sub>2</sub>S, MgS, CaS, SrS, and BaS.
- All ionic compounds containing CO<sub>3</sub><sup>2-</sup>, PO<sub>4</sub><sup>3-</sup>, and CrO<sub>4</sub><sup>2-</sup> are insoluble except Na<sub>2</sub>CO<sub>3</sub>, Na<sub>3</sub>PO<sub>4</sub>, Na<sub>2</sub>CrO<sub>4</sub>, K<sub>2</sub>CO<sub>3</sub>, K<sub>3</sub>PO<sub>4</sub>, K<sub>2</sub>CrO<sub>4</sub>, (NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub>, (NH<sub>4</sub>)<sub>3</sub>PO<sub>4</sub>, and (NH<sub>4</sub>)<sub>2</sub>CrO<sub>4</sub>.
- All common acids are soluble.

### Develop an Empirical Data Template for Knowns (Working with a partner complete pg. 76)

0.1 M AgNO<sub>3</sub>    0.1 M Ba(NO<sub>3</sub>)<sub>2</sub>    0.1 M NaCl    0.1 M KSCN  
 0.1 M FeCl<sub>3</sub>    0.1 M Na<sub>2</sub>SO<sub>4</sub>    0.1 M Pb(NO<sub>3</sub>)<sub>2</sub>

	Pb(NO <sub>3</sub> ) <sub>2</sub>	KSCN	FeCl <sub>3</sub>	Ba(NO <sub>3</sub> ) <sub>2</sub>	NaCl	Na <sub>2</sub> SO <sub>4</sub>
AgNO <sub>3</sub>						
Pb(NO <sub>3</sub> ) <sub>2</sub>						
	KSCN					
		FeCl <sub>3</sub>				
			Ba(NO <sub>3</sub> ) <sub>2</sub>			
				NaCl		

Mix solutions and predict the result for:  
 AgNO<sub>3</sub>(aq) + Ba(NO<sub>3</sub>)<sub>2</sub>(aq)



No Reaction / NR

### Develop an Empirical Data Template for Knowns (Working with a partner complete pg. 76)

0.1 M AgNO<sub>3</sub>    0.1 M Ba(NO<sub>3</sub>)<sub>2</sub>    0.1 M NaCl    0.1 M KSCN  
 0.1 M FeCl<sub>3</sub>    0.1 M Na<sub>2</sub>SO<sub>4</sub>    0.1 M Pb(NO<sub>3</sub>)<sub>2</sub>

	Pb(NO <sub>3</sub> ) <sub>2</sub>	KSCN	FeCl <sub>3</sub>	Ba(NO <sub>3</sub> ) <sub>2</sub>	NaCl	Na <sub>2</sub> SO <sub>4</sub>
AgNO <sub>3</sub>				No Rxn		
Pb(NO <sub>3</sub> ) <sub>2</sub>						
	KSCN					
		FeCl <sub>3</sub>				
			Ba(NO <sub>3</sub> ) <sub>2</sub>			
				NaCl		

Mix solutions and predict the result for:  
 AgNO<sub>3</sub>(aq) + Ba(NO<sub>3</sub>)<sub>2</sub>(aq)

**Develop an Empirical Data Template for Knowns**  
(Working with a partner complete pg. 76)

0.1 M AgNO<sub>3</sub>   0.1 M Ba(NO<sub>3</sub>)<sub>2</sub>   0.1 M NaCl   0.1 M KSCN

0.1 M FeCl<sub>3</sub>   0.1 M Na<sub>2</sub>SO<sub>4</sub>   0.1 M Pb(NO<sub>3</sub>)<sub>2</sub>

	Pb(NO <sub>3</sub> ) <sub>2</sub>	KSCN	FeCl <sub>3</sub>	Ba(NO <sub>3</sub> ) <sub>2</sub>	NaCl	Na <sub>2</sub> SO <sub>4</sub>
AgNO <sub>3</sub>				No Rxn		
Pb(NO <sub>3</sub> ) <sub>2</sub>						
		KSCN				
			FeCl <sub>3</sub>			
				Ba(NO <sub>3</sub> ) <sub>2</sub>		
					NaCl	

Mix solutions and predict the result for:  
AgNO<sub>3</sub>(aq) + NaCl(aq)

AgNO<sub>3</sub>(aq) + NaCl(aq) → [White Precipitate: ppt]

**Double Displacement Equation:**  
AgNO<sub>3</sub>(aq) + NaCl(aq) → AgCl(?) + NaNO<sub>3</sub>(?)

AgNO<sub>3</sub>(aq) + NaCl(aq) → AgCl(s) + NaNO<sub>3</sub>(aq)

**Net Ionic Equation:**  
Ag<sup>+</sup>(aq) + Cl<sup>-</sup>(aq) → AgCl(s)

**Develop an Empirical Data Template for Knowns**  
(Working with a partner complete pg. 76)

0.1 M AgNO<sub>3</sub>   0.1 M Ba(NO<sub>3</sub>)<sub>2</sub>   0.1 M NaCl   0.1 M KSCN

0.1 M FeCl<sub>3</sub>   0.1 M Na<sub>2</sub>SO<sub>4</sub>   0.1 M Pb(NO<sub>3</sub>)<sub>2</sub>

	Pb(NO <sub>3</sub> ) <sub>2</sub>	KSCN	FeCl <sub>3</sub>	Ba(NO <sub>3</sub> ) <sub>2</sub>	NaCl	Na <sub>2</sub> SO <sub>4</sub>
AgNO <sub>3</sub>				No Rxn	White ppt	
Pb(NO <sub>3</sub> ) <sub>2</sub>						
		KSCN				
			FeCl <sub>3</sub>			
				Ba(NO <sub>3</sub> ) <sub>2</sub>		
					NaCl	

Mix solutions and predict the result for:  
AgNO<sub>3</sub>(aq) + NaCl(aq)

**Develop an Empirical Data Template for Knowns**  
(Working with a partner complete pg. 76)

0.1 M AgNO<sub>3</sub>   0.1 M Ba(NO<sub>3</sub>)<sub>2</sub>   0.1 M NaCl   0.1 M KSCN

0.1 M FeCl<sub>3</sub>   0.1 M Na<sub>2</sub>SO<sub>4</sub>   0.1 M Pb(NO<sub>3</sub>)<sub>2</sub>

	Pb(NO <sub>3</sub> ) <sub>2</sub>	KSCN	FeCl <sub>3</sub>	Ba(NO <sub>3</sub> ) <sub>2</sub>	NaCl	Na <sub>2</sub> SO <sub>4</sub>
AgNO <sub>3</sub>				No Rxn	White ppt	
Pb(NO <sub>3</sub> ) <sub>2</sub>						
		KSCN				
			FeCl <sub>3</sub>			
				Ba(NO <sub>3</sub> ) <sub>2</sub>		
					NaCl	

Mix solutions and predict the result for:  
AgNO<sub>3</sub>(aq) + NaCl(aq)

(Everyone is to show Dr. R. their individual table, pg. 76, & get an individual unknown. Every partner will do their own individual unknown)

**Complete reactions with unknown, then compare Individual Unknown results to Known results to identify the 7 solutions**

0.1 M AgNO<sub>3</sub>   0.1 M Ba(NO<sub>3</sub>)<sub>2</sub>   0.1 M NaCl   0.1 M KSCN

0.1 M FeCl<sub>3</sub>   0.1 M Na<sub>2</sub>SO<sub>4</sub>   0.1 M Pb(NO<sub>3</sub>)<sub>2</sub>

	1	2	3	4	5	6	7
1							

(Show Dr.R. completed table, pg. 80, before leaving lab.)

**Post Lab Questions**  
Due Next Week with Report pp. 76-80

Due: 10/31/19

Name: \_\_\_\_\_

Post Lab Questions: 7 Solutions Problem

AgNO<sub>3</sub>(aq) + NaCl(aq) → AgCl(s) + NaNO<sub>3</sub>(aq)

- Write the balanced chemical equation for the reaction of AgNO<sub>3</sub> and NaCl. How many moles of AgNO<sub>3</sub> are needed to react with 0.100 moles of NaCl? How many moles of AgCl are produced?
- How many moles of AgNO<sub>3</sub> are needed to react with 0.100 moles of NaCl? How many moles of AgCl are produced?
- The following table includes observed results for each of the 7 unknown solutions. Complete the table below.

Unknown	AgNO <sub>3</sub>	Ba(NO <sub>3</sub> ) <sub>2</sub>	NaCl	Na <sub>2</sub> SO <sub>4</sub>	FeCl <sub>3</sub>	KSCN	Pb(NO <sub>3</sub> ) <sub>2</sub>
1							
2							
3							
4							
5							
6							

- What was the highest concentration of each of the 7 unknown solutions? How many moles of each?
- What was the height of the precipitate in each of the 7 unknown solutions? How many moles of each?
- What was the molar mass of each unknown solution? How many moles of each?

(Show Dr.R. the completed known table to get an individual unknown.)