Chem 108: Lab

Week 11

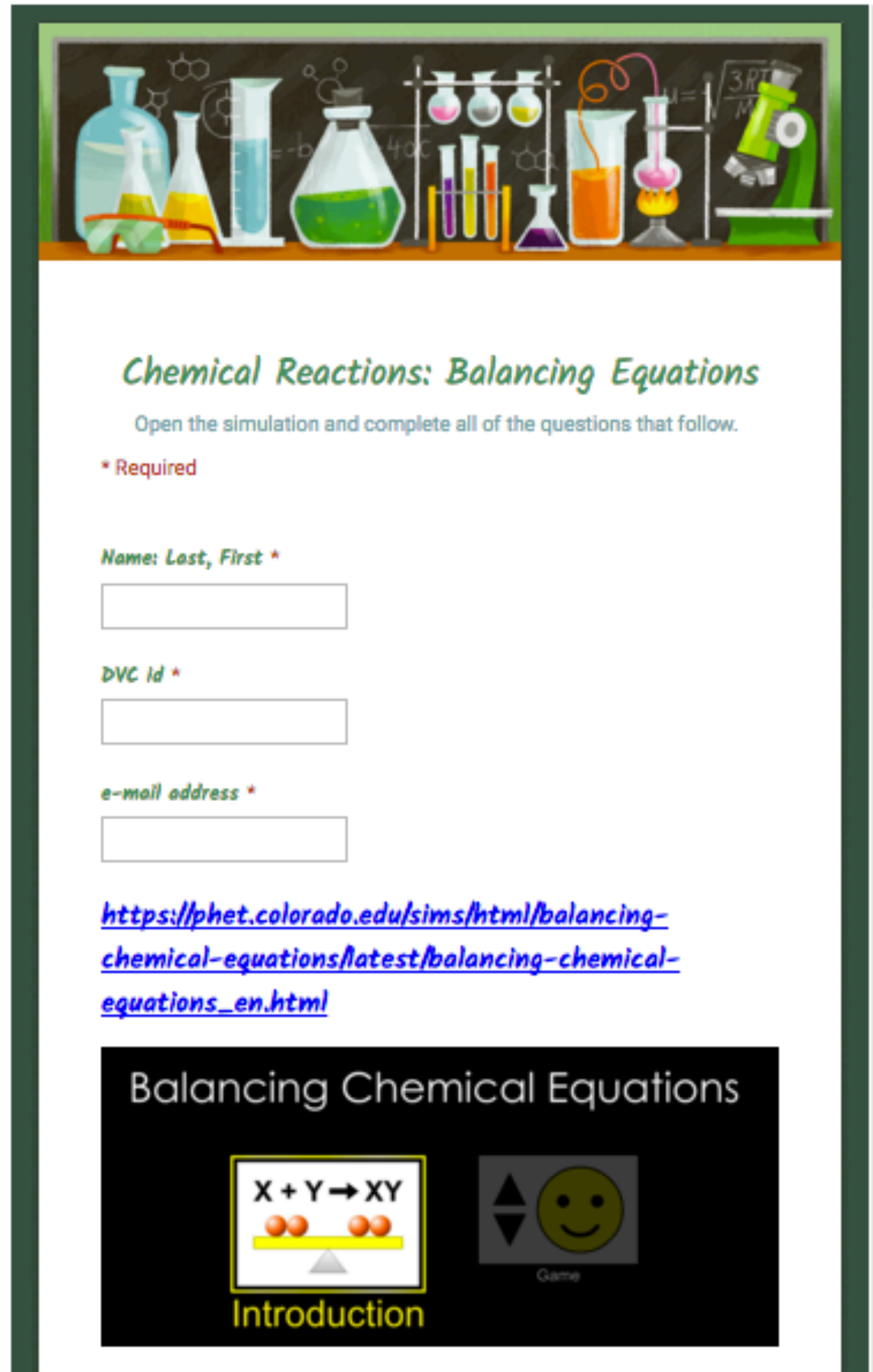
Sign in
Pick up graded papers
Sit at Lab Drawer Station

Chemical Reactions

Laboratory Manual: Report Form

pp.46-52 DUE Today

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



"It is clear that under these circumstances the classical theory can not be retained. All experimental material indicates that its fundamental starting point should be abandoned, and that, in particular, an equilibrium calculated on the basis of the mass action law does not correspond to the actual phenomena."

P. Debye and E. Hückel

Solutions

To a chemist, a solution is nothing more than a homogeneous mixture. The defining phrase is comprised of two words, each of which has a very specific meaning in chemistry: Homogeneous, meaning that the sample has a uniform appearance and composition throughout, plus mixture, a sample that consists of two or more substances. If both of these definitions are met, a sample is a solution.

Solutions are frequently, both in the chemistry laboratory and in everyday life. In the laboratory, solutions are an excellent medium for promotion of chemical reactions and growing crystals. The particles are much closer together than in a gas, and they have more freedom of movement than in a solid. Outside of the laboratory, the process of life itself depends on solutions. The air we breathe and the oceans, lakes, and streams that cover most of our planet are examples of solutions.

7 Solution Problem

Laboratory Manual: Procedure pp. 73-75; Report Form pp. 76-80;

Aqueous Reactions including Net Ionic Equations

Do Today

"Begin at the beginning...and go on till you come to the end: then stop."

Lewis Carroll

Ions in Solution

Early ideas of atoms and compounds, developed primarily through the reactions of solids and gases, did not include the concept of charge. Atoms and molecules were seen as neutral particles. However, as the study of chemistry progressed to include solutions, new models were needed because the old models could not explain electrical conductivity. Studies of the electrical conductivity of solutions, and other properties of solutions such as freezing point depression and osmotic pressure, showed an interesting dichotomy. Solutions of compounds like sugar did not increase the electrical conductivity of water, yet they had lower freezing points than pure water. Solutions of compounds such as sodium chloride greatly affected the electrical conductivity of water, and they also caused the freezing point of the solution to be reduced twice as much as was observed in sugar water solutions.

A new model that explained these observations was based on the concept that charged particles, which were called ions, formed in solutions. If compounds like sodium chloride broke apart into charged particles when in solution, the ions could carry electrical current. Substances such as sugar must not break into ions in solution because they did not conduct electricity. These studies of the characteristics of solutions led to a more complete and accurate understanding of chemistry at the particulate level.

Solvent and Solute

When a solid dissolves in a liquid to form a solution, the solid is called the *solute*, and the liquid is called the *solvent*. This is the only case that we will consider in this workshop. Note, these few terms are insufficient to describe solutions in general. They will be expanded upon in the workshop *Solutions*.

Exam #2: Monday April 15th

Includes (GQ) Solutions & Concentrations Guiding Questions

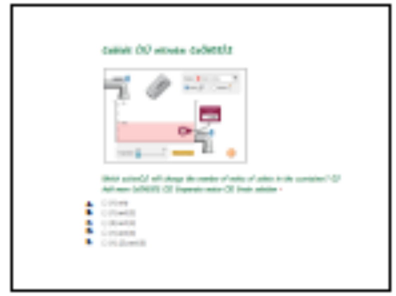
PhET: Concentration / Calculations
Guiding Questions

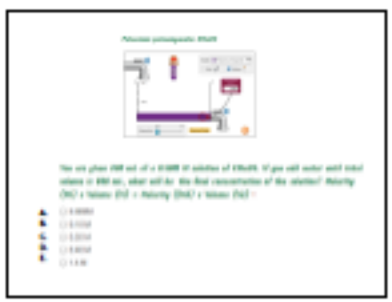
http://chemconnections.org/general/chem108/Solutions%20Guide.html

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)

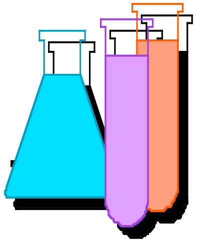
Molarity (M) = mol$_{solute}$ / Liter of solution

Net Ionic Equations

Dr. Ron Rusay

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:

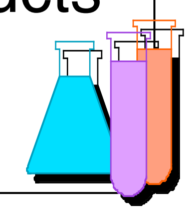
1) **Precipitation:** An insoluble salt forms from the addition of solutions. (Cloudiness is oberved**. Solubility governs):**

(aq) $\longrightarrow$ (s)

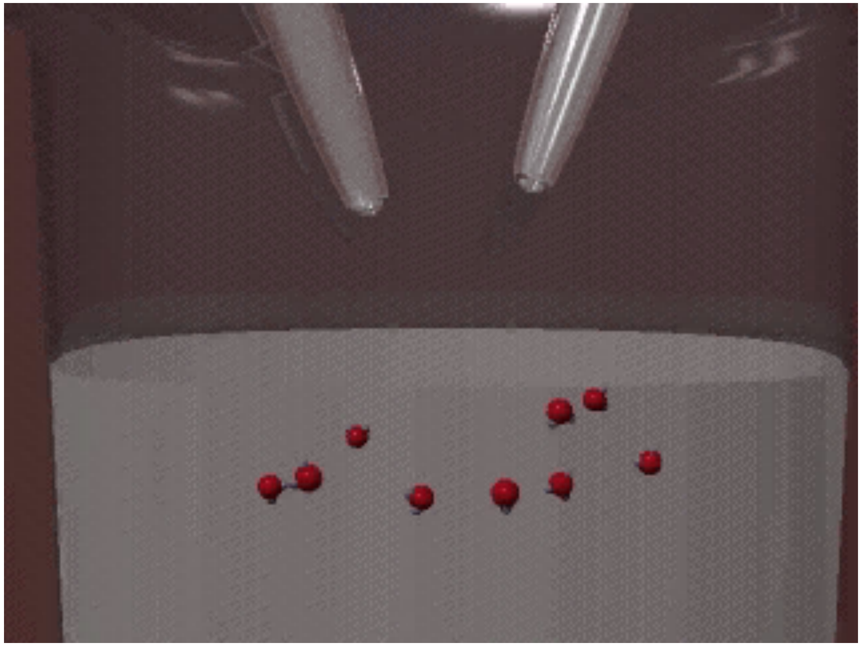
2) **Acid-Base (Neutralization):** generally produces a salt, plus heat + water (l):

(aq) $\longrightarrow$ (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

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$$

- ð $HCl_{(aq)} \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}$
- ð $NaOH_{(aq)} \longrightarrow Na^+_{(aq)} + OH^-_{(aq)}$
- ð $NaCl_{(aq)} \longrightarrow Na^+_{(aq)} + Cl^-_{(aq)}$

$$\cancel{Na^+}_{(aq)} + OH^-_{(aq)} + H^+_{(aq)} + \cancel{Cl^-}_{(aq)} \longrightarrow \cancel{Na^+}_{(aq)} + \cancel{Cl^-}_{(aq)} + H_2O_{(l)}$$

$$H^+_{(aq)} + OH^-_{(aq)} \longrightarrow H_2O_{(l)}$$

QUESTION

In the balanced molecular equation for the neutralization of sulfuric acid, $H_2SO_{4\,(aq)}$, with sodium hydroxide, the products in the balanced equation are:

A) $NaSO_{4\,(aq)} + H_2O_{(l)}$
B) $NaSO_{3\,(aq)} + 2\ H_2O_{(l)}$
C) $2\ NaSO_{4\,(aq)} + H_2O_{(l)}$
D) $Na_2S_{(aq)} + 2\ H_2O_{(l)}$
E) $Na_2SO_{4\,(aq)} + 2\ H_2O_{(l)}$

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, $H_2SO_{4\,(aq)}$, nitric acid HNO_3, phosphoric acid H_3PO_4 and all others.

A) True
B) False

$$x\ H^+_{(aq)} + x\ OH^-_{(aq)} \longrightarrow x\ H_2O_{(l)}$$

Aqueous Reactions: Acid-Base

The Reaction of $Pb(NO_3)_2$ and NaI

What type of reaction is it?

Double Displacement
& Precipitation

Write a balanced equation for the reaction.

$$Pb(NO_3)_{2\,(aq)} + 2\ NaI_{(aq)} \rightarrow$$
$$2\ NaNO_{3(aq)} + PbI_{2(s)}$$

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

The Reaction of $Pb(NO_3)_2$ and NaI

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Double Displacement
& Precipitation

Write a balanced equation for the reaction.

$Pb(NO_3)_{2\,(aq)} + 2\ NaI_{(aq)} \rightarrow$

$2\ NaNO_{3(aq)} + PbI_{2(s)}$

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 (NO_3^-) salts are soluble.
2. Most salts containing the alkali metal ions (Li^+, Na^+, K^+, Cs^+, Rb^+) and the ammonium ion (NH_4^+) are soluble.
3. Most chloride, bromide, and iodide salts are soluble. Notable exceptions are salts containing the ions Ag^+, Pb^{2+}, and Hg_2^{2+}.
4. Most sulfate salts are soluble. Notable exceptions are $BaSO_4$, $PbSO_4$, Hg_2SO_4, and $CaSO_4$.
5. Most hydroxide salts are only slightly soluble. The important soluble hydroxides are NaOH and KOH. The compounds $Ba(OH)_2$, $Sr(OH)_2$, and $Ca(OH)_2$ are marginally soluble.
6. Most sulfide (S^{2-}), carbonate (CO_3^{2-}), chromate (CrO_4^{2-}), and phosphate (PO_4^{3-}) salts are only slightly soluble.

The Reaction of $Pb(NO_3)_2$ and NaI

Double Displacement & Precipitation

$$Pb(NO_3)_2\,(aq) + 2\ NaI\,(aq) \rightarrow 2\ NaNO_3(aq) + PbI_2(s)$$

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

$$Pb^{2+}\,(aq) + 2\ I^-\,(aq) \rightarrow PbI_2(s)$$

The Reaction of $Pb(NO_3)_2$ and NaI

$$Pb(NO_3)_{2\,(aq)} + 2\ NaI_{(aq)} \rightarrow 2\ NaNO_{3(aq)} + PbI_{2(s)}$$

Balanced Net Ionic equation for the reaction.

$$Pb^{2+}{}_{(aq)} + 2\ I^{1-}{}_{(aq)} \rightarrow PbI_{2(s)}$$

What are the spectator ions in the reaction?

$2\ Na^{1+}{}_{(aq)}$; $2\ NO_3^{1-}{}_{(aq)}$

QUESTION

Given the insoluble compound $Al_2(CO_3)_3(s)$ predict the ions and coefficients that would be necessary to complete the following net ionic equation:

$$\_\_ \_\_\_\_\_\_ + \_\_ \_\_\_\_\_\_ \rightarrow Al_2(CO_3)_3\ (s)$$

A. 2 $AlCl_3(aq)$ + 3 $Na_2CO_3(aq)$ also include 6 $NaCl(aq)$ on right

B. 3 $Al^{3+}(aq)$ + 2 $CO_3^{2-}(aq)$

C. 2 $Al^{3+}(aq)$ + 3 $CO_3^{2-}(aq)$

D. 2 $Al^{3+}(aq)$ + 6 $Cl^{-}(aq)$ + 3 $CO_3^{2-}(aq)$ + 6 $Na^{+}(aq)$

Exam #2:

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

7 Solution Problem

Laboratory Manual: Procedure pp. 73-75; Report Form pp. 76-80;

Aqueous Reactions including Net Ionic Equations

Do Today

To Do Today

Chem 108: Lab

Week 11

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

0.1 M $AgNO_3$	0.1 M $FeCl_3$	0.1 M NaCl
0.1 M $Pb(NO_3)_2$	0.1 M $Ba(NO_3)_2$	0.1 M Na_2SO_4
0.1 M KSCN		

When you have recorded all your observations in the table provided, you will receive an unknown consisting of 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 report the identity of the solution in each vial.

Equipment

From the stockroom:
6 micro test tubes

From your drawer:
2 beakers

Procedure

Obtain six micro test tubes from the stockroom. Clean them using a cotton swab as a test tube brush and rinse them with deionized water. Use a beaker to hold the test tubes. Put five to ten drops of silver nitrate solution in each test tube. Add to each of these about the same amount of one of the other solutions. Mix well. Wait for at least a minute and report your observations in the table provided. Empty the test tubes into your waste beaker and rinse them with deionized water. Clean the test tubes. Put five to ten drops of lead nitrate solution into five of the test tubes and mix it with equal amounts of the others, except silver nitrate, which it has already been mixed with. Mix well. Wait for at least a minute and report 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 a net ionic equation 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 letters.*** 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.

7 Solution Problem

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

0.1 M $AgNO_3$ 0.1 M $Ba(NO_3)_2$ 0.1 M $FeCl_3$ 0.1 M NaCl

0.1 M KSCN 0.1 M $Pb(NO_3)_2$ 0.1 M Na_2SO_4

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

1. All ionic compounds containing Na^+, K^+, and NH_4^+ are soluble.

2. All ionic compounds containing NO_3^- are soluble.

3. All ionic compounds containing $C_2H_3O_2^-$ are soluble except $AgC_2H_3O_2$.

4. All ionic compounds containing Cl^-, Br^-, and I^- are soluble except AgCl, AgBr, AgI, $PbCl_2$*, $PbBr_2$, PbI_2, Hg_2Cl_2, Hg_2Br_2, and Hg_2I_2. (*$PbCl_2$'s solubility is very dependent on concentration and temperature.)

5. All ionic compounds containing F^- are soluble except MgF_2, CaF_2, SrF_2, BaF_2, and PbF_2.

6. All ionic compounds containing SO_4^{2-} are soluble except $BaSO_4$, $SrSO_4$, and $PbSO_4$. (Ag_2SO_4 and $CaSO_4$ are slightly soluble)

7. All ionic compounds containing OH^- are insoluble except NaOH, KOH, and $Ba(OH)_2$.

8. All ionic compounds containing S^{2-} are insoluble except Na_2S, K_2S, $(NH_4)_2S$, MgS, CaS, SrS, and BaS.

9. All ionic compounds containing CO_3^{2-}, PO_4^{3-}, and CrO_4^{2-} are insoluble except Na_2CO_3, Na_3PO_4, Na_2CrO_4, K_2CO_3, K_3PO_4, K_2CrO_4, $(NH_4)_2CO_3$, $(NH_4)_3PO_4$, and $(NH_4)_2CrO_4$.

10. All common acids are soluble.

Develop an Empirical Data Template for Knowns

(Working with a partner complete pg. 76)

0.1 M $AgNO_3$ 0.1 M $Ba(NO_3)_2$ 0.1 M $NaCl$ 0.1 M $KSCN$

0.1 M $FeCl_3$ 0.1 M Na_2SO_4 0.1 M $Pb(NO_3)_2$

	$Pb(NO_3)_2$	$KSCN$	$FeCl_3$	$Ba(NO_3)_2$	$NaCl$	Na_2SO_4
$AgNO_3$						
	$Pb(NO_3)_2$					
		$KSCN$				
			$FeCl_3$			
				$Ba(NO_3)_2$		
					$NaCl$	

Mix solutions and predict the result for:
$AgNO_3(aq)$ + $Ba(NO_3)_2(aq)$

$AgNO_3(aq) + Ba(NO_3)_2(aq) \rightarrow$

$\underline{AgNO_3(aq) + Ba(NO_3)_2(aq) \rightarrow \text{Nothing}}$ Observed

Double Displacement Equation:

$$AgNO_3(aq) + Ba(NO_3)_2(aq) \rightarrow Ba(NO_3)_2(aq) + Ag(NO_3)(aq)$$

Net Ionic Equation:

$$\cancel{Ag^+(aq)} + \cancel{NO_3^-(aq)} + \cancel{Ba^{2+}(aq)} + 2\ \cancel{(NO_3^-)_2(aq)} \rightarrow$$
$$\cancel{Ba^{2+}(aq)} + 2\ \cancel{(NO_3^-)_2(aq)} + \cancel{Ag^+(aq)} + \cancel{NO_3^-(aq)}$$

No Reaction / NR

Develop an Empirical Data Template for Knowns

(Working with a partner complete pg. 76)

0.1 M $AgNO_3$ 0.1 M $Ba(NO_3)_2$ 0.1 M NaCl 0.1 M KSCN

0.1 M $FeCl_3$ 0.1 M Na_2SO_4 0.1 M $Pb(NO_3)_2$

	$Pb(NO_3)_2$	KSCN	$FeCl_3$	$Ba(NO_3)_2$	NaCl	Na_2SO_4
$AgNO_3$				No Rxn		
	$Pb(NO_3)_2$					
		KSCN				
			$FeCl_3$			
				$Ba(NO_3)_2$		
					NaCl	

Mix solutions and predict the result for:

$AgNO_3(aq)$ + $Ba(NO_3)_2(aq)$

Develop an Empirical Data Template for Knowns

(Working with a partner complete pg. 76)

0.1 M $AgNO_3$ 0.1 M $Ba(NO_3)_2$ 0.1 M NaCl 0.1 M KSCN

0.1 M $FeCl_3$ 0.1 M Na_2SO_4 0.1 M $Pb(NO_3)_2$

	$Pb(NO_3)_2$	KSCN	$FeCl_3$	$Ba(NO_3)_2$	NaCl	Na_2SO_4
$AgNO_3$				No Rxn		
$Pb(NO_3)_2$						
KSCN						
$FeCl_3$						
$Ba(NO_3)_2$						
NaCl						

Mix solutions and predict the result for:
$AgNO_3(aq)$ + NaCl(aq)

$AgNO_3(aq) + NaCl(aq) \rightarrow$ [White Precipitate: ppt]

Double Displacement Equation:

$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(?) + NaNO_3(?)$

$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

Net Ionic Equation:

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

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

0.1 M $AgNO_3$ 0.1 M $Ba(NO_3)_2$ 0.1 M NaCl 0.1 M KSCN

0.1 M $FeCl_3$ 0.1 M Na_2SO_4 0.1 M $Pb(NO_3)_2$

Report your observations using known solutions in the table below.

	$Pb(NO_3)_2$	KSCN	$FeCl_3$	$Ba(NO_3)_2$	NaCl	Na_2SO_4
$AgNO_3$				No Rxn	White ppt	
$Pb(NO_3)_2$						
KSCN						
$FeCl_3$						
$Ba(NO_3)_2$						
NaCl						

Mix solutions and predict the result for:
$AgNO_3(aq)$ + $NaCl(aq)$

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

0.1 M $AgNO_3$ 0.1 M $Ba(NO_3)_2$ 0.1 M NaCl 0.1 M KSCN

0.1 M $FeCl_3$ 0.1 M Na_2SO_4 0.1 M $Pb(NO_3)_2$

	$Pb(NO_3)_2$	KSCN	$FeCl_3$	$Ba(NO_3)_2$	NaCl	Na_2SO_4
$AgNO_3$				No Rxn	White ppt	
	$Pb(NO_3)_2$					
		KSCN				
			$FeCl_3$			

Mix solutions and predict the result for:
$AgNO_3(aq)$ + $NaCl(aq)$

(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 $AgNO_3$ 0.1 M $Ba(NO_3)_2$ 0.1 M NaCl 0.1 M KSCN

0.1 M $FeCl_3$ 0.1 M Na_2SO_4 0.1 M $Pb(NO_3)_2$

Unknown Solution

Report your observations using your unknown solutions in the table below.

Unknown letters ________

	2	3	4	5	6	7
1						
	2					
		3				
			4			
				5		
					6	

Report the identity of each of your unknown solutions below.

1.__________ 2.__________ 3.__________ 4.__________

5.__________ 6.__________ 7.__________

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

Post Lab Questions

Due Next Week with Report pp. 76-80

Chem 108 / Dr. Rusay

Names: ___________________

Post Lab Questions: 7-Solution Problem

http://chemconnections.org/general/chem120/solutions-mixes.108.html

1. If the maximum concentration of a saturated sodium chloride solution is 5.9M, how many liters of water would a Peruvian salt farmer need to process in order to produce one 50.0 kilogram bag of salt. (Assume that there are no other salts present. Show your calculation.)

2. If the Peruvian water has a TDS of 10.0 grams per liter of water, would it be within the safe limits of drinking water by U.S. standards? (Explain your answer.)

3. The following table includes chemicals that may be found in tap water. Complete the table for allowable limits.

	Allowable Limit
Nitrate	
Fluoride	
Mercury	
Lead	

4. What were the highest tested levels of lead in Flint Michigan's drinking water during the crisis?

5. What was the length of time that Flint residents were exposed to higher than allowable levels of lead?

6. What are the neurological effects of lead exposure particularly on children and infants?

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