

Experiment: Solubility Rules and Net Ionic Equations

This is to be written up in its entirety in your laboratory notebook

OBJECTIVES

In this experiment you will mix small quantities of aqueous ionic solutions together and in some cases, observe the formation of precipitates.

OVERVIEW

1. Mix small quantities of different ionic solutions together.
2. Observe the absence or presence of a precipitate and its physical characteristics such as color, amount, etc.
3. Formulate general solubility rules based on experimental observations.
4. Write net ionic equations to describe the precipitation reactions.

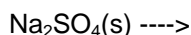
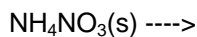
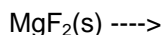
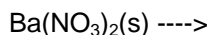
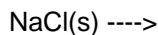
SAFETY

- Wear safety goggles at all times.
- Wear shoes that cover the entire foot.
- Never touch, taste or smell chemicals.
- Keep your hands away from your face, eyes, nose and mouth.
- Always wash your hands before leaving the laboratory.

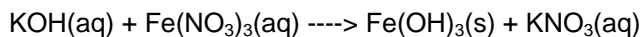
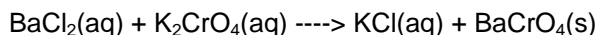
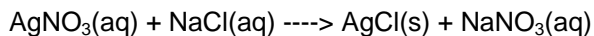
PRELAB QUESTIONS

References: Ebbing, "General Chemistry", 5th ed. pp. 91-94 (Molecular-Ionic Equations), pp. 95-98 (Precip. Reactions)

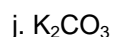
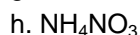
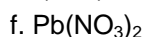
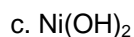
1. Write the balanced equation for dissolving the following solid ionic salts in water:



2. Write the complete ionic and the balanced net ionic equations for the following reactions:



3. Use the general solubility rules to predict which of the following compounds are soluble in water and which are not.



Solubility Rules and Net Ionic Equations Laboratory Experiment

PROCEDURES

This experiment will be conducted on a small scale. That is, only one drop of each solution will be necessary to observe the reactions. This experiment will be a collaborative effort between pairs of students. The partners should determine the division of labor. It is recommended that each student work on a set of solutions and then share the observations from all four sets of solutions tabulated below. Each solution set consists of six solutions (labeled by name and by number).

	Set I	Set II	Set III	Set IV
Solution #1	Ba(NO ₃) ₂	Na ₂ SO ₄	FeCl ₃	BaCl ₂
Solution #2	BaCl ₂	Al ₂ (SO ₄) ₃	Co(NO ₃) ₂	HNO ₃
Solution #3	NaI	Sr(NO ₃) ₂	CoCl ₂	Na ₂ CO ₃
Solution #4	AgNO ₃	CaCl ₂	NaOH	Al ₂ (SO ₄) ₃
Solution #5	NaNO ₃	Ba(NO ₃) ₂	KOH	HCl
Solution #6	KCl	AlCl ₃	NaNO ₃	AgNO ₃

1. Before lab prepare the large grid sheets for Set I, II, III and IV by labeling them appropriately as shown below.

	K ⁺ / Cl ⁻	Na ⁺ / NO ₃ ⁻	Ag ⁺ / NO ₃ ⁻	Na ⁺ / I ⁻	Ba ²⁺ / Cl ⁻
Ba ²⁺ / NO ₃ ⁻					
Ba ²⁺ / Cl ⁻					
Na ⁺ / I ⁻					
Ag ⁺ / NO ₃ ⁻					
Na ⁺ / NO ₃ ⁻					

2. Notice that the headings in the above sheet identify both ions in solution. Prepare two sets of sheets for each set.

3. Place the plastic sheet over the labeled grid sheet and carefully add one drop of each solution to the appropriate squares. When you are finished, all possible combinations of solutions in the set will have been mixed.

4. On the observation grid sheet, record your observations in the corresponding squares, carefully noting any precipitates that form and their color. You may need to use colored paper to contrast a white precipitate.

5. When your observations are complete, use a small amount of water from your wash bottle to rinse the chemicals carefully off the plastic sheet into a waste beaker.

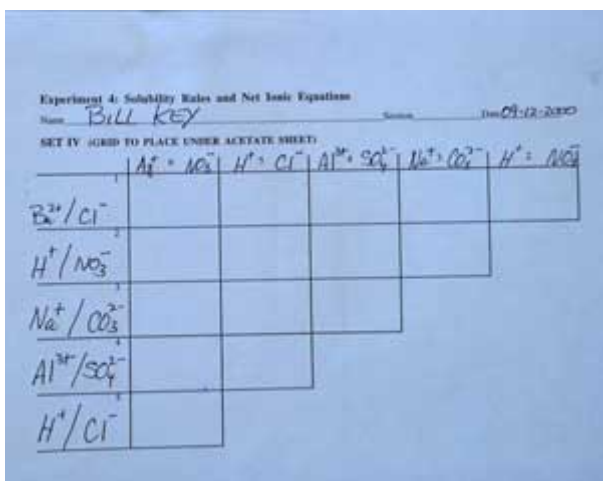
6. Dry the plastic sheet with a paper towel and repeat the procedure for the remaining solution sets.

OBSERVATIONS

Record in ink

- the initial appearance/condition/state of all reactants.
- the final appearance/condition/state of all products.
- all changes and other activity occurring during the experimental procedure.
- anything else of note that occurs during the experiment.
- any known errors that are made.

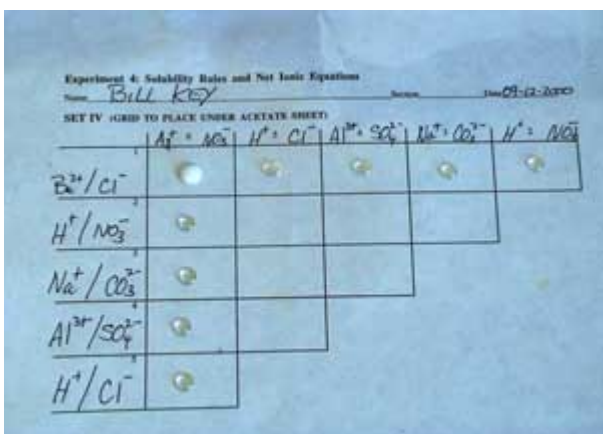
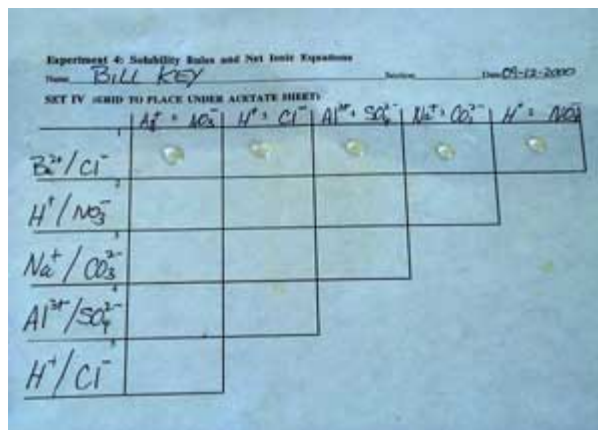
MIXING SOLUTIONS ON PLASTIC SHEET



1. Start with pre-labeled grid

2. Move clear sheet of plastic on top

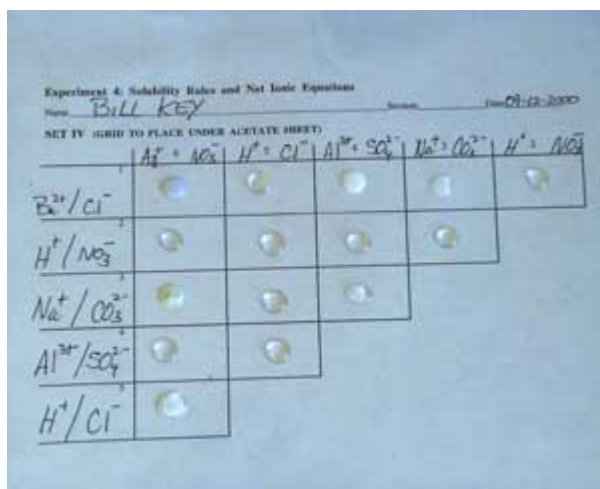
3. Select the chemical in the first row of the left column (BaCl₂) and place one drop on each of the five squares horizontally.



4. Select the chemical in the top row of the second column (AgNO₃) and place one drop on each of the squares vertically.

5. Repeat the procedure by

placing drops from each of the 6 bottles in the set onto the appropriately labeled squares. Some squares will have a cloudy and sometimes colored appearance. These represent precipitates formed from a reaction of the two reagents.



6. Fill out the observation sheet noting the precipitates and their colors. These are the reactions for which you must write net ionic equations.

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Experiment 4: Solubility Rules and Net Ionic Equations

Name _____ Section _____ Date _____

Set IV

	AgNO ₃	HCl	Al(NO ₃) ₃	Na ₂ CO ₃	HNO ₃
BaCl ₂ ₁	WHITE PPT		WHITE PPT	WHITE PPT	
HNO ₃ ₂					
Na ₂ CO ₃ ₃	YELLOW TO TAN PPT		WHITE PPT		
Al(NO ₃) ₃ ₄					
HCl ₅	WHITE PPT				

7. Rinse plastic sheet into the waste beaker using the water squeeze bottle. The plastic sheet should be washed thoroughly in the sink and then dried with paper towels. The waste beaker will be emptied into the central waste container during clean-up.



WASTE DISPOSAL

Waste from each solution set should be contained in a waste beaker at your lab station. When your experiment is complete, dispose of the contents of your waste beaker in the "salt solution waste" jug. In all cases, use as little water as possible to complete the transfer of the waste.

CLEAN-UP

Replace the dropper bottles in their respective kits. Clean the acetate sheets with water, dry them and return them to your instructor. Wipe down your lab station with a wet sponge. Wash your hands before leaving the lab.

WRITE-UP

You will analyze the data for only three of the four solution sets. You and your partner will be assigned Sets I, II, and IV or Sets I, III, and IV. For each solution combination (within your assigned sets) that formed a precipitate, write a complete ionic equation and a balanced net ionic equation. Write your equations on the corresponding data (grid) sheet. Your lab report will consist of your objective, procedure, observations/data (for all four solution sets) and equations for three solution sets and your conclusions.

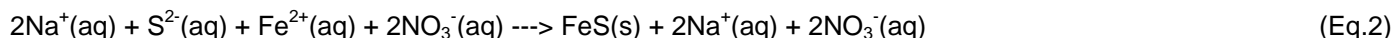
Hints for Writing Net Ionic Equations

1. A molecular equation depicts a chemical reaction by showing the complete formulas for all species involved in the reaction. For example:



2. The molecular equations are useful in stoichiometry where complete formulas of compounds are required for calculations. However, molecular equations do not accurately describe the chemical reactions that take place in solutions.

3. Complete ionic equations depict all of the chemical species present in the solution. The complete ionic equation represents species as ions if they ionize in solution. The complete ionic equation for the reaction above should be written as equation (2):



4. Those species that ionize in aqueous solution are:

- a. Strong acids and strong bases
- b. Soluble ionic salts

5. Those species that do **not** ionize in aqueous solution are:

- a. Weak acids and weak bases
- b. Soluble covalently bonded molecules
- c. Pure solids, liquids (i.e. H_2O), and gases (i.e. H_2)

6. The complete ionic equation (2) was derived from the molecular equation (1). The phase designations help to determine which species ionize and which do not. For example, Na_2S , $\text{Fe}(\text{NO}_3)_2$, and NaNO_3 are all soluble salts (indicated by the (aq) designation). The FeS was followed by a (s) phase designation indicating an insoluble salt or a solid that does not ionize. **Be aware that not all species indicated as aqueous, (aq), will ionize.** For example, $\text{H}_3\text{PO}_4(\text{aq})$ is a weak acid that, according to the guidelines above, should not be written as separate ions in an ionic equation.

7. Finally, the net ionic equation includes only those ions which show the essence of the reaction. Ions that appear unchanged (i.e. appear exactly the same on both sides of the equation) in the reaction are called spectator ions. All spectator ions are canceled from both sides of the equation to arrive at the net ionic equation. The net ionic equation for equation (1) is given as equation (3):



8. Note that the phase indicator (aq) is optional on ionic species but is required on weak acids, weak bases and other soluble, non-dissociating molecules (i.e. sugar - $\text{C}_6\text{H}_{12}\text{O}_6$). These systematic steps may be followed to write any net ionic equation for any chemical reaction.

REVIEW OF SOLUBILITY RULES

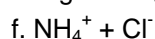
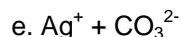
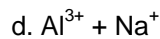
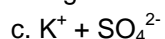
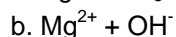
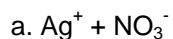
1. All common nitrates, NO_3^- , are soluble in water.
2. All common compounds of the Group IA metal (i.e. Na^+ , K^+ , etc.) and ammonium ion, NH_4^+ , are soluble in water.
3. All common halides (Cl^- , Br^- , I^-) are soluble in water except the halide salts of Ag^+ , Hg_2^{2+} , and Pb^{2+} .
4. All common sulfates, SO_4^{2-} , are soluble in water except PbSO_4 , Hg_2SO_4 , and BaSO_4 . Slightly soluble sulfates include CaSO_4 , Ag_2SO_4 , and SrSO_4 .
5. The important soluble metal hydroxides are NaOH and KOH . Most other metal hydroxides are insoluble. Slightly soluble metal hydroxides include $\text{Ca}(\text{OH})_2$, $\text{Ba}(\text{OH})_2$, and $\text{Sr}(\text{OH})_2$.
6. All common carbonates, CO_3^{2-} , phosphates, PO_4^{3-} , and sulfides, S^{2-} are insoluble in water except those salts of the Group IA metals and NH_4^+ . (The sulfide salts of Group IIA metals are also soluble).

CONCLUSIONS

1. Summarize your results by completing the net ionic equations for those reactions that produced precipitates.
2. State any general solubility rules that you discover. Cite specific net ionic equations that support your rule.

POSTLAB QUESTIONS

1. According to the solubility "rules" that you observed in this experiment, which of the following pairs of ions should produce a precipitate in water solution?



2. What conclusions can you draw regarding the solubility of each of the following groups of ions:

a. hydroxides

b. halide salts

c. sulfate salts

d. salts containing the alkali metal ions

e. nitrate salts

f. carbonates

3. Complete the reactions below. Write the complete ionic and the balanced net ionic equations for the reactions below. If a reaction does not occur, write "NR".

