EXPERIMENT 9: SOLUBILITIES

Pre-lab Questions:

Answer these questions before coming to class. They introduce you to several important ideas that you will use in this experiment. You must turn-in this exercise before you will be allowed to begin the experiment. Be sure to bring a calculator and paper to laboratory.

1. Define solubility.

2. Define precipitation.

3. Write the balanced molecular equation, the complete ionic equation, and the net ionic equation for the reaction of $Na_2CO_{3(aq)}$ with $AgNO_{3(aq)}$.

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EQUIPMENT:
96-well Plate..... 2
50 mL beaker..... 1
dropper..... 1
microstirrers..... 1

PART I: Solubility of Some Selected Salts

Table I. contains a list of salts whose solubilities are to be determined in this experiment.

Table I. Solid Salts

Na_2SO_4	NaCl
Na_2CO_3	NaOH
$NaC_2H_3O_2$	NaBr
NH_4NO_3	NH_4Cl
$Cu(NO_3)_2$	$CuCO_3$
$Ba(NO_3)_2$	$BaSO_4$
KNO_3	
$Ca(NO_3)_2$	
$Pb(NO_3)_2$	
$AgNO_3$	

All of these solid salts are available in the laboratory. Each of the bottles containing the salts has a microspatula inserted into the stopper which is to be used for dispensing. **Do not mix spatulas at any time.** Contamination will result.

Complete Table II by writing the formula (column 2) for each salt and noting the color (column 3) of each of the compounds. Solubilities (column 4) can be determined by placing a *few crystals* into the bottom of a well in the 96–well plate. Carefully label each well (column 1), identifying the salt contained in the solution. As you transfer the salts to the well be careful not to spill the solid in adjacent wells. Fill the wells with deionized water using a dropper, leaving just enough room to stir the mixture. Do not overfill the wells. Use a microstirrer to carefully mix the contents of each well. Be sure to carefully clean the microstirrer between uses! Some solids may dissolve faster than others. Be sure to perform your tests carefully so that you can be confident your observations are correct. <u>You must save the solutions formed for later parts of the experiment.</u> For those compounds which are soluble in water, note the color of the solution (column 5) and also identify the ions in the solution (column 6).

Table II. Solubility Information

Well #	Compound	Color of solid	Solubility in water	Color of solution	Identify ions in solution

For ionic compounds we can write equations which reflect the solubility behavior. If the compound is soluble, the equation is written as:

$$MX_{(s)} \xrightarrow{H_2O_{(l)}} M^+_{(aq)} + X^-_{(aq)}$$

The equation reads as follows: when the solid ionic compound MX is added to water, it dissolves forming the aqueous ions M^+ and X^-. The presence or absence of ions can be determined by conductivity. If the compound is insoluble in water the equation can be written:

$$MY_{(s)} \xrightarrow{H_2O_{(l)}} \text{WND (will not dissolve)}$$

Write the solubility equations for the compounds listed in Table I using the approach described above and the experimental data from Table II.

Equations 1 - 16

Study the list of ions identified in column 6 of Table II. Do you see any patterns of solubility behavior in compounds containing identical cations or anions? Summarize the solubility behavior of each ion below.

Gen. #1

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dropper..... 1
microstirrers..... 1

PART II: Solubility of Other Salts

It is possible to expand our observations by mixing pairs of compounds whose solubilities are known (Table I) and observing the solubility behavior of the products.

What experiment would you perform to determine the solubility of sodium nitrate, assuming that the storeroom has no solid $NaNO_3$ available for your use?

Expl. #1

Check the experiment with your instructor. When he or she approves, perform the experiment. Record your observations on the solubility of $NaNO_3$.

Obs #1

Do you have sufficient information in your solubility data to predict the solubility of $PbSO_4$? If so, what is your prediction?

Pred. #2

What experiment would you perform to determine the solubility of $PbSO_4$, assuming the storeroom has no solid $PbSO_4$ available for you to use?

Expl. #2

In the following portion of the experiment you will be working with solutions you prepared in the first part of the experiment. If the solutions have evaporated, add a few drops of deionized water to each well. The wells will need to be almost full in order to have enough solution to complete the experiment. Use Table II to locate the needed solutions and a dropper to transfer the needed amounts. Be sure to rinse the dropper thoroughly with deionized water when changing solutions.

TABLE A

Na_2SO_4	Na_2CO_3	$NaC_2H_3O_2$	NaCl	NaOH	NaBr

TABLE B

NH_4NO_3	KNO_3	$Cu(NO_3)_2$	$Ba(NO_3)_2$	$AgNO_3$	$Ca(NO_3)_2$	$Pb(NO_3)_2$

Using a clean 96-well plate, place one drop of a nitrate compound (Table B) in the first six wells of a vertical column in your 96-well plate. For example, the first six vertical wells, C1-H1, would each contain one drop of NH_4NO_3. The second six vertical wells, C2-H2, would each contain one drop KNO_3.

Add one drop of each solution in Table A horizontally across the 96-well plate. For example, put one drop of Na_2SO_4 in C1 through C7 followed by one drop of Na_2CO_3 in wells D1 through D7. Record your results, identifying the formation of a precipitate and/or color changes, if any, in each well.

Complete Table III with the well location and the formulas of the possible products formed. Two of the cells in Table III have been completed as examples.

Table III

	NH_4NO_3	KNO_3	$Cu(NO_3)_2$	$Ba(NO_3)_2$	$AgNO_3$	$Ca(NO_3)_2$	$Pb(NO_3)_2$
Na_2SO_4	$NaNO_{3(aq)}$ $(NH_4)_2SO_{4(aq)}$						
Na_2CO_3				$BaCO_{3(s)}$ $NaNO_{3(aq)}$			
$NaC_2H_3O_2$							
NaCl							
NaOH							
NaBr							

Use the information in Tables II and III to complete Table IV. If the compound is insoluble, put an "I" in the cell. If the compound is soluble, put an "S" in the cell. (Note: *Data obtained from Table II.)

Table IV. Solubility Summary

	Na^+	NH_4^+	K^+	Cu^{2+}	Ba^{2+}	Ag^+	Ca^{2+}	Pb^{2+}
SO_4^{2-}	*							
CO_3^{2-}	*							
$C_2H_3O_2^-$	*							
Cl^{-*}	*							
OH^-	*							
Br^{-*}								
NO_3^-		*	*	*	*	*	*	*

Summarize the experimental data contained in Table IV in as few statements as possible.

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PART III: Identifying Solutions of Unknown Salts

You will now try to solve a problem based on the chemical experience you have accumulated to this point. You will be given 4 test tubes which will contain aqueous solutions of substances used in this experiment. You will also be given a list of the ions that are contained in the 4 test tubes. Your assignment is to determine which ions are in each test tube. Note that a given ion may be present in more than one test tube. Remember that if you identify a cation in a test tube there must be a corresponding anion present. You should be able to definitely identify at least one ion in each test tube. If you are unable to identify the counter ion you should make a logical guess. Be sure to differentiate between proof and guesses. You must justify each conclusion in writing!

You may test the unknowns by combining them with any of the substances used previously in this experiment. Use a clean 96-well plate and dropper to perform any needed tests. After receiving your test tubes with the list of ions or molecules, it may be a good idea to review those portions of your previous laboratory work that relates to those ions.

Record *all* experiments you perform on your unknown solutions, note important observations and record any conclusions you make as a result of the experiment. Be careful and accurate when you perform your experiments and when you record your observations and conclusions. Your instructor *must* be able to follow your logic when reading your observations and conclusions.

It is your responsibility to record the unknown number of the set of test tubes given to you. Not only is the number important for correctly grading your results, but in the event you require more unknown to complete all tests you will need the correct number in order to receive more of the same unknown.

Experiments and Observations

UNKNOWN # _____

Conclusions and Explanations

UNKNOWN # _____

A: _____ B: _____ C: _____ D: _____

Post-lab Questions:

The answers to the following problems should accompany your laboratory report.

1. Distinguish between the terms slightly soluble and weak electrolyte. (Refer to Conductivity Lab, Exp. #6.)

2. What is the difference between separation and identification of substances?

3. A sample solution may contain either, both or neither of the following ions: CO_3^{2-} and SO_4^{2-}. Explain how you could determine the identity of the ions in the solution using the solubility data you collected in the experiment. Your answer may consist of a flow chart or a written explanation.