

Mystery Solutions Lab Activity

OBJECTIVES

1. To identify 10 unknown solutions through a systematic process of experimental observations.
2. To distinguish between observation and interpretation.

EXPERIMENT OVERVIEW

Following the scientific method requires applying logical, systematic processes to analyze a problem. One key component of the scientific method is observation, which can be either qualitative or quantitative. *Qualitative* observations involve using the senses to obtain non-numerical information or characteristics during an experiment. *Quantitative* analysis involves making measurements and obtain numerical data that can be used in calculations. In this experiment, you will use qualitative observations to systematically identify 10 unknown solutions. Make sure to be descriptive in your observations (i.e., cloudy light blue PPT rather than just PPT). In Part A, you will follow a systematic process used to identify 10 known solutions and record observations of the experimental results. These 10 solutions are:

barium chloride, BaCl_2
sodium carbonate, Na_2CO_3
aqueous ammonia, $\text{NH}_3(\text{aq})$
hydrochloric acid, HCl

sulfuric acid, H_2SO_4
sodium hydroxide, NaOH
sodium chloride, NaCl

cobalt(II) chloride, CoCl_2
copper(II) sulfate, CuSO_4
copper(II) nitrate, $\text{Cu}(\text{NO}_3)_2$

In Part B, you will use your observations to help identify these same 10 solutions in an unknown solution set.

PROCEDURE

You will need to refer to a separate results PDF with pictures of each step of the procedure. This file will be in the same location on Blackboard as these instructions.

Part A – Observing the Experimental Results of Known Solutions

1. Ten test tubes were placed in a test tube rack. Approximately 2 mL of aqueous cobalt(II) chloride was added to the first test tube, labeled CoCl_2 . This process was repeated for the other nine solutions. Observe the color (or lack of color) of each solution, and record your observations below.

CoCl_2	H_2SO_4	NH_3	HCl	NaOH	NaCl	CuSO_4	$\text{Cu}(\text{NO}_3)_2$	BaCl_2	Na_2CO_3

2. Each colorless solution was tested with neutral litmus paper. Litmus paper is affected by the pH of solutions. Neutral litmus paper starts purple and changes color in response to the acidic (red), basic (dark blue), or neutral (unchanged) character of the solution. Observe the response of each colorless solution to neutral litmus in the picture, and record your observations below. Include the observation (color) and the interpretation (acidic, basic, or neutral).

H_2SO_4	NH_3	HCl	NaOH	NaCl	BaCl_2	Na_2CO_3

3. Next, several drops of sulfuric acid were added to wells in the first row of a well plate; several drops of hydrochloric acid were added to wells of the second row. Drops of NaCl and BaCl_2 were added to the first and second columns, respectively. Record your observations in the table below. ** NVR stands for No Visible Reaction and PPT stands for precipitate. Remember: Make sure to be descriptive in your observations (i.e., cloudy light blue PPT rather than just PPT).

	NaCl	BaCl_2
H_2SO_4		
HCl		

4. The following solutions were identified in steps 1 – 3: CoCl_2 , BaCl_2 , NaCl , H_2SO_4 , and HCl . Now BaCl_2 can be added to each copper solution to distinguish between them. The “before” picture is included for comparison. Record your observations for the “after” picture in the table below.

	CuSO_4	$\text{Cu}(\text{NO}_3)_2$
BaCl_2		

5. In the final step, we must distinguish between the three basic solutions: Na_2CO_3 , NaOH , and NH_3 . There are a number of ways to do this. Let's try combining the bases with two different solutions, copper(II) nitrate and CoCl_2 . Drops of copper(II) nitrate were added to the first row of the well plate, and drops of CoCl_2 were added to the second row of the well plate. Then, drops of each base were added to a column as indicated by the labels in the picture. A "before" picture is provided for comparison; only the $\text{Cu}(\text{NO}_3)_2$ and CoCl_2 reagents are in the wells. The "after" picture has the second reagent added to each column.

Observe the "after" picture and record your observations in the table below.

	Na_2CO_3	NaOH	NH_3
$\text{Cu}(\text{NO}_3)_2$			
CoCl_2			

Part B – Observing the Experimental Results of an Unknown Solution Set

Once you have your observations for Part A, you can use them to help with the observations and interpretation of Unknown Solution Set X. A common error in making qualitative observations is the tendency to conflate an observation (what is seen with the naked eye) and an interpretation (what is inferred from the observation). Make sure to record both observations and interpretations in the appropriate box using the pictures provided.

1. Ten test tubes were placed in a test tube rack. Approximately 2 mL of aqueous solution X1 was added to the first test tube, labeled X1. This process was repeated for the other nine solutions. Observe the color (or lack of color) of each solution, and record your observations and interpretation below.

Observations

Interpretation

2. Each colorless solution was tested with neutral litmus paper. Litmus paper is affected by the pH of solutions. Neutral litmus paper starts purple and changes color in response to the acidic (red), basic (dark blue), or neutral (unchanged) character of the solution. Observe the response of each colorless solution to neutral litmus in the picture, and record your observations and interpretation below.

3. Next, several drops of one acid were added to wells in the first row of a well plate; several drops of the other acid were added to wells of the second row. Drops of each neutral solution were added to the first and second columns, respectively. Record your observations and interpretations in the space provided below. Include the unknown letter and number in your table as they appear in the picture. Remember: Make sure to be descriptive in your observations (i.e., cloudy light blue PPT rather than just PPT). ** NVR stands for No Visible Reaction and PPT stands for precipitate.

Observations

	Neutral____	Neutral____
Acid____		
Acid____		

Interpretation

4. The following solutions were identified in steps 1 – 3: CoCl_2 , BaCl_2 , NaCl , H_2SO_4 , and HCl . Now BaCl_2 can be added to each copper solution to distinguish between them. Record your observations and interpretations in the space provided below. Include the unknown letter and number in your table as they appear in the picture. The “before” picture is included for comparison. Record your observations and interpretation for the “after” picture.

Observations

	Blue____	Blue____
BaCl_2		

Interpretation

5. Finally, the three basic solutions are combined with copper(II) nitrate and CoCl_2 . Drops of copper(II) nitrate were added to the first row of the well plate, and drops of CoCl_2 were added to the second row of the well plate. Then, drops of each base were added to a column as indicated by the labels in the picture. Include the unknown letter and number in your table as they appear in the picture. The “before” picture is provided for comparison; only the $\text{Cu}(\text{NO}_3)_2$ and CoCl_2 reagents are in the wells. The “after” picture has the second reagent added to each column.

Record your observations and interpretation for the “after” picture.

Observations

	Base ____	Base ____	Base ____
$\text{Cu}(\text{NO}_3)_2$			
CoCl_2			

Interpretation

DATA ANALYSIS

1. Report your results below in the form of a table.
2. Write the **molecular, total ionic, and net ionic equations for four (4) reactions** that result in four **different** net ionic equations. Remember that two reactions that have the **same** net ionic equation would only count as **ONE**.

A. REACTION 1

B. REACTION 2

C. REACTION 3

D. REACTION 4

POST-LAB QUESTIONS

1. If 60.0 mL of 0.50 M aqueous calcium nitrate solution react with 25.0 mL of 0.75 M aqueous ammonium carbonate, how many grams of calcium carbonate precipitate will be formed? Show your work.
2. Starting with solid copper (II) nitrate, how would you prepare 1.00 L of copper (II) nitrate solution with a concentration of 2.00 moles/Liter? Show your work.
3. Starting with solid cobalt (II) chloride, how would you prepare 420 mL of 0.60 M cobalt (II) chloride solution? Show your work.