

## Bottles Without Labels

Problem: Predict whether a precipitate will form, a gas will evolve, or no reaction will occur for each pair of eight ionic solutions. Given seven of the eight solutions as unknowns, combine pairs of solutions and observe the results. Compare the predicted and actual results to identify the seven unknown solutions and the missing solution from the set of eight solutions.

### Pre-laboratory Assignment

- An investigation similar to the one you will do in the laboratory involves solutions of lead(II) nitrate, magnesium sulfate, nickel(II) nitrate, sodium hydroxide, and sodium oxalate. The predicted outcomes for pairing these reactants are summarized in this table.

	$\text{NaC}_2\text{O}_4$	$\text{NaOH}$	$\text{Ni}(\text{NO}_3)_2$	$\text{MgSO}_4$
$\text{Pb}(\text{NO}_3)_2$	white precipitate	white precipitate	no reaction	white precipitate
$\text{MgSO}_4$	no reaction	white precipitate	no reaction	
$\text{Ni}(\text{NO}_3)_2$	green precipitate	green precipitate		
$\text{NaOH}$	no reaction			

When the solutions, supplied as unknowns labeled A–E, were combined in pairs in the laboratory, these results were observed.

	E (colorless solution)	D (green solution)	C (colorless solution)	B (colorless solution)
A (colorless solution)	white precipitate	no reaction	white precipitate	no reaction
B (colorless solution)	no reaction	green precipitate	white precipitate	
C (colorless solution)	white precipitate	no reaction		
D (green solution)	green precipitate			

Identify each of the unknown solutions.

A \_\_\_\_\_ D \_\_\_\_\_

B \_\_\_\_\_ E \_\_\_\_\_

C \_\_\_\_\_

2. The solutions you will use in your experiment are barium chloride, calcium chloride, copper(II) nitrate, copper(II) sulfate, sodium carbonate, sodium chloride, sodium hydroxide, and sulfuric acid.
- Write the chemical formula for each of these compounds.
  - Write a balanced chemical equation for the reaction of sulfuric acid with all of the other possible reactants. Indicate the physical state of each reactant and product, using the abbreviations: (aq) for aqueous solution, (s) for solid, (ℓ) for liquid, and (g) for gas. If no reaction is predicted, write “No Reaction” for the products.
  - Summarize the results for all possible reactions in a grid format. For an example grid see Pre-Laboratory Assignment 1.

	<b>H<sub>2</sub>SO<sub>4</sub></b>	<b>NaOH</b>	<b>NaCl</b>	<b>Na<sub>2</sub>CO<sub>3</sub></b>	<b>CuSO<sub>4</sub></b>	<b>Cu(NO<sub>3</sub>)<sub>2</sub></b>	<b>CaCl<sub>2</sub></b>
<b>BaCl<sub>2</sub></b>							
<b>CaCl<sub>2</sub></b>							
<b>Cu(NO<sub>3</sub>)<sub>2</sub></b>							
<b>CuSO<sub>4</sub></b>							
<b>Na<sub>2</sub>CO<sub>3</sub></b>							
<b>NaCl</b>							
<b>NaOH</b>							

## Procedures

**Caution:** Consider all the solutions to be toxic, irritant, or corrosive chemicals.

**Note:** Be careful not to cross-contaminate the stock solutions or your reaction solutions.

1. Seven of the eight solutions listed in Pre-Laboratory Assignment 2 are provided as unknown solutions labeled A–G. Construct a grid in the Experimental Observations section above for recording the results when each pair of solutions is combined. For an example grid see Pre-Laboratory Assignment 1.
2. Systematically, combine 20-25 drops of each possible pair of the seven unknown solutions. Record your observations.

### *Suggestions*

- (a) Carry out your chemical combination in small test tubes.
  - (b) If you are unsure of the color of a precipitate centrifuge the reaction mixture.
  - (c) Reactions resulting in the evolution of a gas may be subtle. Look closely for the formation of small bubbles on the sides of the test tube.
  - (d) Clean your test tubes thoroughly between uses. Rinse with distilled water.
3. Dispose of all reaction mixtures in the designated waste containers.

## Experimental Observations

Hint: It may help to note the color of each solution.

	G	F	E	D	C	B
A						
B						
C						
D						
E						
F						

### Post-Laboratory Questions

1. Identify each unknown solution.

A \_\_\_\_\_

E \_\_\_\_\_

B \_\_\_\_\_

F \_\_\_\_\_

C \_\_\_\_\_

G \_\_\_\_\_

D \_\_\_\_\_

Which solution in the original set of eight is missing? \_\_\_\_\_

2. These questions are based on the five solutions used in Pre-Laboratory Assignment 1.

(a) Two colorless solutions in the set are combined and no precipitate forms. In identifying these two solutions, which of the five possibilities can you definitely eliminate? Briefly explain.

(b) Two colorless solutions in the set are combined and no precipitate forms. Which of the five possibilities is definitely one of the colorless solutions? Briefly explain.

(c) One colorless solution in the set is combined with the green solution in the set and no precipitate forms. Another colorless solution in the set is added and a white precipitate forms. What is the identity of both colorless solutions? Briefly explain.

(d) Two colorless solutions in the set are combined and a white precipitate forms. The reaction mixture is centrifuged and the white precipitate separated from the solution. Another colorless solution in the set is added to the separated solution and a white precipitate forms. Write balanced chemical equations for the reactions that may have occurred. Indicate the physical state of each reactant and product, using the abbreviations: (aq) for aqueous solution, (s) for solid, (l) for liquid, and (g) for gas. Briefly explain.