

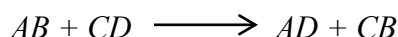
Experiment 4: Double Displacement Reactions

OBJECTIVES

1. To observe a variety of double displacement reactions including precipitation, gas evolution and acid-base neutralization.
2. To predict products and write balanced molecular, total ionic, and net ionic equations for the reactions observed.
3. To identify two unknown aqueous solutions by comparing their reactivity in double displacement reactions with your known results.

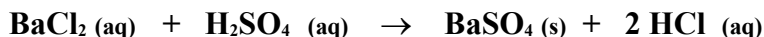
Background on Double Displacement Reactions:

Double displacement reactions, also called double replacement reactions, occur when two soluble ionic compounds exchange cation/anion partners to form new compounds. We could look at this as the following generalized equation:



Where the ions participating in the reaction are cation A, anion B, cation C and anion D. Double displacement reactions generally occur in only one direction in response to a driving force, which provides a reason for the reaction to occur. Three important driving forces for reactions between ions in aqueous solution are formation of a solid (*precipitation reactions*), formation of a gas (*gas evolution reactions*) or formation of a stable, only weakly ionized molecular product (such as water in *acid-base neutralization reactions*). In the absence of a driving force, ionic compounds will remain dissolved in solution and no chemical reaction will take place among the dissolved ions.

Example of precipitation reaction: when barium chloride and sulfuric acid are combined, the following molecular equation takes place:

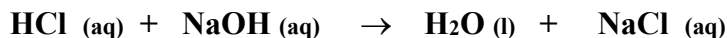


Refer to your solubility rules to determine which of the two products is the precipitate.

Example of gas evolution reaction: when hydrochloric acid and sodium carbonate combine, the molecular equation is:



Example of neutralization reaction: when hydrochloric acid and sodium hydroxide combine, heat is given off, and the molecular equation is:



EXPERIMENT OVERVIEW

You will observe reactions with six different aqueous solutions: sulfuric acid, sodium hydroxide, copper (II) sulfate, lead (II) nitrate, potassium iodide and sodium carbonate. In part A, you will observe the six solutions mixed systemically in well plates creating a 6×6 reaction matrix. For each combination, you will record any evidence of chemical change such as bubbling, precipitation or color change. In part B, you will observe the reactivity of two unknown solutions with your six known solutions. ***The unknown solutions are two of the six aqueous solutions you observed in part A.*** You will identify the unknowns by comparing their reactivity in double displacement reactions to your results in part A. In the post lab analysis, you predict products and write balanced molecular, total ionic, and net ionic equations for the reactions observed.

PROCEDURE

Part A: Reactions of Standard Solutions

1. In this part of the experiment, you will observe double displacement reactions of six standard solutions. Two 24-well plates were oriented vertically to give a matrix of 6 rows and 8 columns. Part A used the first six columns of the well plates and the remaining two columns were saved for Part B (**Figure 1**).
2. The rows and columns were labeled with the formulas of the six standard solutions according to Figure 1.
3. Using the solution dropper, four drops of sulfuric acid, H_2SO_4 , was placed into each of the six wells in column A.
4. Next, four drops of sodium hydroxide, NaOH , was placed into each of the six wells in column B.
5. Using Figure 1 as a guide, four drops of the appropriate solution was placed into each well of Columns C, D, E and F. At this point in the procedure, each well for Part A had just one reagent in it.
6. The second reagent was added to each well by following the labeled rows on the left side of Figure 1. In well A1 (the first well in column A), four drops of sulfuric acid, H_2SO_4 , was added. Then, four drops of sulfuric acid was added to each well moving across Row 1.
7. In the same manner, four drops of the appropriate solution was added to each of the six wells in Rows 2 through 6 as shown in Figure 1.
8. Examine the picture of the results for Part A.
9. Record any evidence of chemical change in the attached data table. If a solid formed and the mixture appears cloudy, you can use the abbreviation PPT (for precipitate). Be careful to identify the color of the solid for example "white ppt." Record if you observe bubbles or any other noticeable color change. In many cases, you may not observe any sign of chemical change in which you may write NVR (for no visible reaction).

10. In Figure 1, notice how each pair of reactants was combined twice. For example, wells B1 and A2 both show the reaction of sulfuric acid, H_2SO_4 , with sodium hydroxide, NaOH . Compare your results for each combination to make sure they are consistent.

	Part A Standard Solutions				Part B Unknowns			
	A: H_2SO_4	B: NaOH	C: CuSO_4	D: $\text{Pb}(\text{NO}_3)_2$	E: KI	F: Na_2CO_3	G: Unkwn A	H: Unkwn B
1: H_2SO_4	X							
2: NaOH		X						
3: CuSO_4			X					
4: $\text{Pb}(\text{NO}_3)_2$				X				
5: KI					X			
6: Na_2CO_3						X		

Figure 1: Set up and labeling of reaction plates. Part A uses the first six columns (Columns A through F). Part B uses the remaining two columns (Columns G and H).

Part B: Reactions of the Unknowns

- Your assigned unknown solutions are the same as any two of the six known solutions from Part A.** Each set of unknowns has a unique number: for example, unknowns 14A and 14B. Record the number of your assigned unknown set in the data table.
- In the remaining two columns in Figure 1, four drops of unknown A was placed in each of the six wells in Column G and four drops of unknown B was placed in each of the six wells in Column H.

3. The second reagent was added to the unknowns by following the labeled rows on the left side of Figure 1. For example, four drops of sulfuric acid, H_2SO_4 , was added to wells G1 and H1 and four drops of sodium hydroxide, NaOH , was added to wells G2 and H2.
4. Examine the picture of your assigned unknown set for Part B. Carefully record any evidence of chemical change for your unknowns in the data table.
5. Note that the pattern you observe for each unknown should match up perfectly with one of the columns from your data table of the known solutions in Part A.

DATA ANALYSIS & POST LAB QUESTIONS

- Write your answers to Questions 1-3 on separate paper to submit together with your data table.
1. Write the molecular, total ionic, and net ionic equations for **6 DIFFERENT** reactions that you observed. (*Do not choose ones with no visible reaction!*) Use subscripts to designate the **state of matter** as (aq), (s), (l) or (g) for all reactants and products.
 2. Identify your unknowns. For each unknown, write 2-3 sentences describing the key reactions and observations that allowed you to identify it. *Be specific.*

Example: We identified unknown 9A as silver nitrate because it formed a white precipitate when we mixed it with sodium chloride.

3. Consider a similar experiment with the following six aqueous solutions:

Potassium carbonate (K_2CO_3)
Silver nitrate (AgNO_3)
Nitric acid (HNO_3)

Lithium hydroxide (LiOH)
Sodium sulfate (Na_2SO_4)
Barium chloride (BaCl_2)

From the list above, identify two compounds that would react to form:

- a. A solid precipitate
- b. A gas
- c. Liquid water in an acid-base neutralization reaction