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PRECIPITATION REACTIONS

Text Reference
Section 11.3

PURPOSE

To determine which combinations of ions form water-insoluble precipitates.

BACKGROUND

Two colorless solutions, cadmium chloride (CdCl_2) and potassium sulfide (K_2S), are poured together. As the solutions mix, a bright yellow solid forms. This insoluble compound, cadmium sulfide (CdS), was once used as a yellow pigment for oil paint. The paint was called cadmium yellow.

An insoluble substance that “falls out” of a solution is called a *precipitate*. The formation of precipitates other than cadmium sulfide is often less dramatic. For example, the scum that forms a ring around the bathtub is, in part, a precipitate formed by the reaction of calcium ions in the bathwater with soap ions. Whenever you mix solutions containing ions, you may obtain new combinations of ions. If one or more of these new ion combinations happens to be insoluble in water, it falls out of the solution as a precipitate.

In this experiment, you will mix pairs of six different ionic solutions in all possible combinations to determine which pairs result in precipitate formation. Based upon your results, you will infer what reactions have occurred and write complete and net ionic equations for each reaction that has taken place.

MATERIALS (PER PAIR)

safety goggles	plastic wash bottle
spot plate or 15 small test tubes	6 dropper pipets
glass stirring rod	distilled water

Set 1

0.1M barium nitrate, $\text{Ba}(\text{NO}_3)_2$	<input type="checkbox"/> <input checked="" type="checkbox"/>
0.1M sodium sulfate, Na_2SO_4	<input type="checkbox"/> <input checked="" type="checkbox"/>
0.1M aluminum sulfate, $\text{Al}_2(\text{SO}_4)_3$	<input type="checkbox"/> <input checked="" type="checkbox"/>
0.1M magnesium nitrate, $\text{Mg}(\text{NO}_3)_2$	<input type="checkbox"/> <input checked="" type="checkbox"/>
0.1M magnesium chloride, MgCl_2	<input type="checkbox"/> <input checked="" type="checkbox"/>
0.1M aluminum chloride, AlCl_3	<input type="checkbox"/> <input checked="" type="checkbox"/>

Set 2

0.1M potassium chloride, KCl	0.2M sodium hydroxide, NaOH
0.1M magnesium chloride, MgCl_2	<input type="checkbox"/> <input checked="" type="checkbox"/>
0.1M sodium sulfate, Na_2SO_4	0.1M barium chloride, BaCl_2

0.1M magnesium sulfate, MgSO_4

Set 3

0.1M barium chloride, BaCl ₂	<input type="checkbox"/> T	<input checked="" type="checkbox"/> C	0.2M aluminum sulfate, Al ₂ (SO ₄) ₃	<input type="checkbox"/> T
0.1M magnesium nitrate, Mg(NO ₃) ₂			0.2M potassium chromate, K ₂ CrO ₄	<input checked="" type="checkbox"/> C <input type="checkbox"/> T
0.2M sodium chromate, Na ₂ CrO ₄	<input type="checkbox"/> T		0.2M silver nitrate, AgNO ₃	<input checked="" type="checkbox"/> C <input type="checkbox"/> T

SAFETY FIRST!

In this lab, the solutions you use may contain harmful materials. Never touch any of the chemicals. In the event of a spill, inform your teacher immediately. Observe all precautions, especially the ones listed below. If you see a safety icon beside a step in the Procedure, refer to the list below for its meaning.



Caution: Wear your safety goggles. (All steps.)



Caution: Potassium chromate, sodium chromate, and sodium hydroxide are toxic, corrosive substances that can cause severe skin and eye injury. (Steps 1, 2.)



Caution: Aluminum chloride is an irritant. Avoid skin contact.



Caution: Silver and barium compounds are poisonous. Silver nitrate will stain skin and clothing. Avoid contact with these chemicals and wash your hands thoroughly after use.



Note: Return or dispose of all materials according to the instructions of your teacher. (Step 3.)



Note: Wash your hands thoroughly after completing this experiment.

PROCEDURES

As you perform this experiment, record your observations in Data Table 1.



1. Obtain a spot plate and a set of chemicals in dropper bottles. (The tests may be done in small test tubes.)



2. Using Data Table 1 as a guide, mix every possible pair of solutions in a set in a separate spot plate depression or test tube. Use two drops of each solution. Do not contaminate the individual droppers with different solutions. Mix the solutions with a stirring rod. Rinse the rod with distilled water after each mixing. Observe each mixture carefully for signs of a precipitate. (Some precipitates are light in color and hard to see.) Note the color of any precipitate formed. Record the results in Data Table 1.



3. Follow your teacher's instructions for proper disposal of the materials.

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OBSERVATIONS

DATA TABLE 1: MIXING PAIRS OF IONIC SOLUTIONS TO TEST FOR PRECIPITATE FORMATION

Solution A	Solution B	Results of Mixing A and B
Set 1:		
1 Ba(NO ₃) ₂	2 Na ₂ SO ₄	
1 Ba(NO ₃) ₂	3 Al ₂ (SO ₄) ₃	
1 Ba(NO ₃) ₂	4 Mg(NO ₃) ₂	
1 Ba(NO ₃) ₂	5 MgCl ₂	
1 Ba(NO ₃) ₂	6 AlCl ₃	
2 Na ₂ SO ₄	3 Al ₂ (SO ₄) ₃	
2 Na ₂ SO ₄	4 Mg(NO ₃) ₂	
2 Na ₂ SO ₄	5 MgCl ₂	
2 Na ₂ SO ₄	6 AlCl ₃	
3 Al ₂ (SO ₄) ₃	4 Mg(NO ₃) ₂	
3 Al ₂ (SO ₄) ₃	5 MgCl ₂	+
3 Al ₂ (SO ₄) ₃	6 AlCl ₃	
4 Mg(NO ₃) ₂	5 MgCl ₂	
4 Mg(NO ₃) ₂	6 AlCl ₃	
5 MgCl ₂	6 AlCl ₃	
Set 2:		
1 KCl	2 MgCl ₂	
1 KCl	3 Na ₂ SO ₄	
1 KCl	4 NaOH	
1 KCl	5 BaCl ₂	
1 KCl	6 MgSO ₄	
2 MgCl ₂	3 Na ₂ SO ₄	
2 MgCl ₂	4 NaOH	
2 MgCl ₂	5 BaCl ₂	
2 MgCl ₂	6 MgSO ₄	
3 Na ₂ SO ₄	4 NaOH	
3 Na ₂ SO ₄	5 BaCl ₂	
3 Na ₂ SO ₄	6 MgSO ₄	+
4 NaOH	5 BaCl ₂	+
4 NaOH	6 MgSO ₄	+
5 BaCl ₂	6 MgSO ₄	+
Set 3:		
1 BaCl ₂	2 Mg(NO ₃) ₂	
1 BaCl ₂	3 Na ₂ CrO ₄	
1 BaCl ₂	4 Al ₂ (SO ₄) ₃	
1 BaCl ₂	5 K ₂ CrO ₄	
1 BaCl ₂	6 AgNO ₃	
2 Mg(NO ₃) ₂	3 Na ₂ CrO ₄	
2 Mg(NO ₃) ₂	4 Al ₂ (SO ₄) ₃	
2 Mg(NO ₃) ₂	5 K ₂ CrO ₄	
2 Mg(NO ₃) ₂	6 AgNO ₃	
3 Na ₂ CrO ₄	4 Al ₂ (SO ₄) ₃	
3 Na ₂ CrO ₄	5 K ₂ CrO ₄	
3 Na ₂ CrO ₄	6 AgNO ₃	
4 Al ₂ (SO ₄) ₃	5 K ₂ CrO ₄	
4 Al ₂ (SO ₄) ₃	6 AgNO ₃	
5 K ₂ CrO ₄	6 AgNO ₃	

ANALYSES AND CONCLUSIONS

1. For each combination of solutions that gave a precipitate, write correct formulas for the two new compounds that could form from the ions present. (Remember to balance the ionic charges!) Enter these formulas in Data Table 2.

DATA TABLE 2: PRECIPITATION RESULTS AND ANALYSIS

Solution Pairs Yielding Precipitates	Formulas of Possible Precipitates (Circle Choice)	Reason for Choice
Set 1: Ba(NO₃)₂ + Na₂SO₄	BaSO₄ NaNO₃ Al(NO₃)₃ BaSO₄ Al(NO₃)₃ BaCl₂	
Set 2: Na₂SO₄ + BaCl₂	BaSO₄ NaCl Ba(OH)₂ NaCl	
NaOH + MgSO₄	Na₂SO₄ Mg(OH)₂	
BaCl₂ + MgSO₄	BaSO₄ MgCl₂	
Set 3: BaCl₂ + Na₂CrO₄	BaCrO₄ NaCl KCl + BaCrO₄	
	Na₂(SO₄)₃ Al₂CrO₄	
Na₂CrO₄ + AgNO₃	Ag₂CrO₄ NaNO₃	
Al₂(SO₄)₃ + K₂CrO₄	Al₂CrO₄ K₂(SO₄)₃	
K₂CrO₄ + AgNO₃	Ag₂CrO₄ KNO₃	

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- For those combinations that produced a precipitate, decide which of the two new compounds is the precipitate by eliminating the other. Remember that all compounds in your sets are soluble, so they cannot be precipitates in any of the reactions. Also, a combination of ions will either always form a precipitate or never form one. Circle the formula of each compound you believe to be a precipitate, and record the reasons for your choices in Data Table 2.
 - Write complete ionic equations for the precipitation reactions that you observed. Show the reactants as ions, the precipitate as a solid, and the spectator ions as unchanged. Balance each equation for mass and charge. The total charge should be zero on each side of the equation.

4. Write the net ionic equations for each reaction in the preceding question.

на сорока. ОДИН землемер засудил земли земельного участка на сумму 100000 рублей, а землемер изъял землю в пользу бюджета. Всего земельных участков, подлежащих изъятию из земельного фонда, было выявлено 150000 единиц.

5. What is the function of spectator ions in a precipitation reaction?

6. Explain in your own words why a precipitate forms.

7. How does a complete ionic equation differ from a net ionic equation?

GOING FURTHER

Develop a Hypothesis

Suppose you are given three different solutions containing Na_3PO_4 , $\text{Ba}(\text{NO}_3)_2$, and K_2CO_3 , respectively. Based on the results of this lab, hypothesize about which combinations of these solutions will produce insoluble precipitates. (Hint: Use your observations of the behavior of the compounds studied in this lab to develop general statements about the solubility of ionic compounds containing Na^+ , Ba^{2+} , K^+ , NO_3^- , and CO_3^{2-} .)
