Solutions

Precipitation Reactions

OVERVIEW

When two aqueous solutions of ionic compounds are combined, a solid precipitate may form.

This occurs when a positive cation from one solution and a negative anion from the other solution form an insoluble compound. The attraction between the oppositely charged ions is stronger than the attraction of the individual ions to the polar water molecules, the solution's solvent. The result is a solid precipitate that rapidly comes out of solution.

For example, when solutions of silver nitrate, $AgNO_3$, and sodium chloride, NaCl are combined, a double displacement reaction occurs and a white precipitate, AgCl, immediately forms:

$$AgNO_{3\,(aq)} + NaCl_{(aq)} \text{ ? } AgCl_{(s)} + NaNO_{3(aq)}$$

The net ionic equation, which removes the un-reacting spectator ions, shows more clearly the ions of interest:

$$Ag^{+}_{(aq)} + Cl^{-}_{(aq)} \text{ ? } AgCl_{(s)}$$

If no insoluble combination between anions and cations exist, no precipitate will form. Instead, all ions remain in solution and no reaction occurs.

In this lab you will use your knowledge of precipitation tables to predict precipitation reactions. Examine the lists of solutions you will be using for this experiment. You will be mixing solutions from Set A with Set B. Which combinations do you predict will result in a precipitate? Record your predictions. You will then test your predictions by combining pairs of solutions to see if a precipitate forms.

Additionally you may be asked to prepare the standard 0.10*M* solutions used for this lab. Your teacher may have you do this in advance of the precipitation tests.

PURPOSE

- To predict precipitation reactions.
- To observe a variety of precipitation reactions
- To write net ionic equations for precipitation reactions
- To prepare 0.10*M* standard solutions

SAFETY

- Follow general lab safety rules for this experiment.

EQUIPMENT AND MATERIALS

- clear acetate overhead sheet or spot plate
- grease pencil to draw a grid on acetate sheet
- solutions as assigned by your teacher. You may have any or all of the following 0.10 *M* solutions:

Set A	Set B
sodium nitrate, $NaNO_3$	sodium chloride, NaCl
potassium nitrate, KNO_3	sodium hydroxide, NaOH
silver nitrate, $AgNO_3$	sodium bromide, NaBr
ammonium nitrate, NH_4NO_3	sodium sulfide, Na_2S
lead(II) nitrate, $Pb(NO_3)_2$	sodium iodide, NaI
calcium nitrate, $Ca(NO_3)_2$	sodium phosphate, Na_3PO_4
magnesium nitrate, $Mg(NO_3)_2$	sodium sulfate, Na_2SO_4
barium nitrate, $Ba(NO_3)_2$	sodium carbonate, Na_2CO_3
copper(II) nitrate, $Cu(NO_3)_2$	
iron(III) nitrate, $Fe(NO_3)_3$	

Alternates	Alternates
sodium acetate, $NaC_2H_3O_2$	potassium carbonate, K_2CO_3
zinc acetate, $Zn(C_2H_3O_2)_2$	potassium phosphate, K_3PO_4
	ammonium sulfate, $(NH_4)_2SO_4$

Optional equipment if preparing standard solutions

- centrigram or electronic balance
- scoopula
- 100 mL volumetric flask or graduated cylinder
- 250 mL or smaller beaker
- dropper bottle to store your solution

PROCEDURE

1. If your teacher has assigned you certain standard solutions to prepare, complete Step 1. If these solutions have already been prepared, continue to Step 2.

   To prepare a standard solution you will need to measure a precise mass of the solid and add to it just enough water to make 100 mL (0.100 L) of solution.

   Calculate the mass of solid needed. Using unit analysis we can easily do this if we first determine the molar mass of the compound (units for molar mass are $g \cdot mole^{-1}$):

$$g = \frac{g}{mole} \times \frac{0.10 mole}{L} \times \frac{0.10 L}{1}$$

$$\text{mass} = \text{molar mass} \times \text{desired concentration} \times \text{desired volume}$$

   For example, to prepare 100 mL of a 0.10*M* solution of NaCl we first calculate the molar mass of NaCl and find it to be $58.5\ g \cdot mole^{-1}$.

   Since we want to prepare 0.100 L of a 0.10 M solution we can determine the mass of NaCl needed:

$$g = \frac{58.5 g}{mole} \times \frac{0.10 mole}{L} \times \frac{0.10 L}{1} = 0.59 g$$

   Check your calculations with your teacher before proceeding.

   Prepare the standard solution. To prepare the solution, accurately measure out the required mass and place it in a beaker. Add enough distilled water (about 20 mL or less) to dissolve the salt.

   Pour this solution into a 100 mL volumetric flask (if available) or a 100 mL graduated cylinder. Add enough distilled water to bring the total volume of solution up to the 100 mL mark on the flask or cylinder.

   Store your solution in the dropper bottle or other container provided by your teacher and label it with the formula of the compound and the molarity of the solution (e.g. "0.10 M NaCl")

2. Your teacher may ask to see your predictions for the precipitation reactions. You may record these on the chart provided.

3. On the blank Test Grid provided, list along the top row the Set A solutions you will be testing by giving the formula ***and charge*** of the ions present in the solution. An example is shown on the grid. Similarly, list the Set B solutions in the first column.

   Prepare a second, identical test grid which you will use to record your results.

   Place one of the test grids underneath the overhead sheet. You may find it useful to trace the grid on the overhead using the grease pencil. This will help prevent drops from one test reaction from running into another test reaction.

   If using a spot plate instead of an overhead, still prepare the Test Grid, and keep it beside your spot plate for reference.

3. On the overhead or the spot plate carry out your test reactions. Place one drop of the solution containing the Set A solution in the first cell; add a drop of the solution containing the Set B solution to that same cell. ***Be careful not to let the dropper bottle touch the drop already in the cell in order to avoid contaminating the solutions!***

   Observe if a reaction occurs. If a precipitate forms, record this on your test grid data sheet as PPT, also noting the colour of the precipitate. If no precipitate forms, write NR (for No Reaction) on your data sheet.

   Continue testing all possible combinations of Set A and Set B solutions.

QUESTIONS AND CONCLUSIONS

1. For every reaction in which a precipitate occurred, write both the full reaction equation and also the net ionic equation.

   In both equations be sure to identify the precipitate as a solid, by (s) after the formula.

   Be sure to balance all equations.

2. Comment on the accuracy of your predictions.

RESULTS: PREDICTIONS

The following table lists the solutions you may be mixing together. Do you predict that a precipitate will form? If so, what would be the formula of the precipitate?

If no precipitate is expected, write “NR” for no reaction.

In the lab you will test your predictions.

Reactants	**Predicted Precipitate**			**Predicted Precipitate**
$NaCl + NaNO_3$			$NaBr + NaNO_3$	
$NaCl + KNO_3$			$NaBr + KNO_3$	
$NaCl + AgNO_3$			$NaBr + AgNO_3$	
$NaCl + NH_4NO_3$			$NaBr + NH_4NO_3$	
$NaCl + Pb(NO_3)_2$			$NaBr + Pb(NO_3)_2$	
$NaCl + Ca(NO_3)_2$			$NaBr + Ca(NO_3)_2$	
$NaCl + Mg(NO_3)_2$			$NaBr + Mg(NO_3)_2$	
$NaCl + Ba(NO_3)_2$			$NaBr + Ba(NO_3)_2$	
$NaCl + Cu(NO_3)_2$			$NaBr + Cu(NO_3)_2$	
$NaCl + Fe(NO_3)_3$			$NaBr + Fe(NO_3)_3$	
$NaOH + NaNO_3$			$Na_2S + NaNO_3$	
$NaOH + KNO_3$			$Na_2S + KNO_3$	
$NaOH + AgNO_3$ $NaOH + NH_4NO_3$			$Na_2S + AgNO_3$ $Na_2S + NH_4NO_3$	
$NaOH + Pb(NO_3)_2$			$Na_2S + Pb(NO_3)_2$	
$NaOH + Ca(NO_3)_2$			$Na_2S + Ca(NO_3)_2$	
$NaOH + Mg(NO_3)_2$			$Na_2S + Mg(NO_3)_2$	
$NaOH + Ba(NO_3)_2$			$Na_2S + Ba(NO_3)_2$	
$NaOH + Cu(NO_3)_2$			$Na_2S + Cu(NO_3)_2$	
$NaOH + Fe(NO_3)_3$			$Na_2S + Fe(NO_3)_3$	

PREDICTIONS (continued)

Reactants	Predicted Precipitate			Predicted Precipitate
NaI + $NaNO_3$			Na_2SO_4 + $NaNO_3$	
NaI + KNO_3			Na_2SO_4 + KNO_3	
NaI + $AgNO_3$ NaI + NH_4NO_3			Na_2SO_4 + $AgNO_3$ Na_2SO_4 + NH_4NO_3	
NaI + $Pb(NO_3)_2$			Na_2SO_4 + $Pb(NO_3)_2$	
NaI + $Ca(NO_3)_2$			Na_2SO_4 + $Ca(NO_3)_2$	
NaI + $Mg(NO_3)_2$			Na_2SO_4 + $Mg(NO_3)_2$	
NaI + $Ba(NO_3)_2$			Na_2SO_4 + $Ba(NO_3)_2$	
NaI + $Cu(NO_3)_2$			Na_2SO_4 + $Cu(NO_3)_2$	
NaI + $Fe(NO_3)_3$			Na_2SO_4 + $Fe(NO_3)_3$	
Na_3PO_4 + $NaNO_3$			Na_2CO_3 + $NaNO_3$	
Na_3PO_4 + KNO_3			Na_2CO_3 + KNO_3	
Na_3PO_4 + $AgNO_3$			Na_2CO_3 + $AgNO_3$	
Na_3PO_4 + NH_4NO_3			Na_2CO_3 + NH_4NO_3	
Na_3PO_4 + $Pb(NO_3)_2$			Na_2CO_3 + $Pb(NO_3)_2$	
Na_3PO_4 + $Ca(NO_3)_2$			Na_2CO_3 + $Ca(NO_3)_2$	
Na_3PO_4 + $Mg(NO_3)_2$			Na_2CO_3 + $Mg(NO_3)_2$	
Na_3PO_4 + $Ba(NO_3)_2$			Na_2CO_3 + $Ba(NO_3)_2$	
Na_3PO_4 + $Cu(NO_3)_2$			Na_2CO_3 + $Cu(NO_3)_2$	
Na_3PO_4 + $Fe(NO_3)_3$			Na_2CO_3 + $Fe(NO_3)_3$	

SET A SOLUTIONS

SET B SOLUTIONS

	Na^+ NO_3^-	K^+ NO_3^-	Ag^+ NO_3^-						
Na^+ Cl^-									
Na^+ OH^-									

SAMPLE DATA

SET A SOLUTIONS

SET B SOLUTIONS

	Na^+ NO_3^-	K^+ NO_3^-	Ag^+ NO_3^-							
Na^+ Cl^-	NR	NR	white PPT							
Na^+ OH^-										

SET A SOLUTIONS

SET B SOLUTIONS
