Experiment 8 Double Displacement Reactions and NIE

This lab explores double displacement reactions of aqueous solutions. In this lab, you will observe whether a reaction occurs and predict the products by mixing paired solutions together. These results will be verified with the solubility table in the lab (Table 1).

A double displacement reaction involves two ionic compounds that are dissolved in water. In a double displacement reaction, it appears as though the ions are "trading places," as in the following hypothetical reaction:

$$AB_{(aq)} + CD_{(aq)} \rightarrow AD_{(aq)} + CB_{(aq)}$$

Where AB exists as A^+ and B^- ions in solution and CD exists as C^+ and D^- ions in solution. As the ions encounter each other, there are six possible combinations that might conceivably cause a chemical reaction. Two of these combinations are the meeting of ions of like charge; that is, $A^+ + C^+$ and $B^- + D^-$. Since like charges repel, no reaction will occur with these combinations. Two other possible combinations are those of the original two compounds; that is, $A^+ + B^-$ and $C^+ + D^-$. Since we originally had a solution containing each of these pairs of ions, they can mutually exist in the same solution; therefore, they do not recombine. Thus, the two possibilities for chemical reaction are the combination of each of the positive ions with the negative ion of the other compound; that is, $A^+ + D^-$ and $C^+ + B^-$.

Three equations can be written for reactions that involve ions in solution: the molecular equation, the ionic equation, and the net ionic equation. These types of equations are discussed in the lab assignment, "Writing Net Ionic Equations".

In Part 1 of this lab, we will observe that a double displacement reaction will occur if at least one of the following classes of substances is formed by the reaction:

1. A precipitate.
2. A gas.
3. A slightly ionized compound (a weak electrolyte).
4. A non-ionized compound (a non-electrolyte).

USEFUL TABLES

TABLE 1: General Solubility Rules for Ionic Compounds at 25°C

1. A compound will be soluble if it contains at least one of the following ions: Li^+, Na^+, K^+, NH_4^+, NO_3^-, or $C_2H_3O_2^-$.
2. A compound containing Cl^-, Br^-, or I^- is soluble **unless** the cation is Ag^+, Pb^{2+}, or Hg_2^{2+}.
3. Compounds that contain SO_4^{2-} are soluble **except** those sulfates that also contain Ba^{2+}, Ag^+, Pb^{2+}, or Ca^{2+}.
4. Most other ionic compounds are insoluble (in other words, the amount of solute that dissolves is extremely small and will be regarded as negligible). Compounds containing S^{2-}, CO_3^{2-}, PO_4^{3-}, and OH^- are insoluble unless the cation is one of those listed in 1 above.

NOTE: This is another statement of the general solubility rules listed in your textbook and the handout from lecture. You can use any one of these.

Materials: hot water bath, test tube rack, 12 -15 test tubes, distilled water, slop beaker for waste, dropper(s)-please return to hood if borrow, spot plates if needed.

Safety Precautions:

- Wear your safety goggles.
- Silver nitrate ($AgNO_3$) solutions will stain skin and clothes. If you suspect you may have spilled $AgNO_3$ on yourself, rinse it off immediately. The stains are dark brown and they don't show up right away. You'll know the next day whether or not you spilled $AgNO_3$ on yourself.

Waste Disposal:

- All of the waste from this lab may be dumped in the **inorganic waste** bottles (which have a blue label) in the fume hood.

PROCEDURE

Observing Double Displacement Reactions: The prelude to qualitative analysis.

GENERAL INSTRUCTIONS FOR EACH TEST:

- Reactions involving liquids in this part of the experiment consists of mixing equal volumes of two solutions in a test tube.
- Make sure the test tubes are clean and have been rinsed with de-ionized water and shaken dry. **Use about one milliliter of each solution**.
- It is **not** necessary to measure each volume accurately.
- Carry out the test for each of the ions as described below.
- Record your observations before and at the time of mixing.
- Where there is no visible evidence of reaction, feel each tube, or check with a thermometer, to determine if heat is evolved.

- When there is no evidence of reaction, write the words "no reaction" as the right-hand side of the equation.

REACTIONS TO BE STUDIED

1. Mix 0.1 M sodium chloride ($NaCl$) and 0.1 M potassium nitrate (KNO_3) solutions.
2. Mix 0.1 M sodium chloride ($NaCl$) and 0.1 M silver nitrate ($AgNO_3$) solutions.
3. Mix 0.1 M sodium carbonate (Na_2CO_3) and 6 M hydrochloric acid (HCl) solutions.
4. Mix 10% sodium hydroxide ($NaOH$) and 6 M hydrochloric acid (HCl) solutions.
   a. Do litmus test on reactants. Lay out piece of paper towel. Put one strip of red litmus and one strip of blue litmus on the towel. Wet the litmus paper with water. Add one drop of each reactant to the litmus paper. Observe the reaction of acid with red and with blue litmus. Observe the reaction of base with red and blue litmus.
5. Mix 0.1 M barium chloride ($BaCl_2$) and 3 M sulfuric acid (H_2SO_4) solutions.
6. Mix 6 M ammonia (NH_3) and 3 M sulfuric acid (H_2SO_4) solutions **in the hood**. [Note: Use NH_4OH when balancing equations]
7. Mix 0.1 M copper (II) sulfate ($CuSO_4$) and 0.1 M zinc nitrate ($Zn(NO_3)_2$ solutions. [If available, substitute cobalt nitrate for zinc nitrate]
8. Mix 10% sodium hydroxide ($NaOH$) solutions and 0.1 M zinc nitrate ($Zn(NO_3)_2$) solutions. If you do not see a solid form, shine a light through the solution.
9. Mix 0.1 M copper (II) sulfate ($CuSO_4$) and 0.1 M ammonium chloride (NH_4Cl) solutions.
10. Mix 0.1 M sodium carbonate (Na_2CO_3) and 0.1 M iron (III) chloride ($FeCl_3$)
11. Mix 10% sodium hydroxide ($NaOH$) and 6 M nitric acid (HNO_3) solutions.
12. Mix 0.1 M iron (III) chloride ($FeCl_3$) and 10% sodium hydroxide ($NaOH$) solutions.
13. Add 1 g of solid sodium bicarbonate ($NaHCO_3$) to 1 mL of water and shake to dissolve. Add about 1 mL of 1 M hydrochloric acid (HCl) solution, drop wise, using a medicine dropper.
14. Mix 0.1 M sodium chloride ($NaCl$) and 10% sodium hydroxide ($NaOH$) solutions.
15. 0.1M sodium acetate and 0.1M copper(II) sulfate (if available)
16. 0.1 M sodium acetate and 3M H_2SO_4(if available)

RESULTS

Write the correct molecular, ionic, and net ionic equation for the reactions in which you observed evidence of a reaction properly. Indicate formation of a gas, formation of a solid, relative temperature change, color change, odor etc for the reactants and the products. [Most students see 10 possible reactions out of the 16 presented] These equations go in your results table.

POST LAB QUESTIONS

See pre-lab sheet for post lab questions.