

7 Ionic and Covalent Compounds

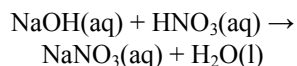
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- **The electrical conductivity of various solutions to determine if any substances have dissociated into ions.**
- **Write net ionic equations for several reactions based upon your laboratory observations.**

DISCUSSION

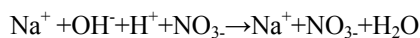
In a solution, substances may exist as atoms, molecules, or ions. If the particles are neutral atoms or molecules, the solution will not conduct electricity. If they are electrically charged ions, however, the solution will conduct. Solutions that conduct electricity are called *electrolytes*. If a solution contains lots of ions, it will be a good conductor or a *strong electrolyte*. Smaller amounts of ions yield *weak electrolytes*. A solution that contains no ions (or an insignificant amount) is a *non-electrolyte*.

Whether or not ions exist has no effect on the stoichiometry of a reaction. Only a balanced equation is necessary. Thus, a *full-molecular equation*, without ions expressed, is satisfactory for stoichiometric purposes. For example,

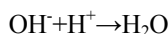


is a full-molecular equation.

In reality, however, ions do exist in many solutions. To understand better the chemistry of their reactions, you will often need to display them in equations. (Indeed, that skill will be vital to your success in Chemistry 106.) Each of the aqueous substances in the above example are strong electrolytes, and they exist as ions in solution. Displaying them as ions gives a *total-ionic equation*:



In this equation, sodium ions and nitrate ions remain unchanged. Deleting the ions that do not participate (called spectator ions) leads to a *net-ionic equation*:



To write a net-ionic equation, follow the following steps: (1) write the full-molecular equation and balance it; (2) ionize all strong acids, strong bases, and soluble salts (do not

ionize gases, liquids, or insoluble salts) and write the total ionic equation from these ionizations; and (3) delete the spectator ions and write the net-ionic equation.

PROCEDURE**A. Conductivity Measurements**

1. In the balance room, you will find ten bottles connected to a source of electric current and to an ammeter by means of a rotary switch. You can display the electrical conductivity of each numbered solution by turning the dial to the corresponding number. Record the identity of each solution together with its conductivity on the report sheet. (Strictly speaking, you will be recording the magnitude of the electric current in milliamperes that passes through the liquid. This is directly proportional to conductivity.)

Since only one conductivity apparatus serves all the students in the laboratory, not everyone can do this step at once. Only 5 or 6 of you can take data simultaneously. Work on the second part of this experiment until space becomes available around the apparatus.

2. Return to your lab bench so that other students may use the apparatus. Rank the ten solutions in order of conductivity, with the best conductor on top and the worst at the bottom. (If any have the same conductivity, list those in any order relative to each other.) Now, by your own standards, assign each into one of the following categories: strong electrolyte, weak electrolyte, or non-electrolyte. Then write the formulas of the individual species (ions, molecules, or both) present in solution that account for the observed conductivity.

B. Net-Ionic Equations**Formation of soluble but non-ionized or poorly ionized products**

3. Place 2 to 3 mL of 3 M NH_4Cl in a small test tube. Check for the odor of ammonia (NH_3). Next add 1 mL of 6 M NaOH . Check again for the odor. Record your observations. Write the

overall, full-molecular equation for the reaction, the total-ionic equation, and the net-ionic equation.

4. Place 2 to 3 mL of 3 M $\text{NaC}_2\text{H}_3\text{O}_2$ in a small test tube. Check for the odor of vinegar (acetic acid, $\text{HC}_2\text{H}_3\text{O}_2$). Next add 1 mL of 3 M H_2SO_4 . Check again for the odor. Record your observations, and write equations for the reaction.

Formation of gases

5. Place 2 to 3 mL of 0.1 M Na_2CO_3 in a small test tube, and add 1 mL of 6 M HCl . The reaction is a regular metathesis, but one of the products, H_2CO_3 , is unique. It immediately decomposes into CO_2 and H_2O , and it is usually written as the two separate substances in an equation. Record your observations, and write equations for the reaction.

6. Place a small marble chip (CaCO_3) in each of two small test tubes. Add 2 to 3 mL of 6 M HNO_3 to one and 2 to 3 mL of 6 M $\text{HC}_2\text{H}_3\text{O}_2$ to the other. Compare the two reactions, record your observations, and write the equations for both.

7. Explain why all three net-ionic equations in Steps 5 and 6 are different.

Formation of precipitates

8. Combine 2 mL of 0.1 M CaCl_2 and 2 mL of 0.1 M Na_2CO_3 in a small test tube. Record your observations, and write equations for the reaction.

9. Place 2 mL of 0.1 M CaCl_2 in each of two test tubes. Add 2 mL of 0.25 M $(\text{NH}_4)_2\text{C}_2\text{O}_4$ to one, and 2 mL of 0.25 M $\text{H}_2\text{C}_2\text{O}_4$ to the other. Compare the two reactions, record your observations, and write equations for each.

10. Based on the amounts of precipitate in the two reactions of Step 9, tell whether $\text{H}_2\text{C}_2\text{O}_4$ is a weak or strong acid. Justify your conclusion, and make sure the net-ionic equation for the oxalic acid reaction is written consistently.

NET-IONIC EQUATIONS***Formation of soluble but non-ionized or poorly ionized products***

3. Ammonium chloride and sodium hydroxide

Observations:

Full-molecular equation:
Total-ionic equation:
Net-ionic equation:

4. Sodium acetate and sulfuric acid

Observations:

Full-molecular equation:
Total-ionic equation:
Net-ionic equation:

Formation of gases

5. Sodium carbonate and hydrochloric acid

Observations:

Full-molecular equation:
Total-ionic equation:
Net-ionic equation:

6a. Calcium carbonate and nitric acid

Observations:

Full-molecular equation:
Total-ionic equation:
Net-ionic equation:

6b. Calcium carbonate and acetic acid

Observations:

Full-molecular equation:
Total-ionic equation:
Net-ionic equation:

7. Explain why all three net-ionic equations in Steps 5 and 6 are different.

Formation of precipitates

8. Calcium chloride and sodium carbonate

Observations:

Full-molecular equation:
Total-ionic equation:
Net-ionic equation:

9a. Calcium chloride and ammonium oxalate

Observations:

Full-molecular equation:
Total-ionic equation:
Net-ionic equation:

9b. Calcium chloride and oxalic acid

Observations:

Full-molecular equation:
Total-ionic equation:
Net-ionic equation:

10. Is oxalic acid a strong or a weak acid? Why?