Table of Contents

Chemistry and Experiments
   Lab 1: Introduction and Safety
   Lab 2: The Scientific Method

Introducing Chemical Reactions
   Lab 3: Chemical Reactions I
   Lab 4: Chemical Reactions II
   Lab 5: Metals and Oxidation

Classification of Elements
   Lab 6: The Mole and Avogadro’s Number
   Lab 7: The Periodic Table
   Lab 8: Stoichiometry

Gas Laws
   Lab 9: Ideal Gas Law

Reaction Rates
   Lab 10: Reaction Rate
   Lab 11: Catalysts

Acids and Bases
   Lab 12: Acids and Bases
   Lab 13: Titration
Lab 3: Chemical Reactions I
Concepts to explore:
- Understand qualitative tests for ions that are based on solubility
- Learn that Na⁺, K⁺, NH₄⁺, NO₃⁻, and CH₃COO⁻ are water soluble
- Recognize balanced chemical equations
- Qualitatively test for fluoride ions in mouth rinses

Introduction

Have you ever wondered how toothpaste helps prevent cavities?

Remember your last visit to the dentist to have your teeth cleaned and a check-up? You most likely waited anxiously as the dentist finished checking your teeth and breathed a big sigh of relief if he pronounced, “No cavities!” But what causes cavities anyway, and how does brushing your teeth help to prevent them?

Your teeth, like many other bones in the body, are mostly made of a substance called hydroxyapatite. The empirical formula of hydroxyapatite is Ca₁₀(PO₄)₆(OH)₂. Plaque organisms that live in your mouth produce acids that dissolve minerals, such as the calcium and phosphorous found in hydroxyapatite. The active ingredient in toothpaste, fluoride, help replace those lost minerals. It has been found that the hydroxyapatite in your teeth can easily replace lost minerals with fluoride. Because of this, a tooth’s crystal structure that has incorporated fluoride is more resistant to decay than the original structure, which is why we need to brush our teeth with toothpaste that contains fluoride every day!

Ions have very different chemical and physical properties than atoms. For instance, fluoride (F⁻) as an ion is safe enough to add to drinking water and toothpaste to help prevent cavities; while fluorine (F₂) is a very poisonous gas. Throughout history, scientists have developed many ways to test for the presence of different types of ions. These are called qualitative tests. In many of these tests, one ion replaces another to produce a solid precipitate. There are also some useful generalizations that can help a chemist know whether or not a particular chemical is soluble in water. One of the useful solubility rules for ionic compounds states that compounds containing Li⁺, Na⁺, K⁺, or NH₄⁺ are soluble in water. The water solubility of many other compounds can also be found in handbooks.
Lab 3: Chemical Reactions I

You can see that nitrates (NO₃⁻), acetates (CH₃COO⁻ or C₂H₃O₂⁻), and ammonium ions (NH₄⁺) all have a charge like the fluoride ion, but they are made up of more than one atom. These are called polyatomic ions, which are molecules with a net charge.

Calcium acetate can be used to qualitatively test for the existence of fluoride in a solution. This relates to another important solubility rule, which states that nitrates and acetates are water soluble—therefore calcium acetate, Ca(C₂H₃O₂)₂, is soluble in water. A solution of calcium acetate will react with fluoride to make calcium fluoride, which is not very soluble in water and will form a solid precipitate that is easily observed.

Chemists have a short way to write out what is happening in a reaction. It is called a chemical equation. The chemicals that are reacting are called the reactants and placed on the left side of an arrow. The chemicals that result from the reaction are called products and are placed on the right side of the arrow. The reaction that you will be observing in this lab can be written as the following chemical equation:

\[ 2 \text{ NaF}_{(aq)} + \text{Ca(C}_2\text{H}_3\text{O}_2)_2_{(aq)} \rightarrow \text{CaF}_2_{(s)} + 2 \text{ Na(C}_2\text{H}_3\text{O}_2)_{(aq)} \]

The abbreviation “aq” by the chemical formula stands for “aqueous,” meaning that reactant or product is dissolved in water, while the “s” indicates that the substance is a solid.

This chemical equation has also been balanced. This means there is the same number of each of the different atoms on either side of the equation. This may not be very clear when you first look at it. Notice that there is a 2 in front of the NaF and no number in front of the Ca(C₂H₃O₂)₂. A number in front of a molecule, such as the 2 in front of the NaF, is called a coefficient. A coefficient of 1 is usually not written, but can be assumed. As you can see, one molecule of a substance does not always react with just one molecule of another substance. The coefficients tell us the ratio of how the molecules react. In this reaction 2 NaF react with 1 Ca(C₂H₃O₂)₂.

A subscript after an element’s symbol in a chemical formula indicates the quantity of atoms of that element in the compound. For example, the CaF₂ molecule has one calcium (Ca) and two fluorine molecules (F). This is also true for polyatomic ions. In Ca(C₂H₃O₂)₂, the ion (C₂H₃O₂)⁻ is in parentheses and has a subscript 2. This means there are two (C₂H₃O₂)⁻ ions in calcium acetate. You can think of it as a shorter way of writing Ca(C₂H₃O₂)(C₂H₃O₂). In total, Ca(C₂H₃O₂)₂ has one Ca atom, four C atoms, six H atoms, and four O atoms. If a molecule with a polyatomic ion in it does not have it in parenthesis it means that there is only one of them for each molecule. The NaC₂H₃O₂ has only one (C₂H₃O₂)⁻.

Now that you know how a chemical equation is written, you can count the number of each elements on the reactants side and on the products side for the reaction above. Did you get 2 Na, 2 F, 1 Ca, 4 C, 6H, and 4 O on each side? If so, you are correct! Since there is the same number of each atom on both sides of the arrow, the chemical equation is balanced.
Pre-lab Questions

1. Name the chemical that makes up teeth.

2. How does plaque harm teeth?

3. How does fluoride promote dental health?

4. Write two solubility rules that are used in this lab.
Experiment: Battle of the Mouth Rinses

Some mouth rinses also contain fluoride, usually in the form of sodium fluoride which is soluble in water. In this lab, you will determine which one of two mouth rinses would be better at preventing cavities by replacing lost minerals with fluoride. You will do this by determining which mouth rinse contains fluoride.

Materials

Safety Equipment: Safety goggles, gloves
Mouth rinse A (10 mL)
Mouth rinse B (10 mL)
1 M Calcium acetate \( \text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2 \)
Test tube rack
2 Test tubes
10 mL Graduated cylinder
Stirring rod
Permanent marker

Procedure

1. Label the two test tubes with a Sharpie: A, and B. HINT: Make sure to write down which rinse is A and which is B.
2. Pour 10 mL of Rinse A into the test tube marked A. HINT: If using the same graduated cylinder, rinse WELL to prevent cross contamination.
3. Pour 10 mL of Rinse B into the test tube marked B.
4. Pour 3 mL of 1 M \( \text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2 \) solution into each of the test tubes. Gently stir each test tube with a stirring rod to mix. Be sure to clean your stirring rod each time before placing it in a solution. CAUTION: Mixing should be done gently to prevent glass breakage and injury.
5. Observe the reactions for at least 10 minutes to insure it is finished. HINT: A positive test is indicated by a cloudy appearance of the solution. The precipitate formed can be more easily seen if the test tube is held up to the light. The precipitate will eventually settle to the bottom of the test tube.
6. Record all observations in the Data section.
7. To clean up, you can rinse the small amount of precipitate down the drain.
Data

- Observations of NaF and Ca(C$_2$H$_3$O$_2$)$_2$ (See sequence of pictures below):

Addition of Ca(C$_2$H$_3$O$_2$)$_2$ to NaF; 57 seconds after the addition of Ca(C$_2$H$_3$O$_2$)$_2$; 20 minutes after the addition of Ca(C$_2$H$_3$O$_2$)$_2$; 35 minutes after the addition of Ca(C$_2$H$_3$O$_2$)$_2$; and 1 hour after the addition of Ca(C$_2$H$_3$O$_2$)$_2$.

- Observations of Rinse A and Ca(C$_2$H$_3$O$_2$)$_2$:

- Observations of Rinse B and Ca(C$_2$H$_3$O$_2$)$_2$: