Making Solutions

Introduction

Antifreeze, rubbing alcohol, juice, blood plasma, hairspray, soda pop...these are just a few examples of solutions with consistent chemical compositions that we often take for granted. By learning more about solutions in your general chemistry course, we hope you’ll appreciate their broader significance in our world.

In previous science courses you may have taken, the solutions you used were probably aqueous, meaning that they consisted mostly of water. That will be true in Chemistry 184 laboratories, as well. In scientific vocabulary, water is the solvent. The substance dissolved in the water is called the solute. The quantity of substance dissolved in the water is usually pretty important. Chemists, and others who work with solutions, should know how to calculate the quantities of solutes needed to make a given solution; they should also know how to prepare such solutions in the laboratory.

To study general chemistry, we need solutions of well-defined chemical composition. For most lab experiments, Chem 184 students do not have to dissolve solids, liquids, or gasses in water to make solutions. Instead, "Gary the stockroom guy" combines appropriate components to make each solution in a quantitatively logical, reproducible way. For example, several Chem 184 experiments require 1.00 M NaOH (called “one molar sodium hydroxide”). The notation 1.00 M means that 1.00 mole of the solute, NaOH, is contained in each liter of solution. Gary routinely weighs 1.00 mole (40.0 g) of NaOH and carefully dissolves it in water to make a total final volume of 1.00 liter using a 1-L-size volumetric flask. If he needs more or less NaOH solution, he adjusts the quantity of NaOH and the size of the volumetric flask. Click here to learn more about the techniques and calculations solution preparation.

Although Gary has already prepared several of the solutions you'll need, we have respectfully asked him to save a few of the calculation and solution preparation steps for you, the students. This week, you'll work with your group members to calculate and weigh necessary amounts of the solid chemicals KIO₃, C₃H₄O₄, and MnSO₄ • H₂O. (For the chemical naming buffs in Chem 184: these chemicals are known as potassium iodate, malonic acid, and manganese(II) sulfate monohydrate, respectively.) The formula for manganese sulfate monohydrate is MnSO₄ • H₂O. If you are not familiar with hydrates, refer to Chapter 2, section 2.7, p. 67 of your Chang Chemistry text.

Finally, at the end of the lab period, your group should be able to produce a colorful mixture by combining your solutions as described below!

Pre-lab

Safety

Always wear your safety goggles in the laboratory. Your TA will ask you to leave the laboratory unless you are wearing proper protective eyewear. Any chemical that comes in contact with your
eyes should be flushed out with running water for at least ten minutes prior to seeking medical attention. Locate the safety shower and eyewash station prior to beginning the experiment.

**Hydrogen Peroxide** (H₂O₂) is a corrosive material that is often used as a bleach. It is capable of bleaching human skin. Rinse immediately if skin or eyes are exposed.

**Strong Acids** such as **Sulfuric Acid** (H₂SO₄) and **Weak Acids** like **Malonic Acid** (HO₂CCH₂CO₂H, or simply C₃H₄O₄) are hazardous if splashed on clothing, exposed skin or in the eyes. Prolonged exposure of the skin to even fairly dilute solutions of acid can cause serious burns. If acids splash on skin or clothes, remove the affected clothing and flush the affected areas thoroughly with cold water.

**Potassium Iodate** (KIO₃) may cause skin irritation. As with all chemicals, wash hands thoroughly if skin is exposed.

**Manganese(II) Sulfate Monohydrate** (MnSO₄ ∙ H₂O) may cause eye and skin irritation. Breathing dust may cause respiratory tract irritation. Avoid generating dust when working with dry chemicals. If powder or solution contacts skin or clothes, remove affected clothing and flush the affected areas thoroughly with water.

Answer the following questions on a single sheet of paper for submission to your TA at the start of lab.

1) The molecular formula of malonic acid is C₃H₄O₄. How many grams is contained in one mole of malonic acid? *(Hint: By calculating the molar mass, you identify the number of grams in one mole of a chemical compound!)*

2) How many grams of malonic acid would be needed to make 50.0 milliliters (0.0500 L) of 0.200 M malonic acid solution?

3) The formula for manganese sulfate monohydrate is MnSO₄ ∙ H₂O. What is its molar mass? *(Hint: If you are not familiar with hydrates, refer to Chapter 2, section 2.7, p. 67 of your Chang *Chemistry* text.)*

**Experiment Part 1: Planning**

Work with your group to determine how the materials listed below can be used to make 50.0 mL of each of the following two solutions, **Solution 1** and **Solution 2**. Don’t forget to discuss the glassware and other supplies you need.

**Solution 1.** 0.20 M malonic acid solution and 0.026 M MnSO₄ ∙ H₂O

**Solution 2.** 0.27 M KIO₃ in 0.10 M H₂SO₄
In addition to the usual items found in your Chem 184 lab drawers, the following supplies will be available for your use in making **Solution 1** and **Solution 2**.

**Pre-Made Solutions**
0.10 M H₂SO₄
3.0% starch solution
3.0% H₂O₂ solution

**Dry Powders**
KIO₃
C₃H₄O₄ (HO₂CCH₂CO₂H; malonic acid)
MnSO₄ • H₂O

**Glassware**
50-mL-size volumetric flasks

**Experiment Part 2: Solutions Preparation**

Work with your group to execute the plan to prepare **Solution 1** and **Solution 2**. Here are some procedural hints to consider before you get started.

**Solution 1** contains two solutes. Don’t forget to place both solutes in your container before you adjust the total solution to a net size of 50.0 mL. Should the solutes be completely dissolved before you “top off” to 50.0 mL? Why?

To produce **Solution 2**, it is not necessary to make your own 0.10 M H₂SO₄ solution; this premixed reagent is provided for you in an autopipetter. This means that when you dissolve the appropriate mass of KIO₃ to make Solution 2, you must dissolve it in 0.10 M H₂SO₄ rather than in plain water! The autopipetter for the 0.10 M H₂SO₄ solution is set at 23.5 mL, and must not be adjusted. Accordingly, dispense two complete volumes from the autopipetter into a clean beaker to obtain a net volume of 47.0 mL. KIO₃ does not dissolve very rapidly at room temperature. Nonetheless, it is important to dissolve the KIO₃ to produce a completely colorless, transparent solution while it is still in the beaker. If the KIO₃ isn’t dissolving as quickly as you would like, you may work with your group to discuss how to dissolve it more quickly; ask your TA if your proposed strategy is reasonable. Finally, if you need a bit more 0.10 M H₂SO₄ solution, find the small dropper bottle containing 0.10 M H₂SO₄. It is identical to 0.10 M H₂SO₄ obtained from the autopipetter.

Finally, place a white sheet of paper under a clean 400 mL beaker. Place 100.0 mL of 3.0% H₂O₂ solution and a few drops of 3.0% starch solution into the beaker. Without delay, add **50.0 mL each of Solution 1 and Solution 2** to the beaker. Stir the solution briefly with a clean stirring rod and watch for changes.

**Note:** The solutions and chemical reactions for this Chem 184 lab are based on the published work of M. Rachel Wang [*J. Chem. Ed.*, 249-250 (2000)]. If you are interested in more information about how this experiment works, you may [click here](#).