Experiment 1:
Conservation of Matter

Instructor Notes and Lab Preparation

Chemicals and Equipment:

3.0 M HCl in 1-Liter bottles with pour spout
Bottle of anhydrous copper (II) sulfate
Weighing boats
Bottle of zinc metal (mossy)
50 mL volumetric flasks with stopper
125 mL flasks with side arm
#4 black rubber stoppers *** **DO NOT USE CORK** ***
1 bag of 7-inch balloons
1 box of calipers
Long tweezers
Disposable pipets
Parafilm
1 box of baking soda for acid spills

Setup:

- Make sure there are Kimwipes near the balance(s).
- Set out equipment and chemicals.
- Place 1 bottle of HCl on each lab bench.
- Place 50 mL volumetric flasks on each lab bench.

Preparation:

3.0 M HCl –

Use 247.93 mL of concentrated HCl per 1 L of solution.

Prepare a large carboy:

To prepare 12 L of 3.0 M HCl: Fill a carboy with approximately 5 L of water. Add 2.98 L of concentrated HCl (in the hood). Then dilute to 12L with D.I. water. (Supply for 20 classes sections @ 24 students) Mix well.

To prepare 6 L of 3.0 M HCl: Fill a carboy with approximately 3 L of water. Add 1.49 L of concentrated HCl (in the hood). Then dilute to 6 L with D.I. water. (Supply for 10 classes sections @ 24 students) Mix well.

Instruction Notes:

The Conservation of Matter experiment was originally developed for our non-majors course. For that course we prepare the copper (II) sulfate solution for the students. When we adapted it for the majors we decided to have them prepare their own solution and introduce the use of volumetric glassware. If you feel your students are not ready to mix their own solution, this is an easy change that both shortens and simplifies the experiment. The experiment is very visual as both the color of the solution changes dramatically in a short period of time and the balloon is inflated to a large size. This leaves no doubt that a reaction has taken place.

Points to stress:

Students are working with 3.0 M HCl. This is strong acid and it should be stressed repeatedly that all safety precautions must be taken to avoid burns. All spills of any size should be cleaned up by lab personnel, not the students. I provide my teaching assistants with baking soda and gloves to handle the clean-up.

When the students are preparing the solution, they should weigh the $CuSO_4$ in a weigh boat and then use a small amount of HCl to assist in the transfer of the salt to the volumetric flask. $CuSO_4$ is a “sticky, wet” salt and thus clumps, making dry transfer difficult (the neck of the 50 mL volumetric flask is small). You can also use paper funnels but the “stickiness” of the salt may cause a loss of mass there as well. We have found that using the HCl to aid in the transfer reduces the loss of mass best and also keeps the lab benches much cleaner.

Potential Problems:

As mentioned above, the necks of the volumetric flasks are fairly small so students should be shown the proper way to transfer the salt so that they don’t make a huge mess on the bench tops and, more importantly, don’t lose mass of salt.

The only other problem that sometimes occurs is a hole in a balloon or a balloon that is not securely fastened to the side-arm of the flask. Have your students blow the balloon up once before attaching it to the side-arm. This will allow them to determine if the balloon is air tight and it also stretches the balloon so that the resistance is lowered when the reaction starts to fill it with hydrogen gas.

You might note tweezers in the list of items needed for this lab. Because our lab balances are only capable of weighing up to ~100g of material, at the end of the lab we have to remove the pellets from the solution and weigh them separately using a tared weigh boat. If you have the same difficulty, tweezers work well as long as the students are gentle. The removal and separate measurement also reinforces the notion that the total mass of the products is what is important; not that they all remain in the same state or container.

Pre-Lab Key

Experiment 1

Pre-Laboratory Assignment

Name: ______________________________ **Date:** ___________________

Instructor: _______________________________ **Sec. #:** ____________

Show all work for full credit.

1) Based on your reading of the laboratory Introduction and Background, prepare a hypothesis regarding what results you expect from your experiment. Be detailed.

   This answer will vary based on the student's interpretation of the reason for the experiment but should contain a reference to both the concepts of conservation of matter and also the techniques that will be employed to explore the concepts.

2) Calculate the number of moles or grams in each of the following quantities of salt.

   5.233 g of $Cu(NO_3)_2 \cdot 6H_2O$ = **_________0.01770 mol____**

   7.77 g of zinc nitrate trihydrate = **_________0.0319 mol_____**

   6.215×10^{-2} mol of $Na_2SO_4 \cdot 10H_2O$ = **_________20.02 g_________**

   2.0×10^{-2} mol of zinc nitrate hexahydrate = **_________6.0 g__________**

3) You would like to make up 100 mL of a 0.23 M solution of $Na_2SO_4 \cdot 10H_2O$. How many moles of the salt do you need? How many grams of the salt do you need?

0.023 mol

You have a 2.5 M solution of $Cu(NO_3)_2 \cdot 6H_2O$. What volume of the solution (in mL) must you measure in order to have 0.50 moles of the salt?

200 mL

You have a 0.75 M solution of $ZnSO_4 \cdot 7H_2O$. What volume of the solution (in mL) must you measure in order to have 32.5 grams of the salt?

Mol amount = 0.11 mol; Vol = 151 mL

4) In your laboratory you will be required to make a solution of 0.25 M $CuSO_4 \cdot 5H_2O$ in a 25.00 mL volumetric flask. This exercise will walk you through the steps involved. After completion, write down the values for your answers in your notebook and take them to the laboratory to use in preparing your solution.

a. What is the formula weight of $CuSO_4 \cdot 5H_2O$?

  249.684 g/mol

b. How many moles of $CuSO_4 \cdot 5H_2O$ are required to make 25.00 mL of a 0.25 M solution?

  0.010 mol

c. What mass of $CuSO_4 \cdot 5H_2O$ will be needed to make this solution?

  1.56 g

d. You will add the salt to a weighing boat, which you determine has a mass of 1.9785 g. What will be the reading on the balance when you have put sufficient $CuSO_4 \cdot 5H_2O$ in the boat?

  3.54 g

Post-Lab Key

Experiment 1

Post-Laboratory Questions

Name: ____________________________ **Date:** __________________

Instructor: _____________________________ **Sec. #:** ___________

Show all work for full credit.

1) Based on your experimental results, does the Law of Conservation of Mass apply to this experiment? Explain.

The answer here will depend on the student's results. If they have a high value of recovery they should indicate that the Conservation of Mass does apply. If they get a lower value of recovery it will most likely lead them to assume that the conservation of mass is not upheld.

2) If the balloon had expanded more how would the mass of H_2 and the mass percent recovered have changed?

Both the mass obtained and the percent recovery would increase.

3) How would increasing the molar concentration of $CuSO_4$ have affected this reaction?

Assuming that there was an excess of zinc, the increase in copper sulfate concentration would lead to a higher product amount but the conservation of mass should stay relatively constant.

4) Zinc metal reacts with acid solution to produce hydrogen gas and zinc ion as follows:

$$Zn(s) + 2H^{+}(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$$

You add 6.825 grams of Zn metal to 29.0 mL of 1.70 M HCl and set up the flask to

catch the hydrogen in a balloon as in the following picture:

How many moles of Zn have you added to the flask?

0.1044 mol

How many moles of H^+ are in the solution?

0.0493 mol

How many moles of Zn will have reacted with the H^+ when the reaction is complete?

0.02465 mol

How many moles of Zn will remain unreacted?

0.07975 mol

What mass of Zn will remain unreacted?

5.214 g

How many moles of H_2 gas will be produced?

0.02465 mol

What mass of H_2 gas will be produced?

0.04969 g

Assuming that one mole of H_2 gas would occupy a volume of 22 L at the temperature and pressure in the balloon, what would be the volume of the balloon?

0.5423 L