CHEM 231

Experiment 4

Determination of a Chemical Formula

You will react metallic zinc with iodine to produce zinc iodide. By carefully accounting for the masses of the reactants and the products of the reaction, it is possible to determine the chemical formula of zinc iodide.

Preliminaries

After reading this entire procedure and making the proper entries in your notebook, you should construct a summary table of reaction masses such as the one shown. Make entries in this table as you determine these quantities in the course of the experiment.

Reaction Masses:

	Mass before reaction	Mass after reaction	Net mass reacted
Zinc (Zn)			
Iodine (I)		0 gram	
Total mass of zinc and iodine reacted			
Final mass of zinc iodide			

Procedure

Step 1: Measuring the reactants

Weigh a clean, dry 125-mL Erlenmeyer flask as precisely as possible on an analytical balance. Record the mass of the empty flask. Preweigh approximately 2.0 g of powdered zinc metal on the weighing paper provided using one of the less precise lab balances. Add the zinc to the Erlenmeyer flask and weigh again on the analytical balance.

In a similar manner, preweigh approximately 2.0 of iodine crystals. Add these to the Erlenmeyer flask containing the zinc and weigh it again precisely on the analytical balance. **CAUTION: Iodine is very corrosive, especially to balance pans. Avoid getting the iodine on the balance and clean up after yourself thoroughly!**

The precise masses should be recorded in a table such as the one shown.

Mass of empty flask	
Mass of flask + zinc	
Mass of flask + zinc + iodine	

Questions

Answer the following questions before continuing:

What is the net mass of the zinc in the flask? Enter the result into the Reaction Masses *table as the mass of zinc before reaction.*

What is the net mass of the iodine in the flask? Enter the result into the Reaction Masses *table as the mass of iodine before reaction.*

Step 2: Reaction of zinc and iodine

Working in the fume hood, obtain 25 mL of methanol, and add it to the Erlenmeyer flask. **(Caution: methanol vapors are flammable and toxic.)** Place an aluminum foil cap on the flask, crimping it around the edges to hold it in place. Place the flask on a hot plate on a low setting in the fume hood. You should see distinct changes indicating the progress of the reaction. After about 15 to 20 minutes, the reaction should be complete. Take care that the methanol solvent does not evaporate completely. If a significant amount does evaporate in the course of heating remove the flask from the hot plate and replenish the methanol solvent. **CAUTION: Do this only if necessary and only at some distance away from the hot plate.**

While the reaction is taking place, weigh a clean, dry 250 mL beaker for use in the next step. You may also work on answering the questions for this section to the extent possible.

When the reaction is complete, remove the Erlenmeyer flask from the hot plate. You may use a folded strip of paper towel wrapped around the neck of the flask to protect your fingers from the heat.

Questions

Answer the following questions before continuing:

Is zinc metal soluble in methanol? How can you tell?

Is iodine soluble in methanol? How can you tell?

Describe the appearance of the methanol solution before reaction.

Describe the appearance of the methanol solution after the reaction.

Is there any solid remaining after the reaction? What is it?

In this experiment, iodine is the so-called limiting reagent. This means that this reactant is completely consumed in the reaction even though some of the other reactant remains. How can you tell that iodine is the limiting reagent?

The product of the reaction between zinc and iodine is soluble in the methanol solvent and produces a colorless solution. How can you tell that this is the case?

All relevant observations concerning the reaction should be entered into your notebook.

Step 3: Separation of the unreacted zinc and the zinc iodide

Pour the warm liquid contents of the flask into the previously weighed 250-mL beaker. Be careful not to let any of the solid zinc particles escape. Use a stirring rod to guide the methanol solution into the beaker as demonstrated by your instructor. (The process of pouring off a liquid from the top of a settled solid is called **decanting**.) Add 5 mL of methanol to the Erlenmeyer flask, agitate to mix it thoroughly with the remaining solid zinc for 15 s. Allow the zinc to settle and decant again, pouring the methanol into the same beaker. Repeat the decanting process at least two more times.

The product of the zinc-iodine reaction, which is soluble in methanol, should now be completely transferred from the Erlenmeyer flask to the beaker. The Erlenmeyer flask contains only unreacted zinc and methanol.

Step 4: Determination of leftover zinc and zinc iodide product

Place the Erlenmeyer flask containing the unreacted zinc back on the hot plate to dry. Leave the foil cap off. The hot plate should be on a medium setting. Also, put the beaker containing the zinc iodide in methanol on the hot plate. Swirl the Erlenmeyer flask containing the zinc occasionally to speed up the drying.

When the methanol has completely evaporated from the flask and the zinc appears dry, remove the flask from the hot plate. Allow it to cool to room temperature (10 to 15 min) in your dessicator.

Question: Does the zinc in the flask look like the same metallic zinc grains you started with? Or do they have a white residue on them? If there is a white residue, you will need to rinse and decant with methanol a few more times and repeat the drying of the zinc. The rinse should go into the same beaker as the previous rinses.

After the flask containing the zinc has cooled, reweigh it on the analytical balance. Record the mass.

Meanwhile, continue heating the beaker containing the methanol and the zinc iodide product. If it shows a tendency to boil irregularly or spatter, stir it occasionally with a glass stirring rod until the methanol has nearly all evaporated. It normally takes about 25 minutes to completely evaporate the methanol. When the last traces of methanol have completely disappeared, allow the beaker to heat 2 min more; then remove it from the hot plate. Allow the beaker to cool to room temperature in your dessicator for 15 minutes.

You should see a residue remaining in the beaker. This is the product of the reaction between zinc and iodine. Weigh the beaker containing the dry zinc iodide on the analytical balance and record the mass.

Questions

Answer the following questions before continuing:

Subtract the mass of the empty Erlenmeyer flask from the mass of the flask containing the leftover zinc. This is the net mass of the remaining zinc metal. Enter this into the space for zinc – after reaction – into the summary table of Reaction Masses*.*

Subtract the mass of the empty beaker from the mass of the beaker with the white residue. Enter this into the Reaction Masses *table as the final mass of the zinc iodide product.*

Finish filling in the Reaction Masses *table. The mass of zinc reacted must be the difference between the zinc before the reaction with and the zinc left over after the reaction. Because iodine was the limiting reagent, there should have been none left over; the mass of iodine reacted will be the same as the mass of iodine before the reaction.*

Add the masses of the zinc and iodine reacted in the last column of the Reaction Masses *table. Is this the same as the mass of the zinc iodide product? Do the results confirm the conservation of mass? If there is a difference, to what do you attribute the error?*

Analysis (Option 1)

This procedure presents two ways to analyze the outcome of this experiment. Your instructor will tell you which to use. If he or she chooses Option 2, go to the next section.

Copy the net masses reacted from the *Reaction Masses* table into a table such as the one shown below. Look up the atomic weights of zinc and iodine in the periodic table and enter them into the table. Use these to calculate the number of moles of iodine and zinc and enter these results into the table.

	Net mass reacted (g)	Atomic weights (g/mole)	Moles of reactants
Zinc (Zn)			
Iodine (I)			

Divide the moles of iodine by the moles of zinc: $mole\ ratio = \frac{mole\ I}{mole\ Zn}$. This ratio should correspond to the formula of zinc iodide.

Questions

From what you have learned in class, you should be able to determine the formula of zinc iodide. If not, look it up. What is it?

Does the mole ratio of iodine to zinc give the result you expect from the formula of zinc iodide? If not, how do you explain the difference?

Analysis (Option 2)

Imagine that you are an early chemist trying to determine the mass of an atom of iodine, a new element that you have discovered. The properties of zinc are well known to you. Specifically, zinc has a mass of 65.39 on the scale of atomic masses and it has a "valence" of 2. (This corresponds to its charge in ionic compounds. As early chemists, we don't yet know about ions.) The formula the compound made from zinc and iodine is either ZnI (if this new element, iodine, has a valence of 2) or ZnI_2 (if iodine has a valence of 1). On the basis of other physical and chemical properties of iodine, we believe that its atomic mass is less than 175 mass units.

Questions

From the net masses in the Reaction Masses table divide the iodine mass by the zinc mass to find the I/Zn ratio: $mass\ ratio = \frac{mass\ I}{mass\ Zn}$.

If one zinc atom weighs 65.39 mass units, find the mass of iodine atoms combining with one zinc atom by using the mass ratio calculated above:

$$mass\ I\ atoms = (mass\ ratio) \times 65.39$$

This either represents the mass on one iodine atom (if the formula is ZnI) or two (if the formula is ZnI_2*).*

Assuming that iodine atoms weigh less than 175 mass units, what can you conclude about the mass of an iodine atom and the formula of zinc iodide?

Does this result correspond to the known mass of iodine from the periodic table? If not, can you explain the discrepancy?