The Empirical Formula of Zinc Chloride

# Introduction

Chemistry is the study of the properties and composition of matter, and how properties change under different conditions. The composition of a pure substance is summarized by its chemical formula, which lists the types and number of each element in the substance.

A chemical formula can be one of two types: an empirical formula or a molecular formula. An empirical formula shows the simplest whole number ratio of the elements in the compound; a molecular formula shows the actual number of each element in a molecule. For example, the molecular formula of hydrogen peroxide is H2O2, but the empirical formula is HO, since for each hydrogen atom there is one oxygen atom. It is also worth noting that not all substances have a molecular formula. Table salt, for example, is an ionic crystal with equal numbers of sodium and chlorine (empirical formula NaCl), but as a crystal, table salt does not consist of sodium atoms unique bonded to specific chlorine atoms. It would be like trying to identify unique pairs of black and white squares on a chess board.

Chemists use the structure of the periodic table and theories of ions and charge to predict the chemical formulas of substances, and the theories are so well established that predictions of chemical composition are almost always correct. But it is important to remember that chemical formulas are determined from experimental data. Water doesn’t have the formula H2O because of the placement of hydrogen and oxygen on the periodic table, or the theory that hydrogen forms ions with +1 charge and oxygen with -2 charge. The formula for water is H2O because when we decompose water into is elements and measure the masses of hydrogen and oxygen produced, we discover that there are twice as many atoms of hydrogen as oxygen in the decomposed sample.

In this experiment, we determine the empirical formula of a pure compound by dissolving zinc metal in hydrochloric acid and evaporating the solution to retrieve the product, zinc chlorine. The moles of zinc are calculated from the mass of the metal in the trial. The mass of chorine in the sample is determined by subtracting the mass of zinc from the mass of the product. The moles of chlorine are found from the mass of chlorine and its molar mass. The empirical formula is deduced from the simplest mole:mole ratio of the two constituents.

# Materials and Methods

Zinc powder

6 M HCl – Corrosive, Poisonous, Toxic

10 mL beaker

Hot plate

# Procedure

Because hydrogen gas is flammable, the reaction takes place in a fume hood.

1) Weigh a 10-mL beaker to the closest 0.001 gram on an electronic balance. Record the mass on the Report Sheet then ‘zero’ the balance with the beaker still on it.

2) Add approximately 0.1 g of zinc measured to the closest 0.001 gram on the balance and record the mass on the Report Sheet. The mass of zinc should not exceed 0.110 g Zn (10% excess), but it can also be slightly less than 0.100 g.

3) Obtain 5.0 ml of 3.0 M HCl solution in a 10-mL graduated cylinder and pour it into the beaker. Place the beaker on a hot plate and begin heating the solution on medium-high heat.

Hydrogen gas bubbles will be produced at the zinc as the metal dissolves; the solution will begin evaporating. Heat the mixture so that a vigorous reaction can be seen at the surface of the zinc powder, but not so hot that the solution boils.

4) If the zinc has not completely dissolved when the total volume of solution reaches around 1.0 mL (about 2 mm of depth), then add approximately 1 mL of the acid solution to continue the dissolving process. The total time to react all the zinc may be 8 – 10 minutes.

5) After all the metal has dissolved (no visible gray powder), continue heating the solution to complete the evaporation. Crystals will begin to form at the bottom of the beaker: keep heating until the product appears dry (not shiny).

6) Let the beaker cool for a few minutes then weigh it again on a balance to the closest 0.001 gram. (Zinc chloride is very hygroscopic, so if too much time passes then the sample will begin to absorb water from the air and dissolve.)

7) Dispose of the zinc chloride crystals in the labeled container.

# Data and Results

1) Use the atomic mass of zinc, 65.39 g/mol, to calculate the moles of zinc.

2) Subtract the mass of the beaker plus product from the mass of the beaker to find the mass of the product. Then subtract the mass of zinc in the product from the mass of the product to find the mass of chlorine in the product.

3) Use the atomic mass of chlorine, 35.45 g/mol, to calculate the moles of chlorine in the product.

4) To find the simplest whole number ratio between the moles of zinc and the moles of chlorine, write the two molar amounts as:

mol Zn: mol Cl = x.xx: y.yy

where x.xx and y.yy are the number of millimoles of zinc and chlorine, respectively.

5) Divide both numbers by the *smaller* amount. Report the values as 1:00:z.zz, *or* z.zz:1.00, depending on which molar amount was the smallest.

6) Round the decimal to the closest integer and record the ratio on the line of the Report Sheet.

7) Report the empirical formula of zinc chloride on the Report Sheet.

If the second value ends in 0.5 or a decimal close to it, multiply both numbers by 2 to determine the simplest whole number ratio.