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Synthesis of Manganese(II) Chloride

Mole Relationships and the Balanced Equation

Introduction

Students learn in different ways. By varying your teaching style you can help students sharpen their learning skills. Use the technique of the silent lecture to demonstrate the various factors that effect reaction rates.

Concepts

- Density
- Combustion

Background

In this experiment you will synthesize manganese(II) chloride by allowing a known mass of manganese metal to react with an excess of hydrochloric acid. From the theoretical yield (calculated from the mass of metal used) and the actual mass of product recovered, you will calculate the percentage yield. The balanced equation for the reaction is:

$$Mn(s) + 2HCl(aq) \rightarrow MnCl_2(aq) + H_2(g)$$

According to the equation, 1 mole (54.94 g) of manganese will generate precisely 1 mole (125.84 g) of manganese(II) chloride. These relative masses must apply regardless of the actual mass of manganese used.

Evaporation of the solution remaining in the flask after reaction will yield solid manganese(II) chloride. The product is very hygroscopic (water absorbing), so it will be necessary for it to cool in a location that will not allow absorption of atmospheric moisture. Such dry-atmosphere cooling chambers are called desiccators.

Experiment Overview

1. Synthesize manganese(II) chloride, using manganese metal and hydrochloric acid.
2. Determine the theoretical yield, based on the mass of manganese used.
3. Determine the percentage yield, by comparing the theoretical yield with the actual yield.

Pre-Lab Questions (optional)

1. Explain the difference between theoretical yields and actual yields.
2. Why is it important for the manganese to react entirely before proceeding at step 5?
3. What is a desiccator, and why is it needed in this experiment?
4. If 10 M HCl(aq) accidentally spills or splashes on your skin or clothing, describe in detail what you should do. What, if anything, would you do differently if the acid spilled on the surface of the lab bench or hood?
5. When you are done with the manganese(II) chloride, how should you dispose of the product?

Materials

Hydrochloric acid, 10 M, 1.5 mL	Erlenmeyer flask, 10-mL
Manganese metal, 0.1 g	Milligram balance
Apparatus	Reagents
Boiling stone	Sand bath
Desiccator	Tongs or forceps for handling (hot flask)

Safety Precautions

10 Molar hydrochloric acid is severely corrosive to all body tissues, especially skin and eyes. Inhalation of the concentrated solution vapor may cause lung and throat irritation; it is toxic by ingestion and inhalation. Perform this experiment in a well-ventilated area or fume hood. Avoid contact of all acid solutions with eyes, skin, and clothing. The sand bath will be hot (>200 ºC), avoid skin contact. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Check that the sand bath is on and the controller is set at 40% power.
2. Add a small boiling stone to a labeled 10-mL Erlenmeyer flask and determine the mass of the flask. Place about 0.05–0.1 g of manganese metal in the flask; then reweigh the flask with the boiling stone and the metal. Record both masses in the Data Table.
3. Bring your flask to the fume hood and add about 1.5 mL (estimated) of 10 M hydrochloric acid, HCl(aq).
4. Allow the acid to react with the metal until the sample has dissolved completely (about 5 to 15 minutes). All the manganese must be converted to manganese(II) chloride before you begin the evaporation. During the dissolving process, try to determine whether the reaction is exothermic or endothermic.
5. Place the flask on the hot sand bath to evaporate the water and unreacted HCl. Continue until the water has entirely evaporated, leaving only a pinkish-white solid residue. If droplets persist on the flask walls, use tongs to lay the flask carefully on an angle, with the lip of the flask on the rim of the sand bath.
6. When the flask is thoroughly dry, use tongs or a hot-pad to remove it from the sand bath to a place where it can cool for 5–10 minutes. A desiccator made from a large coffee can with a drying agent in the bottom is ideal. The drying agent keeps the product from absorbing moisture from the air.
7. After the flask has cooled to room temperature, determine the mass of the flask and product.
8. Return the flask to the hot sand bath for an additional 3–5 minutes heating. Cool the flask in the desiccator, then measure its mass and record it in your Data Table. Ideally, this mass should agree to within 0.003 g of the previous weighing.
9. Dispose of the contents of the flask as directed by your teacher.

Name: ____________________________________

Synthesis of Manganese(II) Chloride Worksheet

Data Table(s)

Mass of empty Erlenmeyer flask (with boiling stone):	__________ g
Mass of Erlenmeyer flask and manganese metal:	__________ g
Mass of flask and manganese(II) chloride (step 7):	__________ g
Mass of flask and manganese(II) chloride (step 8):	__________ g

Calculations and Post-Lab Questions

1. Calculate the mass and the number of moles of manganese metal used.

   Mass of Mn used __________ g

   Moles of Mn used __________ mol

2. Use the final mass of the flask and product to find the mass and number of moles of manganese(II) chloride produced. This is your actual yield.

   Mass of $MnCl_2$ __________ g

   Moles of $MnCl_2$ __________ mol

3. Calculate the mass of manganese(II) chloride you would expect to produce from the mass of manganese metal that you began with. This is your theoretical yield.

   Theoretical yield of $MnCl_2$ __________ g

4. Determine the percent yield of manganese(II) chloride.

   Actual Yield __________

   Theoretical Yield __________

   Percent yield of $MnCl_2$ = __________%

5. Predict the effect on your yield for the following procedural errors. In each case, will the reported mass of manganese(II) chloride be too high or too low? Give a reason for each answer.

   a. The manganese metal used was impure; it had a coating of manganese oxide.

   b. Some of the solution was lost during evaporation because of spattering.

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c. The water was not completely evaporated.

d. During cooling, the flask was left in the open air instead of in a desiccator.

6. Was your percent yield greater than or less than 100%? Suggest one or more possible explanations for any variation from 100% yield. You are not limited to the choices given in question 1. Base your answer on your own experience doing the experiment.

7. Explain how you arrived at the number of significant figures you show for your percentage yield.

Teacher's Notes
Synthesis of Manganese Chloride

Materials *(for a class of 30 students working in pairs)*

Hydrochloric acid solution, 10 M, 50 mL
Manganese metal, Mn, 3 g
Boiling stones
Desiccator
Erlenmeyer flasks, 10-mL, 15
Graduated cylinder, 100-mL
Mortar and pestle or hammer
Ring stands and clamps, 3*
Sand baths, 3*
Thermometers, 0–200 ºC, 3*
Tongs or forceps, 15

* Three sand bath set ups should accommodate 10 working groups.

Pre-Lab Preparation

Manganese metal – Break up large manganese pieces into smaller pieces using a hammer ot mortar and pestle.

10 M HCl – Prepare 100 mL of 10 M HCl by adding 83 mL of concentrated HCl, slowly and with stirring, to 17 mL of distilled or deionized water. The ideal dispenser is an acid dropping bottle, with ground glass stopper and a test tube taped to the side to hold a dropper.

Safety Precautions

10 Molar hydrochloric acid is severely corrosive to all body tissues, especially skin and eyes. Inhalation of the concentrated solution vapor may cause lung and throat irritation; it is toxic by ingestion and inhalation. Perform this experiment in a well-ventilated area or fume hood. Avoid contact of all acid solutions with eyes, skin, and clothing. The sand bath will be hot (>200 ºC), avoid skin contact. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Remind students to wash their hands thoroughly with soap and water before leaving the laboratory. Please consult current Material Safety Data Sheets for additional safety, handling, and disposal information.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Have the students to pour their manganese chloride wastes into one waste container. The waste manganese chloride solid may be disposed of according to Flinn Suggested Disposal Method #27f.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure of atoms, structure and properties of matter, chemical reactions

Lab Hints

- The experiment can be completed in a 50-minute period if 10-mL Erlenmeyer flasks are used. The shape of the flask reduces (but does not entirely eliminate) spattering. To further minimize loss due to spattering, students are directed to include a boiling stone in the initial weighing of the flask.
- The flask can sit on the surface of the sand (it should not be immersed) throughout most of the heating. Water droplets clinging to the sides of the flask can be evaporated by leaning the flask on its side, with the lip resting on the side of the bowl. The flask is rotated about a quarter turn every 30 seconds or so until evaporation is complete.
- While a centigram balance will do, milligram is much to be preferred. If centigram is what you have, increase the mass of manganese to 0.7–1.0 g; this will retain the two digit precision. Use of the larger mass significantly affects the time needed to dissolve the metal sample. In such cases, it is best to complete the experiment through step on the first day, then complete the experiment during the following lab period.
- A simple desiccator can be made from a 2–3 lb coffee can with about a centimeter of Drierite (or 4-mesh anhydrous calcium chloride) on the bottom. Remind students that the flask will need to be labeled for identification before the first weighing, so that the label will not introduce errors.
- Dissolving times run from 5- to 15 minutes, assuming students use the suggested mass of manganese. Occasionally, the dissolving results in emission of hydrogen sulfide gas, due presumably to traces of manganese sulfide on the chips. For this reason, and because of occasional off-gassing of HCl(g), an efficient fume hood should be available.
- The product is nearly white with a pale pinkish cast. It is quite hygroscopic, with the hydrated form having a more distinctly pink color. Some hydration between heating and weighings is almost unavoidable, and of the sources of experimental error listed in the Conclusions, it is the only one that leads to yields >100%. Anhydrous manganese(II) chloride is quite thermally stable, so the decomposition referred to is not likely to occur.
- An effective and safe sand bath can be assembles using fine white sand and a crystallizing dish (See Figure 1.).

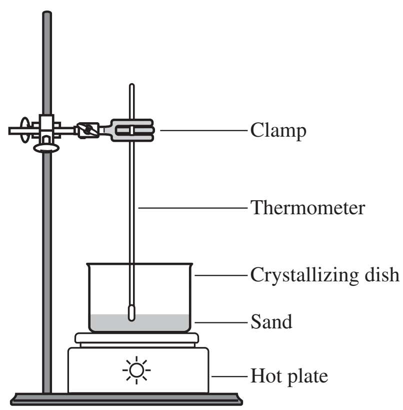

Figure 1.

A shallow layer of sand, no more than a 10–15 mm depth, should be added to the crystallizing dish. When heated, the temperature of the sand steeply rises as you go deeper into the sand layers. Having only a shallow layer of sand and a thermometer to monitor the bath temperature will prevent the lower layers from posing a serious hazard. The high sides of the dish block air drafts from cooling the sides of the flasks.

Answers to Post-Lab Questions *(Student answers will vary.)*

1. Mass is found by subtraction (Data Table, line 2 – line 1). Divide by molar mass of Mn to convert to moles.
2. Mass is found by subtraction (Data Table, line 4 – line 1). Divide by molar mass of $MnCl_2$ to convert to moles.
3. (mass of Mn used) × (125.9 g $MnCl_2$/54.9 g Mn) = theoretical yield.
4. Equation for percent yield is given in student version.
5. *a.* Too low; the original sample was not entirely Mn, so less $MnCl_2$ can be produced.

   b. Too low; product is lost.

   c., d. Too high; in both cases, the observed mass includes water.
6. (Student answers) Should fit their results and be realistic. Do not accept explanations involving improper technique, calculation errors, etc.
7. The number of significant figures will probably be two, three at the most. The mass of manganese metal is going to determine how many digits are allowed.

Reference

This experiment is based loosely on the macroscale experiment found in *Heath CHEMISTRY* (Herron, et al), D.C. Heath, 1988. It was first converted to small-scale by Jim Tarnowski, then of Avon H.S., Indianapolis, IN, and the idea of using the sand bath is his. Additional modifications were made by John Little.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Synthesis of Manganese(II) Chloride* activity, presented by Bob Lewis, is available in *Mole Relationships and the Balanced Equation,* part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Synthesis of Manganese(II) Chloride* are available from Flinn Scientific, Inc.

Catalog No.	Description
GP9172	Crystallizing Dish, 150mm × 75mm
S0003	Sand, Fine White
GP9166	Erlenmeyer Flask, Borosilicate, 10-mL
M0130	Manganese, Chips
H0031	Hydrochloric Acid, 12M, 100 mL
AP8559	Flinn Digital Thermometer, -50ºC to +200ºC

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.

