THE LAW OF DEFINITE AND MULTIPLE PROPORTIONS

AP CHEMISTRY LAB/ A. COLLINS 2013/14 97 POINTS

Joseph Proust first proposed the Law of Definite Proportions in 1799. It states that a pure compound always consists of the same elements combined in the same proportion by mass. In this experiment, you are going to confirm this law by preparing a manganese-chlorine compound. You will dissolve manganese metal in hydrochloric acid. From the mass of each element reacted, you can calculate the ratio of atoms which have combined. From the ratio of the atoms combined, you can calculate the "empirical" or simplest formula.

There are two ways to represent the formula for a compound. The first type of formula is called the empirical formula, which is simplest formula possible for the compound. It consists of the whole number ratio of the atoms, which have combined chemically. The second type of formula of a compound is called the molecular formula. It represents the actual ratio of the different kinds of atoms present in the compound. For example, the empirical formula of benzene, is C_1H_1, and its molecular formula is C_6H_6. In order to determine the molecular formula for a compound, you must know both its empirical formula and its molecular weight. For example, benzene has a mass of 13.02 g/mole according to its empirical formula of C_1H_1 (one atom of carbon @ 12.01 g/mole and one atom of hydrogen @ 1.01 gram/mole) and a molecular weight of 78.12 grams/mole (6 atoms of carbon, plus 6 atoms of hydrogen). The ratio of the molecular weight to the empirical formula weight is 6:1 (78.12/13.02 = 6) Therefore, the actual ratio of the atoms or molecular formula of benzene is six times C_1H_1 or C_6H_6.

PURPOSE: (5 PTS)

INQUIRY IDEAS/PRE LAB QUESTIONS: (16 pts)

1. Do a little research about manganese/chlorine compounds. What are the common oxidation states (charges) for manganese? Cite your source. (4 pts)
2. What form of Mn_xCl_y do you think you will make in this lab? What will it physically look like? Support your reasoning and cite your source! (4 pts)
3. What will a properly balanced equation look like for this reaction? (2 pts) Also, include a written word equation for this reaction. (2 pts)
4. In a laboratory setting Cu (s) was reacted with I2 (s). Calculate the empirical formula of an iodide of copper that contains .098 grams of copper and 0.190 grams of iodine. Be sure to show all of your work and to include the proper significant figures. (4 pts)

MATERIALS:

Powdered Manganese, Mn(s)	Beral pipette	10.0 molar hydrochloric acid
18 X 150 mm test tube	scoopula	Bunsen Burner
test tube clamp	Test tube rack	Fume Hood

SAFETY:

Caution: Manganese metal powder is toxic. Please be very careful when measuring the mass of the powder. If you spill any powder, wipe it up with a wet soapy sponge. Rinse the powder off the sponge before putting the sponge back in the soapy water.

Caution: 10 M HCl is very dangerous and corrosive. If you spill any acid, neutralize with baking soda and clean up with a soapy sponge. When reacting and heating the Mn metal,
carry out the entire process in a chemical fume hood. Do not breathe the vapor or evaporating liquid. It will contain acid fumes.

Caution: Do not touch the test tube as you carry out the reaction or heat it in the flame. It will become quite hot during the experiment. Use a test tube clamp to hold the test tube.

Caution: When heating the test tube in the Bunsen burner, be sure to aim the opening of the tube away from yourself and others. Do not blast the product intensely with the flame. Slowly heat the entire length of the test tube.

PROCEDURE: (10 PTS)

1.
Find the mass of a large (18 x 150 mm) clean, dry test tube. Add manganese metal powder to the test tube until its mass increases by 0.150 to 0.200 grams. Record these mass measurements.

2.
Using test tube tongs in the fume hood, carefully add 5 drops of 10.0 molar hydrochloric acid to the manganese metal. When the reaction subsides, add another 5 drops of hydrochloric acid. Continue to add the hydrochloric acid in five-drop increments until the reaction no longer effervesces or you have added a total of 30 drops of acid. Observe the temperature of the test tube. Look for the presence of unreacted Manganese.

3.
When the reaction is complete, light a Bunsen Burner and *slowly* heat your product to dryness. Be sure to aim the opening of the tube away from yourself and others. Do not blast the product intensely with the flame. Slowly heat the entire length of the test tube. Listen to the test tube. It will sizzle or crackle as the water leaves the hydrate. Continue heating *gently* for one minute after it no longer makes noise to be certain all the water has been driven from the salt. Using a test tube clamp, remove it from the hood and place it on the cool lab bench. Leave the clamp attached so the test tube does not roll off on to the floor. The bench will act as a heat sink, conducting the heat away from the test tube.

4.
Once the test tube has cooled, measure the mass of the test tube containing the dried salt to the precision of your available balance.
5.
Repeat the heating and cooling process until the mass of the test tube and its contents are somewhat constant. That is, the mass has not changed by more than 0.010 grams between measurements.
6.
If time allows, repeat your experiment.
7.
When you are finished with lab, be sure to rinse the product out of the test tube and clean it with a test tube brush. Wash down your lab station and be sure to wash your hands before leaving lab.

SAFETY DATA/PHYSICAL DATA: (10 PTS)

DATA: (7 PTS)
What did you measure?
What measurements will be necessary to determine the empirical ratio of Manganese to Chlorine?
This is what should appear in your data table!

OBSERVATIONS: (5 PTS)

CALCULATIONS: (10 PTS)
A) Calculate the mass of manganese metal.
B) Calculate the mass of the manganese chloride.
C) Calculate the mass of chlorine, which has combined with Mn.
D) Calculate the number of moles of manganese metal, which has reacted.
E) Calculate the number of moles of chlorine, which has reacted.
F) Calculate the ratio of the number of moles of Manganese to Chlorine. In this calculation, make Mn the denominator. In other words, express chlorine as a multiple of the Mn. Be sure to let the limitations of the equipment decide how many decimal places are in your ratio.

CONCLUSION: (2 PTS)
State yours.

ERROR ANALYSIS: (10 PTS)
- The accepted value for the formula of Mn to Cl is (?) You can ask me when you have figured out your ratio.
- How does your formula compare?
- Is it chlorine heavy or chlorine light?
- What is your percent error - based on your ratio of chlorine?
- Is it minorly flawed or significantly flawed?
- Create a logical argument, which is supported by something you observed. This point of argumentation could be a procedural error or a limitation of the procedure. How does this procedural error/limitation account for your ratio being something other that the accepted one? Can you quantify how much your stated errors actually manifest themselves in your final result? Dig deep on this one. It is tough to do!

POST LAB QUESTIONS: (22 points)
1.
According to your observations, what evidence is there that a chemical reaction has taken place? (3 pts)
2.
According to your results, how does the mass of product (manganese chloride) compare with the mass of manganese metal reacted? How do you explain the difference (gain in mass)? (3 pts)
3.
If your test tube was not properly dry after step 5 of the procedure, how would this affect the ratio of your final empirical formula? Be sure to explain in great detail. (6 pts)
4.
Which expression best describes this chemical reaction;
- ☐ endothermic and spontaneous,
- ☐ endothermic and non spontaneous,
- ☐ exothermic and spontaneous,
- ☐ exothermic and non spontaneous?

Be sure to include in your response specific things you observed that support your answer. (4 pts)
5.
When massing your powdered manganese, you (hypothetically) dropped a little bit outside of the test tube, but it still landed on the balance pan. How would this affect the mathematical ratio of your final empirical formula? Be sure to explain in great detail. How would this error actually affect the ratio of the final product? Details please. (6 points)