Activity 13 - Measuring Mass: A Means of Counting[1]

Goals

- Properly use a top loading balance to determine the mass of a sample.
- Use molar masses to connect the measured mass of a sample to the number of particles in that sample.
- Use safe lab techniques to characterize matter.
- Apply principles to samples of both pure substances and mixtures.
- Apply dimensional analysis techniques to count small particles such as atoms and molecules.

Pre-Lab Lecture Questions. *Answer these questions on a separate sheet using complete sentences.*

1. What is the difference between weight and mass? How do you "properly" use a balance in the laboratory?
2. What determines the number of significant figures/digits in a measurement?
3. What determines the number of significant figures/digits in a calculation?
4. What is molar mass?
5. What is Avogadro's number?
6. Write as many different conversion factors as you can using the chemical formula of water, the molar mass of water, the definition of a mole, and Avogadro's number.
7. Read through the experimental procedure and classify substances as either pure or a mixture.

Concepts to Review

Classification of Matter: What is a pure substance (element, atom, molecule, compound?) and what is a mixture?
Significant Figures/Digits
Chemical Formulas
Unit Conversion Methods (Dimensional Analysis describing Atoms, Molecules and Ions)

Introduction

Our world contains groupings of objects everywhere: a dozen eggs, a pair of socks, a gross of pencils. These collections are convenient "packets" of individual pieces. The individual "pieces" of pure substances can be described by chemical formulas, e.g., H_2O is the chemical formula for water. This formula indicates that each molecule of water consists of two atoms of hydrogen combined with one atom of oxygen. The mass of this molecule is the sum of the masses of the atoms combined to form this compound. We cannot directly measure the mass of one molecule of water but we can recognize its relative mass and use a convenient "packet" of molecules to describe real world quantities. The **mole** is the chemist's standard collection of particles and is defined **as the amount of substance in a sample that contains as many units as there are atoms in exactly 12 grams of carbon-12**. That number of carbon-12 atoms is $\mathbf{6.022 \times 10^{23}}$ and is known as **Avogadro's number**.

1 mole carbon atoms = 12.0 g C = 6.022×10^{23} atoms C

1 mole H_2O = 2(1.008 g H) + 1(16.00 g O) = 18.02 g H_2O = 6.022×10^{23} molecules of water

Using these relationships, any mass of water can be converted into a number of molecules:

[1] Adapted from: Waterman, E. L. *Chemistry: Small-Scale Chemistry Laboratory Manual;* Addison-Wesley/Prentice-Hall, Inc.: Upper Saddle River, New Jersey, 2002; pp 59-62.

$$100.00 \text{ g } H_2O \left(\frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O} \right) \left(\frac{6.022 \times 10^{23}}{1 \text{ mol}} \right) = 3.34 \times 10^{24} \text{ molecules } H_2O$$

In this lab you will measure amounts of substances. You will then calculate the number of particles contained in the sample, numbers that cannot be counted—only calculated.

Safety

Act in accordance with the laboratory safety rules of Cabrillo College.
Wear safety glasses at all times.
Avoid contact with all chemical reagents and dispose of reactions using an appropriate waste container.

Materials:

Reagent Central solutions include:

Sucrose ($C_{12}H_{22}O_{11}$), sodium chloride (NaCl), chalk (calcium carbonate)

✓**Check out** a sample containing:

Glass slides (assumed to be pure silicon dioxide), polystyrene peanuts, sulfur, fluorite, hematite, (or other minerals as provided by stockroom)

Equipment: Balance Plastic spoons

Experimental Procedure

1. Using a weighing paper or boat and balance, "weigh" one level teaspoon of sodium chloride and record its mass in your laboratory notebook and/or Table 1. This mass is the mass of your "sample." Using the same balance, measure the mass of one teaspoon of water and one of sucrose.
2. "Weigh" a glass slide, and record its mass in your laboratory notebook and/or Table 2. Repeat for the piece of chalk and a polystyrene peanut.
3. "Weigh" a piece of sulfur, and record its mass in your laboratory notebook and/or Table 3. Repeat for a piece of fluorite and a piece of hematite.
4. A nickel coin is a mixture of metals called an alloy. It consists of 75% copper and 25% nickel. Design and carry out an experiment to find out how many nickel atoms there are in one 5-cent piece. Record your experiment procedure in your laboratory notebook and/or in Table 4. Show all your calculations and give your final answer with the correct number of significant figures and in scientific notation.

Chemical Calculations

For each of the masses recorded:

1. Use the formula (see below) to determine the molar mass in units of g/mol.
2. Use the molar mass to determine the number of moles.
3. Use the number of moles of the substance and molar ratios to calculate the moles of each element.
4. Use the moles of each element in each sample along with Avogadro's number to calculate the number of atoms of each element.
5. Use the above calculations as a model to help you determine the number of nickel atoms in one 5-cent piece.

   Make sure your worksheet is complete, legible and turned in on time.

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Name_____

Section_____ **Date**_____

Experimental Data and Calculations

1. Complete the following tables:

Table 1. Counting Particles in Common Substances

Formula	Name	Sample Mass (g)	Molar Mass (g/mol)	Moles in sample	Moles each element in sample	Atoms each element in sample
NaCl						
	Water					
$C_{12}H_{22}O_{11}$						

Table 2. Counting Particles in Common Items.

Formula	Name	Sample Mass (g)	Molar Mass (g/mol)	Moles in sample	Moles each element in sample	Atoms each element in sample
SiO_2 (molecule)	Glass slides					
$CaCO_3$ (formula unit)	Chalk					
$C_{8000}H_{8000}$ (molecule)	Polystyrene					

Table 3. Counting Particles in Minerals.

Formula	Name	Sample Mass (g)	Molar Mass (g/mol)	Moles in sample	Moles each element in sample	Atoms each element in sample
S_8 (molecule)						
CaF_2 (formula unit)	Fluorite					
Fe_2O_3 (_____)	Hematite					

Table 4. Counting the Atoms of Nickel in a Nickel

Describe your experimental procedure:
Show all the steps of your calculations and your final answer including the correct number and units: