

Experiment 8 The Mole!

Skills

- Completing calculations involving Avogadro's number
- Understanding the concept of a mole

Relevant Reading

Hein & Arena: 7.1–7.2

Introduction

Avogadro's number is the number of atoms in a 12 g sample of carbon: 6.022×10^{23} . A mole is a collection of Avogadro's number of objects. Because atoms and molecules are so small, laboratory scientists often work in units of moles rather than numbers of atoms or molecules. The molar mass of an atom or compound is the mass of one mole. The molar mass of atoms is given in atomic mass units, which are equivalent to 1 g/mol.

In this lab, you will get familiar with the concept of a mole and its quantity. You will determine the identity of 1-mole samples of metals based on their mass. Using the volume of the samples, you will calculate the approximate volume of an atom. The general equations are as follows

$$\text{mass of an atom} = \frac{\text{mass of 1 mole}}{\text{Avogadro's Number}}$$

$$\text{volume of an atom} = \frac{\text{volume of 1 mole}}{\text{Avogadro's Number}}$$

The Factor-Label method shows how these equations make sense in terms of units. Consider the following example:

$$\text{mass of 1 carbon atom in a diamond} = \frac{12.01 \text{ g}}{6.022 \cdot 10^{23} \frac{\text{g}}{\text{mol}}} = 12.01 \text{ g} \cdot \frac{\text{mol}}{6.022 \cdot 10^{23} \text{ g}} = 1.931 \cdot 10^{-23} \text{ g}$$

Name: _____

Pre-Lab

1. Calculate the mass of a single sodium atom.

2. Diamond is pure, solid carbon. It has the density of 3.5 g/cm^3 .
 - a. What is the mass of 1 mole of carbon atoms.

 - b. What is the volume of 1 mole of carbon atoms.

 - c. What is the volume of 1 carbon atom in a diamond?

3. Procedure

Molar Mass

There are three 1-mole samples of pure metals. In this section of the lab, you will identify each of the metals by measuring their mass.

1. Use your periodic table to fill in the blank information in table 1 below.
2. Mass the three samples and record the data in table 2.
3. Identify the samples based on their mass in table 2 and complete the information in the table.

Table 1: Metal Data

| | | | | | |
|---------------------------|------|----|-------|-----|----|
| Metal | Gold | | | Tin | |
| Symbol | | Fe | | | Cu |
| Molar Mass (g/mol) | | | 26.98 | | |

Table 2: Masses and Identities of 1-mole Samples of Unknown Metal

| | | | |
|---------------------------|---|---|---|
| Sample Number | 1 | 2 | 3 |
| Measured Mass (g) | | | |
| Metal | | | |
| Element Symbol | | | |
| Molar Mass (g/mol) | | | |

Approximating the Volume of an Atom

1. Fill a graduated cylinder part way with water.
2. Record the volume of the water.
3. Submerge the metal sample in the water and note the new volume.
4. Calculate the volume of the metal sample.
5. Note that $1 \text{ mL} = 1 \text{ cm}^3$.
6. Assume the sample is exactly 1 mole of atoms. Calculate the approximate volume of one atom of that metal.

Table 3: Volume Measurements and Calculations in cm^3

Grey areas denote calculated values

| Sample Number | 1 | 2 | 3 |
|---------------|---|---|---|
| Water | | | |
| Water + Metal | | | |
| Metal | | | |
| Atom | | | |

Determining the Number of Atoms in a Sample

There are two samples that are not calibrated to be equal to 1 mole of atoms. Using the molar mass, you will determine the number of atoms in each sample.

1. Mass each sample and record the mass below.
2. Use the molar mass of the sample to calculate the number of moles.

Table 4: Mass Measurements and Calculations for Tin and Aluminum

Grey areas denote calculated values

| Sample | 4: Tin | 5: Aluminum |
|---------------------|--------|-------------|
| Mass of Sample (g) | | |
| Molar Mass (g/mol) | | |
| Mass of an Atom (g) | | |

Name: _____

Lab Partner: _____

Post-Lab**Results**

Table 1: Metal Data

| | | | | | |
|---------------------------|------|----|-------|-----|----|
| Metal | Gold | | | Tin | |
| Symbol | | Fe | | | Cu |
| Molar Mass (g/mol) | | | 26.98 | | |

Table 2: Masses and Identities of 1-mole Samples of Unknown Metal

| | | | |
|---------------------------|---|---|---|
| Sample Number | 1 | 2 | 3 |
| Measured Mass (g) | | | |
| Metal | | | |
| Element Symbol | | | |
| Molar Mass (g/mol) | | | |

Table 3: Volume Measurements and Calculations in cm³

Grey areas denote calculated values

| | | | |
|----------------------|---|---|---|
| Sample Number | 1 | 2 | 3 |
| Water | | | |
| Water + Metal | | | |
| Metal | | | |
| Atom | | | |

Calculation of Volume of Atom for Sample 1:

Table 4: Mass Measurements and Calculations for Tin and Aluminum

Grey areas denote calculated values

| Sample | 4: Tin | 5: Aluminum |
|---------------------|--------|-------------|
| Mass of Sample (g) | | |
| Molar Mass (g/mol) | | |
| Mass of an Atom (g) | | |

Calculation of Mass of a Single Tin Atom:

Discussion

- 1) Consider the proximity of molecules and atoms in different phases. Explain why we cannot use the density of a gas to approximate the volume of a molecule.

- 2) Would you prefer to conduct laboratory work in terms of the number of atoms or molecules of a substance or in terms of moles of a substance? In other words, would you prefer laboratory instructions of "combine 1.0 mole of substance A and 1.5 moles of substance B" or "combine 6.022×10^{23} molecules of A with 9.033×10^{23} molecules of B"? Explain why.

- 3) What is the difference between a mole and Avogadro's number?