Mole and Molar Mass

Why?

To keep track of the huge numbers of atoms and molecules in samples large enough to see, chemists utilize the concepts of *mole* and *molar mass*. These concepts provide a way to count atoms and molecules. By using the idea of a *mole* and the *molar mass*, you will be able to count out specific numbers of atoms or molecules by weighing them.

Learning Objectives

- λ Understand the concepts of mole and molar mass.
- λ Relate the number of atoms, molecules, moles, and the mass of a sample to each other.

Success Criteria

- λ Quickly relate the mass of a sample of a given substance to the number of atoms, molecules, and moles present in the sample.

Resources

Olmsted and Williams (*Chemistry 3/e*, Wiley, 2002) pp. 91-104.

Prerequisites

unit conversion, SI units and abbreviations, significant figures, atomic mass, atoms and isotopes, calculating average quantities

New Concepts

Avogadro's number, mole, molar mass, chemical compound

Vocabulary

mass, element, mixture

Definitions

In your own words, write definitions of the terms in the **New Concepts** and **Vocabulary** sections.

Model: Definition of a Mole and the Molar Mass

Just as the term dozen means 12 objects, the term mole means 6.02214 x 10^{23} objects. This very large number, 6.02214 x 10^{23}, is called Avogadro's number.

Avogadro's number is determined by the number of carbon atoms in exactly 12 g of pure carbon-12.

The molar mass is the mass of 1 mole of objects, i.e. 6.02214 x 10^{23} objects. The molar mass has units of g/mol.

Natural samples of most elements are mixtures of different isotopes. The mass of Avogadro's number of atoms in such a sample is not the molar mass of a single isotope but is an abundance-weighted average of the molar masses of all the isotopes for that element.

Key Questions

1. In your own words, what are the definitions of the terms: *mole* and *molar mass*?

2. What determines the value of Avogadro's number?

3. How many apples are in a dozen apples, and how many apples are in a mole of apples?

4. How can one determine the mass of one carbon-12 atom from the information in the model?

5. What are the unit conversion factors for changing
   (a) moles of an element to number of atoms.

   (b) grams of an element to moles.

   (c) grams of an element to number of atoms.

6. Why are abundance-weighted average molar masses listed in tables of the elements?

7. When might it be useful to know how many atoms or molecules are present in a sample of material?

Exercises

1. If the average mass of an apple is 0.15 kg, calculate
   (a) the mass of a dozen apples.

   (b) the mass of a mole of apples.

2. Calculate the number of atoms are in a 6.00 g sample of carbon-12.

3. Calculate the mass in grams of one carbon-12 atom.

4. Calculate the number of moles in 75 g of iron.

5. Calculate the number of atoms in 0.25 moles of uranium.

6. Calculate the number of moles corresponding to 12.04×10^{23} atoms of uranium.

7. Calculate the mass of 12.04×10^{23} atoms of uranium.

Got It!

1. If you have 1 g samples of several different chemical compounds, which sample will contain the fewest molecules?

Problems.

1. A mass of 30.0 g of oxygen reacts with 6.02214 x 10^{23} atoms of carbon.
   (a) What is the molar ratio of carbon to oxygen in the product?

   (b) Given that mass is conserved in a chemical reaction, what is the mass of the product produced?

   (c) Is the product carbon monoxide, CO, or carbon dioxide, CO_2?

Model: Beads in a Jar - Average Mass of a Mixture of Objects

Properties of Beads in a Jar

Bead Color	Mass of a Single Bead	Number in the Jar
red	2.0 g	50
blue	2.5 g	30
yellow	3.0 g	20

Key Questions

8. How can you estimate the average mass of a bead in the jar by examining the data in the model in order to identify *a, b,* or *c* below as the answer?
   (a) equal to 2.5 g
   (b) between 2.0 and 2.5 g
   (c) between 2.5 and 3.0 g

9. How can you calculate the average mass of a bead in the jar from the data in the model?

Exercises

8. Calculate the average mass of a bead in the jar.

Problems

2. The molar mass of ^{35}Cl is 34.971 g. and the molar mass of ^{37}Cl is 36.970 g. In a natural sample, 75.77% of the atoms are ^{35}Cl, and 24.23% are ^{37}Cl. Show how to calculate the average molar mass of a natural sample of chlorine.