6.6: Counting Particles By Weighing

The following relationships have previously been established:

- 1 mol Al = 26.98 g Al = 6.022×10^{23} atoms Al
- 1 mol $C_{12}H_{22}O_{11}$ = 342.3 g $C_{12}H_{22}O_{11}$ = 6.022×10^{23} molecules $C_{12}H_{22}O_{11}$
- 1 mol NaCl = 58.44 g NaCl = 6.022×10^{23} formula units NaCl

These relationships may be used to count atoms, molecules, or formula units by weighing just like we counted pennies by weighing.

Counting Atoms, Molecules, or Formula Units By Weighing

In the case of aluminum, here are the possible conversions:

$$\text{mol Al} \rightleftarrows \text{g Al} \qquad \frac{26.98\ \text{g Al}}{1\ \text{mol Al}} \text{ or } \frac{1\ \text{mol Al}}{26.98\ \text{g Al}}$$

$$\text{mol Al} \rightleftarrows \text{atoms Al} \qquad \frac{6.022\times10^{23}\ \text{atoms Al}}{1\ \text{mol Al}} \text{ or } \frac{1\ \text{mol Al}}{6.022\times10^{23}\ \text{atoms Al}}$$

$$\text{g Al} \rightleftarrows \text{atoms Al} \qquad \frac{6.022\times10^{23}\ \text{atoms Al}}{26.98\ \text{g Al}} \text{ or } \frac{26.98\ \text{g Al}}{6.022\times10^{23}\ \text{atoms Al}}$$

When converting from grams of aluminum to atoms of aluminum, a conversion that places atoms of aluminum in the numerator and grams of aluminum in the denominator would be used to enure the proper cancellation of units:

$$\text{g Al} \xrightarrow[26.98\ \text{g Al}]{6.022\times10^{23}\ \text{atoms Al}} \text{atoms Al}$$

How many atoms are required to make the average empty aluminum beverage can that has a mass of 14.9 g?

$$14.9\ \cancel{\text{g Al}} \times \frac{6.022 \times 10^{23}\text{atoms Al}}{26.98\ \cancel{\text{g Al}}} = \boxed{3.33 \times 10^{23}\ \text{atoms Al}}$$

This calculation shows how it is possible to to count atoms by weighing using the definitions for molar mass and Avogadro's number.

✅ Example 6.6.1

If a glass contains 9.64×10^{24} molecules H_2O, how many moles of water are in the glass?

Solution

Steps for Problem Solving	
Identify the "given" information and what the problem is asking you to "find."	Given: 9.64×10^{24} molecules H_2O Find: mol H_2O
List known relationship(s).	1 mol H_2O = 18.02 g H_2O = 6.022×10^{23} molecules H_2O
Prepare a concept map and use the proper conversion factor.	$\text{molecules } H_2O \xrightarrow[6.022\times10^{23}\ \text{molecules } H_2O]{1\ \text{mol } H_2O} \text{mol } H_2O$
Calculate the answer.	$9.64 \times 10^{24}\ \cancel{\text{molecules } H_2O} \times \frac{1\ \text{mol } H_2O}{6.022 \times 10^{23}\ \cancel{\text{molecules } H_2O}} = \boxed{16.0\ \text{mol } H_2O}$

Steps for Problem Solving	
Think about your result.	The given number of water molecules was greater than Avogadro's number, so the number of moles of water molecules must be greater than 1 mole. The answer is rounded to three significant figures since the fewest significant figures in the calculation is three.

✅ Example 6.6.2

⅛ tsp of table salt (NaCl) has a mass of 0.69 g. How many formula units of NaCl are in this mass of salt?

Solution

Steps for Problem Solving	
Identify the "given" information and what the problem is asking you to "find."	Given: 0.69 g NaCl Find: formula units NaCl
List known relationship(s).	1 mol NaCl = 58.44 g NaCl = 6.022×10^{23} formula units NaCl
Prepare a concept map and use the proper conversion factor.	$\text{g NaCl} \xrightarrow{\frac{6.022\times10^{23}\ \text{formula units NaCl}}{58.44\ \text{g NaCl}}} \text{formula unit}$
Calculate the answer.	$0.69\ \cancel{\text{g NaCl}} \times \frac{6.022 \times 10^{23}\ \text{formula units NaCl}}{58.44\ \cancel{\text{g NaCl}}} = \boxed{7.1 \times 10^{21}\ \text{formula units NaCl}}$
Think about your result.	There should be a huge number of formula units of NaCl. However, 0.69 g NaCl is quite a bit less than the mass of one mole NaCl (58.44 g), so there should be less than Avogadro's number of formula units. The answer is rounded to two significant figures since the fewest significant figures in the calculation is two.

✏️ Exercise 6.6.2

A. What is the mass of one molecule of water, expressed in units of grams? Provide your answer to 3 significant figures.

B. Which of the following amounts contains the fewest atoms?

12.01 g C 26.00 g Cr 40.08 g Ca 58.93 g Co 63.55 g Cu

Answer A

2.99×10^{-23} g H_2O

Answer B

26.00 g Cr