

Counting by Measuring Mass

In chemistry, the particles (atoms, molecules, and ions) that react in chemical changes are extremely small, such that we need appropriate units to conveniently describe them. For example, a tablespoon of water contains approximately 6.02×10^{23} water molecules, give or take a few hundred quintillion. This is also known as 1 mole of water. 1 mole of any substance contains 6.022×10^{23} particles of that substance. If the substance is an element, then it contains 6.022×10^{23} atoms; if the substance is a molecular compound, then it contains 6.022×10^{23} molecules; if the substance is an ionic compound, then it contains 6.022×10^{23} formula units (the lowest ratio of ions that balances). This number is known as Avogadro's constant, named after the Italian scientist Amadeo Avogadro di Quaregna, Count of Turin (1776-1856), who helped distinguish molecules from atoms in gases. The Avogadro constant is defined as the amount of carbon-12 atoms in exactly 12 grams of carbon 12. Moles of a substance are a more convenient unit of count to work with than individual particles, similar to how it is more convenient to sell and purchase paper by the ream (300 sheets) instead by individual sheets of paper.

Since the particles are so small, directly measuring the mass of an individual atom is impossible, but measuring the mass by the mole is much more practical. The mass of an average oxygen atom is 2.66×10^{-23} grams, but the mass of 1 mole of oxygen atoms is 15.999 grams. This can be obtained from the periodic table, and it also represents the mass of an individual atom in atomic mass units (amu). So as obtained from the periodic table, the number 14.007 underneath the symbol for nitrogen (N) means that the mass of the average nitrogen atom is 14.007 amu, and the mass of 1 mole of nitrogen atoms is 14.007 grams, containing 6.022×10^{23} atoms of nitrogen. Therefore, using the atomic mass as a ratio, it is possible to determine the amount of nitrogen atoms in a given mass of nitrogen.

In this lab, you will determine the mass of several substances and use the data to count the number of atoms of each element in the substance.

EQ: How can mass be used to count the number of atoms in a substance?

Data Table

Part A	Al (s)	H ₂ O (l)	NaHCO ₃ (s)	C ₆ H ₁₂ O ₆ (s)
Mass (g)	4.123 grams	5.553 grams	4.616 grams	7.941 grams
Molar Mass (g/mol)	26.982 grams	18.015 grams	64.007 grams	180.16 grams
Moles of Each Substance	0.153 grams	0.308 grams	0.055 grams	0.044 grams
Number of Representative Particles	3.519×10^{23} atoms	7.084×10^{23} atoms	1.265×10^{23} atoms	1.014×10^{23} atoms
Moles of Each Element	0.153	H = .616 O = .308	Na = 0.055 H = 0.055 C = 0.055 O = 0.165	C = 0.264 H = 0.528 O = 0.264
Atoms of Each Element	3.519	H = 14.168 O = 7.084	Na = 1.265 H = 1.265 C = 1.265 O = 3.795	C = 6.084 H = 12.168 O = 6.084

Answer Key Small Scale Lab

Richard Worthy Sharpe

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Addison-Wesley Small-scale Chemistry Dennis D. Staley, Edward L. Waterman, 1995 **New perspectives and emerging directions in predator-prey functional response research: Hommage to C.S. Holling (1930- 2019)**

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