I'm not a bot

Learning Objectives Describe the unit mole. Relate the mole quantity of substance to its mass. So far, we have been talking about chemical substances in terms of individual atoms and molecules. Yet we don’t typically deal with substances an atom or a molecule at a time; we work with millions, billions, and trillions of atoms and molecules at a time. What we need is a way to deal with macroscopic, rather than microscopic, amounts of matter. We need a unit of amount that relates quantities of substances on a scale that we can interact with. Chemistry uses a unit called mole. A mole (mol) is a number of things equal to the number of atoms in exactly 12 g of carbon-12. Experimental measurements have determined that this number is very large: 1 mol = 6.02214179 × 1023 things Understand that a mole means a number of things, just like a dozen means a certain number of things—twelve, in the case of a dozen. But a mole is a much larger number of things. These things can be atoms, or molecules, or eggs; however, in chemistry, we usually use the mole to refer to the amounts of atoms or molecules. Although the number of things in a mole is known to eight decimal places, it is usually fine to use only two or three decimal places in calculations. The numerical value of things in a mole is often called Avogadro’s number (NA), which is also known as the Avogadro constant, after Amadeo Avogadro, an Italian chemist who first proposed its importance. How many molecules are present in 2.76 mol of H2O? How many atoms is this? Solution The definition of a mole is an equality that can be used to construct a conversion factor. Also, because we know that there are three atoms in each molecule of H2O, we can also determine the number of atoms in the sample. To determine the total number of atoms, we have Test Yourself How many molecules are present in 4.61 × 10−2 mol of O2? Answer 2.78 × 1022 molecules How big is a mole? It is very large. Suppose you had a mole of dollar bills that need to be counted. If everyone on earth (about 6 billion people) counted one bill per second, it would take about 3.2 million years to count all the bills. A mole of sand would fill a cube about 32 km on a side. A mole of pennies stacked on top of each other would have about the same diameter as our galaxy, the Milky Way. A mole is a lot of things—but atoms and molecules are very tiny. One mole of carbon atoms would make a cube that is 1.74 cm on a side, small enough to carry in your pocket. Why is the mole unit so important? It represents the link between the microscopic and the macroscopic, especially in terms of mass. A mole of a substance has the same mass in grams as one unit (atom or molecules) has in atomic mass units. The mole unit allows us to express amounts of atoms and molecules in visible amounts that we can understand. For example, we already know that, by definition, a mole of carbon has a mass of exactly 12 g. This means that exactly 12 g of C has 6.022 × 1023 atoms: 12 g C = 6.022 × 1023 atoms C We can use this equality as a conversion factor between the number of atoms of carbon and the number of grams of carbon. How many grams are there, say, in 1.50 × 1025 atoms of carbon? This is a one-step conversion: But it also goes beyond carbon. Previously we defined atomic and molecular masses as the number of atomic mass units per atom or molecule. Now we can do so in terms of grams. The atomic mass of an element is the number of grams in 1 mol of atoms of that element, while the molecular mass of a compound is the number of grams in 1 mol of molecules of that compound. Sometimes these masses are called molar masses to emphasize the fact that they are the mass for 1 mol of things. (The term molar is the adjective form of mole and has nothing to do with teeth.) Here are some examples. The mass of a hydrogen atom is 1.0079 u; the mass of 1 mol of hydrogen atoms is 1.0079 g. Elemental hydrogen exists as a diatomic molecule, H2. One molecule has a mass of 1.0079 + 1.0079 = 2.0158 u, while 1 mol H2 has a mass of 2.0158 g. A molecule of H2O has a mass of about 18.01 u; 1 mol H2O has a mass of 18.01 g. A single unit of NaCl has a mass of 58.45 u; NaCl has a molar mass of 58.45 g. In each of these moles of substances, there are 6.022 × 1023 units: 6.022 × 1023 atoms of H, 6.022 × 1023 molecules of H2 and H2O, 6.022 × 1023 units of NaCl ions. These relationships give us plenty of opportunities to construct conversion factors for simple calculations. What is the molar mass of C6H12O6? Solution To determine the molar mass, we simply add the atomic masses of the atoms in the molecular formula but express the total in grams per mole, not atomic mass units. The masses of the atoms can be taken from the periodic table or the list of elements in Chapter 17 “Appendix: Periodic Table of the Elements”: Per convention, the unit grams per mole is written as a fraction. Test Yourself What is the molar mass of AgNO3? Answer 169.87 g/mol Knowing the molar mass of a substance, we can calculate the number of moles in a certain mass of a substance and vice versa, as these examples illustrate. The molar mass is used as the conversion factor. What is the mass of 3.56 mol of HgCl2? The molar mass of HgCl2 is 271.49 g/mol. Solution Use the molar mass as a conversion factor between moles and grams. Because we want to cancel the mole unit and introduce the gram unit, we can use the molar mass as given: Test Yourself What is the mass of 33.7 mol of H2O? Answer 607 g How many moles of H2O are present in 240.0 g of water (about the mass of a cup of water)? Solution Use the molar mass of H2O as a conversion factor from mass to moles. The molar mass of water is (1.0079 + 1.0079 + 15.999) = 18.015 g/mol. However, because we want to cancel the gram unit and introduce moles, we need to take the reciprocal of this quantity, or 1 mol/18.015 g: Test Yourself How many moles are present in 35.6 g of H2SO4 (molar mass = 98.08 g/mol)? Answer 0.363 mol Other conversion factors can be combined with the definition of mole—density, for example. The density of ethanol is 0.789 g/mL. How many moles are in 100.0 mL of ethanol? The molar mass of ethanol is 46.08 g/mol. Solution Here, we use density to convert from volume to mass and then use the molar mass to determine the number of moles. Test Yourself If the density of benzene, C6H6, is 0.879 g/mL, how many moles are present in 17.9 mL of benzene? Answer 0.201 mol Key Takeaways The mole is a key unit in chemistry. The molar mass of a substance, in grams, is numerically equal to one atom’s or molecule’s mass in atomic mass units.

 When most people hear the word "mole," they picture furry underground rodents that burrow through gardens. However, in the field of chemistry, the term "mole" couldn't be more different from that image. In fact, the chemical mole is one of the most important concepts in science since it allows chemists and students to count atoms and molecules. A chemical mole is the amount of a substance required for the atomic particles of that substance to equal the number of atoms in 12 grams of carbon. Chemists estimate this to be 6.022 x 1023 or 602 hexillion, also called Avogadro's constant. A mole is simply a unit of quantity just like a dozen or a millennium are units of quantity. When it comes to calculating atomic particles during chemical reactions, all the common units of quantity are far too small to be useful for scientists. This is because atoms themselves are so infinitesimally small. To illustrate, 500,000 carbon atoms stacked together roughly compare to the width of a single human hair. To solve the problem of measuring such tiny particles, chemists need a very large unit of quantity: a mole. Just like the term "a dozen" means twelve items and "a millennium" means a thousand items, a mole means 602 hexillion items. The figure behind the concept of the chemical mole is 19th century Italian scientist Amedeo Avogadro. This major thinker was the first person to suggest that elements can link together to form molecules and not just exist as individual atoms and that equal volumes of gases held under equivalent conditions also contain equivalent numbers of molecules. Avogadro's work was largely ignored during his lifetime but later formed the basis for calculating one of the most crucial numbers in chemistry, which became known as Avogadro's constant. Avogadro's constant is equivalent to the number of atoms in 12 grams of the most abundant form of carbon (carbon-12), or 6.022 x 1023. Chemists use this number to determine moles. A mole of any substance is the amount of that substance required for the number of atomic particles to equal Avogadro's constant, which is approximately 602 hexillion particles. So a mole of water is the amount of water that contains 602 hexillion atomic particles. This is true for anything: a mole of iron, a mole of helium and a mole of elephants all contain 602 hexillion particles. The concept of the mole is important for scientists because it means that one mole of any element has exactly the same number of atoms as one mole of any other element. This information allows chemists to count atomic particles for even very complex chemistry formulas and reactions. For individual elements, one mole is also equal to the atomic weight of that element in grams, which you can find on the periodic table. For a molecule like water (H2O), which has two parts hydrogen with one part oxygen, one mole of water is equal to the atomic weight of each hydrogen (1.008 grams plus 1.008 grams) plus the oxygen (16 grams) or 18.016 grams per mole. The unit is often abbreviated as mol, so one mole of water is usually written 18.016 g/mol. While the chemical mole might not be as cute as the garden rodent that shares its name, the concept of the mole is the foundation for the field of chemistry. Understanding the somewhat abstract idea of the mole as a unit of quantity can be tricky but is key to success as a chemist or chemistry student. Mayer, Melissa. "What Is A Mole?" sciencing.com, . 20 April 2018. APA Mayer, Melissa. (2018, April 20). What Is A Mole?. sciencing.com. Retrieved from Chicago Mayer, Melissa. What Is A Mole? last modified August 30, 2022.