Introductory Chemistry Lab: The Mole

Outcomes

As a result of today's lab, you will have:
Viewed a video about "The Mole."

Used the molar mass concept and Avogadro's number to identify three unknown elements and to determine the number of moles and formula units or molecules in three compounds.

Prelab

Prepare a Title (can use the lab handout for this), Purpose (a concise statement) and a Procedure (short "to do" list … see "Writing a Procedure" in the lab handouts folder), and Data Tables.

Purpose

To identify elements by weighing and to count by weighing using the mass of a substance, molar mass, and Avogadro's number.

Background Information

Chemistry is the study of matter and its interactions. When a chemical change occurs the reactants of the original materials interact and regroup into different combinations to form new materials called products. Since atoms and molecules are too small to see, chemists rarely deal with one atom or molecule at a time. Instead, chemists work with materials containing very large numbers of atoms and molecules, too numerous count. Because they cannot actually count the number of atoms/molecules/ions that react, chemists use mass measures as a means of counting the molecular amounts of the reactants and products. The process is called "counting by weighing" and involves relative masses and a basic chemical unit of counting called the mole.

Chemists want to be able to weigh out samples of different substances that will each contain the same number of units. The Periodic Table shows the relative masses of an average atom of each element. An average oxygen atom weighs ~16 amu while an average sulfur atom weighs ~ 32 amu. So, the relative masses are 16:32. This can be simplified by dividing both numbers by the smallest: (16/16):(32/16) or 1:2. This means that each sulfur atom is ~2 times heavier than each oxygen atom. To have samples of oxygen and sulfur contain equal numbers of atoms, the mass of the sulfur will have to be twice the mass of the oxygen. The table below shows masses of sulfur and oxygen samples with the same number of O and S atoms.

# atoms	Mass Oxygen	Mass Sulfur	Ratio	Simplified Ratio
1	16 amu	32 amu	16:32	1:2
2	32 amu	64 amu	32:64	1:2
12	192 amu	384 amu	192:384	1:2
20	320 amu	640 amu	320:640	1:2
100	1600 amu	3200 amu	1600:3200	1:2
1 dozen	192 amu	384 amu	192:384	1:2
1 mole	16 grams	32 grams	16:32	1:2

The mole is a chemical measurement unit equal to the mass of an element found in the Periodic Table expressed in grams. A mole of oxygen atoms weighs 16.00 grams. A mole of carbon atoms weighs 12 grams. The important thing to notice about a mole is that a mole of any substance always contains the same number of atoms/molecules/ions. Because atoms have little mass, the mole will contain a very large number of items. The chemist's mole concept is similar to the baker's dozen. A dozen of anything is always 12 items.

Because the mass of each item is different, you don't expect a dozen cookies to weigh the same as 12 marbles or 12 bowling balls. In the same way, a mole of chromium atoms will not weigh the same as a mole of fluorine atoms, but each will contain the same number of atoms. This number (Avogadro's number) is very large and has been experimentally measured to be 6.02×10^{23}. The number of items in a mole is named after Amedeo Avogadro (1776-1856), an Italian physicist, whose experiments with gases led to the mole concept. If we were to count out Avogadro's number of marbles and stack them on top of each other, the entire earth would be covered with marbles to a depth of 50 miles.

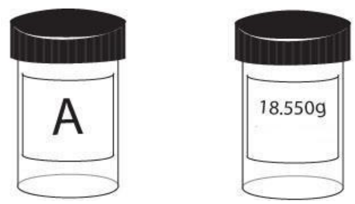
The mole has been defined in terms of carbon-12 atoms. The actual definition of a mole is "the amount of substance that contains as many particles as there are atoms of carbon-12 in exactly 12 g of carbon-12." This rather complicated statement is really saying that a mole of carbon-12 atoms weighs 12 g and contains a certain number of carbon-12 atoms. Since all masses on the Periodic Table are relative masses, whenever you take the formula mass of a substance in grams, you will have one mole of that substance and it will contain 6.02×10^{23} formula units. The mass of a mole of any substance is called the molar mass. The molar mass of any substance will be the formula mass in grams. For example, the molar mass of an oxygen atom is 16.00 grams, the molar mass of water is 18.02 grams, and the molar mass of sodium chloride is 58.44 grams

Procedure – Work in pairs **Use the same balance for the entire procedure.**

Part 1. Identify elements by weighing

1. Obtain three vials each representing a different chemical element.

2. There are two labels on the vials. One label has a letter to identify the unknown sample. The second label has the mass of the empty container.



3. Each vial contains 0.100 mole of the element.

4. Record the information from the labels for each element in Table 1.

5. Weigh each of the vials and record this as the mass of the container + unknown in Table 1.

Part 2. Determine number of moles and formula units in a sample of sodium chloride and potassium nitrate.

1. Obtain a vial of sodium chloride and a vial of potassium nitrate.

2. There are two labels on the vials; a sample number and the mass of the empty container.

2. Record the formulas, sample numbers, and mass of empty vials in Table 2.

3. Weigh each vial and record this as mass of vial + compound in Table 2.

Part 3. Determine number of moles and molrcules in 40.0 mL of de-ionized water.

1. Obtain a clean 50.0 mL graduated cylinder.

2. Place the cylinder on the balance and tare.

3. Add de-ionized water until the bottom of the meniscus is at the 40.0 mL mark.

4. Record the water mass and volume in table 3.

Data

Table 1: Indentify Elements by Weighing

Unknown Letter On Vial			
Mass of Empty Container			
Mass of Container + Unknown			
Moles Present	0.100	0.100	0.100

Table 2: Determine moles and formula units in samples of sodium chloride and potassium nitrate

Compound	**Formula**	**Sample Number**	**Empty Vial Mass (g)**	**Mass Vial + Unknown (g)**
Sodium Chloride				
Potassium Nitrate				

Table 3: Determine Number of moles and molecules in 40.0 mL of de-ionized water .

Compound	**Formula**	**Volume (mL)**	**Mass (g)**
water			

Calculations

Part 1 *Identify elements by weighing*

1. Calculate the mass of unknown element in each container by subtracting the mass of the empty vial from the mass of the vial + compound.

2. Calculate the number of grams per mole (molar mass) of each unknown element by dividing mass of unknown element in the container by the number of moles (0.100) present in the container.

3. Use a periodic table to locate an element of the same atomic mass, identify each of the elements. Report the identity of each element in table 4 and in your conclusion.

Part 2 *Determine the number of moles and formula units in sodium chloride and potassium nitrate samples.*

1. Determine the mass of the sodium chloride and potassium nitrate samples.
2. Use the Periodic Table to calculate the molar mass of sodium chloride and potassium nitrate.
3. Use the molar masses to determine how many moles of each compond are present.
4. Use Avogadro's number to determine how many formula units of each compound are present.
5. Record all answers in table 5.

Part 3 *Determine the number of moles and molecules in 40.0 mL of de-ionized water*.

1. Use the Periodic Table to calculate the molar mass of water.
2. Use the molar mass of water to determine how many moles of water are present in 40.0 mL.
3. Use Avogadro's number to determine how many molecules of water are present in 40.0 mL.
4. Record all answers in table 6.

Results

Table 4: Unknown Elements Determination

Unknown Letter on Vial			
Molar Mass (g / mole)			
Element Identity			

Table 5: Moles and Formula Units in Sodium Chloride & Potassium Nitrate Samples

Compound	Formula	Sample Mass (g)	Moles Present	Formula Units Present

Table 6: Number of moles and molecules in water

Compound	Formula	Sample Mass (g)	Molar Mass (g/mole)	Moles Present	Molecules Present
water					

Conclusion:

State the identity of the elements in part 1. State the number of moles and formula units present in the samples of sodium chloride and potassium nitrate and number of moles and molecules in 40.0 mL of de-ionized water.

Questions Show your work with units and correct sig figs on ALL quantities for credit.

1. A chemist needed 1.25 moles of iron (III) chloride to carry out a reaction. How many grams of the iron (III) chloride did the chemist weigh out?

2. How many formula units were contained in the sample that the chemist weighed out in problem 1?

3. As part of a lab assignment a student was asked to give the instructor a sample of calcium chloride that contained 2.30×10^{22} formula units. What mass of calcium chloride should the student have given the instructor?