ChemQuest 39

Intro to Moles

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Hour: \_\_\_\_\_

**Information: Thinking in Quantities**

A “mole” is simply a quantity of atoms just like a dozen is a quantity of eggs. If you have 2 dozen eggs we know you have 24 eggs. Similarly, chemists can speak of having 2 moles of carbon atoms or 4 moles of water molecules. Just like the number “12” goes with “dozen,” there is a number that goes with a mole also, but we will worry about that later.

Below are two pictures of containers that contains atoms of neon gas. There are a lot of atoms of neon in each container.

This container represents 0.50 mole of neon gas. The gas has a mass of about 10 grams.

This container represents 1.00 mole of neon gas. The gas has a mass of about 20 grams.

**Critical Thinking Questions**

1. In the following container, put the correct number of atoms (black dots) to represent 2.00 moles of neon gas.
2. What is the mass of the gas in the container in question 1?
3. Draw black dots to represent neon atoms and place 30 grams worth of neon in the following container.
4. The container in question 3 contains \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ moles of neon atoms.
5. Each black dot in the above examples stands for about 100,000,000,000,000,000,000,000 atoms! Approximately how many atoms are in a mole?

**Information**: Atomic Mass Using Atomic Mass Units (amu) and Grams (g)

One atomic mass unit (amu) is equal to 1.6611x10-24 grams.

**Critical Thinking Questions**

1. According to the periodic table, a single carbon atom has a mass of 12.011 amu. What is the mass of a single carbon atom in grams?
2. How many carbon atoms does it take to equal 12.011 grams?
3. According to the periodic table, a single phosphorus atom has a mass of 30.973 amu. What is the mass of a single phosphorus atom in grams?
4. How many phosphorus atoms does it take to equal 30.973 grams?
5. Compare your answers to questions 2 and 4.

**Information**: What is a Mole?

Hopefully, you found that your answers to questions 2 and 4 were about the same. Both answers should be about 6.02x1023. The quantity, 6.02x1023 is Avogadro’s constant and we call it the “mole”. Just like the quantity “12” is called a “dozen”, so the quantity 6.02x1023 is called a “mole”.

By definition, a mole is the quantity of atoms necessary to equal the element’s atomic mass in grams. So, according to the periodic table, one atom of sodium has an atomic mass of about 22.99 amu. If you weighed out 22.99 grams on a balance, you would have 6.02x1023 atoms of sodium present.

Look at your periodic table and find gold (atomic number = 79). What is the mass of one gold atom? You should note that one gold atom has a mass of 196.97 amu. How many gold atoms would you need to get 196.97 grams? You would need to put 6.02 x 1023 atoms of gold on the balance before you would have 196.97 grams of gold. One mole of an atom will always equal the atom’s atomic mass in grams.

**Critical Thinking Questions**

1. What is the mass of one atom of aluminum? (include units)
2. If you had 6.02 x 1023 atoms of aluminum, what mass of aluminum would you have? (include units)
3. What is atomic mass?
4. If you had one mole of pennies, how many pennies would you have?
5. If you had 3 moles of sand, how many grains of sand would you have?

**Information**: Molecular Mass (also known as Formula Mass) and Molar Mass

Just as atomic mass is the mass of an atom, molecular mass is that mass of a molecule. It is found by adding up all of the masses of the atoms in the molecule. Because ionic compounds are not properly called molecules, the term formula mass is used in place of molecular mass for ionic compounds. Consider the following examples:

1. The atomic mass of hydrogen 1.0 amu and the atomic mass of oxygen is 16.0 amu. One molecule of water (H2O) has a molecular mass of 18.0 amu. This number is obtained by adding the masses of two hydrogens (each at 1.0 amu) and the mass of one oxygen (16.0 amu).
2. Aluminum chloride (AlCl3) has a formula mass of about 133.5 amu. This is found by adding the mass of one aluminum atom (27.0 amu) to the mass of three chlorine atoms (3 x 35.5 amu). Verify this on your calculator.

Just as one mole of atoms equals the atomic mass of an atom in grams, so also one mole of molecules equals the molar mass of the molecule in grams. Molar mass is the mass (in grams per mole) of one mole of a substance. Therefore we expect that 6.02 x 1023 molecules of water will have a mass of 18.0 g and 6.02 x 1023 formula units of AlCl3 will have a mass of 133.5 g. We say, then, that the molar mass of water is 18.0 g/mol and the molar mass of AlCl3 is 133.5 g/mol. (g/mol is read grams per mole where mol is the abbreviation for mole.)

**Critical Thinking Questions**

1. Verify using a periodic table and calculator that the molecular mass of N2O5 is approximately 108 amu.
2. How many molecules of N2O5 are required to equal 108 grams?
3. Why is the term “molecular mass” applied to water, but the term “formula mass” applied to aluminum chloride?
4. Find the molecular or formula mass for each of the following (include units):

a) magnesium phosphide b) sodium sulfate

c) Ca(NO3)2 d) C4H8

1. Find the molar mass of each of the following (include units):

a) CaCl2 b) barium nitrate

1. What is the difference between the terms molecular mass and molar mass.

**Information**: Beginning Mole Conversions

The mole (often abbreviated as mol) is the link between the microscopic (atoms and molecules) and the macroscopic (things measured in grams). If you know how many grams of a substance you have and you know the molar mass, you can find out how many molecules you have. Two examples of how to do this using a method similar to converting units is shown below:

1. How many atoms of carbon does it take to equal 23.5 g?

 atoms

 molar mass of carbon, from the periodic table

1. How many molecules of carbon monoxide gas does it take to equal 50.0 g?

 

molar mass of carbon monoxide found by adding molar mass of C and of O

**Critical Thinking Questions**

1. Using your calculator, verify that if you have 125 g of gold, you have about 3.82x1023 atoms of gold. Show the calculations below.
2. Consider 210 g of N2O5. How many molecules are present?
3. If you exhale 7.25 x 1024 molecules of CO2…
4. How many moles of CO2 do you exhale? (Hint: use the conversion factor that one mole = 6.02x1023 molecules)
5. How many grams of CO2 do you exhale? (Hint: find how many grams are in a mole by finding the molar mass of CO2. Use this as a conversion factor.)
6. In a bag full of pennies, you may have 2.15 moles of copper. How many grams do you have?