

Stoichiometry 3

So *This* is What the Mole is For...

INFORMATION

The previous activity (see **Stoichiometry 2 – What is Stoichiometry?**) ended with this question:

A hardware company sells tool kits that include four tools – one pair of pliers, one adjustable wrench, and two screwdrivers. The company needs to ship 1000 toolkits by the end of the day. They have 88.22 kg of pliers, 77.81 kg of wrenches, and 45.69 kg of screwdrivers in stock. Does the hardware company have enough tools to make all of the toolkits?

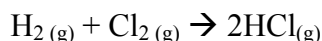


As you discovered, it is not possible to accurately answer this question. So what exactly does this have to do with the mole?

In the question above, it is not possible to know if there are enough tools on hand even though there is very precise data on the mass of tools available. Since the *number* of tools in each kit is important, not the *mass* of each tool, more information about the number of each tool is required – an inventory count, for example. With that, this problem can easily be solved.

The mole serves the same purpose when counting molecules that an inventory of tools does for counting toolkits. Just as a screwdriver has a different mass than a wrench, so do the atoms of different elements have masses different from each other. Each proton or neutron an atom has increases its mass slightly. One hydrogen atom has a different mass than one chlorine atom, for example; hydrogen has only one proton, but chlorine has many protons and neutrons. Therefore, a certain mass of chlorine atoms will have fewer atoms in it than an equivalent mass of hydrogen atoms.

Examine the following equation:



The goal of this reaction is to pair each hydrogen atom with at least one chlorine atom. If you know that you have 2 H atoms and 2 Cl atoms, you know that you can create 2 pairs – this is what the reaction above is indicating. But if you are told that you have 2 *grams* of H atoms and 2 *grams* of chlorine atoms, this does not necessarily guarantee that every H atom will have a Cl companion at the end of the reaction. This is because the masses of each of the two different individual atoms is different, so equal mass does not necessarily mean equal numbers of atoms.

The mole is what normalizes the quantities of atoms. One mole of H₂ molecules contains 6.02 x 10²³ molecules; similarly, one mole of Cl₂ molecules also contains 6.02 x 10²³ molecules. Since the numbers are the same, each hydrogen atom is guaranteed to have a chlorine atom to pair with. One mole of hydrogen gas (H₂), however, has a mass of only 2 grams (the atomic [molar] weight of hydrogen is 1 gram, so a mole of H₂ has 1 gram x 2 moles = 2 grams/mole of hydrogen). A mole of chlorine gas (Cl₂) has a mass of nearly 71 grams (the atomic [molar] weight of chlorine is 35.5 grams, so a mole of Cl₂ has 35.5 gram x 2 moles = 71 grams/mole of chlorine). A significant difference separates the masses of the two samples, yet each has the same number of atoms.

Key Questions

1. A sporting goods store has golf balls and bowling balls in stock. The mass of the bowling balls is greater than the mass of the golf balls. Based only on this data, is it possible to know which of the two balls the store has more of? Explain your answer in grammatically correct sentences.
2. Which has a greater number of atoms – a mole of sodium or a half of a mole of gallium? Explain your answer in grammatically correct sentences.
3. If you wish to pair 24 grams of carbon with enough oxygen to make an exact number of carbon monoxide molecules, what mass of oxygen is required?