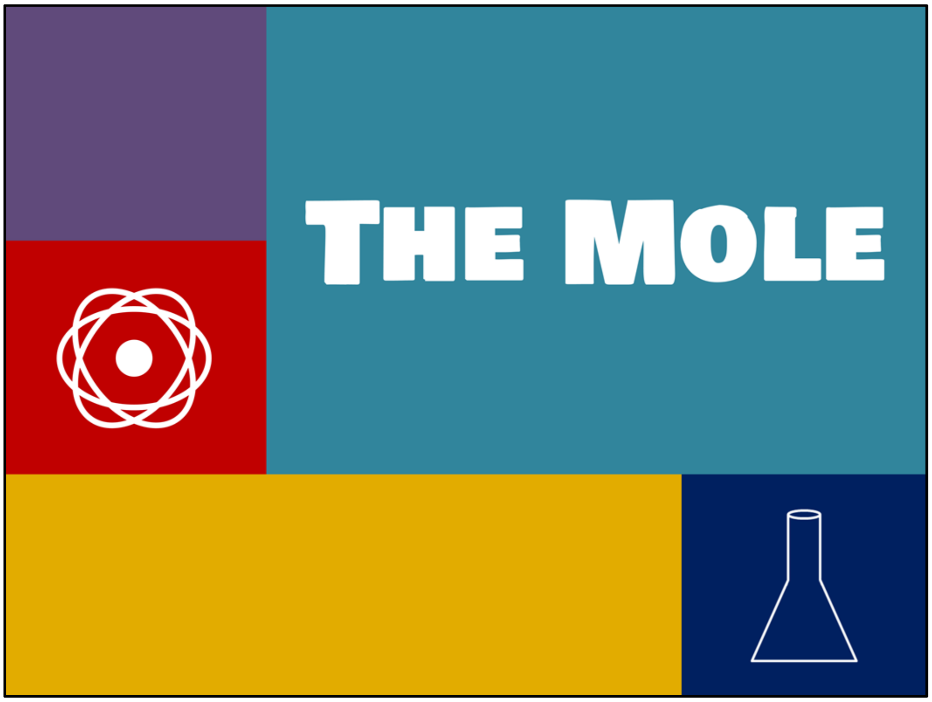
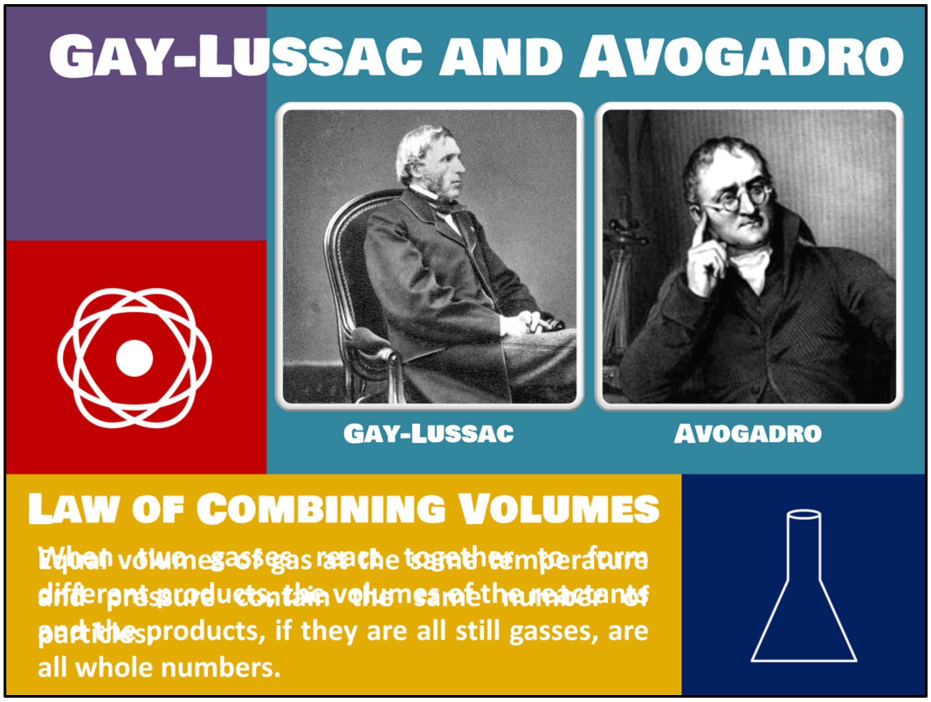
Module 5: Chemical Quantities and Composition
Topic 1 Content: The Mole and Molarity Presentation Notes



The Mole



The history of the molar concept can be traced back to work done by Joseph Louis Gay-Lussac and Amedeo Avogadro in the 18th and 19th centuries. Joseph Louis Gay-Lussac's research stated that when two gasses react together to form different products, the volumes of the reactants and the products, if they are all still gasses, are all whole numbers. This was called the Law of Combining Volumes. According to Avogadro, equal volumes of gas at the same temperature and pressure contain the same number of particles. He never used the word mole, but he helped established the groundwork for further defining the amount.

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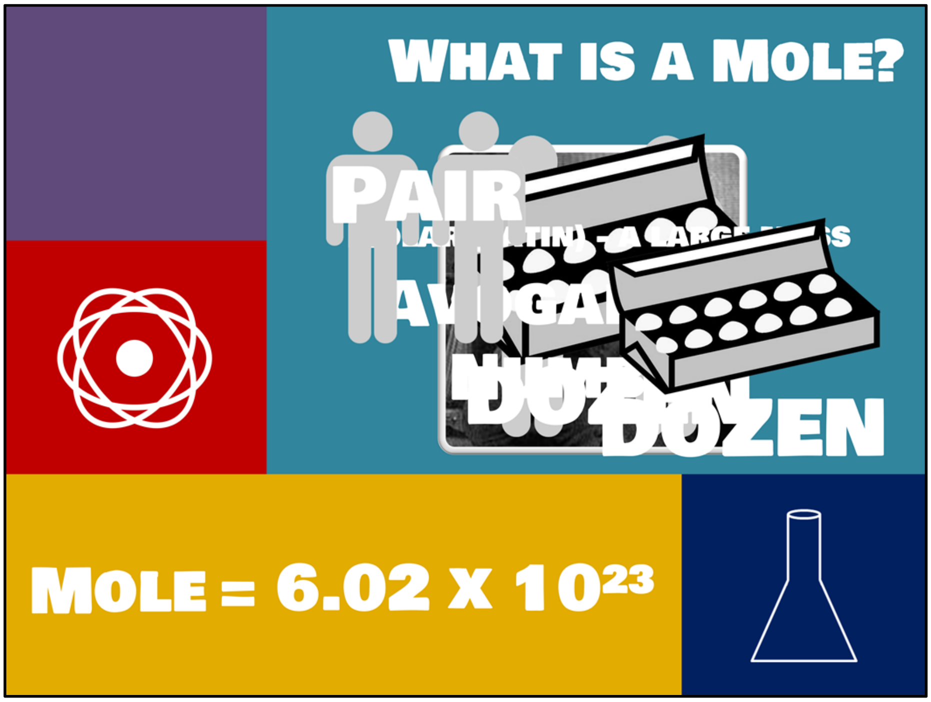
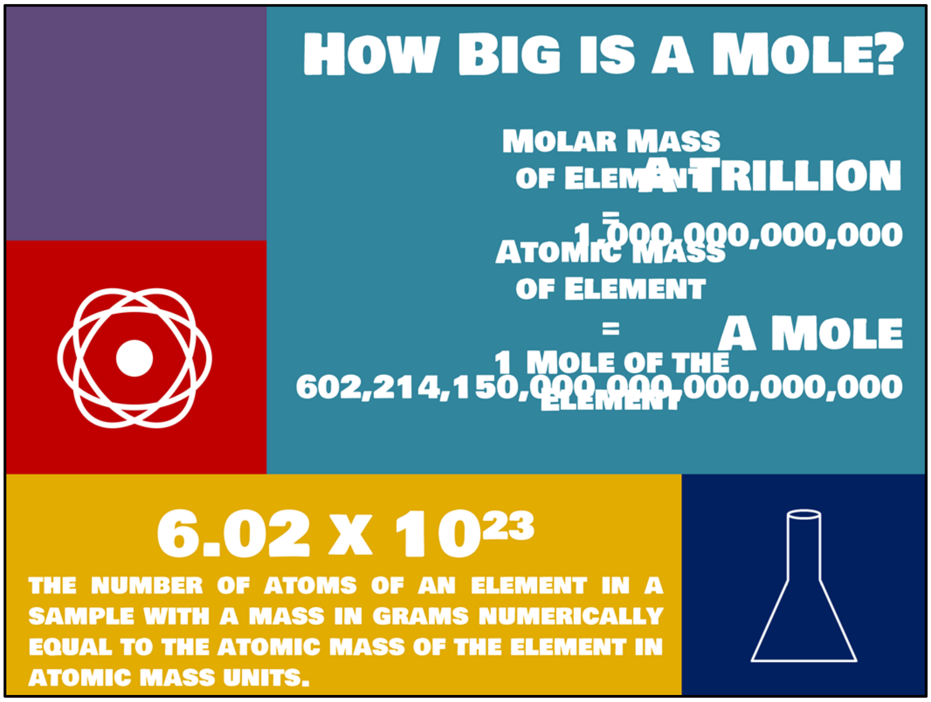
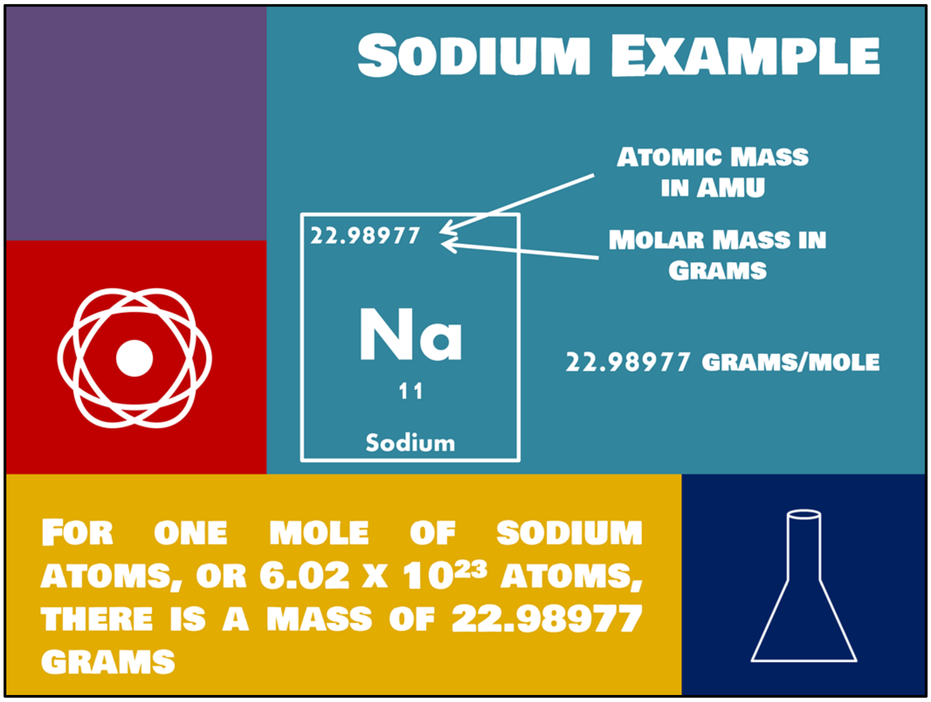


Just as the word “pair” represents two and the word “dozen” represents twelve, the word “mole” represents a specific amount. In fact, it is a really LARGE amount. The word “molar” comes from the Latin term meaning “a large mass.” What amount does a mole signify? A mole is 6.02 x 10^{23}, which is also known as Avogadro's number. Just like a pair of twins or a dozen eggs, a mole is a number of something. In your study of chemistry, that “something” is atoms or molecules.



How big is 6.02×10^{23}? A trillion is shown here. A mole is a over six-hundred two sextillion, or almost a trillion trillions! Why is a mole so big? This number was determined experimentally based on the relationship between carbon's mass in atomic mass units and grams. Atoms are small. It takes a lot of these miniscule particles to make a measurable mass. Avogadro's number represents the number of atoms of an element in a sample with a mass in grams numerically equal to the atomic mass of the element in atomic mass units. What does this mean? It means that the molar mass of an element, which is equal to the element's atomic mass, is also equal to one mole of that element.



Take a look at an example for a single element. Here you see the periodic table information for the element sodium. Sodium has an atomic symbol of eleven and an atomic mass of 22.98977 amu, and a molar mass 22.98977 grams per mole. This means that for one mole of sodium atoms, or 6.02 x 10^{23} atoms, there is a mass of 22.98977 grams.

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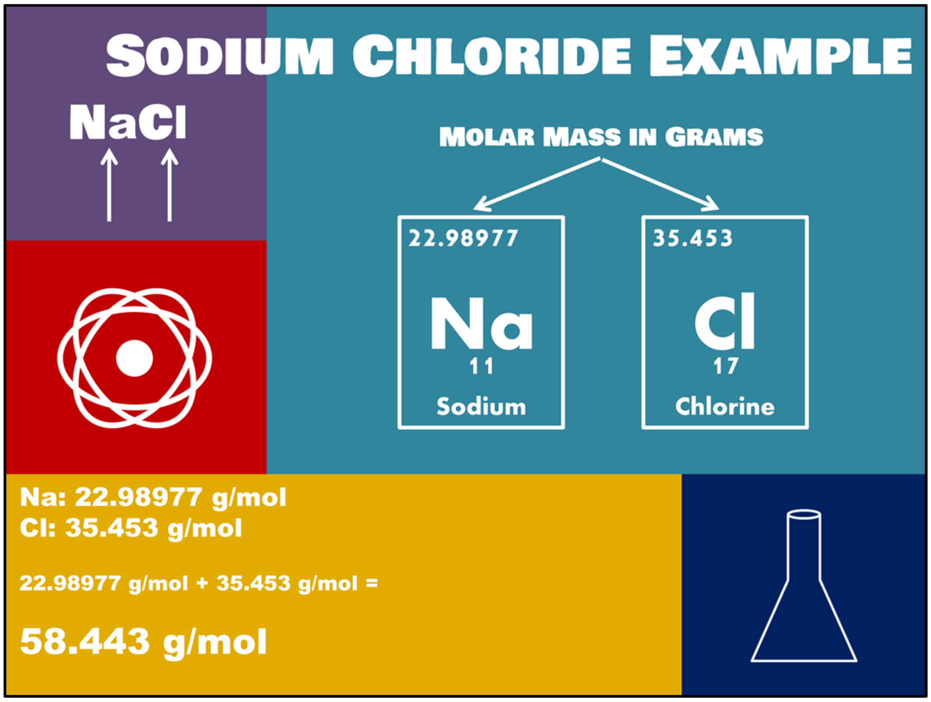

Now, take a look at an example for a common compound, sodium chloride, or table salt. In this compound, there is one sodium atom and one chlorine atom. Here, you see the periodic table information for the elements sodium and chlorine. From this information, you can obtain each of these elements' molar mass in grams per mole. Using your knowledge of determining molar mass, you know that to determine the compounds molar mass, you need to add the molar mass for each of the atoms involved in the compound. Once you complete that calculation, you will find that one mole, or 6.02×10^{23} formula units, of the compound sodium chloride has a molar mass of 58.443 grams per mole.

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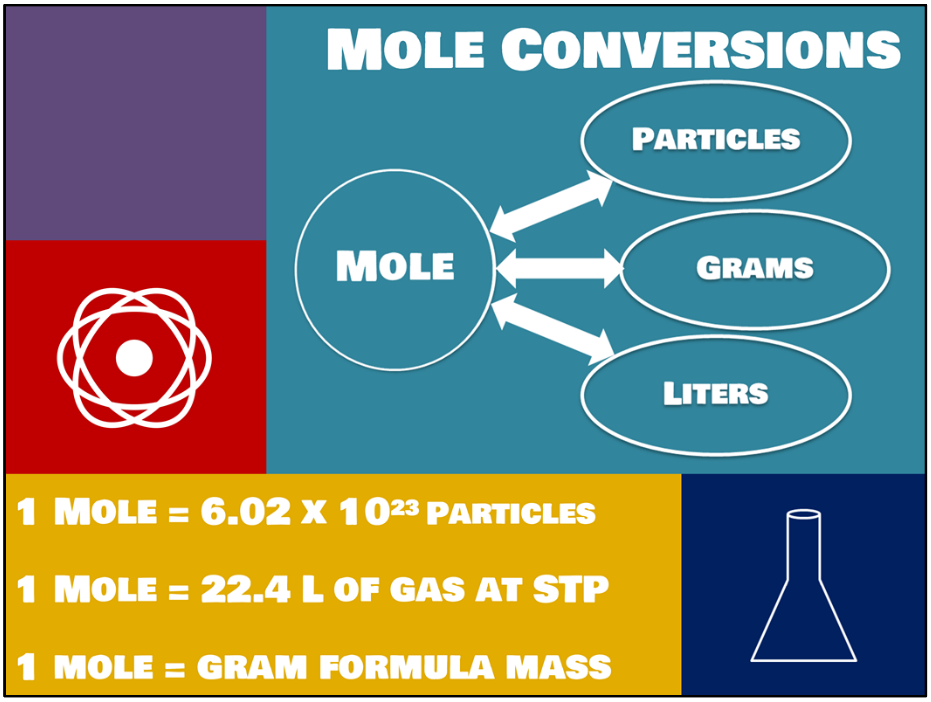
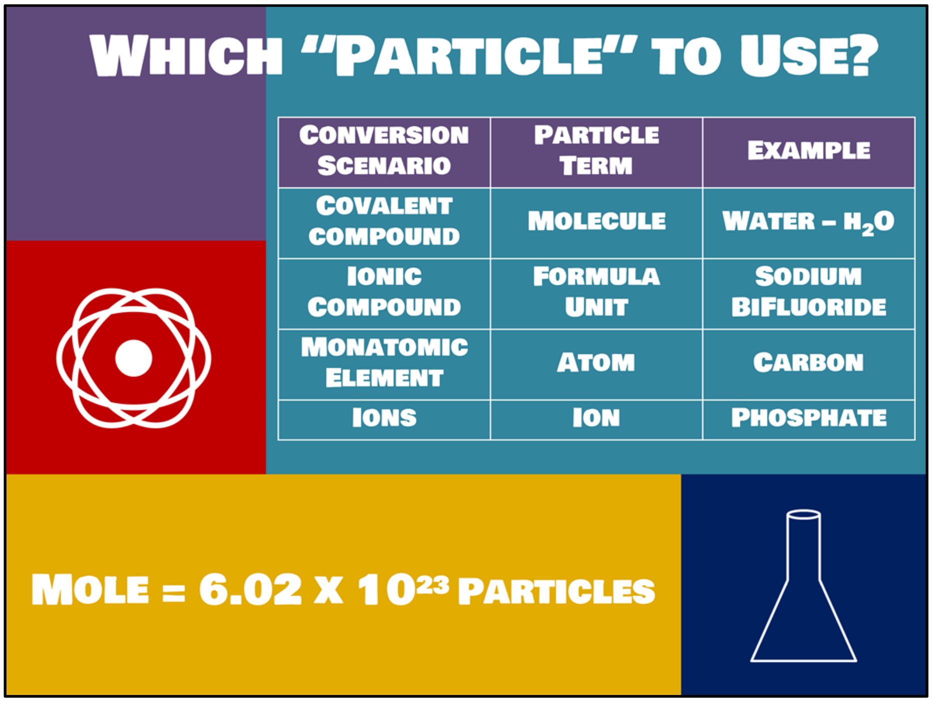


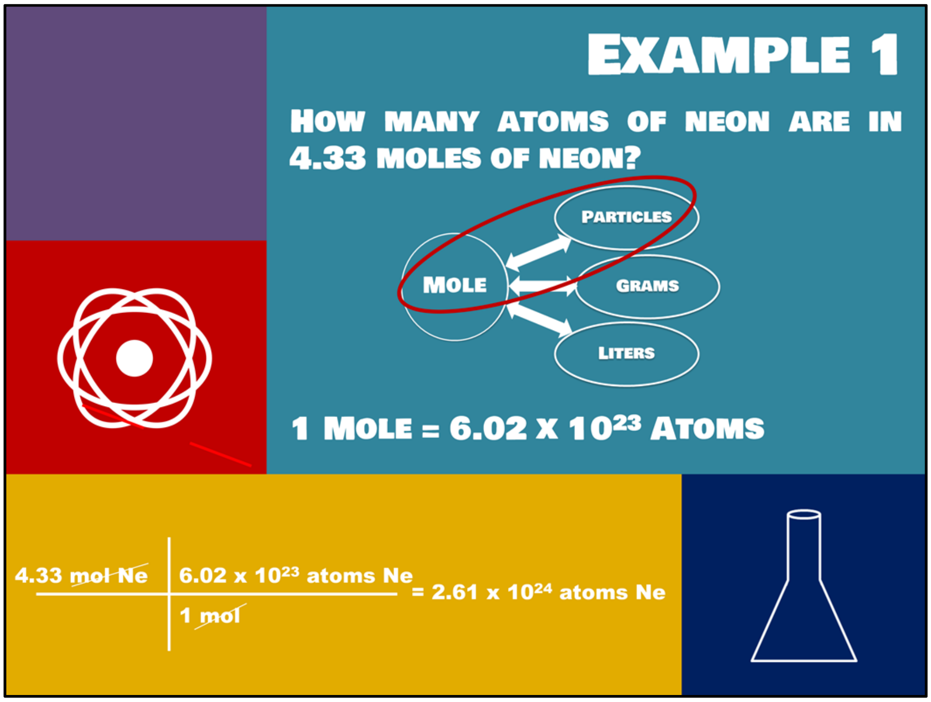
In chemistry, you will convert from mass to moles, particles to moles, and even volume to moles based on the relationships between particles, grams, moles, and liters. This mole conversion map provides a great visual way to plan out your problem solving strategy.

When completing conversions, you will need to use dimensional analysis. To do this, it is important to know the conversion value of moles to particles, grams, and liters:

- One mole equals 6.02×10^{23} particles.
- One mole equals 22.4 liters of gas at standard temperature and pressure conditions, abbreviated as STP. The volume conversion from moles to liters is specifically used when gases are at standard temperature and pressure conditions.
- One mole is equal to the molar mass of an element.

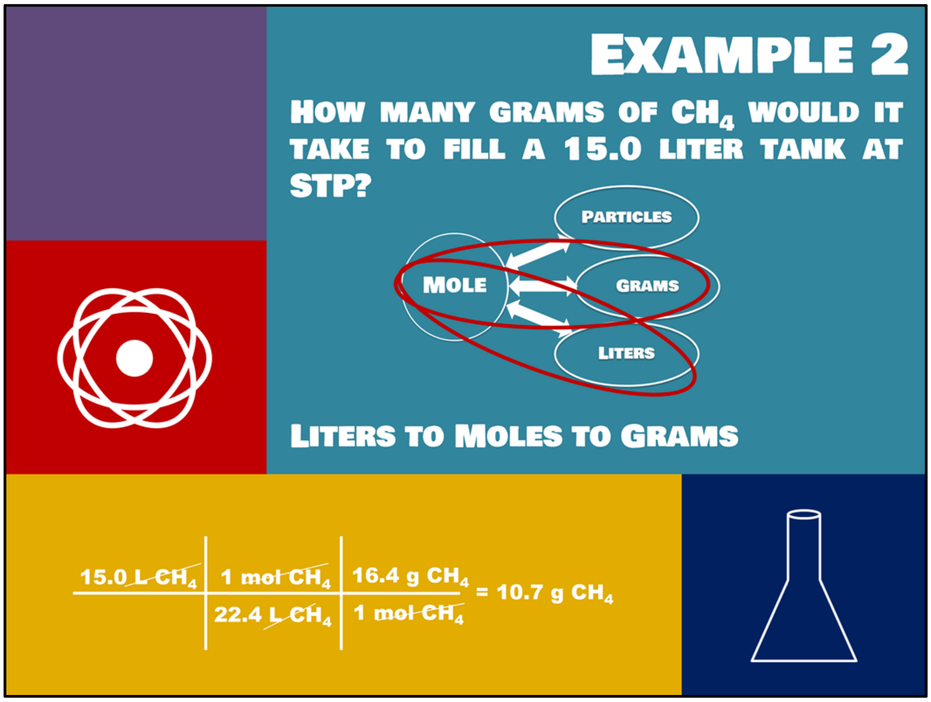


So far, you have seen the broad term "particles" used to describe the components of a mole. Depending on the scenario, the term "particle' is replaced by one of the following terms: atoms, molecules, formula units, or ions. If the conversion is related to a covalent compound, then the term molecule should be used. If the conversion is related to an ionic compound, then the term formula unit should be used. If the conversion is related to a monatomic element, like carbon, then the term atom should be used. Finally, if the conversion is related to an ion, like phosphate, then the term ion should be used. All of these words represent the particle unit for these specific particle types.



Take a look at this example of a conversion scenario. Pretend that you have a sample of 4.33 moles of neon and you are being asked to find the number of atoms in the sample. Refer back to the mole map when determining the steps of the scenario. This problem uses particles and moles. Remember, one mole equals 6.02×10^{23} atoms. To solve this, you will need to use dimensional analysis.

When writing out the dimensional analysis, add the given part of the problem first. Here, it is 4.33 moles of neon. Since you know that there are 6.02×10^{23} atoms in one mole, then next step is to add this information. You can then cancel out the units and solve the problem by multiplying 4.33 times 6.02×10^{23} to find that 4.33 moles of neon is equal to 2.61×10^{24} atoms of neon.



In this example, you are being asked to determine the number of grams of methane it would take to fill a 15.0 liter tank at STP. Dimensional analysis will be used to solve this, but this will actually involve the conversion from liters to moles and then from moles to grams.

Both conversions are important because there is not a direct relationship between liters and grams. When setting up this equation, first write the given information, 15. 0 liters of CH_4, which is methane. The equivalence of moles to liters is one mole of CH_4 equals 22.4 liters of CH_4 at standard temperature and pressure. The problem is asking for the amount of grams of methane it will take to fill the tank, so now it is time to convert moles to grams.

You know that one mole equals the molar mass of CH_4. So, multiply by the gram formula mass of CH_4, which is 16.4 grams CH_4, over one mole of CH_4. Now it is time to solve for the grams of methane. On the left-hand side, "liter of CH 4" will cancel out first. Then, "mole CH_4" will cancel out. After you multiply and divide going from left to right, the answer is 10.7 grams of CH_4. This shows that it will take 10.7 grams of methane to fill a 15.0 liter tank at standard temperature and pressure.