

Name: _____

Section: _____

THE MOLE

This lesson is an introduction to the concept of the **Mole** and calculating conversions related to the **Mole**. The best analogy for understanding a mole is the dozen. A dozen is simply a word that describes a numerical value – twelve. A mole is the same thing, just a word, but it describes a different number. You will do various conversions with dozens to help transition your understanding to the **Mole**.



CALCULATING DOZENS

Directions: The questions below will help refresh your memory on how to go through the process of dimensional analysis and how to use scientific notation on your calculator. Using the provided “map” and equalities, answer the following questions in the space provided.



1 doz. Basketballs (Bb) = 2.21×10^3 g

1 doz. Soccer balls (Sb) = 1.44×10^3 g

1 doz. Tennis balls (Tb) = 5.76×10^2 g

1 doz. Ping-Pong balls (Pb) = 2.94×10^1 g

1000 grams = 1 kilogram

1. What is the mass of **2.3 doz. Soccer balls (Sb)**?

2. Given a mass of **5.00×10^3 g of tennis balls (Tb)**, how many dozen tennis balls would you have?

DOZENS TO MOLES

How many is a dozen?

How much do you think a dozen weighs?

A dozen is a number that has been given a name. The same can be said for a mole. The only difference is that the number defined as a mole is very, big!!!

1 mole = 6.02×10^{23} = Avogadro's Number

Based on the information in the box above, how many is a mole?

How much do you think a mole weighs?

Can you think of other words that represent numerical values?

Why do you think scientists use such a large number in Chemistry?

IS A MOLE REALLY THAT BIG? (HELPFUL ANALOGIES)

- If an atom were the size of a marble and one mole of marbles were spread over the surface of the Earth, our planet would be covered by a 50 mile-thick layer.
- A new supercomputer can count all of the people in the United States in one-quarter of a second, but it would take almost two million years for it to count one mole of people at the same rate.
- If you made \$40,000 (4 million pennies) every second at your job that you had been working at since the formation of earth, 4.5 billion years ago, you would not yet have earned Avogadro's number (a mole's worth) of **pennies**.
 - *Is this true/possible? Do the calculations in the open space below to find out. You must first convert 4,500,000,000 years to seconds and then multiply the seconds by 4,000,000 pennies*

SO HOW IS A MOLE HELPFUL?

Scientists obviously can't mass quantities of chemicals in atomic mass units (amu) because an amu is far too small. When scientists work with a substance like H₂O, they can't deal with single molecules – we can't see or mass 2 atoms of hydrogen and one atom of oxygen. Scientists obviously have to work with much larger quantities. To solve this problem, scientists use the mole. However, to be useful the mole has to be somehow related to amu. Officially, the **mole** (symbol **mol**) is the SI term for the amount of substance containing as many elementary particles as there are atoms in 0.012 kg of carbon-12 (which is about 6.02×10^{23} atoms).

WHERE DO YOU FIND HOW MUCH A MOLE OF SOMETHING WEIGHS?

The atomic mass given on the periodic table is not only the mass of one atom of that element, but it is also the mass (in grams) of 1 mole of the atoms of that element. Therefore, since the mass of one carbon atom is 12 amu, the mass of one mole of Carbon atoms would be 12 grams. When dealing with a molecule or compound you simply calculate the molecular/formula mass using the periodic table, and this (like with atoms) is not only the mass of one molecule/compound, but it is also the mass (in grams) of 1 mole of the molecule/compound. Therefore, since the mass of one molecule of ozone (O₃) is 48 amu, the mass of one mole of ozone molecules would be 48 grams.

USING YOUR PERIODIC TABLE, DETERMINE THE MOLAR MASS OF THE FOLLOWING:

1 mole of Oxygen = _____ grams

1 mole of Sodium = _____ grams

2 moles of Carbon = _____ grams

3 moles of Hydrogen = _____ grams

1 mole of water molecules (H₂O) = _____ grams

USING WHAT YOU HAVE LEARNED SO FAR, COMPLETE THE FOLLOWING EQUALITIES:

1 mole apples = _____ apples

6.02 x 10²³ peanuts = _____ mole(s) of peanuts

1 mole people = _____ people

16 grams of Oxygen = _____ mole(s) of Oxygen

1 mole of Lithium = _____ grams of Lithium

MOLE CONVERSIONS/PROBLEMS

(WHAT THEY LOOK LIKE)

ONE STEP PROBLEM

1. Calculate the mass of 7.5 moles of Carbon.

$$\frac{7.5 \text{ moles of C}}{1} \times \frac{12 \text{ grams}}{1 \text{ mole of C}} = \boxed{90 \text{ grams of C}}$$

TWO STEP PROBLEM

2. How many atoms are in 45.8 grams of Na?

$$\frac{45.8 \text{ grams of Na}}{1} \times \frac{1 \text{ mole of Na}}{23 \text{ grams of Na}} \times \frac{6.02 \times 10^{23} \text{ atoms of Na}}{1 \text{ mole of Na}}$$

$$= \boxed{1.20 \times 10^{24} \text{ atoms of Na}}$$

ONE STEP PROBLEM THAT REQUIRES YOU TO CALCULATE THE MOLECULAR/FORMULA MASS

3. Calculate the mass of two moles of the compound $\text{Ca}(\text{NO}_3)_2$.

A. $\text{Ca} = 40 \text{ g/mol} \times 1 = 40 \text{ g/mol}$

$$\text{N} = 14 \text{ g/mol} \times 2 = 28 \text{ g/mol}$$

$$+ \text{O} = 16 \text{ g/mol} \times 6 = 96 \text{ g/mol}$$

$\text{Ca}(\text{NO}_3)_2$ has a mass of **164 grams/mol**

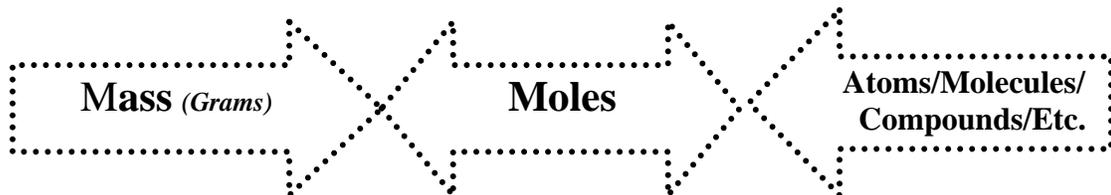
(to be used as a fraction below)

B. $\frac{2 \text{ moles of Ca}(\text{NO}_3)_2}{1} \times \frac{164 \text{ grams of Ca}(\text{NO}_3)_2}{1 \text{ mole of Ca}(\text{NO}_3)_2}$

$$= \boxed{328 \text{ grams of Ca}(\text{NO}_3)_2}$$

GUIDED PRACTICE

Now that you have reviewed the process of converting units (dimensional analysis), learned what a mole is, determined how to figure out the mass of a mole of an element/molecule/etc., and taken a look at some sample mole conversions, it is time to tie it all together. Use your “Mole Road Map” and a periodic table to complete the following problems. Although they get progressively harder, you should not get frustrated because you have all of the skills necessary to get the correct answer; you just have to tie all of those skills together.



1. How many atoms are in 2.3 moles of sodium?

$$\frac{(2.3 \text{ moles of Na})}{(1)} \left(\frac{\text{_____ atoms of Na}}{\text{_____ mole of Na}} \right) =$$

2. How many moles are in 88 grams of CO₂?

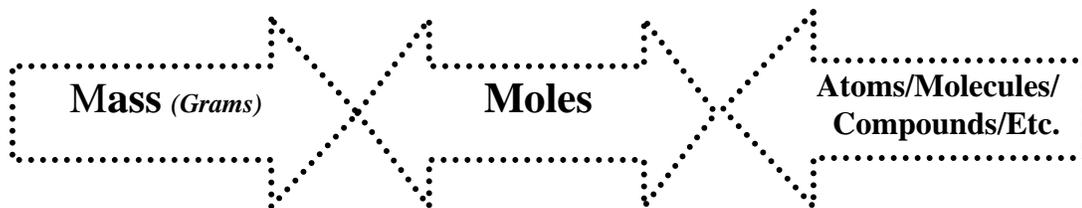
$$\frac{(88 \text{ grams of CO}_2)}{(1)} \left(\frac{\text{_____ mole of CO}_2}{\text{_____ grams of CO}_2} \right) =$$

3. What is the mass of 9.76 x 10³⁵ atoms of lithium?

$$\frac{(9.76 \times 10^{35} \text{ atoms of Li})}{(1)} \left(\frac{\text{_____ mole of Li}}{\text{_____ atoms of Li}} \right) \left(\frac{\text{_____ grams of Li}}{\text{_____ mole of Li}} \right) =$$

4. How many moles are in 6.02 x 10²³ atoms of Carbon

$$\frac{(6.02 \times 10^{23} \text{ atoms of C})}{(1)} \left(\frac{\text{_____}}{\text{_____}} \right) =$$



5. What is the mass of 5 moles of H₂O?

$$\frac{(5 \text{ moles of H}_2\text{O})}{(1)} \left(\frac{\quad}{\quad} \right) =$$

6. How many atoms are in a 550 gram sample of gold?

$$\frac{(550 \text{ grams of Au})}{(1)} \left(\frac{\quad}{\quad} \right) \left(\frac{\quad}{\quad} \right) =$$

7. What is the mass of 9 moles of nitrogen?

$$\left(\frac{\quad}{(1)} \right) \left(\frac{\quad}{\quad} \right) =$$

8. How many molecules are in 0.25 moles of CH₄?

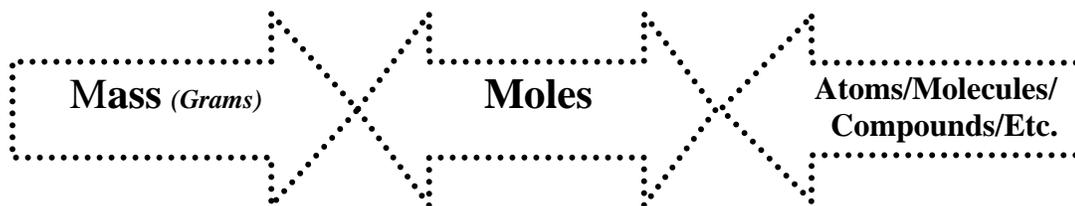
$$\left(\frac{\quad}{(1)} \right) \left(\frac{\quad}{\quad} \right) =$$

9. What is the mass of 1.27 x 10¹⁵ atoms of rubidium?

$$\left(\frac{\quad}{(1)} \right) \left(\frac{\quad}{\quad} \right) \left(\frac{\quad}{\quad} \right) =$$

MOLE PRACTICE PROBLEMS

Directions: Complete the following problems on a separate sheet of paper by using the “Mole Road Map” and a periodic table.



ONE STEP PROBLEMS

1. How many moles are in 19.5 grams of platinum?
2. How many grams are in 1.25 moles of nickel?
3. How many moles are present in 86.2 grams of sodium?
4. What is the mass of 1.89×10^{-4} moles of lead?
5. How many atoms are in 6.3 moles of Oxygen?

TWO STEP PROBLEMS

6. What is the mass of 3.50×10^{22} atoms of Mg?
7. How many atoms are found in a piece of gold with a mass of 2.89 grams?
8. What is the mass (in grams) of 7.99×10^{17} atoms of platinum?
9. How many atoms are in a 56 gram sample of oxygen?
10. How much do 2000 atoms of Uranium weigh (in grams)?

ONE AND TWO STEP PROBLEMS

(THESE REQUIRE YOU TO CALCULATE THE MOLECULAR/FORMULA WEIGHT)

11. Find the mass of 1.34 mol of CaCl_2 .
12. A bottle contains 45.3 grams of KNO_3 . How many moles of KNO_3 are in the bottle?
13. How many molecules of H_2O are in 0.583 mol of H_2O ?
14. How many grams are in 3.4 moles of HCl ?
15. How many moles are in 13.2 grams of $\text{Sn}(\text{CO}_3)_2$?