

Moles & Gram Formula Mass

The SI (système international) unit for "amount of a substance" is the **mole**. A mole is equal to 6.022×10^{23} . Thus, a mole of pennies would be 6.022×10^{23} pennies. This number is very large and difficult to comprehend. A mole of soda cans would cover the **surface of the earth** to a depth of over 200 miles; a mole of un-popped popcorn kernels spread across the United States would be cover it to a depth of over 9 miles; if you counted atoms at a rate of 10 million per second, it would take about 2 billion years to count the atoms in one mole.

Chemicals are made up of molecules, ions and atoms. Since experimentally there are far too many of these **representative particles** (atoms, ions & molecules) to count individually, and they are too small, chemists count moles instead.

Although 6.022×10^{23} is often called **Avogadro's number**, **Amadeo Avogadro (1776-1856)** never determined his number. Avogadro's Law, postulated in 1811, was based on the work of Joseph Louis Gay-Lussac (whose work we will study later this year). **Avogadro's Law states that, so long as temperature and pressure are equal, an equal volume of any gas will contain the same number of molecules.** Avogadro's Law was ignored until 1858, when Stanislao Cannizzaro proved it experimentally by using it to determine accurate atomic weights.



Avogadro's number can be determined experimentally by observing the actual mass (usually via the momentum) of a "single" atom or molecule, then comparing that to the mass of one gram-molecular-weight (or mole) of the same substance. One mole of any element is equal to its atomic weight in grams. For example, **one mole of carbon would have a mass of 12.011 grams.**

Today we will learn how to calculate the **gram formula mass (or molar mass)** of a compound. **Gram formula mass is defined as the atomic mass of one mole of an element, molecular compound or ionic compound.** The answer must always be written with the unit **g/mol (grams per mole)**.

Calculating a substance's gram formula mass:

Example: Calculate the gram formula mass of **ammonium phosphate**.

| Description of Action | Action |
|---|---|
| 1. Write the formula for the compound. | 1. $(\text{NH}_4)_3\text{PO}_4$ |
| 2. Determine how many of each atom there are in the compound. If there is a number outside the parenthesis, multiply each subscript by this number. If there is no subscript, assume it is one. | 2. N: 3 H: 12 P: 1 O: 4 |
| 3. Multiply the number of atoms by its atomic weight. Round the atomic weight to the tenth's place. | 3. N: $3 \times 14.0 = 42.0$ H: $12 \times 1.0 = 12.0$ P: $1 \times 31.0 = 31.0$ (31.0 is rounded from 30.97) O: $4 \times 16.0 = 64.0$ (16.0 is rounded from 15.99) |
| 4. Add your results and use the unit g/mol (grams per mole) on the end. | 4. $42.0 + 12.0 + 31.0 + 64.0 = 149.0 \text{ g/mol}$. |

Now you try it with **aluminum nitrate**.

| Description of Action | Action |
|-----------------------|--------------------------------------|
| 1. | 1. |
| 2. | 2. |
| 3. | 3. |
| 4. | 4. Answer= 213.0 g/mol |

Homework: Write the formula for each of the following compounds and then calculate its gram formula mass. Your final answer must match the answer given.

1. ammonium sulfide **Answer = 68.1 g/mol**

2. ferric oxide

Answer = 159.6 g/mol

3. mercury(II) phosphate **Answer = 791.8 g/mol**

4. manganese(III) silicate

Answer = 338.1 g/mol

5. plumbic perchlorate **Answer = 605.2 g/mol**

6. copper(I) iodide

Answer = 190.4 g/mol

7. tin(IV) nitride **Answer = 412.1 g/mol**

8. cesium nitrite

Answer = 178.9 g/mol

9. barium hydroxide **Answer = 171.3 g/mol**

10. stannous phosphide

Answer = 418.1 g/mol

11. ammonium carbonate **Answer = 96.0 g/mol**

12. iron(II) bromide

Answer = 215.6 g/mol

13. What is the SI unit for amount of a substance? _____

14. What is the value of a mole? _____

15. What is meant by the term representative particles? _____

16. What is another name for 6.022×10^{23} ? _____

17. Define gram formula mass. _____

18. What unit is used when measuring gram formula mass? _____

19. When calculating gram formula mass, atomic weight should be measured to the _____ place.