



Sometimes it is important to know exactly how many particles (e.g. atoms or molecules) are in a sample of a substance, or what quantity of a substance is needed for a chemical reaction to take place.

The amount of substance is so important in chemistry that it is given its own name, which is the mole. Just like **a dozen = 12** and **a gross = 144**, so **a mole = $6,02 \times 10^{23}$** . This is called Avogadro's number (N_A).

Remember when we learned about Relative Atomic Mass (the Mass Number on the Periodic Table). The units we gave to the mass were amu or just u and this came from the number of protons and neutrons in an atom – a TINY little mass for every atom! Scientists realised it would be so much easier to work with a larger mass that can be handled, like grams.

Think about Carbon: Mass Number = 12
 Relative Atomic Mass = 12 amu

The Italian scientist, Avogadro, discovered that if you take **12 grams** of Carbon, it contains $6,02 \times 10^{23}$ atoms. So he called this number of atoms "a mole".

That's why we call it **Avogadro's number!**

And, in fact, if you change the Relative Atomic Mass of ANY element to grams, it will contain Avogadro's number of atoms!

So: 12 g C contains $6,02 \times 10^{23}$ atoms
 24 g Mg contains $6,02 \times 10^{23}$ atoms
 32 g S contains $6,02 \times 10^{23}$ atoms

Examples: calculating mass

- 1) 1 mole of Sodium = 23g ([Hint: you need to use your Periodic Table!](#))
- 2) 1 mole of potassium = g
- 3) 2 moles of boron = g
- 4) 3 moles of S = g
- 5) 2,5 moles of Ne = g

Question 1

Calculate the mass of:

- 1.1) 1 mole of a Lithium g
- 1.2) 2 moles of calcium g
- 1.3) 5 moles of phosphorus g

Calculate how many moles there are in:

- 1.4) 24 g of magnesium moles
- 1.5) 24 g of carbon moles

Question 2:

Element	Relative atomic mass (u)	Sample mass (g)	Number of moles in the sample
Hydrogen	1,01	1,01	
Magnesium	24,3	24,3	
Carbon	12,0	24,0	
Chlorine	35,45	70,9	
Nitrogen	14,0	42,0	

Definitions:

Avogadro's number, N_A , is the number of particles (atoms, molecules, formula units) present in 1 mole

One mole of a substance contains the same number of particles as there are atoms in 12 g of C-12.

Watch the following short video which explains what a mole is:

Molar mass

Molar mass (M) is the mass of 1 mole of a substance measured in g.mol^{-1}

The molar mass of a substance is the mass of 1 mole of that substance. The word “molar” means per mole. The units for the molar mass of any substance is “grams per mole” or “ g.mol^{-1} ”.

- Molar mass of an atom = relative atomic mass (from the periodic table)
- Molar mass of a molecule = sum of relative atomic masses of elements

So 1 mole of oxygen atoms, O = 16 g and contains $6,02 \times 10^{23}$ atoms

But 1 mole of oxygen molecules, O₂ = 16 x 2 = 32 g and contains $6,02 \times 10^{23}$ molecules

Examples: molar mass

Calculating molar masses :

$$\text{eg 1) NaCl} = 23 + 35,5 = 58.5 \text{ g.mol}^{-1}$$

$$2.) \text{H}_2\text{O} = 2(1) + 16 = \text{ g.mol}^{-1}$$

$$3.) \text{Al}_2(\text{CO}_3)_3 = 2() + 3[12 + 3(16)] = \text{ g.mol}^{-1}$$

$$4.) \text{CuSO}_4 \cdot 5\text{H}_2\text{O} = 63,5 + 32 + 4() + 5[2(1) + 16] = \text{ g.mol}^{-1}$$

Question 3

Calculate the molar mass of the following:

$$3.1) \text{ NaOH: } \quad + \quad + \quad = \quad \text{g.mol}^{-1}$$

$$3.2) \text{ CuSO}_4: \quad + \quad + (4 \times \quad) = \quad \text{g.mol}^{-1}$$

$$3.3) \text{ Ca(OH)}_2: \quad + 2 (\quad + \quad) = \quad \text{g.mol}^{-1}$$

$$3.4) \text{ Mg(NO}_3)_2: \quad + 2 [\quad + (3 \times \quad)] = \quad \text{g.mol}^{-1}$$

$$3.5) \text{ Ba}_3(\text{PO}_4)_2: \quad (3 \times \quad) + 2 [\quad + (4 \times \quad)] = \quad \text{g.mol}^{-1}$$

On the periodic table, the relative atomic mass that is shown can be interpreted in three ways:

- 1. The mass (in grams) of a single, average atom of that element relative to the mass of an atom of carbon.*
- 2. The average atomic mass of all the isotopes of that element. This use is the relative atomic mass.*
- 3. The mass of one mole of the element. This third use is the molar mass of the element in g.mol⁻¹.*

THE MOLE: 6.022×10^{23}



What is a Mole?

One mole is the amount of a substance that contains 6.022×10^{23} atoms or molecules. It is specifically defined as the number of atoms contained in 12 grams of carbon-12. This is also known as 'Avogadro's Number' (N_A); it is named after the Italian scientist Amedeo Avogadro (left), a suggestion put forward by French scientist Jean Perrin to recognise Avogadro's work.



One mole is essentially 602,214,179,000,000,000,000,000
of something - in chemistry, atoms or molecules



Water



Iron



Oxygen



Table Salt



Gold



Helium

ONE MOLE IS A DIFFERENT MASS FOR DIFFERENT ELEMENTS & COMPOUNDS

This may seem confusing; however, it's similar to comparing a dozen elephants to a dozen mice. Although their masses may be very different, you still have a dozen of each!



A mole is often referred to as 'a chemist's dozen'

IT'S JUST AN EASIER WAY TO COUNT LARGE NUMBERS OF ATOMS & MOLECULES

$$\text{NO. OF MOLES} = \text{MASS (g)} \div \text{MASS OF 1 MOLE (g)}$$



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