The Mole

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 x10^{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 x 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 x 10^{23} atoms
24 g Mg contains 6,02 x 10^{23} atoms
32 g S contains 6,02 x 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 <u>atom</u> = relative atomic mass (from the periodic table)
- Molar mass of a <u>molecule</u> = sum of relative atomic masses of elements

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

But 1 mole of oxygen <u>molecules</u>, O_2 = 16 x 2 = 32 g and contains $6{,}02 \times 10^{23}$ <u>molecules</u>

Examples: molar mass

Calculating molar masses :

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

2.) H_2O = 2(1) + 16 = $g.mol^{-1}$

3.) $Al_2(CO_3)_3$ = 2( ) + 3[12 + 3(16)] = $g.mol^{-1}$

4.) $CuSO_4.5H_2O$ = 63,5 + 32 + 4( ) + 5[2(1) + 16] = $g.mol^{-1}$

Question 3

Calculate the molar mass of the following:

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

3.2) $CuSO_4$: + + (4 x) = $g.mol^{-1}$

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

3.4) $Mg(NO_3)_2$: + 2 [+ (3 x)] = $g.mol^{-1}$

3.5) $Ba_3(PO_4)_2$: (3 x) + 2 [+ (4 x)] = $g.mol^{-1}$

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}

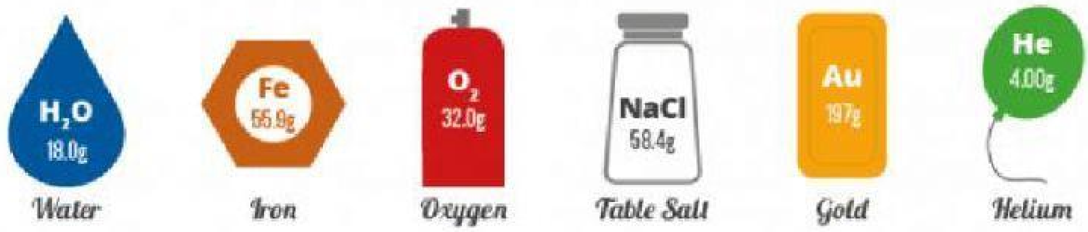
What is a Mole?

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

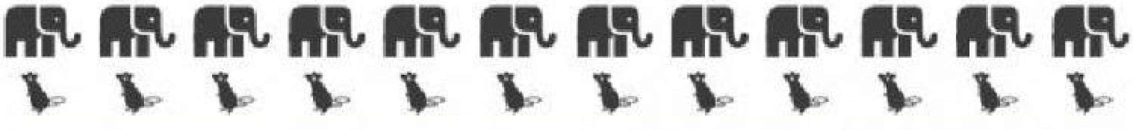
602,214,179,000,000,000,000,000

of something - in chemistry, atoms or molecules



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

NO. OF MOLES = MASS (g) ÷ MASS OF 1 MOLE (g)