### Calculation of the molar mass of elements

<table>
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<tr>
<th>Element</th>
<th>Structure</th>
<th>Calculation</th>
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</table>
| copper (Cu) | metallic lattice—cations in a ‘sea of electrons’ | Its molar mass is simply its atomic weight. Atomic weight of copper from Periodic Table = 63.55  
**Molar mass of copper is 63.55g** |
| oxygen (O₂) | diatomic molecule                       | Its molar mass is twice its atomic weight. Atomic weight of oxygen from the Periodic Table = 16.00  
Molar mass of oxygen = 2 x 16.00 = 32.00g  
**Molar mass of oxygen molecules is 32g** |
| carbon (C)  | a covalent lattice in the allotropic form, diamond | The molar mass of carbon (diamond) is simply its atomic weight taken from the Periodic Table.  
**Molar mass of carbon is 12.01g** |

### Calculation of the molar mass of compounds

<table>
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<th>Compound</th>
<th>Structure</th>
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| water (H₂O)                    | covalent compound consisting of molecules of two atoms of hydrogen and one of oxygen | Molecular weight = sum of the atomic weights of the product of each atom and the number of times it occurs in the compound  
From the Periodic Table  
Molecular weight = (2 x 1.01) + (1 x 16.00) = 18.02  
**Molar mass of water is 18.02g** |
| sodium chloride (NaCl)         | an ionic compound consisting of a lattice of sodium ions (Na⁺) and chloride ions (Cl⁻) on a one-to-one ratio | Use the empirical formula for sodium chloride to calculate its molar mass.  
Empirical formula = NaCl  
Molar mass = sum of atomic weights of each ion component  
From the Periodic Table  
Molar mass = 22.99 + 35.45 = 58.44g  
**Molar mass of NaCl is 58.44g** |
| silicon dioxide (SiO₂)         | covalent lattice network compound              | Does not have a molecular formula so its empirical formula or formula weight is used for calculating its molar mass.  
Molar mass = 28.09 + (2 x 16.00) = 60.09g  
**Molar mass of silicon dioxide is 60.09g** |
| copper(II) sulfate pentahydrate or CuSO₄.5H₂O. | ionic compound as crystals in which some water still remains | Add the atomic weights of all the component atoms including the water.  
M = 63.55 + 32.07 + (4 x 16.00) + 5 ((2 x 1.008) + 16.00) = 249.70g  
**Molar mass of copper(II) sulphate pentahydrate is 249.70g** |
Using the formula \( n = \frac{m}{M} \)

\( n = \frac{m}{M} \)

\( n \) is the number of moles

\( m \) is the number of grams of the substance

\( M \) is the molar mass of the substance

**Example 1**

I have 22.45 g of copper. How many moles of copper do I have?

\( m = 22.45\text{g} \quad M = 63.55\text{g} \)

\( n =? \)

\[ n = \frac{22.45}{63.55} = 0.35 \text{ mol} \]

I have **0.35 mol of copper**

**Example 2**

I have 12.3 moles of copper. How many grams do I have?

Use \( n = \frac{m}{M} \)

\( n = 12.3 \text{ mol} \quad M = 63.55 \)

\( m =? \)

\[ 12.3 = \frac{m}{63.55} \]

Multiply both sides of the equation by 63.55

\[ 12.3 \times 63.55 = m = 781.67 \text{ g} \]

I have **781.67 g of copper**

**Example 3**

I have 4.2 mol of a metal with a mass of 266.91 g. What is its molar mass, and what is the substance?

\( n = 4.2 \text{ mol} \quad m = 266.91 \text{ g} \)
\[ M = ? \]

\[ 4.2 = \frac{266.91}{M} \]

Multiply both sides by \( M \)

\[ 4.2M = 266.91 \]

Divide both sides by 4.2

\[ M = \frac{266.91}{4.2} = 63.55 \]

**The molar mass of the substance is 63.55**

Scanning the Periodic Table shows the substance with a. atomic weight of 63.55 is copper.

**The substance is copper.**

(Note we can assume the molar mass is the atomic mass because we are told that the substance is a metal.)

**Using Avogadro’s Number, \( N_A \)**

The number of atoms, molecules or formula units in a mole is Avogadro’s number, \( N_A \).

We can then say that \( n = \frac{N}{N_A} \) where \( N \) is the number of atoms, molecules or formula units.

**Example 1**

I have 0.5 mol of copper. How many atoms of copper do I have?

1 mol of copper has \( N_A \) or \( 6.022 \times 10^{23} \) atoms

0.5 mol of copper has \( 6.022 \times 10^{23} \times 0.5 \) atoms

I have \( 3.011 \times 10^{23} \) atoms of copper

Or \( n = \frac{N}{N_A} \)

\[ 0.5 = \frac{N}{6.022 \times 10^{23}} \]

\[ N = 0.5 \times 6.022 \times 10^{23} = 3.011 \times 10^{23} \text{ atoms of copper} \]

I have \( 3.011 \times 10^{23} \) atoms of copper

**Example 2**

I have 29.2 g of copper. How many copper atoms do I have?
I first have to calculate how many moles of copper I have and then multiply by Avogadro’s number.

\[ m = 29.2 \quad M = 63.55 \]

\[ n = \frac{m}{M} = \frac{29.2}{63.55} \]

\[ n = 0.46 \text{ mol of copper} \]

1 mol of copper has \(6.022 \times 10^{23}\) atoms

0.46 mol of copper has \(6.022 \times 10^{23} \times 0.46\) atoms

\[ 2.77 \times 10^{23} \text{ atoms are in 29.2 g of copper} \]