Chemistry 2.1
Quantitative Analysis

Chemical calculations 1

Systeme International d'Unites

- All measurements made in science use the same set of units for convenience.
- Here are a few examples that are commonly used in chemistry

Used in formula

10^0

Measurement	symbol	Base unit name	Base unit symbol
Mass	*m*	*Grams*	*g*
Time	*t*	*Seconds*	*s*
Volume	*V*	*Litres*	*L*
Amount	*n*	*Mole*	*mol*
Energy	*E (or H)*	*Joules*	*J*

Prefix

Prefix	Symbol	Meaning
Tera-	*T*	10^{12}
Giga	*G*	10^{9}
Mega	*M*	10^{6}
Kilo	*k*	10^{3}
Deci-	*d*	10^{-1}
Centi-	*c*	10^{-2}
Milli-	*m*	10^{-3}
Micro	*μ*	10^{-6}
Nano	*n*	10^{-9}
Pico	*p*	10^{-12}

Mole

- 1 dozen means 12
- 1 **mole** means **6×10^{23}**

Example

In one mole of NaCl

There are 6×10^{23} Na^{+} ions

There are 6×10^{23} Cl^{-} ions

There are 1.2×10^{24} ions

The Avogadro's Number (N_A)

- A mole always contains $6(.02) \times 10^{23}$ particles.
- This is called the Avogadro's number
- This number will ALWAYS be given even in university level.

How many moles of **Hydrogen atoms** in 2400000000 molecules of water?

☺ For the geeks in the class ☺

The currently accepted value of N_A is

6.0221367×10^{23}

Molar Mass

Mass per Amount

Grams per mole ($gmol^{-1}$)

The Molar Mass (M)

- The **molar mass** is the **average mass of one mole** of an element, ion or compound.
- It has a unit **grams per mole**

$g\ mol^{-1}$

- The molar mass of a compound is the **SUM of all the molar mass** in the chemical formula

Example

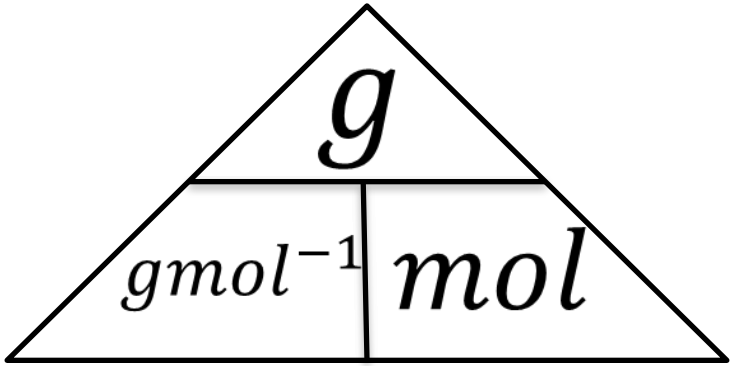
- The molar mass for Ethanoic Acid (CH_3COOH)

2 x Carbon	= 2 x 12.0	= 24.0 $gmol^{-1}$
4 x Hydrogen	= 4 x 1.0	= 4.0 $gmol^{-1}$
2 x oxygen	= 2 x 16.0	= 32.0 $gmol^{-1}$

Molar Mass for CH_3COOH = <u>60.0 $gmol^{-1}$</u>

Molar mass calculation

$$\frac{m}{n} = M = g\ mol^{-1} = \frac{g}{mol}$$



Example

- What is the amount of sodium ion in 45.3 g of sodium carbonate.

Calculate the **molar mass of sodium carbonate**

$$Na_2CO_3 = 23 \times 2 + 12 + 16 \times 3 = 106\ gmol^{-1}$$

Calculate the **mole of sodium carbonate**

$$45.3\ g \div 106\ gmol^{-1} = 0.427\ldots\ mol$$

Ratio of sodium ion and sodium carbonate

$$Na^+ : Na_2CO_3 = 2 : 1$$

Apply the ratio to determine the mole of Na^+

$$0.427\ldots \times 2 = \underline{0.855\ mol}\ (3s.f.)$$

Exercise

- Calculate the amount (in mole) of carbon dioxide (CO_2) of 25.7 g of carbon dioxide.
- Calculate the mass of 0.235 mol of sodium chloride (NaCl)
- Calculate the amount (in mole) of iodine atoms in 87.3 g iodine (I_2) solid.

Concentration

Amount per volume

Mole per Litre ($molL^{-1}$)

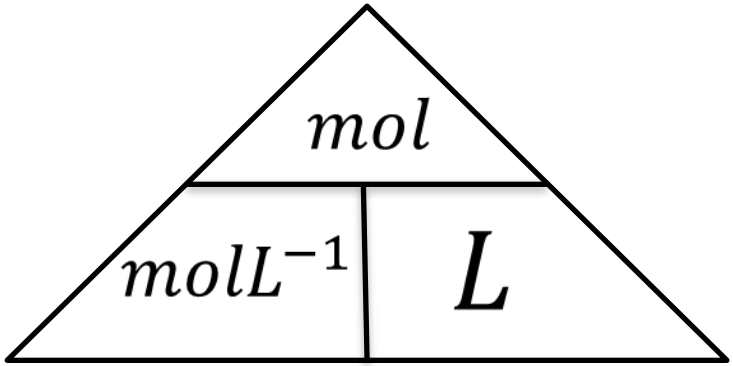
Concentration (c)

- Concentration is an expression of the amount of particle per volume space
- Amount is measured in mole
- Volume is measured in Litre
- Therefore the unit for concentration is

mol per litre ($molL^{-1}$)

Concentration Calculation

$$\frac{n}{V} = c = molL^{-1} = \frac{mol}{L}$$



Example

- What is the concentration when 9.8 g of sodium chloride dissolved in 500 mL of water

Calculate the molar mass of sodium chloride

$$23.0 + 35.5 = 58.5 \text{ g mol}^{-1}$$

Calculate the amount (in mole) of sodium chloride

$$9.8 \text{ g} \div 58.5 \text{ g mol}^{-1} = 0.168\ldots \text{ mol}$$

Calculate the volume (in litre)

$$500 \text{ mL} \div 1000 \text{ mLL}^{-1} = 0.500 \text{ L}$$

Calculate the concentration

$$0.168\ldots \text{ mol} \div 0.500 \text{ L} = \underline{0.335 \text{ molL}^{-1}}$$

Exercise

- What is the concentration when 52.3 g of sodium sulfate (Na_2SO_4) dissolved in 250 mL of water?
- What is the mass of Zinc Chloride ($ZnCl_2$) needed to create 40mL of 0.1molL^{-1} solution?