Concentration

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Concentration (or Molarity)

Moles of a substance can be related to other properties of a substance including the concentration and volume of a substance.

$$\text{concentration} = \frac{\text{moles}}{\text{volume of solution (in dm}^3\text{)}}$$

The unit of concentration (which is also called Molarity) is **mol dm^{-3}** or M

The biggest error students make when doing calculations with concentration is that the do not convert other units of volume into dm^3

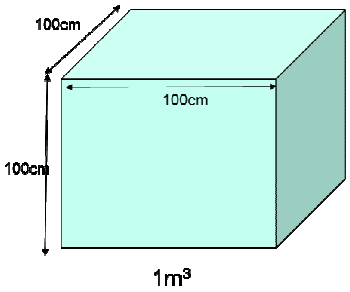
Different units of volume

A cm^3 is equivalent to a cube 1cmx1cmx1cm

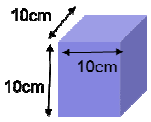
$1cm^3$ = 1 ml

A dm^3 is equivalent to a cube 10cmx10cmx10cm= $1000cm^3$

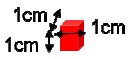
$1dm^3$ = 1litre



$1m^3$



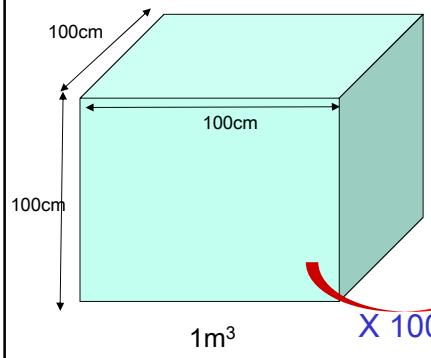
$1dm^3$ or 1 litre



$1cm^3$

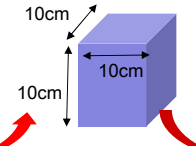
A m^3 is equivalent to a cube 100cmx100cmx100cm= $1000000cm^3$

Converting into dm^3



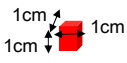
$1m^3$

X 1000



$1dm^3$ or 1 litre

X 1000



$1cm^3$

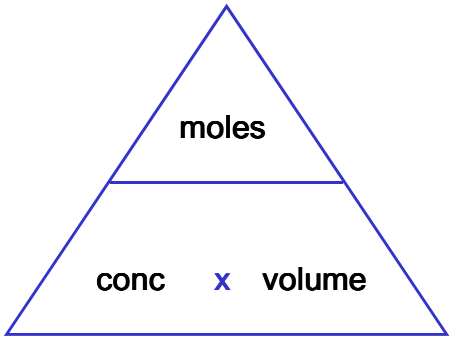
1 dm^3 = 1000 cm^3 or 1000mL

To convert cm^3 into dm^3 divide by 1000

1 m^3 = 1000 dm^3 or 1000L

To convert m^3 into dm^3 multiply by 1000

Calculations with concentration



Moles = conc x vol (in dm^3)

$$\text{concentration} = \frac{\text{moles}}{\text{volume of solution (in } dm^3\text{)}}$$

Calculating concentration

$$\text{concentration} = \frac{\text{moles}}{\text{volume of solution (in } dm^3\text{)}}$$

Example:

What is the concentration of a solution containing 0.2 moles of NaCl dissolved in 300 cm^3 of water?

Convert volume into dm^3 : 300 cm^3 = 0.3dm^3

$$\text{concentration} = \frac{\text{moles}}{\text{volume of solution (in } dm^3\text{)}}$$

$$\text{concentration} = \frac{0.2}{0.3}$$

Concentration = 0.67 mol dm^{-3}

Calculating concentration from mass

Example:

What is the concentration of a solution containing 0.500 grams of KCl dissolved in 50.0 cm^3 of water?

Work out Relative Formula mass of KCl = 39+35.5 = 74.5 $gmol^{-1}$

Number of moles = $\frac{\text{mass}}{\text{relative formula mass}}$ **=** $\frac{0.500}{74.5}$ =0.00671 mol

Convert volume into dm^3 : 50 cm^3 = 0.05dm^3

concentration = $\frac{\text{moles}}{\text{volume of solution (in } dm^3\text{)}}$

concentration = $\frac{0.00671}{0.05}$

Concentration = 0.134 mol dm^{-3}

Give answer to same number of sig figs as data given

Calculate the concentrations of the following solutions:

1) 1.2 moles of calcium chloride ($CaCl_2$) in 1.2 dm^3 of solution.
2) 0.09 moles of sodium sulphate (Na_2SO_4) in 12 cm^3 of solution.
3) 0.75 moles of lithium fluoride (LiF) in 75 mL of solution.
4) 120 grams of calcium hydroxide ($Ca(OH)_2$) in 250 cm^3 of solution.
5) 98 grams of sodium hydroxide in 2.2 dm^3 of solution.
6) 1.2 grams of hydrochloric acid in 25 cm^3 of solution.

Calculating the mass needed to make a solution

Example: What is the mass of NaOH would be needed to make 500cm^3 of 0.75 M solution?

Convert volume into dm^3 : 500 cm^3 = 0.5dm^3

Calculate Moles in solution = conc x vol (in dm^3)

Moles = 0.75 x 0.5 = 0.375 mol

Work out Relative Formula mass of NaOH = 23+16+1 = 40 gmol^{-1}

Calculate mass of NaOH

Mass = moles x M_r

Mass = 0.375 x 40

Mass NaOH = 15g

Give answer to same number of sig figs as data given

What mass of the following solutes would be needed to make the volume of solution specified?

1) 2 dm^3 of 6 M HCl
2) 1.5 dm^3 of 2 mol dm^{-3} NaOH
3) 0.75 dm^3 of 0.25 M Na_2SO_4
4) 45 cm^3 of 0.12 mol dm^{-3} sodium carbonate

Exam Question

Calculate the mass, in grams, of HCl in 560 cm^3 of hydrochloric acid of concentration 0.145 mol dm^{-3}.

Making a solution using a volumetric flask

- Weigh out required amount of solid, and write down the weight at the balance.
- Transfer solid to small beaker and add 50 cm^3 of water and stir to dissolve all solid.
- Transfer solution to volumetric flask using a funnel
- Add water so that the bottom of the meniscus sits on the graduation mark. Use a squeezy pipette to add the last few drops.
- shake the solution well.

Converting concentration (mol dm^{-3}) into solubility (also known as mass concentration) (g dm^{-3})

solubility = concentration x M_r of substance

(g dm^{-3}) (mol dm^{-3}) g mol^{-1}