Other Expressions for Concentration – % Solutions

There are other ways for expressing concentration of a solution – besides stating the Molarity.

These are % expressions:

The amount of solute in the solution is described as a percentage of the total solution.

There are 3 different ways to express a % solution.

% Solutions - Definitions

1) Percent weight (% w/w)

(weight really means "mass"!)

Grams of solute per 100 g of solution

10%: 10g / 100 g (or 0.1g/g)

1% : 1 g / 100 g (or 10 mg/ g)

e.g. to make 10% (w/w) sucrose, add 10 g sucrose to 90 g of de-ionised water

% Solutions - Definitions

2) Percent by volume (v/v):

mls of solute per 100 ml solution

Examples:

- To make a 10 % (v/v) solution from a fully concentrated stock (100% stock) solution: dilute 10 mL stock in 90 mL solvent.

- To make 1% (v/v) solution from a 10% stock: dilute 10 mL stock in 90 mL solvent.

% Solutions - Definitions

3) Percent weight by volume (w/v)

Grams of solute per 100 mL of solution

(Probably the most common of the % expressions.

If you just see % without any units you can assume that it is w/v %)

e.g. A 20% (w/v) NaCl solution has 20 g NaCl dissolved in 100 mL of solution. (*To make it you would dissolve the NaCl in 70 mL water and then bring volume up to 100 mL).*

% composition - Example

Example

Normal spinal fluid contains 3.75 mg of glucose in 5.0 g of fluid. What is the % mass of glucose in spinal fluid.

$$\% \text{ by mass} = \frac{0.00375 \text{ g}}{5.0 \text{ g}} \times 100$$

$$= 0.075\ \%$$

Conversion from % Mass and Mass

Question: What mass of HCl is contained in 0.5 L conc. HCl of density 1.19 g/mL and contains 37.2 % HCl by mass.

1) Using formula: density = mass / volume:

Density = mass / volume and Mass = Density x volume

Therefore mass of solution = 500 mL x 1.19 g/mL = 595 g

37.2% of this mass is HCl

Therefore mass of HCl = 595 x 0.372 = 221.34 g

Conversion between % Mass and Molarity

What is the molarity of HNO_3 solution (nitric acid) of density 1.42 g/mL that contains 68 % HNO_3 by mass?

Work with 1 litre:

Mass = density x volume = 1.42 x 1000 = 1420 g

68% of this mass is HNO_3

Mass of HNO_3 = 0.68 x 1420 = 965.6 g

Molar mass of HNO_3 = 63.012 g/mol

Therefore moles present = 966 g / 63.012 g/mol = 15.3 mol

And these moles are in 1 litre

Therefore Molarity = 15.3 M

Conversion between Molarity and % w/v

- The molarity of a solution of nitric acid is 15.3M.

What is the % w/v of Nitric acid in the solution?

15.3 moles in 1 litre

15.3 moles in 1000 mL

1.53 moles in 100 mL

Definition of % w/v: mass (grams) in 100 mL:

Mass of 1.53 moles of HNO_3 ?

= 1.53 x 63.012 = 96.41 g

Therefore = 96.41 g/ 100 mL = 96.41 %w/v

N.B. If we wanted to know what is the % w/w (% by mass), we would need to know that mass of the SOLUTION (so we would need the density)

Percent Composition (from Formulae)

If X is one constituent of a sample then the percentage by mass of it in the sample is:

mass of (X / mass of sample) x 100

Example

Aspirin has molecular formula $C_9H_8O_4$. What is its % composition?

% C = 9 x 12.011 / 180.159 g x 100 = 60.002 %

%H = 8 x 1.008 g / 180.159 g x 100 = 4.476%

%O = 4 x 15.999 g / 180.159 g x 100 = 35.22 %

Question: What is the mass of lead in 10.5 g of $PbCO_3$?

$$Molarity = \%w/w \times \frac{density}{mol.\,wght} \times 10$$

$$\%w/w = Molarity \times \frac{mol.\,wght}{density \times 10}$$

$$Molarity = \%w/v \times \frac{1}{mol.\,wght} \times 10$$

$$\%w/v = Molarity \times \frac{mol.\,wght}{10}$$

HNO_3 (page 7)

- molecular weight = 63 g/mol
- density = 1.42g/mL
- %w/w = 68%

$$Molarity = \%w/w \times \frac{density}{mol.\,wght} \times 10$$

$$Molarity = 68 \times \frac{1.42}{63} \times 10 = 15.3M$$

$$Molarity = 15.3M$$

HNO_3 (page 8)

- molecular weight = 63 g/mol
- Molarity = 15.3M

$$\%w/v = Molarity \times \frac{mol.\,wght}{10}$$

$$\%w/v = 15.3 \times \frac{63}{10}$$

$$\%w/v = 96.4\%$$

Ppm, ppb, ppt

Other common expressions for concentration:

- Part per million

  1 ppm = 1 mg/kg = 1 µg/g (1x10^{-6} g/g)

- Part per billion

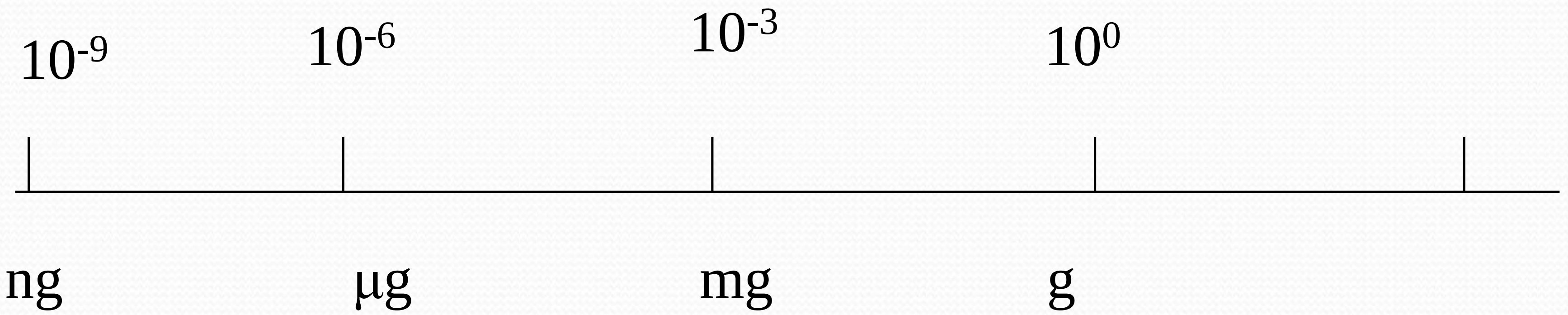
  1 ppb = 1 µg/kg = 1 ng/g (1 x 10^{-9} g/g)

- Part per trillion

  1 ppt = 1 ng/kg = 1 pg/g (1x10^{-12} g/g)

1 ppm = 1000 ppb = 1 000 000 ppt

Submultiples of grams of mass



Analytical Standards

Definition: materials containing a known concentration of an analyte

They provide a reference for:

1) determining unknown concentrations
2) calibrating analytical instruments

Primary Standards

- for titration of acids
  - sodium carbonate
- for titration of bases
  - potassium hydrogen phthalate