Proportions in Solution Mixtures

Expressing Concentration with %, ppm, ppb & ppt

$$\frac{\text{amount of solute}}{\text{amount of solution}} \times \text{representative quantity} \begin{cases} 10^2 \rightarrow \text{parts per hundred} & \% \\ 10^6 \rightarrow \text{parts per million} & \text{ppm} \\ 10^9 \rightarrow \text{parts per billion} & \text{ppb} \\ 10^{12} \rightarrow \text{parts per trillion} & \text{ppt} \end{cases}$$

Concept of ppm: 1 ppm = 1 part of substance in one million parts of water solution, or 1/1,000,000
1 ppm = approximately one second in 11.6 days

Concept of ppb: 1 ppb = 1 part of substance in one billion parts of water solution, or 1/1,000,000,000
1 ppb = approximately one second in 31.7 years

Concept of ppt: 1 ppt = 1 part in one trillion parts of water solution, or 1/1,000,000,000,000
1 ppt = approximately 1.6 days out of the present age of the earth (approx 4.5 billion yrs)

PROCEDURE:

Step 1 convert all volumes to mL and all masses to grams

Step 2 divide → $\frac{\text{amount of solute}}{\text{amount of solution}}$ the units must match dimensions (g/g, g/mL, or kg/L)

Step 3 multiply by $\begin{cases} 10^2 \rightarrow \text{parts per hundred} & \% \\ 10^6 \rightarrow \text{parts per million} & \text{ppm} \\ 10^9 \rightarrow \text{parts per billion} & \text{ppb} \\ 10^{12} \rightarrow \text{parts per trillion} & \text{ppt} \end{cases}$

Example Problem 1 (**percent**):

Find the % concentration of a solution in which 6.8 g of NaCl has been dissolved making a solution with a volume of 85 mL.

$$\% = \frac{\text{amount of solute}}{\text{amount of solution}} \times 100 = \frac{6.8\ g\ NaCl}{85\ mL\ \text{solution}} \times 100 = \boxed{80.\%\ NaCl}$$

Example Problem 2 (**ppm**):

Find the concentration in ppm of a solution in which 0.0059 g of NaCl has been dissolved making a solution with a volume of 750 mL.

$$ppm = \frac{\text{amount of solute}}{\text{amount of solution}} \times 10^6 = \frac{0.0059\ g\ NaCl}{750\ mL\ \text{solution}} \times 10^6 = \boxed{7.9\ ppm\ NaCl}$$

Example Problem 3 (**ppb**):

Find the concentration in ppb of a solution in which 9.6 x 10^{-6} g of NaCl has been dissolved making a solution with a volume of 2.0 L.

$$ppb = \frac{\text{amount of solute}}{\text{amount of solution}} \times 10^9 = \frac{9.6 \times 10^{-6}\ g\ NaCl}{2000\ mL\ \text{solution}} \times 10^9 = \boxed{4.8\ ppb\ NaCl}$$

Example Problem 4 (**ppt**):

An Olympic-size pool is 50 m (164 ft) long, 25 m (82 ft) wide, and 2.0 m (6.6 ft. minimum) deep. It holds 660,000 US gallons or 2,500,000 liters of water. It has 8 racing lanes that are 2.5 m wide with an "empty" lane of 2.5 m in width along each side. (While there are 10 lanes, only the middle 8 are used for racing.) If 1.0 gram of NaCl is dissolved in the water of a pool of this size, what is the concentration of the dissolved salt in ppt?

$$ppt = \frac{\text{amount of solute}}{\text{amount of solution}} \times 10^{12} = \frac{1.0\ g\ NaCl}{2500000000\ mL\ \text{solution}} \times 10^{12} = \boxed{400\ ppt\ NaCl}$$

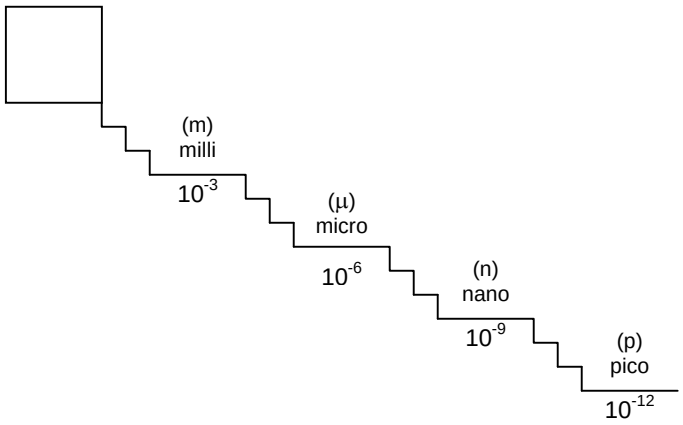
4.0 x 10^2 ppt

Using %, ppm, ppb, ppt

If the concentration is given in %, ppm, etc…, change the units into the unit combinations below:

Type of mixture	%	ppm	ppb	ppt
mass/mass (m/m)	g/100g	μg/g	ng/g	pg/g
mass/volume (m/v)	g/100mL	mg/L	μg/L	ng/L
Volume/volume (v/v)	mL/100mL	μL/L	nL/L	pL/L

Remember your metric conversions:



What you do next depends on what you need to find. There are two possibilities:

- Find amount of solute in a certain amount of solution
- Find volume of solution that gives a certain amount of solute

Decide which of these you are doing and follow the proper procedure as shown below.

Remember that the units we don't want must cancel to give us the units we do want.

Using ppm

Finding the amount of solute in a certain amount of solution

Example Problem:

An NaCl solution has a concentration of 132 ppm. What mass of NaCl is contained in 250 mL of this solution?

Step 1 Change unit label

132 ppm becomes 132 mg/L

Step 2

$$132\frac{mg}{L}\left(\frac{1g}{1000mg}\right)\left(\frac{1L}{1000mL}\right)(250mL)=0.033g$$

Finding the volume of solution that gives a certain amount of solute

Example Problem:

An NaCl solution has a concentration of 132 ppm. What volume of solution will provide a mass of 0.024 g of NaCl?

Step 1 Change unit label

132 ppm becomes 132 mg/L

Step 2

$$0.024g\left(\frac{1000mg}{1g}\right)\left(\frac{1L}{132mg}\right)\left(\frac{1000mL}{1L}\right)=180\ mL$$

Using percent

Finding the amount of solute in a certain amount of solution

Example Problem:

An NaCl solution has a concentration of 5.6%. What mass of NaCl is contained in 25 mL of this solution?

Step 1 Change unit label

5.6% becomes 5.6 g/100mL

Step 2

$$\frac{5.6g}{100mL}(25mL)=1.4g$$

Finding the volume of solution that gives a certain amount of solute

Example Problem:

An NaCl solution has a concentration of 5.6%. What volume of solution will provide a mass of 0.75 g of NaCl?

Step 1 Change unit label

5.6% becomes 5.6 g/100mL

Step 2

$$0.75g\left(\frac{100mL}{5.6g}\right)=13mL$$