Summary of different types of concentration measure

mass of solute / volume of solution	mass of solute (kg) / volume of solution (l)
percent by volume, % (w/v)	100 mass of solute (kg) / volume of solution (l)
mass fraction	mass of solute (kg) / mass of solution (kg)
percent by weight, % (w/w) or %	100 mass of solute (kg) / mass of solution (kg)
milligram per cent by weight, mg%	100 mass of solute (mg) / mass of solution (g)
molarity, M	moles of solute (mol) / volume of solution (l)
molality, $molkg^{-1}$	moles of solute (mol) / mass of solvent (kg)

Example: the various concentrations for a 40g sucrose+60g water mixture

mass of sucrose	40g
mass of water	60g
RMM sucrose	342.3
specific gravity of solution	1.179

- In the solution we have 40g of sucrose and 60g of water, to give 100g in total. Masses are reliable; they add nicely. Volumes don't necessarily e.g. 100ml ethanol+100ml water does not necessarily give 200ml solution.
- The mass fraction is the mass of solute (40g) over the mass of solution (100g). The units have to be the same. So the **mass fraction is 0.4**.
- The percent by weight is 100 $\times$ the mass fraction. So the **percent by weight is 40**.
- The mg percent by weight is 1000 $\times$ the percent by weight. So the **mg percent by weight is 40,000**.
- The molality is the number of moles of solute (here we have 40/342.3 moles) per mass of solvent (expressed in kilograms; we have 60/1000 kg of solvent). So the **molality is $\frac{40/342.3}{60/1000}$ which equals 1.948**
- To work out the molarity, percent by volume and mass solute over volume of solution, we need to know how the volume of solution relates to the amount of solute dissolved in it.
  - The specific gravity says that $1l$ of solution has a mass of $1179g$. A specific gravity of 1 would mean that $1l$ of solution would have a mass of $1000g$.
  - In this hypothetical $1l$ of solution, 40% of the mass would be contributed by the sucrose (that's what the mass fraction told us). So that makes $0.4 \times 1179 = 471.6g$ of sucrose per litre of solution.
  - By the same argument, if we cared, we could work out the mass of water in a litre of solution; that would give us 707.4g.
- The molarity is the number of moles in a litre of solution. There are $471.6g$ of sugar in a litre, which corresponds to 471.6/342.3 moles, that is 1.378 moles in a litre. So the **molarity of the solution is 1.378**.
- Similarly, the mass of solute per volume of solution is trivial now. We want the mass of solute expressed in kilograms, which is 0.4716; hence the **mass of solute per volume of solution is 0.472**.
- The percent by volume is 100 $\times$ the mass of solute per volume of solution; so the **percent by volume is 47.2**. Note that this is slightly larger than the percent by weight, because of the interaction between the sugar molecules and the water.