Chapter 6.3 Concentration

Concentration is the measurement of the part out of the whole.

many types of Concentration

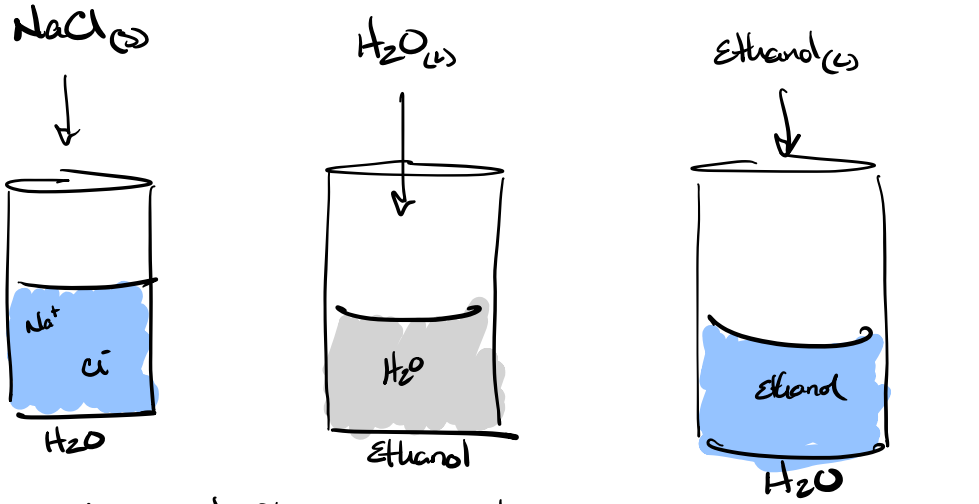
⇒ mainly used for solutions but can also be used for solid mixtures or gases.

$$\text{Solution} = \frac{\text{Solute}}{\text{Solvent}}$$

Solute ⇐ thing that is dissolved (minor component)

Solvent ⇐ The thing doing the dissolving (major component)

Ex



Solute = NaCl
Solvent = H_2O

Solute = H_2O
Solvent = ethanol

Solute Ethanol
Solvent H_2O

Different types of Concentrations

% Types – very dilute solutions where solute is very small

% percent = part per hundred = $\frac{\text{part}}{\text{whole}} \times 100$

ppt = part per thousand = $\frac{\text{part}}{\text{whole}} \times 1000$

ppm = part per million = $\frac{\text{part}}{\text{whole}} \times 1{,}000{,}000$

ppb = part per billion = $\frac{\text{part}}{\text{whole}} \times 1{,}000{,}000{,}000$

$$\% = \frac{\text{part}}{\text{whole}} \times 100$$

part per 100

Molarity Type ⇒ used more in Chemistry

$$\text{Molarity} = \frac{\text{moles Solute}}{\text{L Solution}}$$

moles of part

volume of whole

= Solute + Solvent

Volume ⟷ (molarity) moles → mole bridge & stoichiometry

Molality more rare

Normality, Osmolarity } used in medicine

% as Concentration

Can be wt/wt % = % by weight

$$32\%\text{ by weight} = \frac{32\text{ g part}}{100\text{ g whole}}$$

Ex a solution is 32% by weight NaCl.

$$\frac{32\text{ g NaCl}}{100\text{ g Solution}} \quad \text{or} \quad \frac{32\text{ lbs NaCl}}{100\text{ lbs Solution}}$$

% by volume % v/v

Ex A wine is found to have an alcohol concentration of 12.75% v/v.

$$\frac{12.75\text{ mL alcohol}}{100\text{ mL wine}} \quad \text{or} \quad \frac{12.75\text{ L alcohol}}{100\text{ L wine}}$$

Ex

How many mL of alcohol are in a 750. mL bottle of wine if the concentration is 12.5 % v/v ?

Equality

mL wine → mL alcohol

12.5 mL alcohol = 100 mL wine

mL wine: whole; mL alcohol: part

$$750.\ \text{mL wine} \times \frac{12.5\ \text{mL alcohol}}{100\ \text{mL wine}} = 93.75\ \text{mL alcohol}$$

(3 sig figs; def of %)

$$= 93.8\ \text{mL alcohol}$$

Ex

How many gallons of alcohol are in a 1000. gal vat of wine with a measured alcohol concentration of 9.63 % v/v ?

gal wine → L wine → mL wine → mL alcohol → L alcohol → gal alcohol

9.63 mL alcohol = 100 mL wine

or

9.63 gal alcohol = 100 gal wine

$$1000.\ \text{gal wine} \times \frac{9.63\ \text{gal alcohol}}{100\ \text{gal wine}} = 96.3\ \text{gal alcohol}$$

(4 sig figs; 3 sig figs; exact)

Ex How many grams of Chlorine are consumed when drinking 550. mL of water with a Chlorine Concentration of 4.0 ppm by wt/wt?

$d_{H_2O} = 1.00\ g/mL$

$mL\ H_2O \longrightarrow g\ water \xrightarrow{4.0\ g\ Cl = 1{,}000{,}000\ g\ H_2O} g\ Cl$

$4.0\ g\ Cl = 1{,}000{,}000\ g\ water$

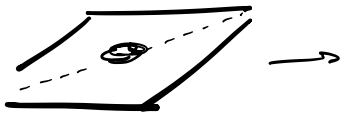
dilute solutions of H_2O can be treated as pure water with a density of $1.0\ g/mL$

$$\overset{3}{550.}\ mL\ H_2O \times \frac{\overset{3}{1.00}\ g\ H_2O}{1\ mL\ H_2O} \times \frac{\overset{2}{4.0}\ g\ Cl}{1{,}000{,}000\ g\ H_2O} = 0.0022\ g\ Cl$$

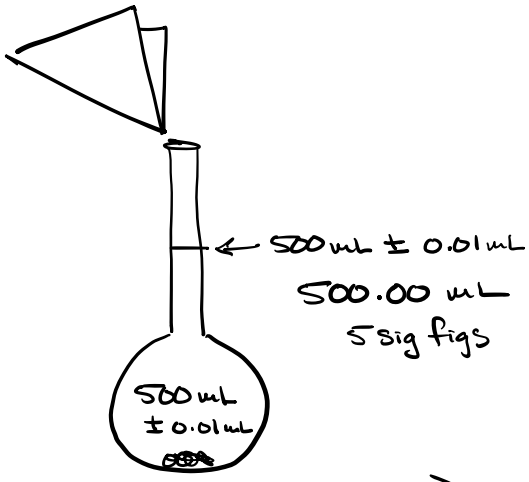
def ppm $= 1 \times 10^{6}$

$= 2.2 \times 10^{-3}\ g\ Cl$

Molarity



NaCl
0.326g



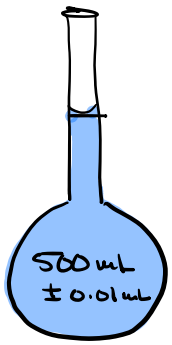
Volumetric flask

Invert & Shake to mix

mass NaCl = 0.326g

Volume Solution = 500.00 mL

NaCl + H_2O



Solution homogeneous

$$\text{Molarity} = \frac{\text{moles Solute}}{\text{L Solution}}$$

Road Map

g NaCl → mole NaCl

mL Solution → L Solution

Na 22.99
Cl 35.45
58.44 g/mol

$$\frac{0.326\ \text{g NaCl}}{500.00\ \text{mL Solution}} \times \frac{1\ \text{mole NaCl}}{58.44\ \text{g NaCl}} \times \frac{1000\ \text{mL Solution}}{1\ \text{L Solution}} =$$

(3 sig figs; 5 sig figs; 4 sig figs; def)

$$= 0.011\,1756741\ \text{moles/L NaCl}$$

$$0.0112\ \text{moles NaCl} = 1\ \text{L Solution}$$

$$= 0.0112\ \text{moles/L NaCl}$$

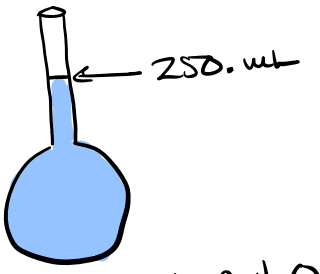
or

$$\text{moles NaCl/L}$$

or

$$\frac{\text{moles NaCl}}{\text{L Sol}}$$

EX What is the molarity of a solution made by dissolving 0.631 g of sodium acetate in enough water to make 250. mL of solution? (sodium acetate = $NaC_2H_3O_2$)



0.631 g $NaC_2H_3O_2$

Na $1 \times 22.99 = 22.99$
C $2 \times 12.01 = 24.02$
H $3 \times 1.008 = 3.024$
O $2 \times 16.00 = 32.00$
82.034

Road map

g $NaC_2H_3O_2$ —(molar mass)→ mole $NaC_2H_3O_2$

mL Sol —(1000 mL = 1 L)→ L Sol

$$\frac{0.631\ g\ NaC_2H_3O_2}{250.\ mL\ Sol} \times \frac{1\ mol\ NaC_2H_3O_2}{82.03\ g\ NaC_2H_3O_2} \times \frac{1000\ mL\ Sol}{1\ L\ Sol}$$

$$= 0.030769230\ \frac{mole\ NaC_2H_3O_2}{L\ sol}$$

$$= 0.0308\ mole/L\ NaC_2H_3O_2$$

$$= 0.0308\ \underline{M}\ NaC_2H_3O_2$$

$\underbrace{M}_{\text{Italic M}} = M = \text{moles/L}$

How do we use molarity?

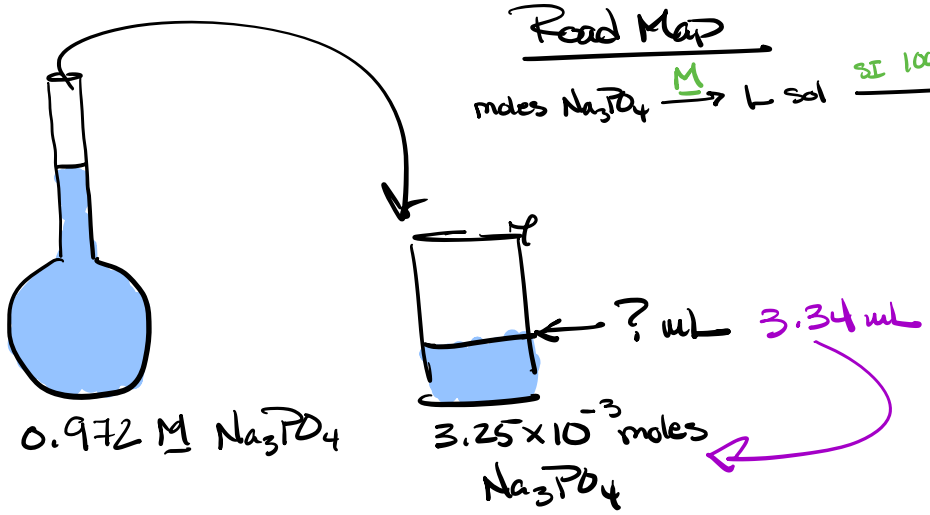
mole solute are linked to vol solution
& so longer need mass to get to moles

Molar mass is "baked" into Molarity.

Ex How many mL (desired) of $0.972\ M\ Na_3PO_4$ (Equality) solution are required to give 3.25×10^{-3} moles (Given) of Na_3PO_4 in a reaction?

Road Map

moles Na_3PO_4 $\xrightarrow{M}$ L sol $\xrightarrow{\text{SI } 1000\,mL = 1\,L}$ mL sol



$0.972\ \text{moles } Na_3PO_4 = 1\ L\ \text{sol}$

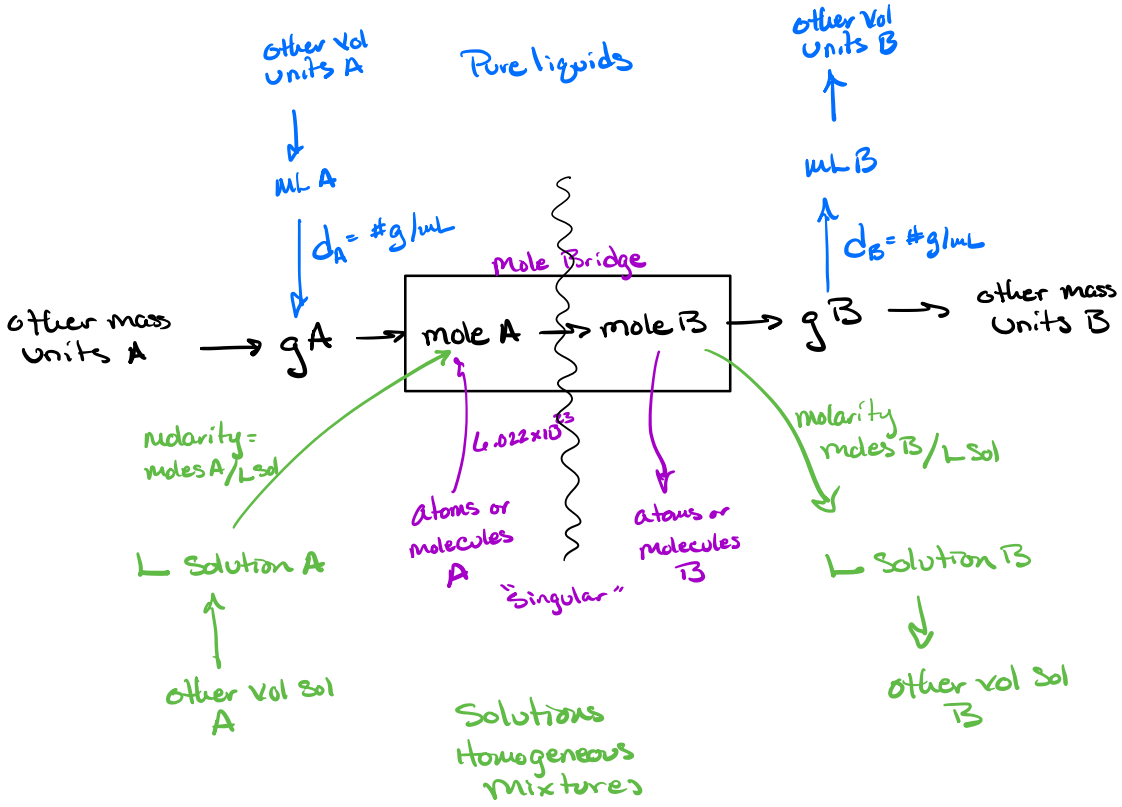
Road Map

moles Na_3PO_4 —M→ L Sol —SI 1000 mL = 1 L→ mL Sol

$$3.25 \times 10^{-3} \text{ moles } Na_3PO_4 \times \frac{1 \text{ L Sol}}{0.972 \text{ moles } Na_3PO_4} \times \frac{1000 \text{ mL Sol}}{1 \text{ L Sol}} = 3.343621$$

(3 sig figs; def)

= 3.34 mL Solution



Ex

How many moles of Iron(III) Chloride are in 525 mL of a 0.062 M $FeCl_3$ solution?

M = moles Solute / L Sol

0.062 moles $FeCl_3$ - 1 L solution

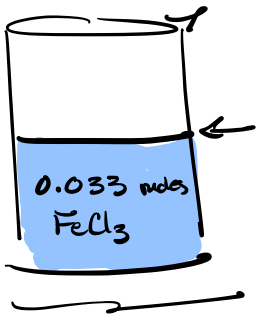
Road Map

mL Sol → L solution → moles $FeCl_3$

$$525\ \text{mL Sol} \times \frac{1\ \text{L Sol}}{1000\ \text{mL Sol}} \times \frac{0.062\ \text{mole } FeCl_3}{1\ \text{L Sol}} = 0.03255\ \text{mole } FeCl_3$$

(3) (def) (2)

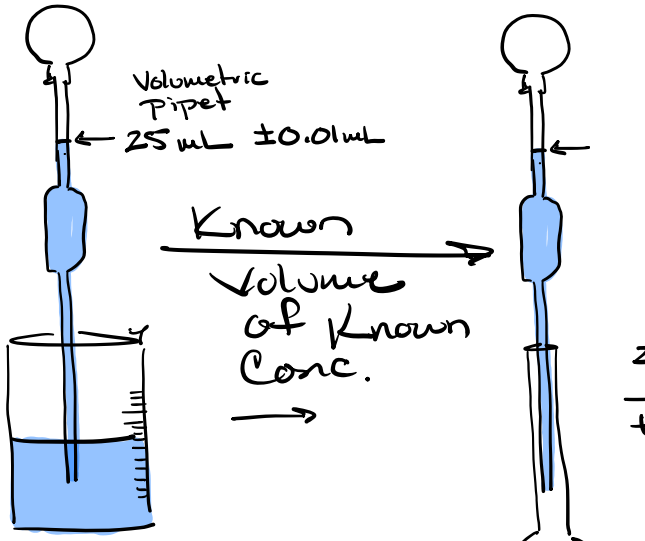
= 0.033 mole $FeCl_3$



← 525 mL Solution

0.062 moles $FeCl_3$ / L

Dilution



Known Volume of Known Conc. →

25mL → transfer

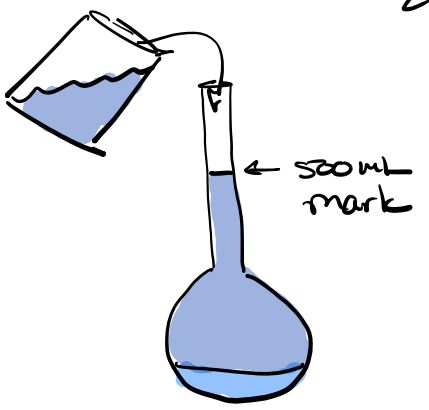
0.500 M NaCl
Solution A

25mL of 0.500 M NaCl

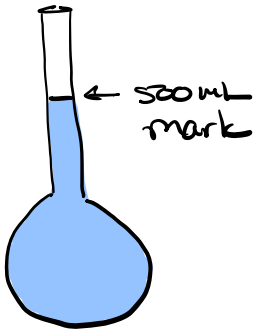
Molar = Molarity = M
= moles / L

↓ Dilute w/ H_2O

Just H_2O



mix ←

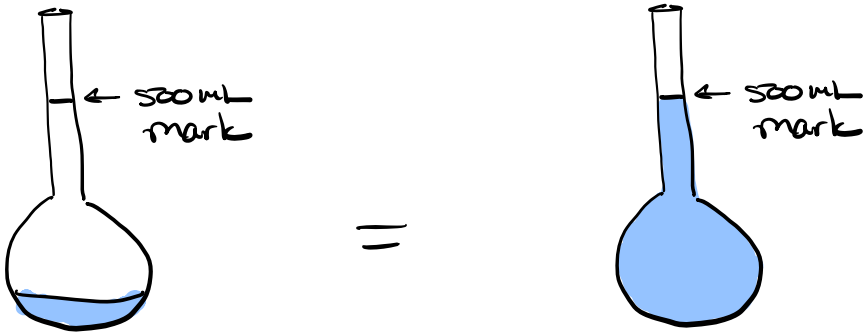


500. mL of ? NaCl

25mL of 0.500 M NaCl

Diluted Concentration

what is the new Concentration?



25 mL of 0.500 M NaCl

=

500. mL of ? NaCl

moles NaCl = moles NaCl

$L \times \frac{moles}{L} = moles\ NaCl = \frac{moles}{L} \times L$

$Vol_1 \times Concentration_1 = Concentration_2 \times Vol_2$

$$C_1V_1 = C_2V_2$$

Dilution Formula = $C_1V_1 = C_2V_2$

$C_1 = 0.500$ moles/L NaCl

$V_1 = 25$ mL

$C_2 = ?$

$V_2 = 500.$ mL

$$\frac{C_1V_1}{V_2} = \frac{C_2V_2}{V_2}$$

$$\frac{C_1V_1}{V_2} = C_2$$

$$= \frac{(0.500 \text{ mols/L})(25 \text{ mL})}{(500. \text{ mL})} = 0.025 \text{ moles/L NaCl}$$