Solutions

Solute – Substance being dissolved. Either solid, liquid or gas. Substance in smaller amount.

Solvent – Usually a liquid. usually in greater amount than the solute

Solution – Is the combination of the solvent & solute

Units for Solutions

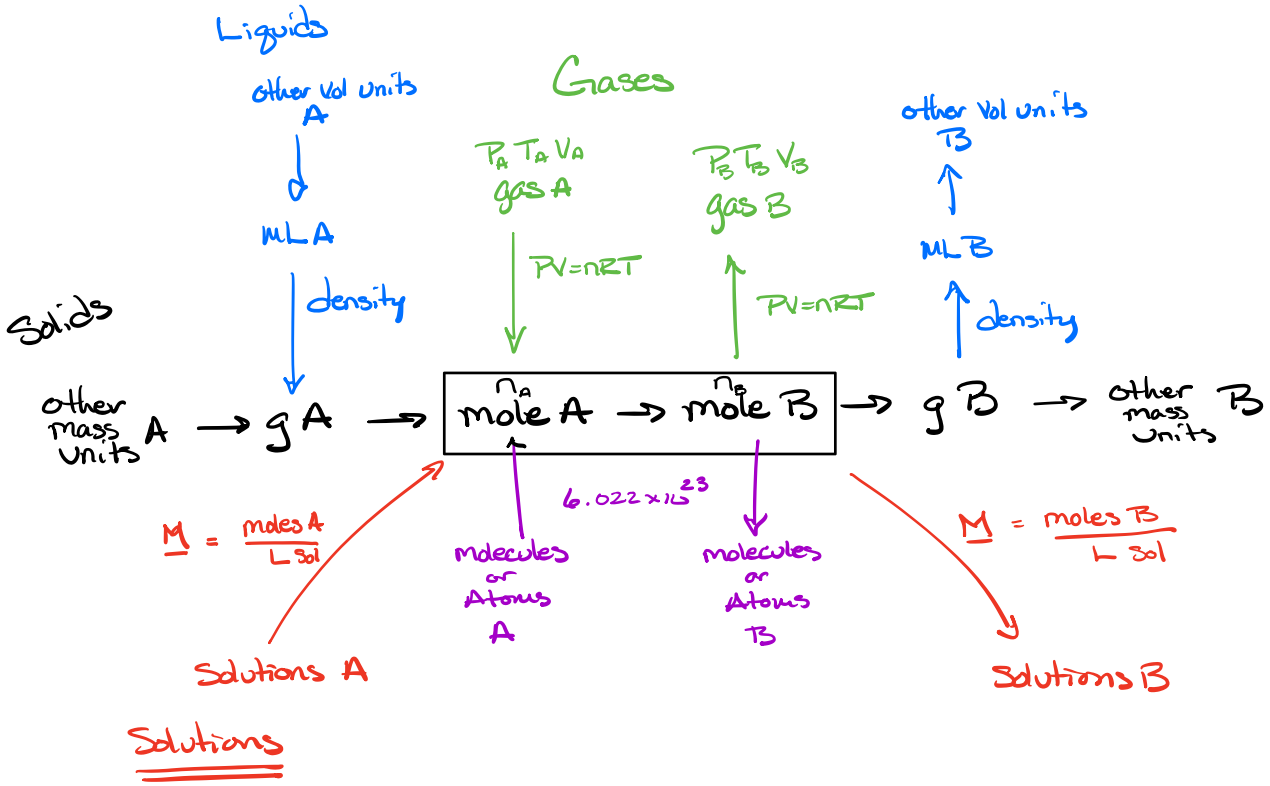
% type

pph % v/v – $\frac{\text{Volume Solute}}{\text{Volume Solution}} \times 100$

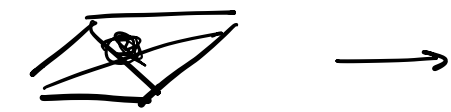
ppm – $\frac{\text{Volume Solute}}{\text{Volume Solution}} \times 10^6$

ppb – $\frac{\text{Volume Solute}}{\text{Volume Solution}} \times 10^9$

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

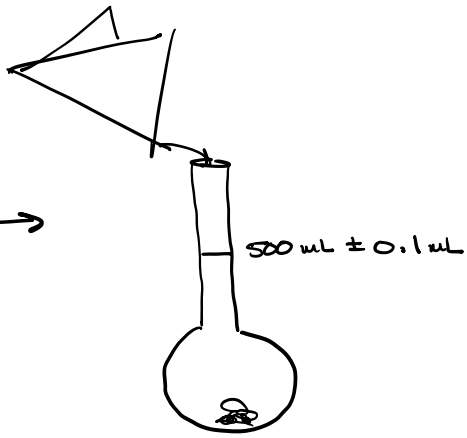


How to make a Solution & determin Molarity?

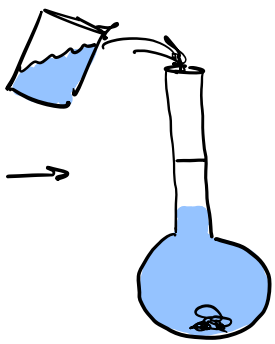


weigh out Solid Solute

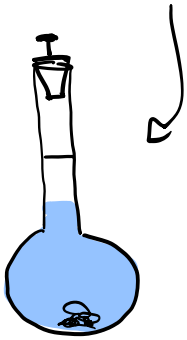
NaCl 3.27 g

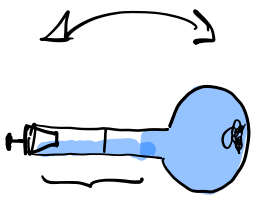


Volumetric flask



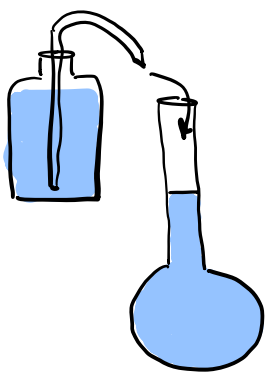
Stop just before line



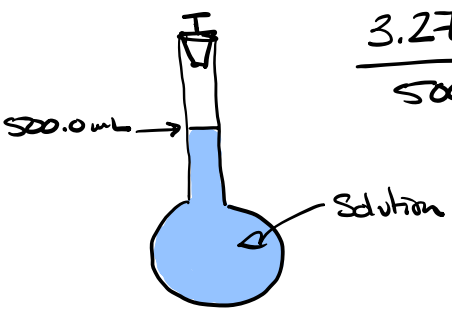


mixing bubble

Invert & Shake until dissolved



Fill to line after all material dissolved



$$\frac{3.27\text{ g NaCl}}{500.0\text{ mL Solution}} \longrightarrow \frac{\text{moles NaCl}}{\text{L Solution}}$$

Na 22.99

Cl 35.45

58.44 g/mole

(3) $\frac{3.27\ g\ NaCl}{500.0\ mL\ Sol}$ (4) $\times \frac{1\ mole\ NaCl}{58.44\ g\ NaCl}$ (4) $\times \frac{1000\ mL\ Sol}{1\ L\ Sol}$ (def) $= 0.111\ 09 \frac{mole\ NaCl}{L\ Sol}$

$= 0.112 \frac{mole\ NaCl}{L\ Sol}$

Molarity

0.112 moles/L NaCl

$0.112 \frac{moles\ NaCl}{L\ Sol}$

$0.112\ \underline{M}\ NaCl_{(aq)}$ ← water; aq = aqueous

↑ underline mean italic

M = molarity

$\underline{M}$ = molarity

Meaning

0.112 mole NaCl = 1 L solution

↑ Sig figs Carried in mole value

Value in using Solutions is that moles are now tied to the volume of Solutions & we no longer need molar mass to do Stoichiometry.

Types of questions

$M = \frac{\text{moles}}{\text{L sol}}$

- Calculate molarity ✓
- Calculate moles for a given volume ✓
- Calculate the volume for a given moles ✓

Road map — Stoichiometry

$C_1V_1 = C_2V_2$ Dilutions

$M_1V_1 = M_2V_2$ Serial Dilutions → making very dilute Solutions

Ex

3.27 g of NaCl is dissolved in enough water to make 500.0 mL of Solution. What is the Concentration of the Solution in moles/L sol?

$$\frac{\text{mass}}{\text{Vol Sol}} = \frac{3.27\text{ g NaCl}}{500.0\text{ mL Sol}} \longrightarrow \frac{\text{moles NaCl}}{\text{L Sol}}$$

$$\frac{3.27\text{ g NaCl}}{500.0\text{ mL Sol}} \times \frac{1\text{ mole NaCl}}{58.44\text{ g NaCl}} \times \frac{1000\text{ mL Sol}}{1\text{ L Sol}} = 0.112 \frac{\text{moles}}{\text{L}}_{\text{NaCl}}$$

0.112 M NaCl

Ex

A chemical reaction is carried out using 29.23 mL of 0.112 M NaCl solution. How many moles of NaCl were used in the reaction?

given → desired

mL Sol $\xrightarrow{1000\ mL = 1\ L}$ L Sol $\xrightarrow{0.112\ moles\ NaCl = 1\ L\ Sol}$ moles NaCl

$$29.23\ mL\ Sol \times \frac{1\ L\ Sol}{1000\ mL\ Sol} \times \frac{0.112\ moles\ NaCl}{1\ L\ Sol} = 0.00327376\ moles\ NaCl$$

(4 sig figs; 3 sig figs; def)

$$= 0.00327\ moles\ NaCl$$

Ex

How many mL of 0.112 M NaCl are needed to deliver 0.955 moles of NaCl?

moles NaCl $\xrightarrow{}$ L Sol $\xrightarrow{0.112\ moles\ NaCl = 1\ L\ Sol}$ mL Sol

$$0.955\ moles\ NaCl \times \frac{1\ L\ Sol}{0.112\ moles\ NaCl} \times \frac{1000\ mL\ Sol}{1\ L\ Sol} = 8526.785\ mL\ Sol$$

(3 sig figs; 3 sig figs; def)

$$= 8530\ mL\ NaCl\ solution$$

Stoichiometry

Standard double displacement

⟹ Acid / Base
- Titration experiments

Redox

$$Pb(NO_3)_{2(aq)} + 2NaCl_{(aq)} \longrightarrow PbCl_{2(s)} + 2NaNO_{3(aq)}$$

A reaction is performed using 21.2 mL of 0.112 M aqueous Sodium Chloride and excess lead (II) nitrate. How many grams of lead (II) Chloride will be formed?

$$Pb(NO_3)_{2(aq)} + \underline{2}NaCl_{(aq)} \longrightarrow \underline{1}PbCl_{2(s)} + 2NaNO_{3(aq)}$$

excess — X

21.2 mL, 0.112 moles/L

? g

mL NaCl Sol $\xrightarrow{1000\,mL = 1\,L}$ L NaCl Sol $\xrightarrow{0.112\,moles = 1\,L}$ mole NaCl $\xrightarrow{2:1\ ratio}$ mole $PbCl_2$ $\xrightarrow{molar\ mass}$ g $PbCl_2$

Pb 1 × 207.20 = 207.20

Cl 2 × 35.45 = 70.90

278.10 g/mol

3 def Exact 5

$$21.2\,mL\,NaCl\,sol \times \frac{1\,L\,Sol}{1000\,mL\,Sol} \times \frac{0.112\,moles\,NaCl}{1\,L\,Sol} \times \frac{1\,mole\,PbCl_2}{2\,moles\,NaCl} \times \frac{278.10\,g\,PbCl_2}{1\,mole\,PbCl_2} =$$

$$= 0.330160\,g\,PbCl_2$$

$$= 0.330\,g\,PbCl_2$$

Closer look at %w/w & %v/v and relationship between density and concentration.

%w/w weight to weight

Units

$$\frac{\text{g Solute}}{\text{g Solution}} \times 100 = \%\ w/w$$

$$\frac{\text{mg Solute}}{\text{mg Solution}} \times 100 = \%\ w/w$$

$$\frac{\text{lbs Solute}}{\text{lbs Solution}} \times 100 = \%\ w/w$$

$$13.2\%\ w/w\ NaNO_3 = \frac{13.2\ g\ NaNO_3}{100\ g\ \text{Solution}}$$

or

$$\frac{13.2\ mg\ NaNO_3}{100\ mg\ \text{Solution}}$$

or

$$\frac{13.2\ lbs\ NaNO_3}{100\ lbs\ \text{Solution}}$$

% v/v volume to volume

units

$$\frac{\text{mL solute}}{\text{mL solution}} \times 100 = \%\ v/v$$

$$\frac{\text{L solute}}{\text{L solution}} \times 100 = \%\ v/v$$

$$\frac{\text{gal solute}}{\text{gal solution}} \times 100 = \%\ v/v$$

12.2 % alcohol v/v

$$\frac{12.2 \text{ mL alcohol}}{100 \text{ mL wine (sol)}}$$

or

$$\frac{12.2 \text{ L alcohol}}{100 \text{ L wine}}$$

$$\frac{12.2 \text{ gal alcohol}}{100 \text{ gal wine}}$$

ppm & ppb done the same

Ex

A solution consists of 232.6 g alcohol and 423.2 g of water. Calculate the % w/w of alcohol.

$$\% \text{ w/w} = \frac{\text{mass solute}}{\text{mass solution}} \times 100$$

$$= \frac{\text{g alcohol}}{\underbrace{\text{g alcohol} + \text{g } H_2O}_{\text{solution}}} \times 100$$

$$= \frac{232.6 \text{ g alcohol}}{(232.6 \text{ g alcohol} + 423.2 \text{ g } H_2O)} \times 100$$

$$= 35.468130 \text{ \% w/w alcohol}$$

$$= 35.47 \text{ \% w/w alcohol}$$

Ex

A person consumes 3 glasses of wine totalling 450. mL (solution) of wine. If the wine has a concentration of 11.5% v/v of alcohol, how many mL of alcohol did they consume?

450. mL Solution

11.5% v/v alcohol = 11.5 mL alcohol = 100 mL Sol

mL alcohol ?

mL Sol $\xrightarrow{\%\ v/v}$ mL alcohol

$$450.\ \text{mL wine (solution)} \times \frac{11.5\ \text{mL alcohol}}{100\ \text{mL wine (solution)}} = 51.75\ \text{mL alcohol}$$

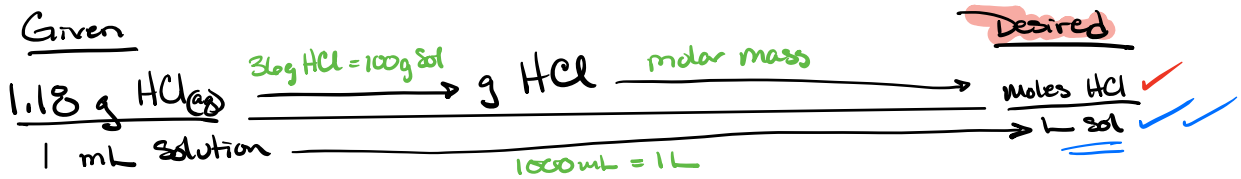
(3 sig figs)

$$= 51.8\ \text{mL alcohol}$$

Ex

Concentrated hydrochloric acid has a density of 1.18 g/mL and is 36% w/w dissolved HCl.

What is the molarity of the concentrated acid?



– Two Road maps –
one for Numerator
one for Denominator

$\frac{36\text{ g HCl}}{100\text{ g solution}}$

$$\frac{1.18\text{ g solution}}{1\text{ mL solution}} \times \frac{36\text{ g HCl}}{100\text{ g solution}} \times \frac{1\text{ mole HCl}}{36.458\text{ g HCl}} \times \frac{1000\text{ mL solution}}{1\text{ L solution}}$$

$$= 11.651763\ \frac{\text{mole}}{\text{L}}\ \text{HCl}$$

= 12 mole/L HCl

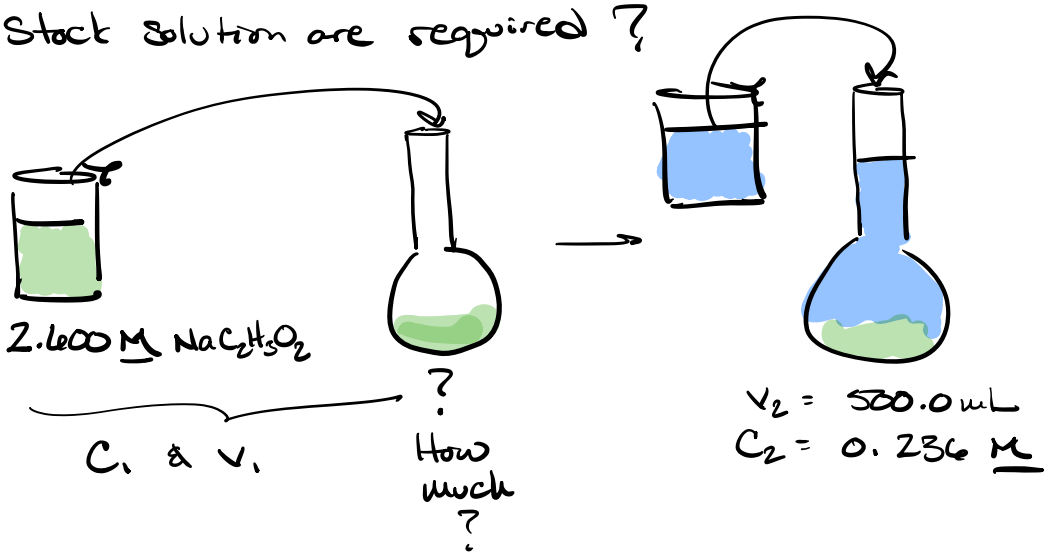
or

12 M HCl

Dilution Problems

$C_1V_1 = C_2V_2$

A stock solution of $NaC_2H_3O_2$ of 2.600 M is used to make 500.0 mL of a 0.236 M solution of $NaC_2H_3O_2$. How many mL of the stock solution are required?



$$C_1V_1 = C_2V_2$$

$C_1 = 2.600\ M$

$V_1 = ?$

$C_2 = 0.236\ M$

$V_2 = 500.0\ mL$

same unit

same unit

$$V_1 = \frac{C_2V_2}{C_1}$$

$$V_1 = \frac{(0.236\ \cancel{M})(500.0\ mL)}{(2.600\ \cancel{M})}$$

$V_1 = 45.384\,615\ mL$

$= 45.4\ mL$ of $2.600\ M\ NaC_2H_3O_2$