General and Organic Chemistry

L5

Ch4: Types of Chemical reactions and Solution Stoichiometry

24/Oct/2024

Ex: NaCl reacts with $AgNO_3$?

$$AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$$

↳ these are solids, so adding them to each other in this state will not cause a reaction, therefore we need a solvent so that these compounds dissociate into ions. then a reaction will start because now there are effective collisions between substances unlike when they are solids

So here we will be talking about solutions
محاليل

Therefore to do calculations for solutions we use the volume & concentration units because it is much easier

* Some concentration units:
  - Molarity → most common
  - Molality
  - Normality
  - Density

* When choosing a solvent مذيب it should have 2 things :

(1) Must be chemically inert خامل لا يتفاعل Doesn't react with the substan in the solution and just dissolves them

(2) Can Dissolve all reactants

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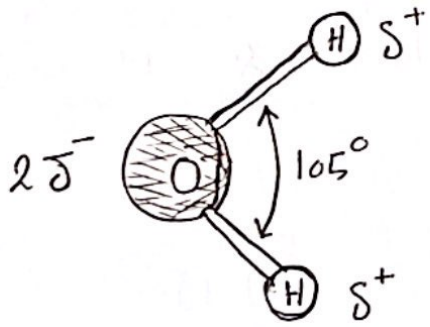
* Most common solvent is water (H_2O)
- it's Polar , Most inorganic substances are salts so they Contain Ions , so they need a polar solvent like water
- Not expensive , so easier to use
- its boiling Point is at the middle so its not hard to get rid of it after the reaction by evaporating it under vaccum



water molecule

* Aqueous solutions consist of:

- Solute: the substance that is being dissolved
  مذاب
- Solvent: liquid water
  مذيب
- Electrolytes: A substance that when dissolved in water produces a solution that can Conduct electricity
  موصل للكهرباء

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* The nature of aqueous solutions:

Electrolytes:

Strong Electrolytes

Comes from a Completely dissociated solution so Conducts electricity very well bc the substance completely ionized in water

Ex: $NaCl \rightarrow Na^+ + Cl^-$

⇩

every thing turns into ions

weak Electrolytes

⇩

Comes from a Partially dissociated solution so it Conducts a small current bc the substance didn't Completely Ionize in water

Ex: Acetic acid

$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

⇩

a small portion turns to ions

Non-Electrolytes

⇩

Comes from a substance that dissolves but doesn't Produce Ions So NO current flows

Ex: Monosaccharides

Di- - - - - -

⇩

they stay as molecules

★ For the chemical reactions of solutions :

★ We first must know :

- The nature of the reaction
- The amounts of chemicals present in the Solutions

★ Some Concepts to Know :

- Molarity (M) : moles of solute per Volume of Solution in liters

(مولات المذاب — حجم المحلول كامل)

$$M = \frac{\text{moles of Solute}}{\text{liters of Solution}} \rightarrow M = \frac{n}{V}$$

the whole solution not just the solvent

Ex : 500.0 g of Potassium phosphate (K_3PO_4) is dissolved in enough water to make 1.50 L of Solution . Calculat the Molarity of the Solution

$M = \frac{n}{V}$

Conv to Mols → $500.0\ g\ K_3PO_4 \cdot \frac{1\ Mol\ K_3PO_4}{212.27\ g\ K_3PO_4}$

$= 2.35\ Mol\ K_3PO_4$

$M = \frac{2.35}{1.50} = 1.57\ mol/L$ → or M

Mr O = 16.00
Mr K = 39.10
Mr P = 30.97
Mr K_3PO_4 = 212.27

★ Concentration of Ions :

- For a fully dissociated solute
  - ↳ it's now all Ions
  - So no Partial ions

Ex: we have 1M $CaCl_2$ solution (M is concentration)

how many Mols of Ions do we have:

$CaCl_2$

$\downarrow$ 1 Ca^{2+} ; $\searrow$ $2Cl^-$

So 3 Mols of Ions

for their concentrations:

Ca^{2+} = (# of mols) • (Concentration of the whole solution) (or mols of solutions)

$1 \cdot 1 = 1M$

$Cl^- = 2 \cdot 1 = 2M$ (M means $\frac{\text{mol}}{\text{Liter}}$)

bc ex: $0.75M = \frac{0.75\,\text{mol}}{1\,L} = 0.75\,\text{mol}$ (always if a certain volume is given that isn't used) ↳ watch the concept check in next page

$\frac{0.25\,\text{mol}}{1\,\text{Liter}}$ so same a 0.25 mol

- Suppose we have 0.25M $CaCl_2$ find the concentration of ions

$CaCl_2$

$Ca^{2+} = 1(0.25M) = 0.25M$

$Cl^- = 2(0.25M) = 0.50M$

So a total of 0.75M of $CaCl_2$ ions

ex: K_3PO_4: how many Mols of ions?

$3K^+$; $1PO_4^{3-}$ ↳ we treat it as a whole

So we have 4 Mols of Ions

link to a video that explains and do examples

https://www.youtube.com/watch?v=H5S4TRAzXhQ&t=382s

* The Concept check:

- which solution contains the greatest number of ions → we have a given volume so Molarity ≠ mols M ≠ n

① V = 400. mL of 0.10 M NaCl
↳ 0.4 L

$n = M \cdot V = 0.4 \times 0.10 =$ 0.04 mol

$Na^+ = 0.04\,(1) = 0.04$ mol of Na^+
$Cl^- = 0.04\,(1) = 0.04$ mol Cl^-
} so 0.080 mol of ions

Same with the others

② 300. mL of 0.10 M $CaCl_2$
↳ 0.300 L

$n = 0.3 \times 0.1 = 0.03$ mol
$Ca^{2+} = (1)(0.03) = 0.03$ mol
$Cl^- = (2)(0.03) = 0.06$ mol
} so 0.09 mol

⋮

③ ↝ 200 mL of 0.10 M $FeCl_3$
= 0.08 mol

④ ↝ 800 mL of 0.10 sucrose
= does not contain ions bc sucrose doesn't break into ions

So answer is ② or b

Notice: The solution with greatest number of ions is NOT necessarily the one:

- That has largest volume bc it depends on concentration too
ex: the sucrose had the largest volume but no ions

- The formula unit has the greatest number of ions
such as K_3PO_4 (3 + 1) $CaCl_2$ (1 + 2)
4 ions 3 ions
} doesn't mean K_3PO_4 has more ions

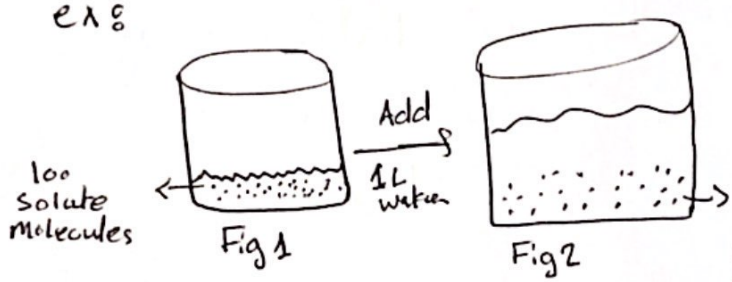
bc it the concentration of ions depends on solution concentration and volume too

* Dilution :
التخفيف

- The process of adding water to a concentrated or stock solution to achieve desired molarity

- Dilution with water does NOT alter the numbers of moles of solute present

ex:



still 100 solute molecules
we just decresed (concentration)
↳ how many molecules for every said volume

ex:
in fig 1 lets say we had 10 molecules per every 1 cm^3 of solution,
when we added more water in fig 2
it changed to 5 molecules for every cm^3
but there is still 100 molecules present

Moles of solute before dilution = moles of solute after dilution

$n_{bf} = n_{After}$ $\quad n = MV$

$M_1 \cdot V_1 = M_2 V_2$

* The Concept check :

- We have 0.50 M solution of NaCl, which process would decrease the concentration of that solution

① Adding water  mistake it will decrease the # of molecules in said volume or space

② Pouring some of the solution out [X] because ~~it~~ you still have same concentration [or number of molecules per space or volume]

③ Add more NaCl [X] this would increase the concentration

④ Let the solution sit in the sun [X] this wouldn't change anything and even if something changes it would be evaporating of water which will increase the concentration

⑤ at least two options will decrease the concentration [X]

Ex: what is the minimum volume of 2.00 M NaOH solution needed to make 150.0 mL of 0.800 M NaOH solution

$M_1 = 2.00\,M$
$V_1 = ??$
$M_2 = 0.800$
$V_2 = 150.0\,mL$

$n_1 = n_2$
$M_1V_1 = M_2V_2$
$2V_1 = 0.800 \times 0.150\,L$
$V_1 = 0.06\,L = 60\,mL$

So we get 60 mL of $^{2.00\,M}$NaOH and $150 - 60 = 90$
add 90 mL of water to it
to make 150 mL of 0.800 M solution

✱ Types of chemical reactions

	Observation: (Evidence of reaction)
- Precipitation reactions: تفاعلات الترسيب	Precipitate appears (راسب)
- Acid – Base reactions: تفاعلات الحمض والقاعدة	Exothermic - Heat
- oxidation - Reduction Reaction: تفاعلات الأكسدة والاختزال	Change in Colour

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✱ Precipitation Reaction

- one of the most common Precipitation reactions is the:

[Double Displacement reaction تفاعل الإحلال المزدوج] $AB + CD \longrightarrow \overset{+}{A}\overset{-}{D} + \overset{+}{C}\overset{-}{B}$

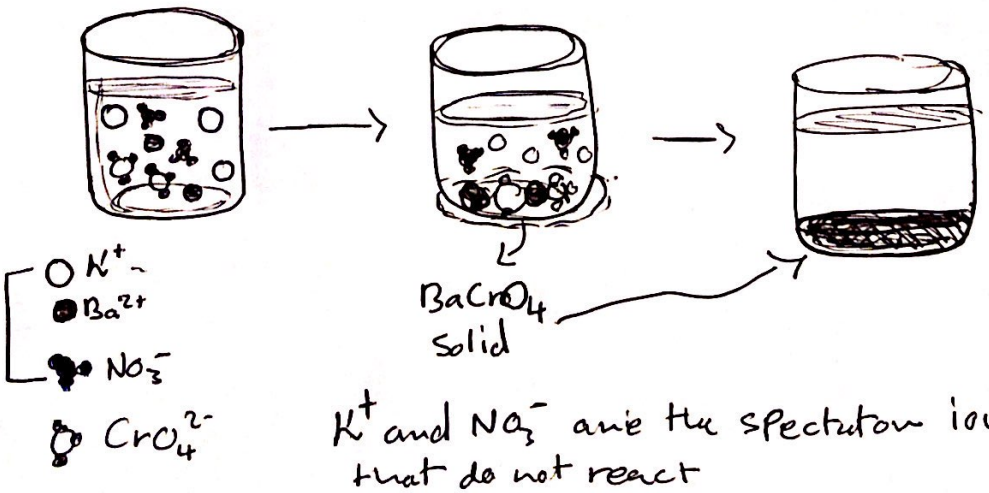
↳ A solid forms and seperates from the solution

- when ionic compounds like salts dissolve in water the resulting solution contains the seperated ions

the solid that forms is called a Precipitate

Ex: reaction of $K_2CrO_4(aq)$ and $Ba(NO_3)_2(aq)$

$$Ba^{2+}(aq) + CrO_4^{2-}(aq) \longrightarrow BaCrO_4(s)$$



K^+ and NO_3^- are the spectator ions that do not react

- Precipitates &

* Soluble - Solid dissolves in Solution (aq), is used in the reaction equation

* insoluble - Solid doesn't dissolve in solution (s), is used in the reaction equation

- insoluble and slightly soluble are often used interchangeably - and we are gonna count both & as insoluble