Ch. 4.5 Concentration

Solution = solute + solvent

solute: usually have a little

solvent: usually have a lot

solute dissolves in solvent

eg 1 teaspoon sugar in 1 cup of H_2O

Concentration

Common unit: molarity, M ← molar

$$\frac{\text{moles of solute}}{\text{L of solution}}$$

Problems

① 5 g NaCl dissolved in 250 mL soln

find M

$$\frac{5\text{ g NaCl}}{250\text{ mL soln}} \longrightarrow \frac{\text{mol NaCl}}{\text{L soln}}$$

$$\frac{5\text{ g NaCl}}{250\text{ mL soln}} \cdot \frac{10^3\text{ mL}}{1\text{ L}} \cdot \frac{1\text{ mol NaCl}}{58.5\text{ g NaCl}} = 0.34\text{ M}$$

(2) How to prepare 250 mL of 10mM NaCl

recall: conc = $\frac{\#\text{mol}}{\text{vol}}$ ⇝ $\#\text{mol} = \text{conc} \cdot \text{vol}$

plan / answer

mix — g NaCl & enough H_2O to make 250 mL soln.

$\#\text{g NaCl} \leftarrow \#\text{mol NaCl} \leftarrow \text{conc \& vol}$

i) $n_{NaCl} = [NaCl]\,L = 10\text{mM} \cdot 250\text{mL}$

$= 10 \cdot 10^{-3} \frac{\text{mol}}{\text{L}} \cdot 250\,\text{mL} \cdot \frac{1\,\text{L}}{10^3\,\text{mL}}$

$= 2.5 \cdot 10^{-3}$ mol

ii) $2.5 \cdot 10^{-3}$ mol NaCl $\cdot \frac{58\text{ g NaCl}}{1\text{ mol NaCl}} = 0.15\text{ g NaCl}$

iii) mix 0.15 g NaCl & 250mL soln using H_2O

(3) find the molarity of H_2O in pure H_2O

recall density of H_2O = $1.0\frac{\text{g } H_2O}{\text{mL soln}}$

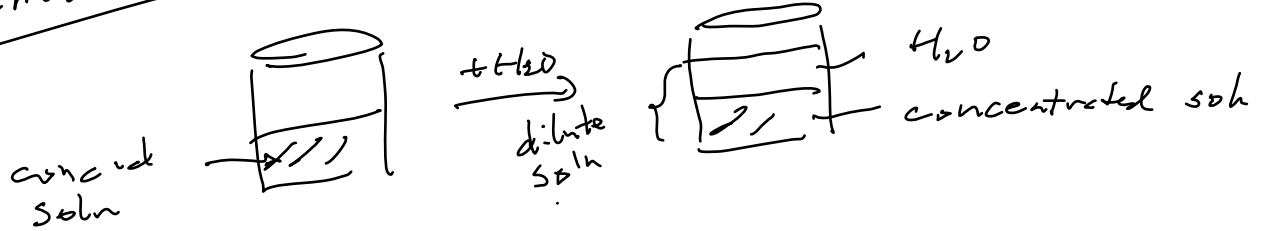
$\frac{1.0\text{ g } H_2O}{\text{mL soln}} \cdot \frac{\text{mol } H_2O}{18\text{ g } H_2O} \cdot \frac{10^3\text{ mL}}{\text{L}}$

$\approx 55\,M$

dilution

- add solvent to a soln to dilute (or reduce) it's concentration
- a method to prepare / "make" a soln

"demonstration"



note: $n_{\text{solute, concid}} = n_{\text{solute, dilute}}$

$$[\text{conc'd}]\, V_{\text{conc'd}} = [\text{dilute}]\, V_{\text{dilute}}$$

④ How to prepare 250 mL of 3 mM NaCl using 5 mM NaCl?

answer: mix — mL concid + — mL H_2O soln

(i)

dilute soln: 250 mL, 3 mM

H_2O V_{H_2O} = ?

conc'd soln: 5 mM, $V_{\text{conc'd}}$ = ? 150 mL

$[\text{conc'd}]\, V_{\text{conc'd}} = [\text{dil}]\, V_{\text{dil}}$

5 mM $V_{\text{conc'd}} = 3\text{ mM}(250\text{ mL})$

$V_{\text{conc'd}} = \frac{3\text{ mM}(250\text{ mL})}{5\text{ mM}}$

$= 150\text{ mL}$

ii) mix 150 mL of 5 mM NaCl & 250 mL with H_2O

or

note: $V_{\text{dil}} = V_{\text{conc'd}} + V_{H_2O}$

$250\text{ mL} = 150\text{ mL} + V_{H_2O}$

$V_{H_2O} = 100\text{ mL}$

i.e. mix 150 mL of 5 mM NaCl & 100 mL H_2O

ch 4.6 solution stoichiometry

problems

① acid-base titration

- experimental method to determine the [ ] using a [known] of another chemical that reacts with it

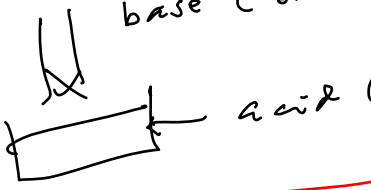
At equivalence point,

$$n_{H^+ \text{ from acid}} = n_{OH^- \text{ from base}}$$

$\Leftarrow$ b/c NIE

$H^+ + OH^- \rightarrow H_2O$

i.e. $\exists$ no excess acid or base



$$a[A]V_A = b[B]V_B$$

a = # H^+ per acid molecule

b = # OH^- per base molecule

ex HCl $a = 1$ b/c $HCl \rightarrow H^+ + Cl^-$

H_2SO_4 $a = 2$ b/c $H_2SO_4 \rightarrow 2H^+ + SO_4^{-2}$

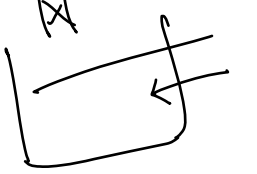
KOH $b = 1$ b/c $KOH \rightarrow K^+ + OH^-$

$Ca(OH)_2$ $b = 2$ b/c $Ca(OH)_2 \rightarrow Ca^{+2} + 2OH^-$

Problem

$[Ca(OH)_2] = 1.0\ M$

$V_{Ca(OH)_2} = 5\ mL$ @ equivalent point



find [HCl]

$$[HCl]\,V_{HCl} = 2\,[Ca(OH)_2]\,V_{Ca(OH)_2}$$

$$[HCl]\,20\ mL = 2\,(1\ M)\,5\ mL$$

$$[HCl] = \frac{2\,(1\ M)\,5\ mL}{20\ mL} = 0.5\ M$$

aside:

$$n_{HCl} : n_{Ca(OH)_2}$$

$$\underbrace{[HCl]\,V_{HCl}}_{n_{HCl}} \quad \underbrace{[Ca(OH)_2]\,V_{Ca(OH)_2}}_{n_{Ca(OH)_2}} \quad \frac{2\ mol\ HCl}{1\ mol\ Ca(OH)_2}$$

$$2HCl + Ca(OH)_2 \rightarrow 2H_2O + CaCl_2$$

$$[HCl]\,V_{HCl} = 2\,[Ca(OH)_2]\,V_{Ca(OH)_2}$$

redox titration

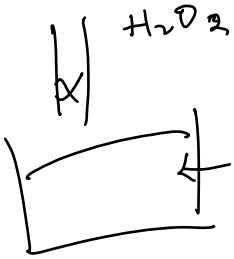
like an acid-base titration

$$5\,H_2O_2 + 2\,MnO_4^- + 6H^+ \longrightarrow 2\,Mn^{+2} + 5\,O_2 + 8\,H_2O$$

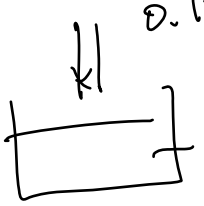
(purple) (colorless)

at the end point = estimate of the equivalence point

↑
"color change"



or



Find $[H_2O_2]$

$$\underbrace{[H_2O_2]\,V_{H_2O_2}}_{n_{H_2O_2}} = \underbrace{[MnO_4^-]\,V_{MnO_4^-}}_{n_{MnO_4^-}} \frac{5 \text{ mol } H_2O_2}{2 \text{ mol } MnO_4^-}$$

$$2\,[H_2O_2]\,V_{H_2O_2} = 5\,[MnO_4^-]\,V_{MnO_4^-}$$

$$[H_2O_2] = \frac{5\,[MnO_4^-]\,V_{MnO_4^-}}{2\,V_{H_2O_2}}$$

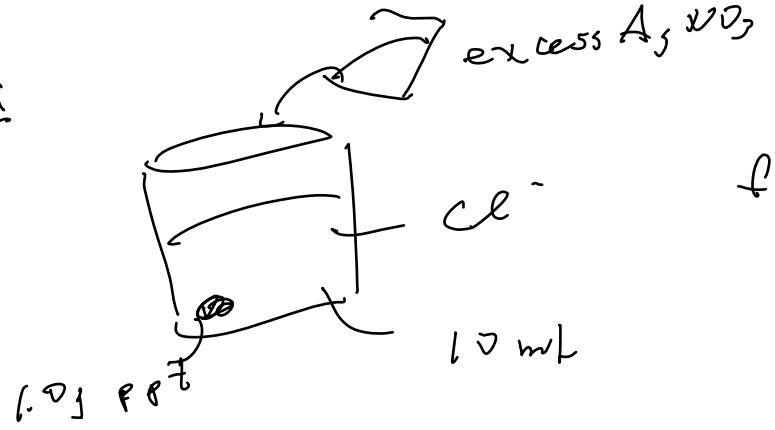
$$= \frac{5\,(0.125\,M)\,18\,mL}{2\,(25\,mL)}$$

$$= 0.225\,M$$

gravimetric analysis

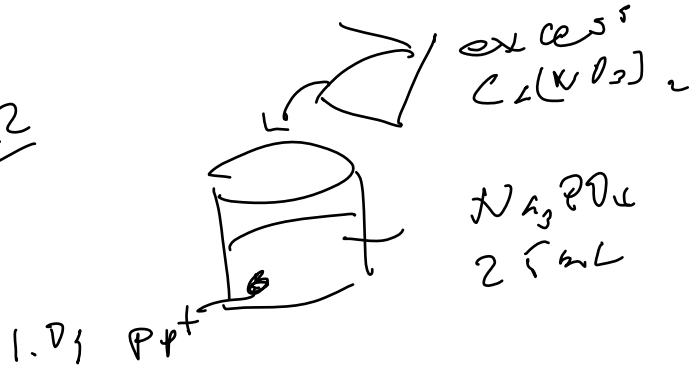
use 'gravity' : exist use filter to collect/analyze ppt

ex1



find $[Cl^-]$ (before add $AgNO_3$)

ex2



find $[PO_4^{-3}]$ (before add $Ca(NO_3)_2$)