Solutions

- Solute (lesser amount) is dissolved …in the solvent (greater amount)
  - Unsaturated: More solute can dissolve
  - Saturated: No more solute will dissolve in solvent
  - Supersaturated: Too much solute dissolved in solvent

- Aqueous: Solvent is water
  - Common in chemical and biological systems
  - Abbreviated "aq" in chemical formulae

Example: $CaCl_{2(aq)}$

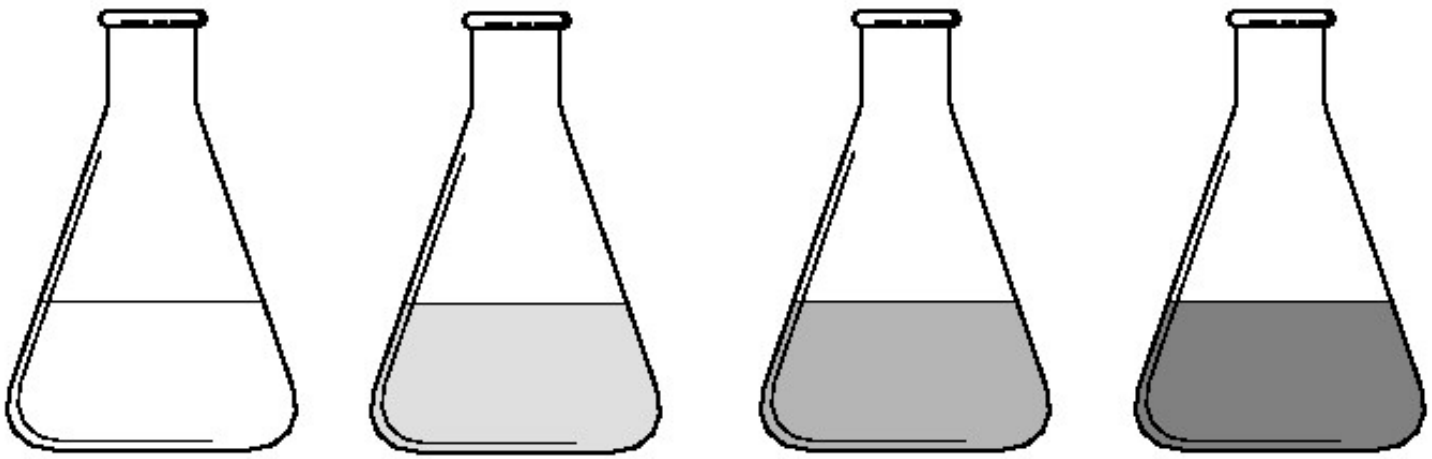
…is solid $CaCl_2$ dissolved in water

Solutions: Mass Percent Concentration

Mass Percent Concentration = $mass_{solute}/mass_{total} \times 100$

Least "Concentrated" — Most "Concentrated"

Most "dilute" — Least "dilute"



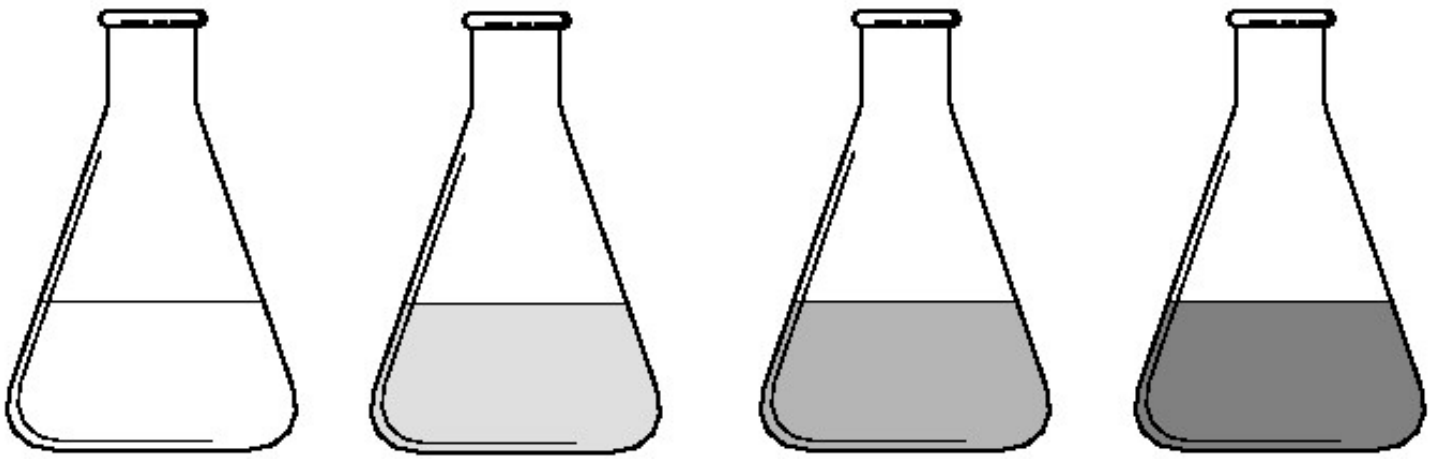
Solvent	200.0 g_{H_2O}	200.0 g_{H_2O}	200.0 g_{H_2O}	200.0 g_{H_2O}
Solute	5.00 g_{CuCl}	20.0 g_{CuCl}	50.0 g_{CuCl}	100.0 g_{CuCl}
Mass % Concentration	$\frac{5.00\ g_{CuCl}}{205.0\ g_{total}} \times 100$	$\frac{20.0\ g_{CuCl}}{220.0\ g_{total}} \times 100$	$\frac{50.0\ g_{CuCl}}{250.0\ g_{total}} \times 100$	$\frac{100.\ g_{CuCl}}{300.0\ g_{total}} \times 100$
	2.44 %	9.09 %	20.0 %	33.3 %

Solutions: Molar Concentration

Molar Concentration (Molarity) = $moles_{solute}/Liters_{solution}$

Least "Concentrated" — Most "dilute"

Most "Concentrated" — Least "dilute"



Solvent	0.200 L_{H2O}	0.200 L_{H2O}	0.200 L_{H2O}	0.200 L_{H2O}
Solute	0.0505057 $moles_{CuCl}$	0.202022 $moles_{CuCl}$	0.505057 $moles_{CuCl}$	1.01011 $moles_{CuCl}$
	$\frac{0.0505057\ moles_{CuCl}}{0.200\ L_{solution}}$	$\frac{0.202022\ moles_{CuCl}}{0.200\ L_{solution}}$	$\frac{0.505057\ moles_{CuCl}}{0.200\ L_{solution}}$	$\frac{1.01011\ moles_{CuCl}}{0.200\ L_{solution}}$
Molar Concentration a.k.a. Molarity	0.252 M	1.01 *moles/Liter*	2.52 M	5.05 M

Molarity and Calculations: Variations on the definition

$$\text{Concentration (Molarity)} = \frac{\text{moles}_{\text{solute}}}{\text{Liters}_{\text{solution}}}$$

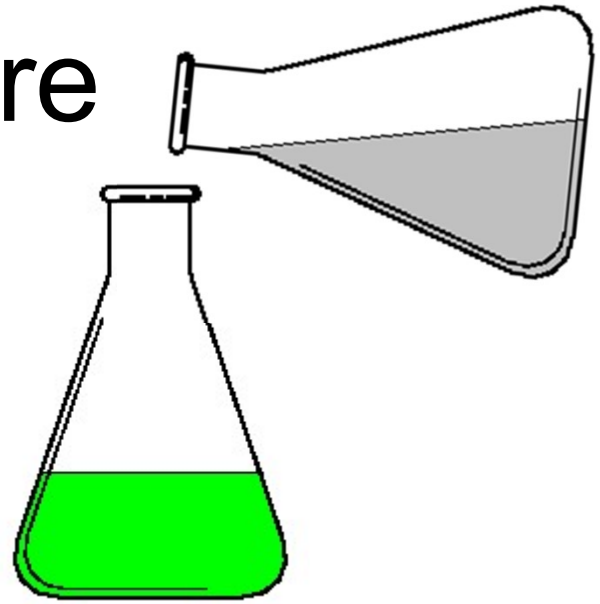
$$\text{Moles}_{\text{solute}} = \text{Molarity} \times \text{Liters}_{\text{solution}}$$

$$\text{Liters}_{\text{solution}} = \frac{\text{Moles}_{\text{solute}}}{\text{Molarity}}$$

Dilution

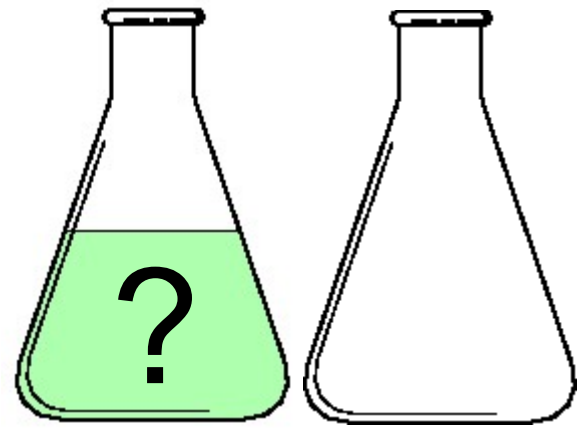
Mixing two or more solutions of known concentration

Before



Pure $H_2O_{(l)}$
Vol. = 53.3 mL

After



Dilute $FeCl_{3(aq)}$

Empty

Conc. = 1.56 M $FeCl_{3(aq)}$

Vol. = 95.6 mL

Vol. = 95.6 mL + 53.3 mL = 148.9 mL

Moles $FeCl_3$ = 1.56 M × 0.0956 L

Moles $FeCl_3$ = 0.149136 moles → Moles $FeCl_3$ = 0.149136 moles

$$\text{Conc.} = \frac{\text{moles}}{\text{Liters}} = \frac{0.149136 \text{ mol } FeCl_3}{0.1489 \text{ L}} = 1.00 \text{ M } FeCl_3$$

Solutions and Stoichiometry

Problem 3.101: How many grams of NaH_2PO_4 are required to react with 38.74 mL of 0.275 M NaOH via the following reaction:

119.97701

$$NaH_2PO_{4(s)} + 2\ NaOH_{(aq)} \rightarrow Na_3PO_{4(aq)} + 2\ H_2O_{(l)}$$

0.639 $grams_{NaH2PO4}$

38.74 mL

0.275 M

Moles = molarity × Liters

0.00532675 $moles_{NaH2PO4}$

0.0106535 $moles_{NaOH}$

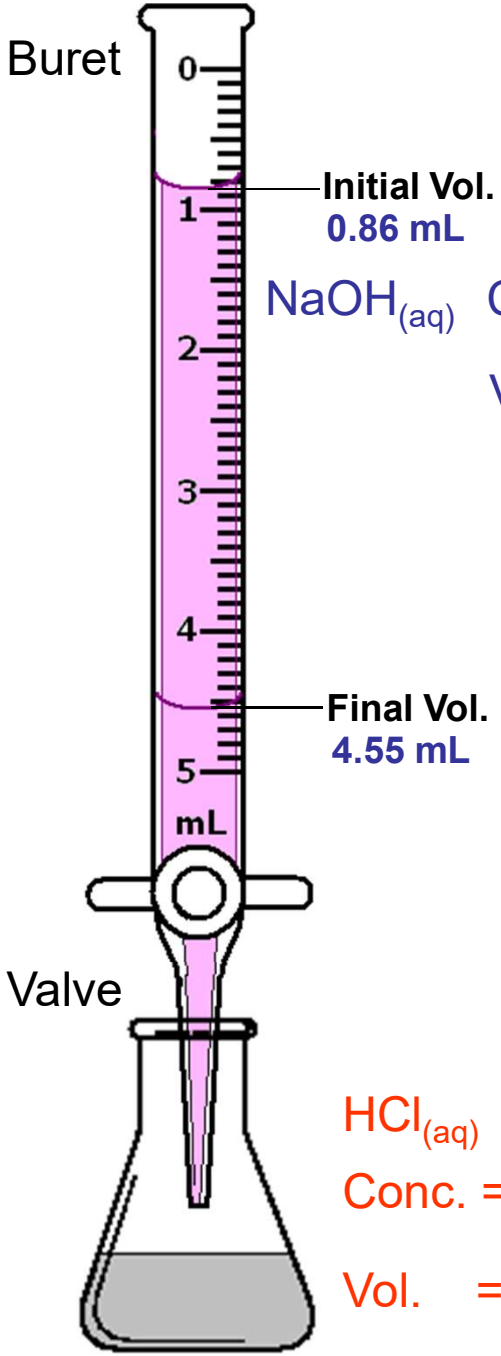
Moles = 0.275 M × 0.03874 L

Moles = 0.0106535 moles

$$\frac{1\ mole_{NaH2PO4}}{2\ mole_{NaOH}}$$

$$0.0106535\ moles \times \frac{1\ mole_{NaH2PO4}}{2\ mole_{NaOH}} = 0.00532675\ moles \times 119.97701 = 0.639\ g$$

Titrations



$NaOH_{(aq)}$ Conc. = ? = 0.657M

Vol. = 4.55 – 0.86 = 3.69 mL

Acid/Base Neutralization Reaction

Base		Acid		
$NaOH_{(aq)}$	+	$HCl_{(aq)}$	→	$H_2O_{(l)} + NaCl_{(aq)}$
0.657 M		0.485 M		
3.69 mL		5.00 mL		
2.425×10^{-3} moles		2.425×10^{-3} moles		

1 mol_{HCl}:1 mol_{NaOH}

$HCl_{(aq)}$

Conc. = 0.485 M

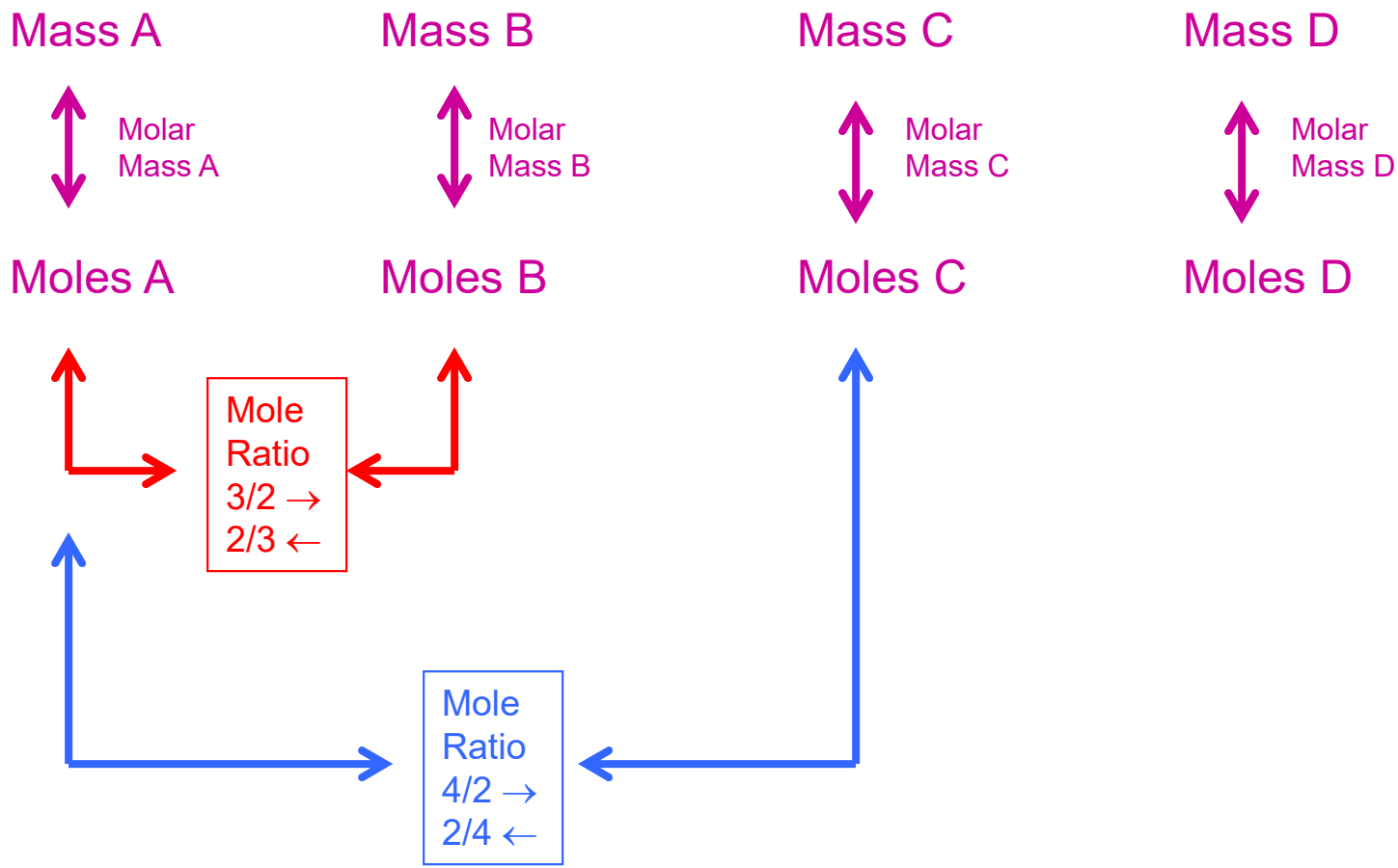
Vol. = 5.00 mL

$0.485\ M \times 0.005\ L = 2.425 \times 10^{-3}$ moles

$$\frac{2.425 \times 10^{-3}\ moles}{0.00369\ L} = 0.65718157\ M$$

Indicator: Changes color at Equivalence Point
(moles $_{NaOH}$ = moles $_{HCl}$)

$$2A_{(s)} + 3B_{(l)} \rightarrow 4C_{(g)} + 5D$$



$$2A_{(s)} + 3B_{(l)} \rightarrow 4C_{(g)} + 5D$$

Volume A Concentration A	Volume B Concentration B	Volume C Concentration C	Volume D Concentration D
↕ M × V = mol	↕ M × V = mol	↕ M × V = mol	↕ M × V = mol
Moles A	Moles B	Moles C	Moles D

Mole Ratio
3/2 →
2/3 ←

Mole Ratio
4/2 →
2/4 ←