# Stoichiometry Involving Molar Concentrations

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## Stoichiometry Calculations Involving: Molar Concentration

Remember… concentration → $C = \frac{n}{V}$ ← number of moles; $V$ ← volume (L)

$M = \frac{mol}{L}$

Stoichiometry calculations are based on the relationship of moles of 1 chemical and moles (or molecules) of another chemical.

2 Types of problems involving volume:

1) Use "22.4L" — gas @ STP

2) Calculate… volume or molarity — NOT @ STP; often [conc.] is used as conversion factor

**IMPORTANT: If a VOLUME is mentioned, and the problem involves a molarity, DO NOT assume that "22.4 L" should be used. The use of "22.4 L" is justified only if the substance being referred to is a gas AND if the key phrase "at STP" is mentioned along with the volume.**

***Example 1***

Tums™ is an antacid composed primarily of calcium carbonate (chalk), and stomach acid is a dilute solution of hydrochloric acid. The neutralization reaction between $CaCO_3$ and stomach acid is represented by the equation:

neutralization: $CaCO_3(s) + 2\ HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$

(carbonate, base → salt, water)

a) A tablet of Tums™ has a mass of 0.750 g. What volume of stomach acid having [HCl] = 0.0010 M is neutralized by a 0.750 g portion of $CaCO_3$?

$[HCl] = \frac{0.0010\ mol\ HCl}{1\ L\ HCl}$ (NOT STP — molarity)

mass $CaCO_3$ → mole $CaCO_3$ → mole HCl → volume HCl

$$0.750\,g\ CaCO_3 \times \frac{1\ mol\ CaCO_3}{100.1\,g\ CaCO_3} \times \frac{2\ mol\ HCl}{1\ mol\ CaCO_3} \times \frac{1\ L\ HCl}{0.0010\ mol\ HCl} = 15\ L$$

(molar mass; mole ratio; molarity) 14.99 → 15 L (2 sf.)

b) What volume of $CO_{2(g)}$ at STP is produced if 1.25 L of 0.0055 M HCl reacts with an excess of $CaCO_3$? (not critical…yet)

$\frac{0.0055\ mol\ HCl}{1\ L\ HCl}$

HCl : $CO_2$ mole ratio 2 : 1

volume HCl → moles HCl → moles $CO_2$ → (@STP, $\frac{22.4\ L}{1\ mol}$) volume $CO_2$

$$1.25\,L\ HCl \times \frac{0.0055\ mol\ HCl}{1\ L\ HCl} \times \frac{1\ mol\ CO_2}{2\ mol\ HCl} \times \frac{22.4\ L\ CO_2}{1\ mol\ CO_2} = 0.077\ L\ CO_2$$

(molarity; mole ratio) 0.0771 → = 0.077 L $CO_2$

***Example 2*** Consider the following reaction:

$$H_2SO_4 + 2KOH \dashrightarrow K_2SO_4 + 2H_2O$$

a) What mass (in g) of water is produced when 125mL of a 0.100M $H_2SO_4$ solution is reacted with excess KOH?

come back to next lesson!

b) What volume of 0.050M KOH solution is needed to completely react with 78mL of 0.28M $H_2SO_4$?

## Titration Reactions

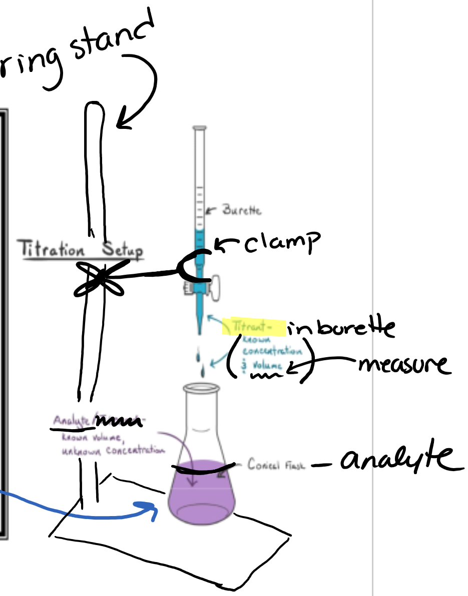
A **TITRATION** is a method used to determine the concentration of an unknown solution.

- **How You Do It:**
  Measure the volume of the solution of known concentration (the ***known solution***) needed to completely react with a certain volume of the solution of unknown concentration (the ***unknown***).
- **Why It Works:**

volume × concentration of titrant = moles titrant

moles titrant × mole ratio = moles analyte

[unknown concentration analyte] = moles of analyte / volume of analyte

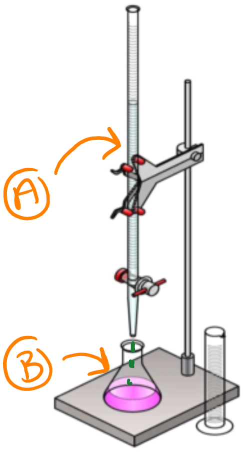


A Titration is a process in which a measured amount of a solution is reacted with known volume of another solution *(one of the solutions has an* unknown *concentration)* until a desired EQUIVALENCE POINT is reached.

Solve

***EQUIVALENCE POINT (Stoichiometric Point):*** the point in the titration where reactants have been used up. The number of moles of acid ($H^+$) = moles of base ($OH^-$)

The equivalence point is recognized by an Indicator ⟹ changes colour




There are many different types of titrations but they all work on the same principle:

*(In Chemistry 11, we will only look at **Acid-Base Reaction Titrations**.)*

eg. A + B ⟶ C + D

- As you combine the solutions, the chemicals react, consuming each other to form products.
  1. Until you've added enough of reactant A, reactant B is in excess ↑
  2. Once you've added just enough to complete the reaction. A = B (equivalence point)
  3. Adding more of reactant A (after reaction is over) results in reactant A in excess ↑

- The equivalence point is the "point" in the acid-base titration where all the reactants have been used up (and none are in excess); the number of moles of each reactant perfectly obeys the stoichiometry (mole ratios) of the reaction equation.

**Example 3**

When 50.0 mL of HCl were titrated with 0.250 M NaOH, it was determined that 75.0 mL were needed to reach the equivalence point. Determine the [HCl].

Titrant (buret)

$1\,HCl + 1\,NaOH \longrightarrow H_2O + NaCl$

① moles of base = $(0.250\,M)(0.0750\,L) = 0.01875\,mol$

② AT EQUIVALENCE POINT moles base = moles acid.

③ ∴ moles of acid = 0.01875 mol   $[HCl] = \frac{mol}{L} = \frac{0.01875\,mol}{0.0500\,L} = 0.375\,M$

**Example 4** If 19.8 mL of phosphoric acid reacts completely with 25.0 mL of 0.500 M KOH, then what is the concentration of the phosphoric acid?