

## matter classification

### all matter

- physical separation? **YES** → **mixture**
  - uniform? **YES** → homogeneous
  - uniform? **NO** → heterogeneous
- physical separation? **NO** → **substance**
  - chemical decompose? **YES** → compound
  - chemical decompose? **NO** → element

## stoichiometry strategies

### combustion analysis key

- all C → CO<sub>2</sub>, all H → H<sub>2</sub>O
- O by difference:  
 $m_O = m_{\text{sample}} - m_C - m_H$
- trap:** find  $n_C$  not  $n_{C_2}$

### simultaneous reactions

**setup:** let  $x$  = moles in main. if total moles  $n$ , then  $(n - x)$  = moles in side rxn

- total reactant:  $n$  = (calculate from given mass)
- products equation: mass of products from  $x$  and  $(n - x)$
- solve for  $x$

### LR with yield

- work **backwards** from desired product
- adjust for yield:  $n_{\text{needed}} = n_{\text{want}}/\text{yield}$
- don't multiply limiting reagent by  $(1 + \text{excess}\%)$ . sometimes this is a trap info!

### finding empirical formula

- find the moles of each element (**trap:** find  $n_X$  not  $m_{X_2}$ )
- find the simplest whole number ratio

### sequential reactions

- find LR in **first** reaction
- product from step 1 becomes reactant in step 2
- check if new reagent limits in step 2

## KMT postulates

- gas = very large number of molecules in ceaseless random straight-line motion
- molecules separated by large distance relative to size
- perfectly elastic collisions (no energy loss)
- no intermolecular forces between molecules

**temperature measures average translational KE**

## gas law strategies

### chamber mixing

**before:**  $P_1V_1$  and  $P_2V_2$  separate

**after:**

$$n_{\text{total}} = \frac{P_1V_1}{RT} + \frac{P_2V_2}{RT} = \frac{P_fV_f}{RT}$$

### combustion with T change

- find initial moles:  $n_i = \frac{P_iV}{RT_i}$
- calculate moles after reaction (balance equation!)
- account for excess reagent remaining
- $P_f = P_i \cdot \frac{n_f}{n_i} \cdot \frac{T_f}{T_i}$  (constant  $V$ )

**key:** excess O<sub>2</sub> leftover contributes to final pressure

### piston problems

- piston controls the **pressure**
- free moving piston → constant P

### determine ideal gas behavior

- calculate P using  $PV = nRT$
- compare to actual P
- if actual P < ideal P, then **attractive forces** dominate
- if actual P > ideal P, then **repulsive forces** dominate
- if equal, then ideal behavior

### decomposition in fixed volume

- moles of solid reactant
- count **gas** products only (exclude condensed liquids/solids)
- $P = \frac{nRT}{V}$

### percent yield from pressure drop

**trick:** let  $x$  = extent of reaction (mol reacted)

- use the information in initial and final to solve for  $x$
- find out  $x_{\text{max}}$
- $\text{yield} = \frac{x}{x_{\text{max}}} \times 100\%$

## tricky concepts

### van der waals adjustments

- high  $a$  = strong intermolecular forces
- high  $b$  = large molecular volume
- deviations largest at high P, low T

### real vs ideal gas

- real → ideal as **density decreases**
- high P, low T = more real (molecules close, interactions matter)
- low P, high T = more ideal (molecules far, move fast)
- ideal gas assumes **no intermolecular forces** and **no molecular volume**

### molecular speed distributions

- never say “every molecule of A is faster than B”
- $u \propto \sqrt{T/M}$ : lighter/hotter → faster average and broader range
- $u_{\text{rms}} > u_{\text{avg}} > u_{\text{mp}}$  always
- width increases** with temperature (broader range)
- same peak position: higher  $M$  needs higher  $T$

### liquid vs gas pressure

- gas:** pressure from molecular collisions with walls
- liquid:** pressure from gravitational weight ( $P = \rho gh$ )

### partial pressure

$$P_i = \chi_i P_{\text{total}} \quad \text{where} \quad \chi_i = \frac{n_i}{n_{\text{total}}}$$

**ideal gas:** mole fraction = volume fraction = pressure fraction

### intermolecular forces

- LDF: ALL molecules, **instantaneous induced dipoles**, increases with molar mass
- dipole-dipole: polar molecules only, **permanent dipoles**
- hydrogen bonding: H with FON
- covalent bonding >> H.B. > dipole-dipole > LDF

### polarizability

= tendency of electron cloud to distort

- larger molecules → more polarizable
- more electrons → more polarizable
- electrons farther from nucleus → more polarizable
- result:** stronger LDF forces

### repulsive forces

- arise from electron orbital overlap
- very strong at short distances
- prevent molecules from collapsing into each other

## useful formulas

### solution concentration conversions

- % (w/w): g solute per 100 g solution
- % (v/v): mL solute per 100 mL solution
- % (w/v): g solute per 100 mL solution
- ppm: g solute per 10<sup>6</sup> g solution
- ppb: g solute per 10<sup>9</sup> g solution

### % excess

$$\% \text{ excess} = \frac{n_{\text{actual}} - n_{\text{stoich}}}{n_{\text{stoich}}} \times 100\%$$

### basic gas laws

**boyle's law:**  $P_1V_1 = P_2V_2$  (constant  $n, T$ )

**charles's law:**  $\frac{V_1}{T_1} = \frac{V_2}{T_2}$  (constant  $n, P$ )

**gay-lussac's law:**  $\frac{P_1}{T_1} = \frac{P_2}{T_2}$  (constant  $n, V$ )

**avogadro's law:**  $\frac{V_1}{n_1} = \frac{V_2}{n_2}$  (constant  $P, T$ )

### conversion in $\Delta T$

$$\frac{1 \text{ K}}{1.8^\circ\text{R}} \quad \frac{1 \text{ K}}{1.8^\circ\text{F}}$$

°C is the same as K here

### dilution

$$M_1V_1 = M_2V_2$$

### empirical → molecular

$$n = \frac{M_{\text{actual}}}{M_{\text{empirical}}}$$

then multiply subscripts by  $n$

### average molar mass

$$\bar{M} = \sum_i x_i M_i$$

given mole fractions

### gas density

$$\rho = \frac{PM}{RT}$$

where  $M$  is molar mass

### mercury pressure

- $P_{\text{gas}} = P_{\text{bar}} \pm P_{\text{Hg}}$   
observe the diagram!
- $\Delta P_{\text{mmHg}} = \Delta h_{\text{Hg}}$   
watch the units
- just compare the mercury level, no more BS

## common traps

- gas products only for  $PV = nRT$  (exclude liquids/solids)
- units: K not °C, L not mL, atm for  $R = 0.082057$
- sig figs rules:  $+-$  least decimal places,  $\times \div$  least sig figs
- NEVER combine simultaneous rxns into a single equation