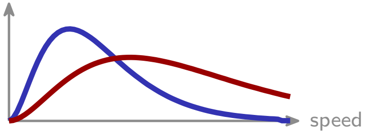
Properties of Substances and Mixtures

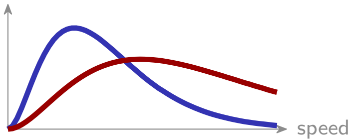
AP Chemistry ▪ Unit 3

AP Chemistry



What we will cover

1. Intermolecular forces
2. Types of solids
3. States of matter and the gas law
4. Kinetic molecular theory
5. Solutions and solubility
6. Separation methods
7. Spectroscopy and Beer-Lambert



Intermolecular forces

IMFs 分子间作用力 are weak attractions *between* molecules – they set boiling points:

- **London dispersion** 伦敦色散力 – all molecules; grows with size
- **dipole-dipole** 偶极-偶极 – polar molecules
- **hydrogen bonding** 氢键 – H bonded to N, O, F

> H-bond > dipole > dispersion – but compare the total.

F_2: $-188°$

HCl: $-85°$

H_2O: $100°$

stronger IMF

Types of solids

A solid's properties follow from its particles and the force holding them:

Ionic 离子型: high melt, brittle, conducts molten

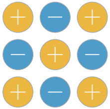
Covalent network 共价网状: very high melt, hard (diamond)

Metallic 金属型: conducts, malleable

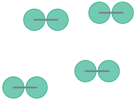
Molecular 分子型: low melt, soft (ice)

> Network solids melt highest – you must break covalent bonds, not just weak IMFs.

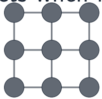
Types of solids



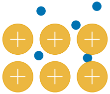
giant ionic
NaCl: high m.p., conducts when molten



simple molecular
I_2, ice: low m.p., weak forces between



giant covalent
diamond, SiO_2: very high m.p., insulating



giant metallic
copper: high m.p., conducts (solid + molten)

States of matter and the gas law

A balance of **kinetic energy** 动能 vs IMFs sets the state:

Ideal gas law

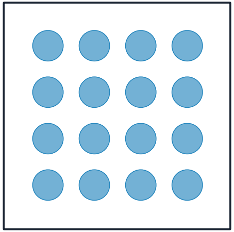
$$PV = nRT \quad (T \text{ in kelvin})$$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

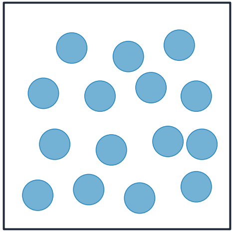
Dalton 道尔顿分压定律: $P_{tot} = \sum P_i$, with $P_i = x_i P_{tot}$.

Gases fill volume; solids hold shape

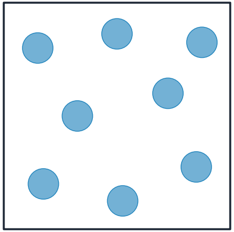
States of matter and the gas law



solid
regular, touching
vibrate in place



liquid
close, random
slide past
each other



gas
far apart,
random
move fast

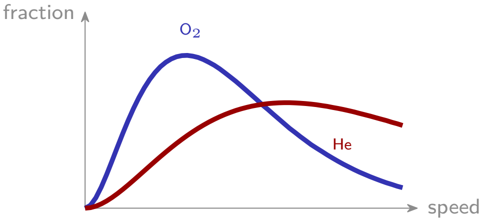
Kinetic molecular theory

KMT 分子运动论: gas particles are tiny points, in constant random motion, with elastic collisions and no attractions.

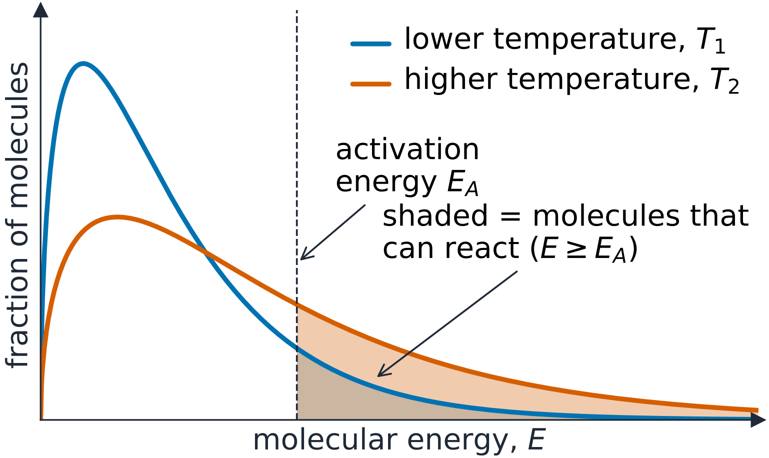
Temperature is average KE

$$\overline{KE} = \frac{3}{2}k_B T = \frac{1}{2}mv^2$$

Same T: lighter particles move faster.
Real gases stray at high P, low T.



Kinetic molecular theory



Solutions and solubility

A **solution** 溶液: **solute** 溶质 dissolved in **solvent** 溶剂.

Molarity and dilution

$$M = \frac{n}{V}, \qquad M_1 V_1 = M_2 V_2$$

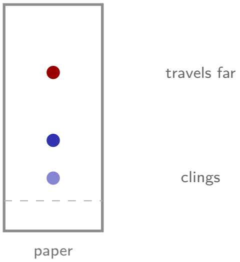
> "Like dissolves like": polar in polar, nonpolar in nonpolar.

Solute and solvent make a solution

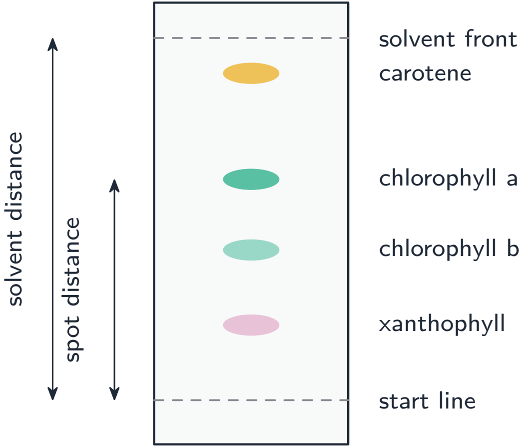
Separation methods

Mixtures separate by physical differences:

- **chromatography** 色谱法 – different pull between a stationary and mobile phase
- **distillation** 蒸馏 – different boiling points
- filtration – different particle sizes



Separation methods



Spectroscopy and the EM spectrum

Absorbed light matches an energy gap:

Photon energy

$$E = h\nu = \frac{hc}{\lambda}$$

- microwave – **rotational** 转动
- **infrared** 红外 – **vibrational** 振动
- UV/visible – **electronic** 电子跃迁

Shorter $\lambda \Rightarrow$ higher energy.

The Beer-Lambert law

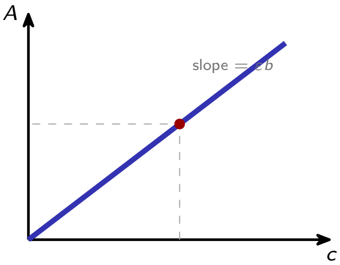
A coloured solution's **absorbance** 吸光度 is proportional to its concentration:

Beer-Lambert

$$A = \varepsilon b c$$

ε = **molar absorptivity** 摩尔吸光系数, b = **path length** 光程.

> A **calibration curve** 校准曲线 of A vs c is a straight line – read an unknown off it.



Unit 3 – key takeaways

1 IMFs

H-bond > dipole > dispersion; they set boiling points

2 Gases

$PV = nRT$; KMT – lighter particles move faster

3 Solutions

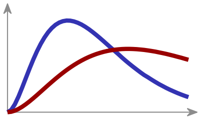
$M = n/V$; dilution $M_1 V_1 = M_2 V_2$; like dissolves like

4 Light

$E = hc/\lambda$; Beer-Lambert $A = \varepsilon bc$

Check yourself

1. Which IMF gives water its unusually high boiling point?
2. At the same temperature, does He or O_2 move faster?
3. Dilute a solution – do the moles of solute change?
4. In Beer-Lambert, absorbance is proportional to what?



Answers **1.** hydrogen bonding **2.** He (lighter) **3.** no (only concentration) **4.** concentration