

Note: 这一版 SG 是书中这几章知识点的详细介绍, 以及一些对知识点的理解, 如果只想要看这次期中的考点和知识点, 请看简洁版的 SG。(标蓝的是公式, 不是考点) (Chapter 3,4 几乎全是高一的知识, 所以只写了一些 (松上课说的))

## Chapter 5: Thermochemistry

### 1. The fundamental principle of thermochemistry:

Energy is released when chemical bonds are formed (Release heat / Do work);

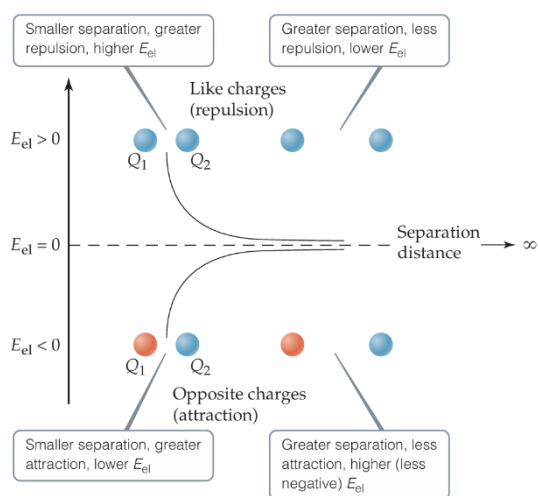
Energy is consumed when chemical bonds are broken.

### 2. The electrostatic potential energy, $E_{el}$

a) Equation:  $E_{el} = \frac{kQ_1Q_2}{d}$

b) 势能是一个系统可以放出/转化的能量,  $E_{el}$  可以理解为此时该体统能够对外放出的能量: ①Like charges: 电荷间距离越近,  $E_{el}$  越大(因为 Repulsion), 且一直为正(Repulsion, 对外放能);

②Opposite charges: 电荷间距离越近,  $E_{el}$  越小(因为 Attraction), 且一直为负(Attraction, 对外吸能)。



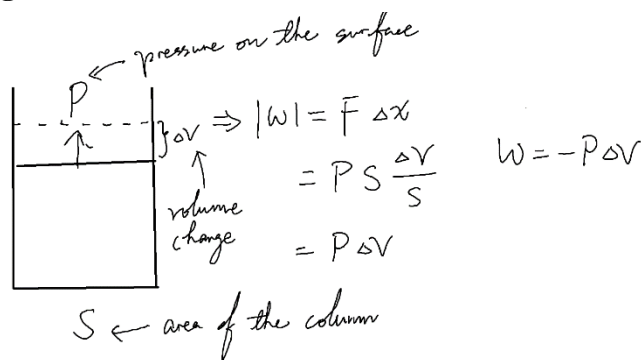
### 3. The First Law of Thermodynamics: Energy can be converted from one form to another, but it is neither created nor destroyed.

### 4. Enthalpy ( $\Delta H$ ) (别和 $\Delta G$ 弄混了: Free-energy change)

a) State Function: The value of a state function depends only on the present state of the system, not on the path the system took to reach that state. (可以理解为表示某一时刻状态的量, 该量的值不依赖于达到这一状态的过程)(不是 state function 的量是 path function, 依赖于达到该时刻状态的过程, 比如功(Work)、热量(Heat)、电流(I))

b) Why is enthalpy defined as  $H = \Delta U + P\Delta V$  (Under constant pressure)

- Primary Purpose: simplify the analysis and calculation of heat changes under constant pressure
- Process:  $\Delta U$  (Internal energy) =  $q_p$  (Heat) +  $w$  (Work) =  $q_p - P\Delta V$ , 但  $q$  是一个 path functions, 不能直接描述状态变化, 所以为了简化计算, 所以引入了  $H = \Delta U + P\Delta V$   
 $\rightarrow$  under constant pressure,  $\Delta H = q_p$
- Derivation Process: ①  $w = -P\Delta V$ :



②  $q_p = \Delta H$ :

Internal Energy  
↓

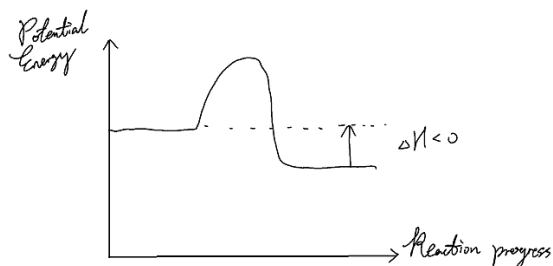
$$\begin{aligned}
 q_p &= \Delta U + w \leftarrow \text{Work} \\
 &= \Delta U + P\Delta V \\
 &= (U_1 - U_0) + P(V_1 - V_0) \\
 &= (U_1 + PV_1) - (U_0 + PV_0) \\
 &= H_1 - H_0 \\
 &= \Delta H
 \end{aligned}$$

c) Standard State Condition: (和最后面提到的 Notation 有关)

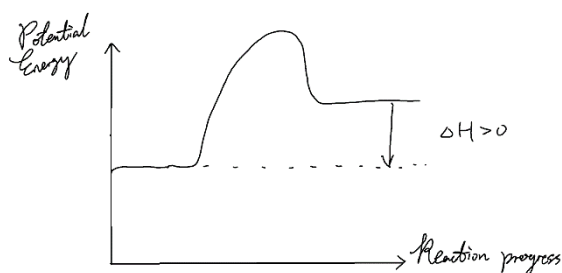
- 1 atm
- Pure liquid or solid
- Solution: 1 M concentration
- 298K, 25°C

d) Enthalpy Change

- $\Delta H = \sum H_{\text{product}} - \sum H_{\text{reactant}}$
- $\Delta H < 0$ : Exothermic reaction, surrounding temperature increases



- iii.  $\Delta H > 0$  : Endothermic reaction, surrounding temperature decreases



e) Calculations:

- i. Hess' Law (The application of the First Law of Thermodynamics: 反应中的总能量保持不变, 所以无论采用何种途径, 整个反应的总焓变也不发生改变):

Total  $\Delta H$  = sum of individual H



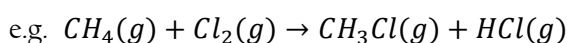
- ii. Enthalpy of Formation (or Heat of Formation)

- I. Conditions: ①The product(The substance you want to calculate) is at the most stable state  
②The reactants(The elements that compose the substance you want to calculate) are elements  
③ 1 mol substances are formed



- iii. Bond Enthalpies

Break bonds release energy; Form bonds absorb energy



- ①(Method 1 全断键重新成键):

$$\Delta H_{rxn}^\circ = [4D(\text{C}-\text{H}) + D(\text{Cl}-\text{Cl})] - [3D(\text{C}-\text{H}) + D(\text{C}-\text{Cl}) + D(\text{H}-\text{Cl})]$$

- ②(Method 2 只计算“真正”断键和成键的数量):

$$\Delta H_{rxn}^\circ = [D(\text{C}-\text{H}) + D(\text{Cl}-\text{Cl})] - [D(\text{C}-\text{Cl}) + D(\text{H}-\text{Cl})]$$

\*①②Methods can be used only when all reactants and products are in gas form (In solids, liquids, and solutions, intermolecular forces between different molecules must also be taken into account. )

- iv. Bond Enthalpies:  $\sum \text{reactants} - \sum \text{products}$

Enthalpy of Formation:  $\sum \text{products} - \sum \text{reactants}$

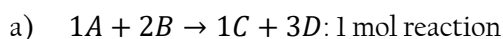
## 5. Calorimetry

a)  $q = Cm\Delta T$

b)  $q_{rxn} = -C_{cal}\Delta T$

# Chapter 3: Chemical Reactions and Stoichiometry

## 1. The number of moles of the reaction



0.5 mol A  $\rightarrow$  0.5 mol reaction

0.5 mol B  $\rightarrow$  0.25 mol reaction

b) Reaction type:

i. Combination

ii. Decomposition

iii. Combustion

iv. Single Displacement (electron transfer)

v. Double Displacement (exchange of ions)

vi. Redox Reaction

c) Formula Weight: sum of relative atomic mass

d) Molecular Weight: the sum of the relative atomic mass of a molecule. Be included in the formula weight.

e) Empirical Formula: the simplest whole-number ratio of the elements in a compound.

f) Percentage Composition:  $\frac{(\text{Number of the atom})(\text{Molecular weight})}{\text{Formula weight}} * 100\% = \text{percentage of the element}$

g) Limiting Reactant: the substance in a chemical reaction that is completely consumed first

# Chapter 4: Reactions in Aqueous Solutions

## 1. Solubility

a) Water doesn't dissolve oil  $\leftarrow$  Since the attraction between water molecules (H-bonds) is significantly greater than water and oil (Dipole-introduced dipole forces) (like dissolve like)

b) e.g. Sesame sauce: water and sesame switch as solute  $\rightarrow$  depends on which is continuous

c) The greater the magnitude of intermolecular forces between solute and solution, the more solubility.

d) Temperature and pressure affect solubility

\*Gas: higher temp, lower pressure, lower solubility

e) Rules:

- I. Most Ag, Pb, and Hg salts are INSOLUBLE, except for their nitrates ( $NO_3^-$ ) and perchlorates ( $ClO_4^-$ )
- II. Most hydroxides ( $OH^-$ ) are INSOLUBLE except those of alkali metals and Barium (Ba)
- III. All nitrates ( $NO_3^-$ ) and perchlorates ( $ClO_4^-$ ) are SOLUBLE
- IV. All alkali metals and ammonium ( $NH_4^+$ ) Compounds are SOLUBLE

2. Reaction efficiency

Surface area influences reaction efficiency → use solution, not solid

\*All reactions happen along the surface

3. Electrolytes: dissolve in water to form a solution that conducts electricity (electrons move freely)

Strong: completely dissolve; weak: portion dissolve

e.g.  $HCl(g) \rightarrow H^+(aq) + Cl^-(aq)$  strong (strong acids, strong bases, soluble salts)

$HAc(l) \leftrightarrow H^+(aq) + Ac^-(aq)$  weak (难电离物 (weak acids, weak bases, water))

$H_2C_2O_4(aq) \leftrightarrow H^+(aq) + HC_2O_4^-(aq)$  weak (gases, elements, oxides ( $Na_2O$ ,  $CuO$ ...))

## Chapter 10: Gases

1. Units of Pressure: mmHg / torr / atm / Pa (1 atm = 760 torr)

2. Boyle's law:  $V \propto \frac{1}{P}$  (constant n, T)

Charles' law:  $V \propto T$  (constant n, P)

Avogadro's law:  $V \propto n$  (constant P, T)

General Gas law:  $V \propto \frac{nT}{P}$

Ideal Gas Law:  $PV = nRT$

3. Gases densities and Molar Mass:  $\frac{n}{V} = \frac{P}{RT} \rightarrow \frac{nM}{V} = \frac{PM}{RT} \rightarrow d = \frac{m}{V} = \frac{nM}{V} = \frac{PM}{RT} \rightarrow M = \frac{dRT}{P}$

4. Partial Pressure

$$P_k = n_k \frac{RT}{V}$$

5. Total Pressure

$$P_t = (n_1 + n_2 + n_3 + \dots) \left( \frac{RT}{V} \right) = n_t \frac{RT}{V}$$

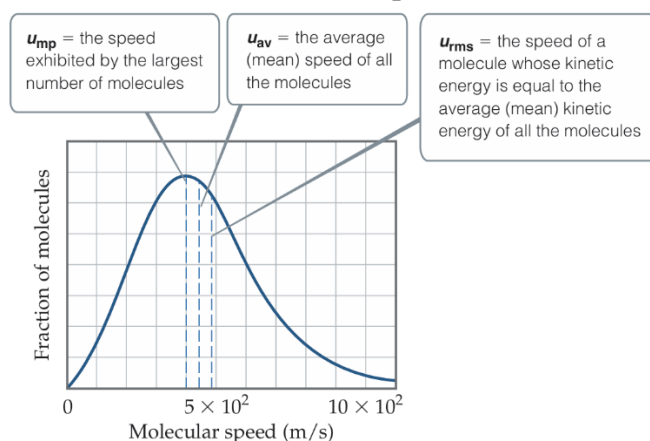
## 6. Ideal gas

- a) Definition: the molecules of an ideal gas do not interact with one another;  
the combined volume of the molecules is much smaller than the volume the gas occupies.
- b) The relationship between real gas and ideal gas
  - i. A real gas behaves most like an ideal gas at high temperature and low pressure.
  - ii. A real gas with a smaller formula weight behaves most like an ideal gas at the same temperature and pressure.

## 7. Kinetic-Molecular Theory of Gases

- a) Random motion
- b) Negligible molecular volume
- c) Constant average kinetic energy
- d) Average kinetic energy proportional to temperature (same temperature,  $\frac{V_A}{V_B} = \sqrt{\frac{\text{molar mass B}}{\text{molar mass A}}}$ )

## 8. Distributions of Molecular Speed



- a)  $u_{mp}$ : The speed is exhibited by the largest number of molecules.

$$u_{mp} = \sqrt{\frac{2RT}{M}}$$

- b)  $u_{rms}$ : The speed of a molecule possessing a kinetic energy identical to the average kinetic energy of the sample.

$$u_{rms} = \sqrt{\frac{3RT}{M}}$$

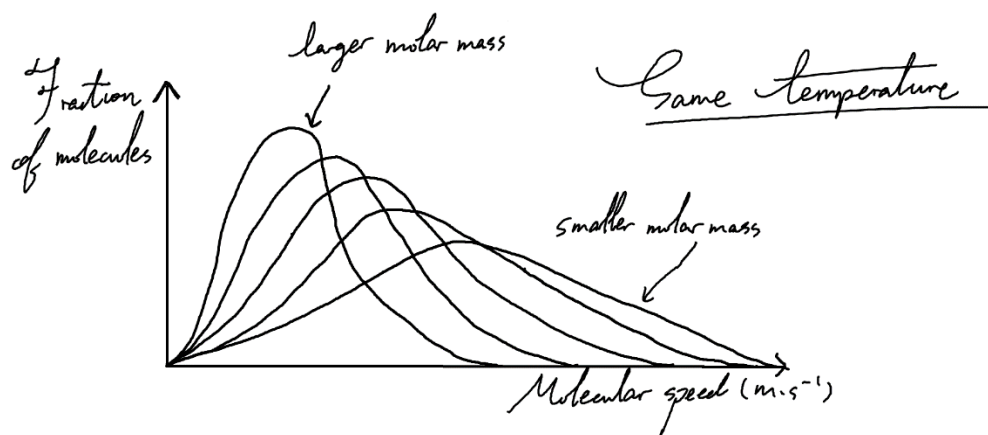
Process:  $\text{Kinetic Energy} = \frac{1}{2} m v_{rms}^2 = \frac{3}{2} k T$   $k$  ← Boltzmann constant

$\Rightarrow m v_{rms}^2 = 3 k T$   $k = \frac{R}{N_A}$  ← universal gas constant

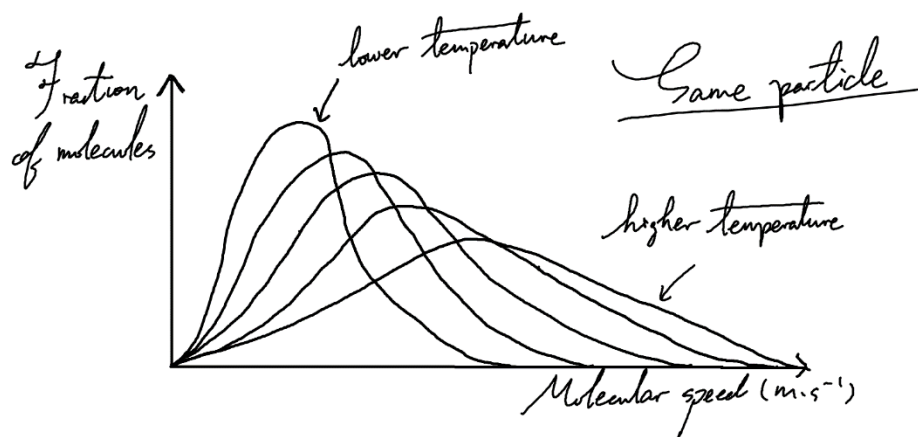
$\Rightarrow v_{rms} = \sqrt{\frac{3 k T}{m}}$   $M = \frac{m}{N_A}$  ← Avogadro's constant

$\Rightarrow v_{rms} = \sqrt{\frac{3 (\frac{R}{N_A}) T}{\frac{m}{N_A}}} = \sqrt{\frac{3 R T}{m}}$

- c)  $u_{av}$ : the average speed of all the molecules.
- d) The relationship  $u_{mp} < u_{av} < u_{rms}$  is always true for an ideal gas.
- e) Maxwell-Boltzmann Diagrams
  - i. Same temperature



- ii. Same particle



- iii. Equation:

$$P_1(v) = 4\pi \sqrt{\left(\frac{m}{2\pi kT}\right)^3} v^2 e^{-\frac{mv^2}{2kT}}$$

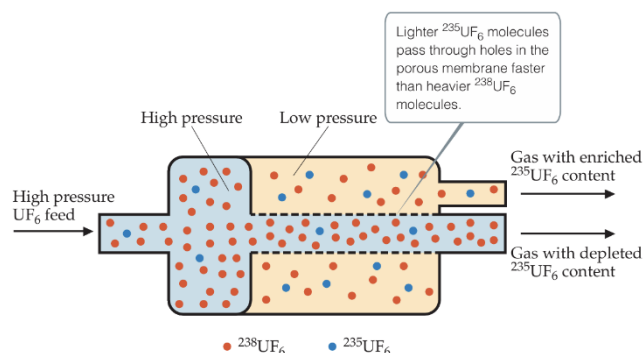
## 9. Effusion

- a) Definition: The escape of gas molecules through a tiny hole
- b) Graham's law

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

At the same pressure, the smaller the molar mass of a specific gas is, the greater the rate of leaking of the gas. The higher the temperature is, the greater the rate of leaking of the gas.

- c) Application:

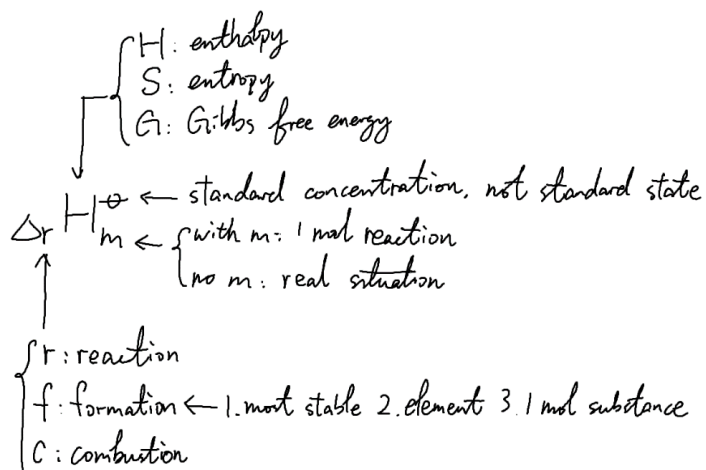


10. Diffusion: The spread of one substance throughout a space or throughout a second substance.

## Chapter 14: Chemical Kinetics

### Others

1. Notation:



2. Effective digits:

- Multiplication and Division: The result should have the same number of significant figures as the factor with the fewest significant figures.  
e.g.  $2.5 \times 3.42 = 8.55$ , which should be reported as 8.6 (two significant figures).
- Addition and Subtraction: The result should have the same number of decimal places as the measurement with the fewest decimal places.  
e.g.  $12.11 + 0.3 = 12.41$ , should be reported as 12.4 (one decimal place).