

9 Entropy and free energy – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)
Entropy	熵	_____
Gibbs free energy	吉布斯自由能	_____
thermodynamically favorable	热力学有利	_____

Recall

You already have a feel for these ideas:

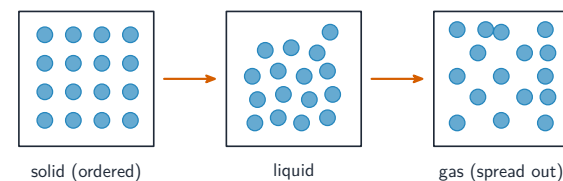
- Gases are more “spread out” and disordered than solids.
- Some reactions happen on their own; others need pushing.
- You have met exothermic (heat out) and endothermic (heat in) reactions.

This sheet explains what decides whether a reaction happens by itself. Each idea has a worked example.

New ideas

■ 1 Entropy

Entropy 熵 S measures how spread-out and disordered a system is. It **increases** going solid $\rightarrow$ liquid $\rightarrow$ gas, when a solid dissolves, or when more gas is made.

entropy increases: $\Delta S > 0$ 

■ 2 Gibbs free energy

Whether a reaction happens on its own depends on **Gibbs free energy** 吉布斯自由能:

$$\Delta G = \Delta H - T\Delta S.$$

A reaction is **thermodynamically favorable** 热力学有利 (it can happen by itself) when $\Delta G < 0$.

	ΔS positive	ΔS negative
ΔH neg.	feasible at all temperatures	feasible only at low temperature
ΔH pos.	feasible only at high temperature	never feasible

$$\Delta G = \Delta H - T\Delta S; \text{ feasible when } \Delta G \leq 0$$

■ 3 Enthalpy and entropy together

- Exothermic ($\Delta H < 0$) **and** entropy-increasing ($\Delta S > 0$) $\rightarrow$ always favorable.
- If they oppose each other, the **temperature** decides.

Worked example. A reaction with $\Delta H = +40$ kJ and $\Delta S = +0.120$ kJ/K becomes favorable only above $T = \frac{\Delta H}{\Delta S} = \frac{40}{0.120} = 333$ K (about 60 °C).

■ 4 Favorable is not the same as fast

$\Delta G < 0$ means a reaction **can** happen, not that it happens **fast**. A favorable reaction can still be very slow if it has a high activation energy (diamond turning to graphite takes ages).

Watch out: match your units before using $\Delta G = \Delta H - T\Delta S$ – ΔH is usually in kJ but ΔS in J, so convert one of them first.

Practice

Try these in order. The methods are all above.

2.1 State whether entropy increases or decreases when a gas condenses into a liquid. [1]

2.2 State the condition on ΔG for a reaction to be thermodynamically favorable. [1]

2.3 A reaction has $\Delta H = -50$ kJ and $\Delta S = +0.10$ kJ/K. State whether it is favorable, and why. [2]

2.4 A reaction has $\Delta H = +30$ kJ and $\Delta S = +0.10$ kJ/K. Find the temperature above which it becomes favorable. [3]

2.5 Explain why a reaction can be thermodynamically favorable but still not happen at a noticeable rate. [2]
