مراجعة القسم الخامس Spontaneity Reaction من وحدة Energy الكيميائية والتغيرات الطاقة and Chemical Change

موقع المناهج ⇦ المناهج الإماراتية ⇦ الصف الثاني عشر المتقدم ⇦ كيمياء ⇦ الفصل الأول ⇦ الملف

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إعداد: SCHOOL ALFAROUQ

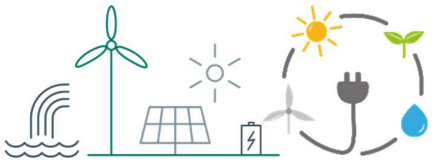
المزيد من الملفات بحسب الصف الثاني عشر المتقدم والمادة كيمياء في الفصل الأول

1	مراجعة القسم الرابع Change Enthalpy Calculating من وحدة Change Chemical and Energy الطاقة والتغيرات الكيميائية
2	مراجعة القسم الثالث Thermochemical من وحدة Energy and Chemical Change الكيميائية والتغيرات الطاقة

المزيد من الملفات بحسب الصف الثاني عشر المتقدم والمادة كيمياء في الفصل الأول	
3	مراجعة القسم الثاني Heat الحرارة من وحدة and Energy الكيميائية والتغيرات الطاقة Chemical Change
4	مراجعة القسم الأول Energy الطاقة من وحدة and Energy الكيميائية والتغيرات الطاقة Chemical Change
5	مذكرة الوحدة الأولى الطاقة والتغيرات الكيميائية أسئلة الاختبارات الوزارية السابقة

Chapter: Energy & Chemical Change

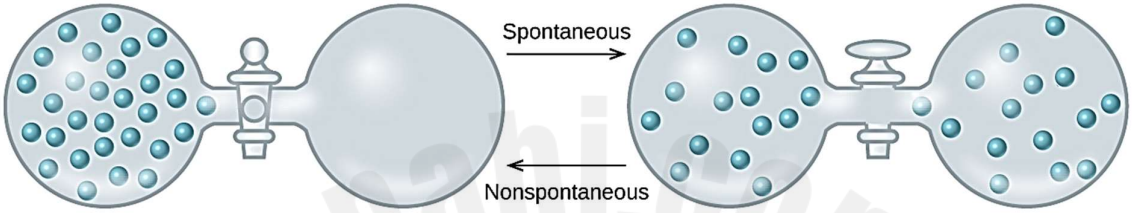
Section (5): Reaction Spontaneity



SPONTANEOUS PROCESS

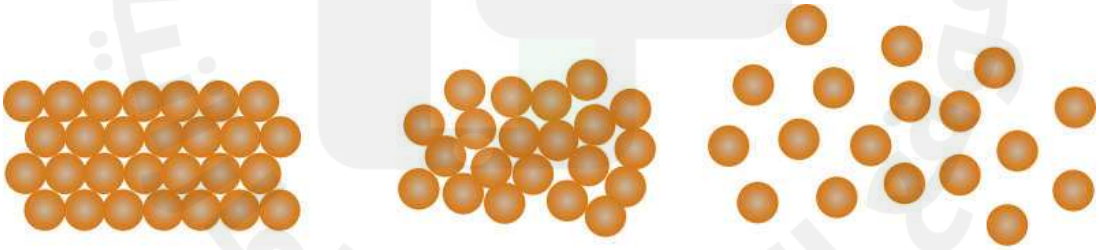
Any physical or chemical change that occurs with no outside intervention.

- However, for many spontaneous processes, some energy from the surroundings must be supplied to get the process started.



ENTROPY (S)

- It's a measure of the **number of possible ways** that the energy of a system can be distributed randomly.
- It's a measure of the **disorder or randomness** of the particles that make up a system.
- It is related to the **freedom of the system's particles** to move and number of ways they can be arranged.



Solids have lower entropy than liquids or gases

Liquids have higher entropy than solids

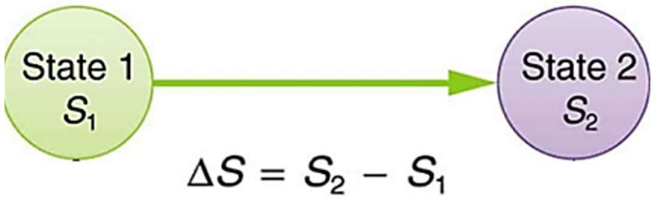
Gases have higher entropy than solids

SECOND LAW OF THERMODYNAMICS

"Spontaneous processes always proceed in such a way that the entropy of the universe increases".

CHANGE OF ENTROPY (ΔS) (J/K)

- It's the difference between the entropy of the products & the entropy of the reactants.



$$\Delta S_{system} = S_{products} - S_{reactants}$$

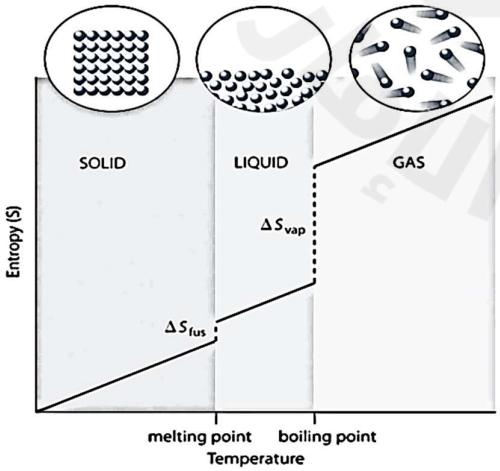
- **If the entropy of a system INCREASES** during a reaction or process,
- $S_{products} > S_{reactants}$ and ΔS_{system} is positive.
- **If the entropy of a system DECREASES** during a reaction or process, $S_{products} < S_{reactants}$ and ΔS_{system} is negative.

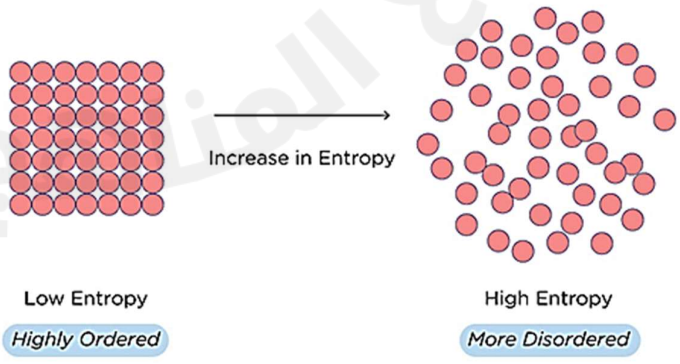
We can predict the ΔS [redacted] in the following (6) cases.

1. **Changes of state** entropy increases as a substance changes from a solid to a liquid and from a liquid to a gas.

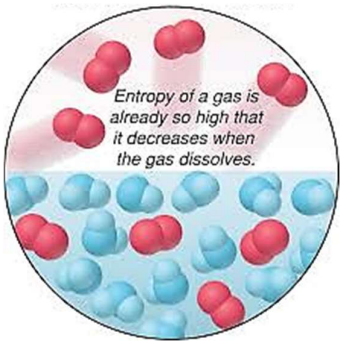
$$H_2O(l) \rightarrow H_2O(g) \quad \Delta S_{system} > 0$$

$$CH_3OH(s) \rightarrow CH_3OH(l) \quad \Delta S_{system} > 0$$





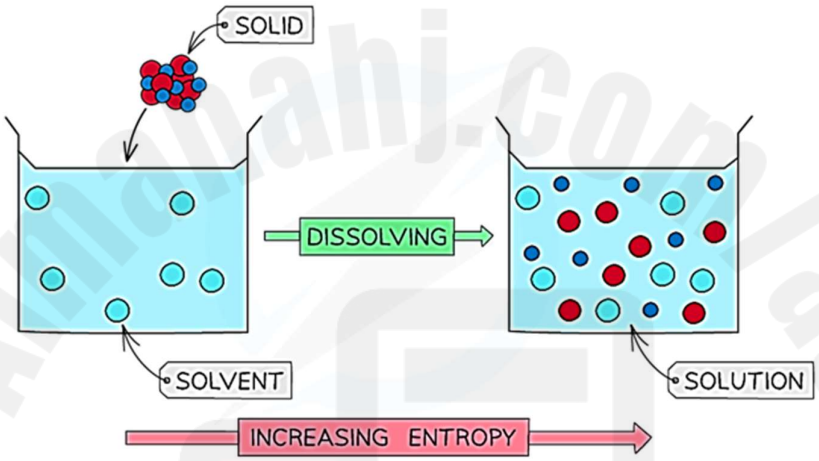
2. **Dissolving gases in a solvent** always results in a decrease in entropy.



$$O_2(g) \rightarrow O_2(aq) \quad \Delta S_{system} < 0$$

3. **Dissolving solids or liquids in a solvent** always results in an increase in entropy.

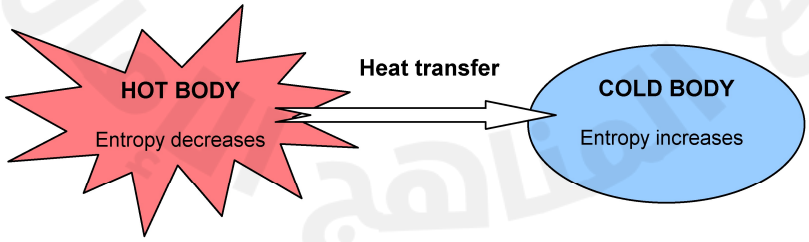
$$NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq) \quad \Delta S_{system} > 0$$



4. The entropy of increases when the **number of gaseous product particles is greater than the number of gaseous reactant** particles.

$$2SO_3(g) \rightarrow 2SO_2(g) + O_2(g) \quad \Delta S_{system} > 0$$

5. The entropy of increases when the **temperature of particles increases.**



6. The entropy of increases at **Exothermic reactions.**

If $\Delta H_{system} < 0$ (Negative), then $\Delta S_{system} > 0$ (positive)

Exercise

- Predict the sign of ΔS_{system} for each of the following changes.

a. $ClF(g) + F_2(g) \rightarrow ClF_3(g)$

b. $NH_3(g) \rightarrow NH_3(aq)$

c. $CH_3OH(l) \rightarrow CH_3OH(aq)$

d. $C_{10}H_8(l) \rightarrow C_{10}H_8(s)$

e. $Fe(s) + Zn^{2+}(aq) \rightarrow Fe^{2+}(aq) + Zn(s)$

Gibb's FREE ENERGY (G_{system})

It's the amount of **energy available** to do work. *(For reactions or processes that take place at constant pressure and temperature).*

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

ΔG = Gibbs free energy
ΔH = Change in enthalpy
ΔS = Change in entropy
T = Temperature in K

- To calculate Gibbs free energy, it is usually necessary to **convert units** because ΔS is usually expressed in J/K, whereas ΔH is expressed in kJ.
- The same rule applies for systems under standard conditions.

(298 K and 1 atm)

$$\Delta G^{o}_{system} = \Delta H^{o}_{system} - T\Delta S^{o}_{system}$$

If the sign of the free energy change (ΔG^{o}_{system}) is **negative**, the reaction is **spontaneous**.

If the sign of the free energy change (ΔG^{o}_{system}) is **positive**, the reaction is **non-spontaneous**.

	$\Delta H < 0$	$\Delta H > 0$
$\Delta S > 0$	Spontaneous at all T ($\Delta G < 0$)	Spontaneous at high T (when $T\Delta S$ is large)
$\Delta S < 0$	Spontaneous at low T (when $T\Delta S$ is small)	Non-spontaneous at all T ($\Delta G > 0$)

Table 6 Reaction Spontaneity $\Delta G_{system} = \Delta H_{system} - T\Delta S_{system}$

ΔH_{system}	ΔS_{system}	ΔG_{system}	Reaction Spontaneity
negative	positive	always negative	always spontaneous
negative	negative	negative or positive	spontaneous at lower temperatures
positive	positive	negative or positive	spontaneous at higher temperatures
positive	negative	always positive	never spontaneous

Exercise

(1) Determine whether each of the following reactions is spontaneous.

a. $\Delta H_{system} = -75.9$ kJ, $T = 273$ K, $\Delta S_{system} = 138$ J/K

b. $\Delta H_{system} = -27.6$ kJ, $T = 535$ K, $\Delta S_{system} = -55.2$ J/K

c. $\Delta H_{system} = 365$ kJ, $T = 388$ K, $\Delta S_{system} = -55.2$ J/K

d. $\Delta H_{system} = 452$ kJ, $T = 165$ K, $\Delta S_{system} = 55.7$ J/K

(2) Given ΔH_{system} = -144 kJ and ΔS_{system} = -36.8 J/K for a reaction, determine the lowest temperature in kelvins at which the reaction would be spontaneous.

(3) Determine whether the system ΔH_{system} = -20.5 kJ, T = 298 K, and ΔS_{system} = -35.0 J/K is spontaneous or nonspontaneous.