Chemical Energetics

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The Chemistry Specialist

Chemistry Energetics

Standard Conditions



An enthalpy change stated under standard conditions is hence called **standard enthalpy change**, denoted by the symbol, $\Delta H\theta$. The ' θ ' indicates that ΔH was measured and calculated under standard conditions, standard states.



Under standard conditions, substances are in their standard states. The **standard state of a substance** is its **most stable form** under standard conditions.

- 1 $\Delta H_r = \sum \Delta H_f$ (products) $\sum \Delta H_f$ (reactants)
- 2 $\Delta H_r = \sum \Delta H_c$ (reactants) $\sum \Delta H_c$ (products)
- 3 $\Delta H_r^{\theta} = \sum BE$ (bonds broken) $\sum BE$ (bonds formed)
- 4 $\Delta H_{sol}^{\theta} = -$ lattice energy $+ \Delta H_{hyd}^{\theta}$ (cations & anions)
- $\Delta G_{sys} = \Delta H_{sys} T\Delta S_{sys}$
- $\Delta G < O \longrightarrow$ Spontaneous
- $\Delta G > O \longrightarrow Not spontaneous$
- $\Delta G=O \longrightarrow$ both forward and backward reactions are in equilibrium (e.g. phase change)





Factors affecting the entropy(s) of a chemical system



2. Change in Phase

Entropy of a substance **increases** as it changes from a solid to a liquid to a gas.

Solid melts or liquid boils \longrightarrow Particles are randomly arranged \longrightarrow More ways to distribute energy \longrightarrow Greater disorder in the system

 \therefore S \uparrow ($\Delta S_{sys} > O$)

3. Change in the Number of Gaseous Particles

When products of a reaction contain more gas particles than the reactants \longrightarrow More ways to distribute energy since there are more gas particles moving randomly \longrightarrow Greater disorder in the system

 $\therefore S \uparrow (\Delta S_{SVS} > O)$

4. Mixing of Particles

4.1 Mixing of gases





 $\begin{array}{rcl} \mbox{Gas mixes} &\longrightarrow & \mbox{Expands to occupy the whole} \\ \mbox{container} &\longrightarrow & \mbox{More ways to distribute energy among} \\ \mbox{the particles in the system} &\longrightarrow & \mbox{Greater disorder} \\ \mbox{in the system} & \mbox{in the system} \end{array}$

 $\therefore S \uparrow (\Delta S_{sys} > O)$

4.2 Mixing of liquids

When mixing liquids of similar particles \longrightarrow Molecules have greater volume of space to move about \longrightarrow More ways to distribute energy \longrightarrow Greater disorder in the system

 $\therefore S \uparrow (\Delta S_{sys} > O)$

4.3 Dissolving an ionic solid

The entropy of a dissolved solid is usually greater than the entropy of the pure solute.





Water molecules

 $NaCl(s) \longrightarrow Na^+(aq) + Cl^-(aq) (\Delta S > O)$

Dissolving of NaCl in water involves the disruption of the crystal lattice of solid NaCl and hydration of Na⁺ and Cl⁻ ions disruption of the crystal lattice increases disorder.

The hydration process however decreases disorder about Na^+ and $Cl^$ since it puts the hydrating water molecules into an orderly arrangement about the Na^+ and Cl^- ions.

Disordering is more dominant \longrightarrow overall dissociation process results in a net increase in entropy.

$$AlCl_3(s) \longrightarrow Al^{3+}(aq) + 3Cl^{-}(aq)$$

For salts such as A/Cl_3 which contain more highly charged ions, the hydrating water molecules are more strongly ordered about the ions.

Since the ordering process is more dominant, the overall dissolution process results in a net decrease in

entropy.

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