VC210 Recitation Class for Quiz2

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Contents

Entropy

- Spontaneous change: can occur without external influences.
- Entropy (S): measure of disorder. Disorder ↑, entropy ↑.

The second law of thermodynamics: The entropy of an **isolated** system increases in the course of any **spontaneous** change.

Entropy Change

In a reversible process,

$$\Delta S = \frac{q_{rev}}{T} \tag{1}$$

If pressure is constant (e.g. vaporization, fusion, etc.), $\Delta H = q$, so

$$\Delta S = \frac{\Delta H}{T}$$

For $\Delta S_{surrounding}$,

$$\Delta S_{sur} = \frac{-\Delta H}{T} \tag{2}$$

Reversible Process

For a change: state 1 to state 2, if we can find some ways to get state 2 back to state 1, the change is a **reversible process**.

Ideal Gas of in a Reversible Process

- Constant temperature & reversible process & ideal gases:

$$\Delta S = nR \ln \frac{V_f}{V_i} = nR \ln \frac{P_i}{P_f} \tag{3}$$

  Hence, volume ↑, entropy ↑.

- Constant volume & constant c & reverse process & ideal gases:

$$\Delta S = c_V \ln \frac{T_f}{T_i} \tag{4}$$

- Constant volume & time-varying c & reverse process & ideal gases:

$$\Delta S = \int_{T_i}^{T_f} \frac{cdT}{T} \tag{5}$$

Trouton' Rule

Approximately, for any liquid converted to vapor, the entropy change:

$$\Delta S = 85 J/(K \cdot mol) \tag{6}$$

Applying the equation $\Delta S = \frac{\Delta H}{T}$,

- $\Delta S_{vap} = \frac{\Delta H_v ap}{T_b}$, T_b: boiling temperature.
- $\Delta S_{fus} = \frac{\Delta H_f us}{T_f}$, T_f: melting temperature.

Qualitively Compare Entropy

1. Gas>Liquid>Solid
2. More complex the molecule, more chaotic the substance is.
3. Heavier atom has more energy
4. Polar molecules have less entropy

where ”more complex molecule” means ”have more atoms”.

Standard Entropy

$$\Delta S^\circ = \sum n\Delta S^\circ(products) - \sum n\Delta S^\circ(reactants) \tag{7}$$

where n is the moles.

Thrid Law of Thermodynamics

Content: The entropy of perfect crystal approaches 0 as the absolute temperature approaches 0.

Boltzmann Formula

$$S = k\ln W \tag{8}$$

- $k = \frac{R}{N_A} = 1.381\times10^{-23} J/K$
- W: microstates, the number of possible positions that atoms/molecules can be arranged.
- S: absolute entropy at any temperature, called "statistical entropy".

Gibbs Free Energy

$$\Delta G = \Delta H_{system} - T\Delta S_{system} \tag{9}$$

- $\Delta G < 0$, reaction is spontaneous.
- $\Delta G = 0$, reaction is in equilibrium (no tendency to proceed in either direction).
- $\Delta G > 0$, reverse reaction is spontaneous.

Gibbs free energy of a reaction (similar to enthalpy and entropy):

$$\Delta G = \sum n\Delta G(products) - \sum n\Delta G(reactants) \tag{10}$$

Maximum Non-expansion Work

$$w_{max} = -\Delta G \tag{11}$$

Non-expansion Work

Work without change of volume. For example, electric work.

End

Welcome