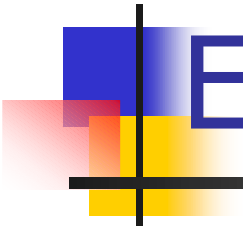


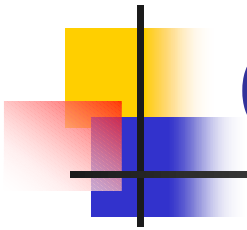
Equilibrium Requirements

(Relating Primarily to Thermal, Phase, and Chemical Equilibrium)

Jamie Sei

Presentation 1 (3-29-2001)

Ch. 15.1



Overview

- Types of Equilibrium
- Thermal and Phase Equilibrium
  - Example
- Second Law of Thermodynamics
  - Increased Entropy Principle
  - Gibbs Function
- Chemical Equilibrium
  - Example

Types of Equilibrium

- Mechanical (not discussed)
  - No change in pressure
- Thermal
  - No change in temperature
- Phase
  - No phase transformation
- Chemical
  - No change in chemical composition

Thermal and Phase Equilib.

- Example: Refrigeration Condenser.

- Theoretical Adiabatic system.
  - No heat lost to surroundings
  - Complete phase change of material from vapor to liquid.

Reacting Systems

- 2nd Law of Thermodynamics.
  - Energy has quality and quantity.
  - Reaction proceed in direction of lowest quality.
- In our example that means:
  - Lowest possible temperature.
  - Lowest possible phase (liquid).

Real World.

- "Ixnay" on the adiabatic systems

- Reactions based on other principles
  - Increase entropy principle
  - Gibbs' function (enthalpy)

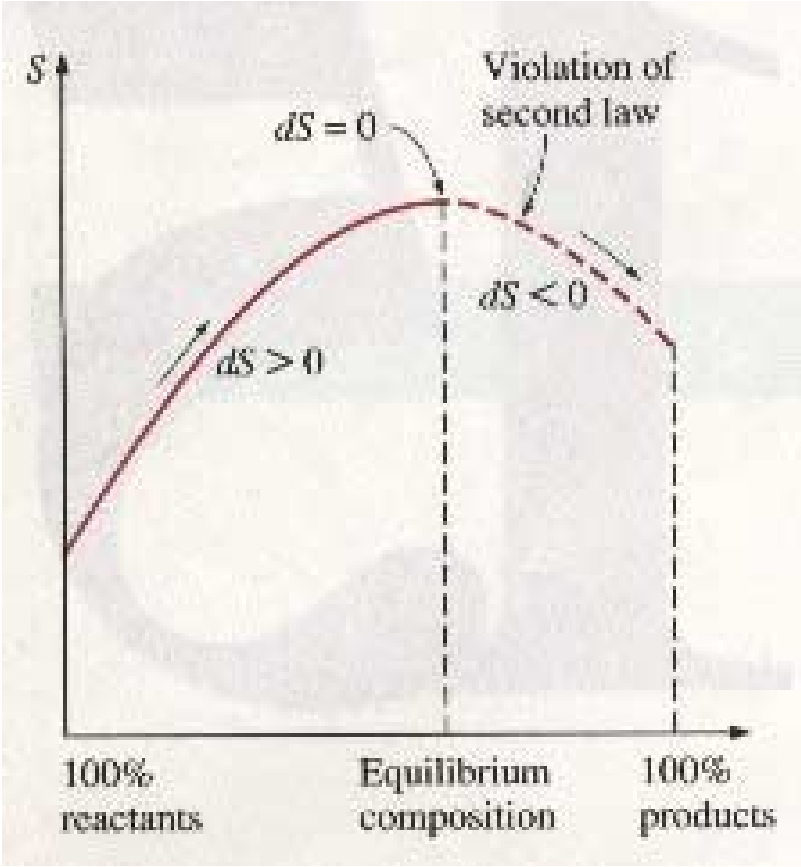
Increased Entropy Principle

- Basic equation: $dS_{sys} \geq dQ/t$.
- Heat transfer?
- Relationship with equilibrium criterion.
  - $dQ - PdV = DU$.
  - $dS_{sys} \geq dQ/t$.
  - Yeilds → $dU + PdV - TdS \leq 0$.
- In English:

  When entropy is maxed out, reaction stops.

Increased Entropy Principle

- Equilibrium is reached at maximum entropy.
- Chemical reaction proceeds to increased entropy

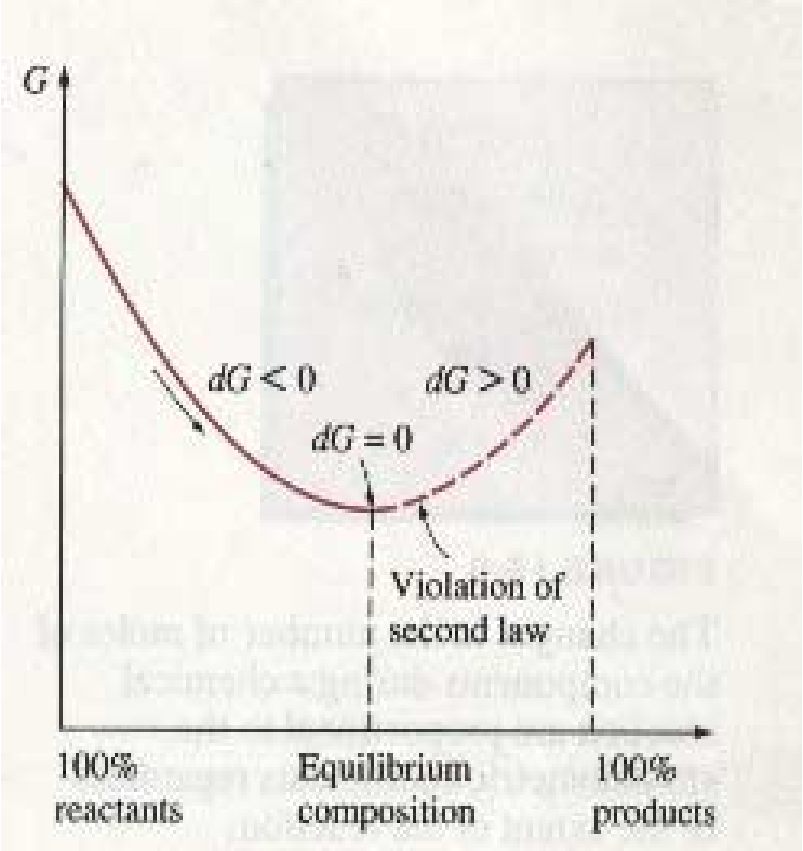


Gibbs Function

- $\Delta G = \Delta H - T\Delta S$
- In English that transfers to:
  - $\Delta G = 0$
- Dumbed down a little bit:
  - Reaction stops when Gibbs is the smallest.

Gibbs Function

- Equilibrium is reached at minimum change in T and P.
- Chemical reaction proceeds to smallest T and P.



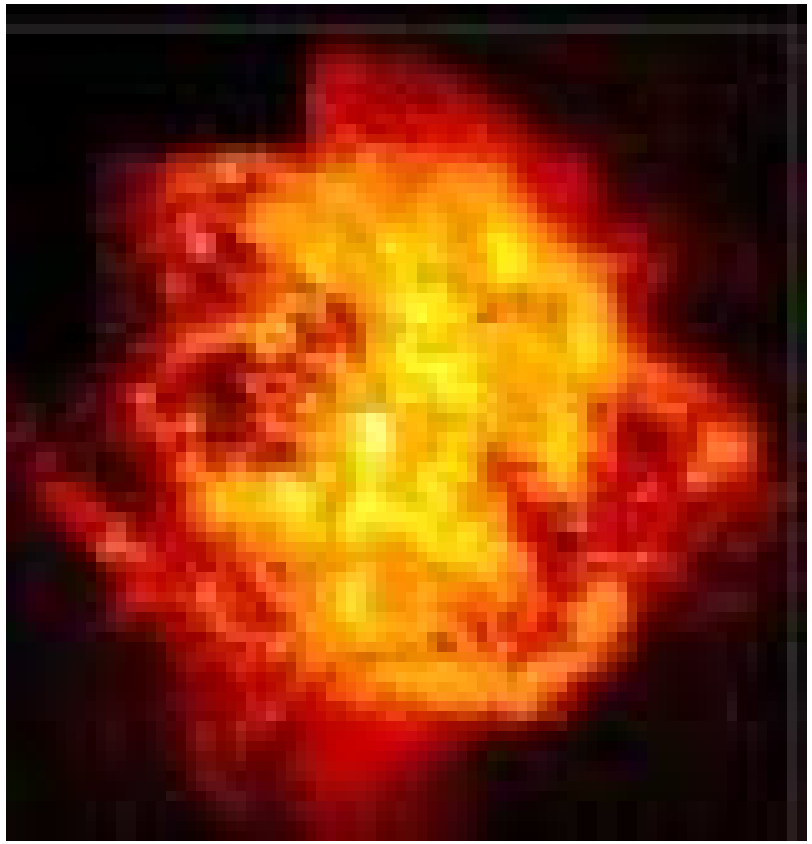
Chemical Equilibrium

- Chemical Equilibrium:
  - A single non-reacting element
  - Two or more elements
    - The amount of reactants **in** the system equal the amount of products **from** the system.

- Does this include Plasma?

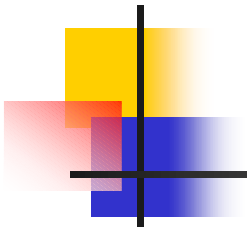
Plasma!!!!!!!!!!

- What does this have to do with Plasma?
- Plasma is a gas
  - Steve Malekos
- Acetylene and Ammonia



Acetylene and Ammonia

- Acetylene → C_2H_2
  - + matches = BOOM!!!!!
- Ammonia → NH_3
  - + cleft lip Bobby = DEAD BOBBY

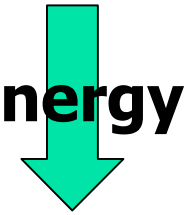


Mixture

- In growing nanotubes the key is to deposit the carbon atoms.
  - Acetylene contains the carbon C_2H_2
- Correct mixture is important!

All up in the Mix

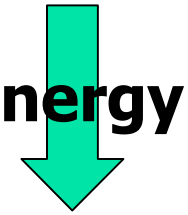
- How it breaks down



- $C_2H_2 + NH_3 \rightarrow C + H_2 + N_2$

All up in the Mix

- Wrong!
  - Stoichiometery
- Correct way



  - $C_2H_2 + 2NH_3 \rightarrow C + 4H_2 + N_2$
  - **NOTE: H^+ and N^{3-} ions are also present due to added energy.**

Blah, Blah, Blah is this important?

- YES, Wes it is!
- Bad mix
  - No equilibrium
  - Non-reacted molecules
- Results
  - Releasing Acetylene and Ammonia as byproducts

Rapn' it up.

- Equilibrium is important!
- Thermal and Phase Equilibrium
- Increased Entropy and Gibbs Function
- Chemical Equilibrium and Plasma

So… How you doin’?