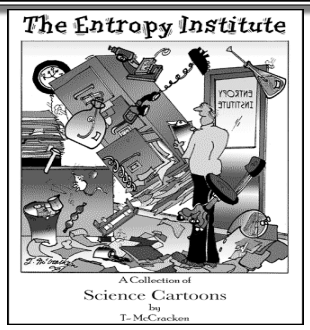
Entropy



1st Law of Thermodynamics

- Energy is neither _____ nor _____
  - The energy of the universe is constant
  - Energy just changes from one form to another

Spontaneity

- _____ process – a process that occurs without intervention
  - Spontaneous processes can be fast or slow
- Spontaneity tells us the _____ of the energy flow
  - It tells us NOTHING about the speed of the reaction

For example…

- A ball spontaneously rolls down a hill
  - It does not spontaneously roll up
- If iron is exposed to air, it spontaneously rusts
  - The rust does not spontaneously turn back into air & iron

Entropy

- _____ (s) – the measure of molecular randomness or disorder
  - Think of entropy as the amount of chaos
- The driving force for a spontaneous process is an increase in entropy

Entropy

- The natural progression of things is from order to disorder

Entropy

- Predict which has the highest entropy

1. CO_2 (s) or CO_2 (g)
2. 1 mol of N_2 at 1 atm or 1 mol of N_2 at 0.001 atm

Entropy

- Predict the sign of the entropy change for the following…

1. Sugar is added to water to form a solution
2. Iodine vapor condenses on a cold surface to produce a liquid

2nd Law of Thermodynamics

- 2nd Law of Thermodynamics – In any spontaneous process there is always an increase in _____ of the universe
- Energy is conserved…entropy is NOT conserved!
- The entropy of the universe is always increasing
  - ΔS_{univ} = + = spontaneous
  - ΔS_{univ} = - = not spontaneous (would be spontaneous in the opposite direction)

Temperature & Spontaneity

$$\Delta S_{surr} = -\frac{\Delta H}{T}$$

T must be in Kelvin

ΔH is usually given in KJ/mol

ΔS will be in KJ/K, but is usually changed to J/K

Example

Sb_2S_3 (s) + 3Fe (s) → 2Sb (s) + 3FeS (s) ΔH = -125 kJ

Calculate ΔS_{surr} for this reaction at 25°C and 1 atm

Example

Sb_4O_6 (s) + 6C (s) → 4Sb (s) + 6CO (g) ΔH = 778 kJ

Calculate ΔS_{surr} for this reaction at 25°C and 1 atm

3rd Law of Thermodynamics

- The entropy of a perfect crystal at 0K is _____

Free Energy

- _____ (G) – a thermodynamic function equal to the enthalpy minus the product of the entropy and the Kelvin temperature
- $\Delta G = \Delta H - T\Delta S$
- A process is only spontaneous in the direction where ΔG is **negative**

Example

- At what temperatures is the following process spontaneous at 1 atm?
  - $Br_2(l) \rightarrow Br_2(g)$
  - $\Delta H = 31.0$ KJ/mol → 31000 J/mol
  - $\Delta S = 93.0$ J/ K mol

Dependence of H & S on Spontaneity

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

ΔH	ΔS	Result
-	+	Spontaneous at all temperatures
+	+	Spontaneous at high temperatures
-	-	Spontaneous at low temperatures
+	-	Not spontaneous at any temperature