CHEM 160 – Thermodynamics.

Laws:

- First Law: all of the energy is conserved.

- Second Law: the entropy in the universe is always increasing. $\Delta S_{surr} = \dfrac{-\Delta H}{T}$

- Third Law: there is an absolute lowest temperature. $T = 0K = -273\ ^\circ C = -460\ ^\circ F$

Formulas:

$W = -P\Delta V = -\Delta nRT$

W = Work (J)
P = Pressure (Pa)
ΔV= Change in Volume (L)
Δn = Change in Moles of Gas (mol)
R = Gas Constant (8.34 J/mol•K, if T = 300 K)
T = Temperature (K)

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

ΔG = Change in Gibbs Free Energy (J/mol)
ΔH = Change in Enthalpy (J/mol)
ΔS = Change in Entropy (J/K•mol)
T = Temperature (K)

$\Delta H = mC\Delta T$

m = Mass of System (g)
C = Specific Heat (J/K)
ΔT = Change in Temperature (K)
ΔH = Change in Enthalpy (J/mol)

$\Delta H = \Delta E + P\Delta V$

ΔE = System Energy (J)
$P\Delta V$ = Expansion Work
ΔH = Change in Enthalpy (J/mol)

$E_{mot} = \frac{1}{2}\,kT$

E_{mot} = Motional Energy (J)
k = Boltzmann Constant (1.38 • 10-23 J/K)
T = Temperature (K)

$S = k \cdot \ln\,(\#PO)$

S = Entropy (J/K•mol)
#PO = Number of Possible Orientations = (# of orientations)$^{\#\ of\ molecules}$

ΔH	ΔS	ΔG	Reaction Characteristics
+	+	+ at low T - at high T	Non-spontaneous at low T Spontaneous at high T
+	-	Always +	Non-spontaneous at all T and Reverse reaction is spontaneous
-	+	Always -	Spontaneous at all T
-	-	- at low T + at High T	Spontaneous at low T Non-spontaneous at high T

Energy Type	Symbol	Sign	Interpretation
Change in **Enthalpy**	ΔH	- +	**Exo**thermic, Heat **Released** **End**othermic, Heat **Absorbed**
Change in **Entropy**	ΔS	- +	System has more order System has less order
Change in **Free Energy**	ΔG	- +	Spontaneous, Compound is unstable Non-Spontaneous, Compound is stable
Work	W	- +	Work done **by** the system Work done **on** the system

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Handout