

Thermodynamics!



internal energy

$$\Delta E = q + w$$

work!

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

at constant P

$$\Delta E = q_p - P\Delta V$$

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

$$\Delta E = \Delta H - \Delta nRT$$

FIRST LAW
Energy cannot be created or destroyed only changed in its form

$$H = E + PV \leftarrow \text{definition of enthalpy}$$

HEATING stuff up!



$$q = n C_m \Delta T$$

$$q = m C_s \Delta T$$

moles
mass in grams

molar heat capacity in $\frac{J}{mol \cdot K}$

specific heat capacity in $\frac{J}{g \cdot K}$

CALORIMETRY

$$\Delta E = q_v \text{ (bomb calorimetry)}$$

$$\Delta H = q_p \text{ (coffee-cup calorimetry)}$$

$$q_{cal} = m_{H_2O} C_{s,H_2O} \Delta T + C_{cal} \Delta T$$

water part hardware

oh yeah! $\rightarrow q_{sys} = -q_{cal}$

system heat is opposite in sign from the calorimeter!

If heating gases you need to know all the different C_v 's + C_p 's

	C_v	C_p
monatomic	$\frac{3}{2}R$	$\frac{5}{2}R$
linear	$\frac{5}{2}R$	$\frac{7}{2}R$
non-linear	$\frac{6}{2}R$	$\frac{7}{2}R$

ISOTHERMAL expansion
 $\Delta T = 0, T$ is constant

$\int dw = \int -P dV$

- $\star w = -nRT \ln \frac{V_2}{V_1}$
- $\star q = nRT \ln \frac{V_2}{V_1}$
- $\star \Delta S = nR \ln \frac{V_2}{V_1}$

$\Delta E = 0$ and $\Delta H = 0$
 $q = -w$

and! $\frac{P_1}{P_2} = \frac{V_2}{V_1}$ (Boyle's Law)

2nd LAW
all spontaneous changes are accompanied by an increase in universal entropy.

$$S = k \ln W$$

Boltzmann Constant $\frac{R}{N_A}$
microstates

FREE ENERGY

$$G = H - TS$$

at constant P + T
 $\Delta G = \Delta H - T\Delta S$

$$dS = \frac{dq_{rev}}{T}$$

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

$$\Delta S = n C_p \ln \frac{T_2}{T_1}$$

\star or C_v

$$\Delta G = -T\Delta S_{universe}$$

governs 2nd Law

for temp. changing

When $\Delta S_{univ} = 0$

for a process, you have reached **EQUILIBRIUM!**

We PREFER

$$\Delta G = 0$$

for defining equilibrium

so at equilibrium $\rightarrow \Delta G = 0 = \Delta H - T\Delta S$

conditional!

$$\Delta H = T\Delta S$$

$$\star T = \Delta H / \Delta S$$

Phase Changes

$$\Delta S_{trans} = \frac{\Delta H_{trans}}{T_{trans}}$$

$$\Delta S_{rxn}^\circ = \sum S^\circ_{(prod)} - \sum S^\circ_{(react)}$$

$$\Delta G_{rxn}^\circ = \sum \Delta G_f^\circ (prod) - \sum \Delta G_f^\circ (react)$$

3rd LAW

The entropy of a perfectly crystalline substance at absolute zero is zero.

HESS' LAW

$$\Delta H_{rxn} = \Delta H_1 + \Delta H_2 + \Delta H_3 + \dots$$

$$\Delta H_{rxn}^\circ = \sum \Delta H_f^\circ (prod) - \sum \Delta H_f^\circ (react)$$

$$\Delta H_{rxn} = \sum BE(react) - \sum BE(prod)$$

Bond Energies