

Thermodynamics!



internal energy $\Delta E = q + w$ work!

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

1st LAW

Energy cannot be created or destroyed only changed in its form

$H = E + PV$ ← definition of enthalpy

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

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

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

CALORIMETRY

$\Delta E = q_v$ (bomb calorimetry)

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



moles $q = n C_m \Delta T$

mass in grams $q = m C_s \Delta T$

molar heat capacity in J/mol·K

specific heat capacity in J/g·K

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

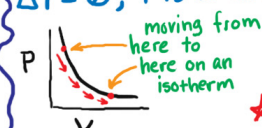
water part hardware

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	$\frac{3}{2}R$	$\frac{5}{2}R$

ISOTHERMAL expansion

$\Delta T = 0, T$ is constant



$\int dw = \int -P dV$

$w = -nRT \ln \frac{V_2}{V_1}$

$q = nRT \ln \frac{V_2}{V_1}$

$\Delta S = nR \ln \frac{V_2}{V_1}$

$\Delta E = 0$ and $\Delta H = 0$

$q = -w$

and! $P_1/P_2 = V_2/V_1$ (Boyle's Law)

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

system heat is opposite in sign from the calorimeter!

2nd LAW

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

$S = k \ln W$

Boltzmann Constant $k = R/N_A$

microstates

FREE ENERGY

$G = H - TS$

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

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

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

for temp. changing $\Delta S = nC_p \ln \frac{T_2}{T_1}$

* or C_v

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

governs 2nd Law

conditional! $\Delta G = 0 = \Delta H - T\Delta S$

and $\Delta H = T\Delta S$

$T = \Delta H / \Delta S$

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

3rd LAW

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

When $\Delta S_{univ} = 0$ for a process, you have reached EQUILIBRIUM

HESS' LAW

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

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

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

Bond Energies

We PREFER $\Delta G = 0$

for defining equilibrium

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

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

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