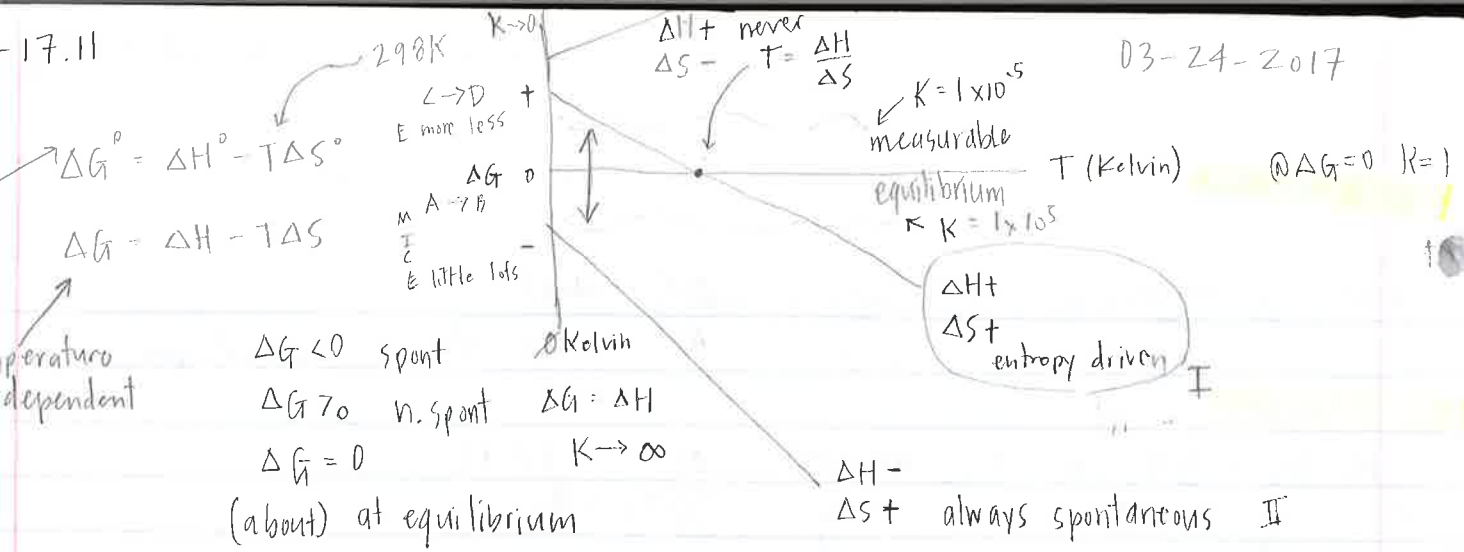
-17.11

03-24-2017



ΔH	ΔS	
+	+	entropy-driven
−	+	always spontaneous
+	−	never spontaneous
−	−	spontaneous at low temp; nonspontaneous at high temp

] enthalpy-driven

1 J = 1000 kJ

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$

$\Delta H^\circ = 55.3\ kJ$

$\Delta S^\circ = 175.7\ J/K$ entropy-driven

$\Delta G^\circ = 2.8\ kJ$

H_f° = +11.1 kJ/mol +33.2 kJ/mol

* −1 mol * +2 mol

ΔH°_{rxn} −11.1 kJ + 66.4 kJ = 55.3 kJ

$\frac{1\ J}{1000}$ *

S° 304.3 J/mol K 240 J/mol K

* −1 mol * 2 mol

ΔS° −304.3 J/K + 480 J/K = 175.7 J/K

$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ (T = 298)

$\Delta G^\circ = +2.9\ kJ$

G° 99.8 kJ/mol 51.3 kJ/mol

* −1 mol * 2 mol

= 2.8 kJ

Physical Chemistry

03-24-2017

A1

Non-standard conditions:

$\Delta G = \Delta G^\circ + RT \ln Q$ (Kelvin)

kJ

$\frac{0.008314\ kJ}{K}$

Q_c $Q > K$ Left

Q_p $Q < K$ Right

M A → B

I Q

C

E K

Q_p for gases

Q_c for solutions

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$ $\Delta G = +2.9\ kJ + \frac{0.008314\ kJ}{K}(298\ K) * \ln Q_p$

p	$N_2O_4(g)$	$\rightleftharpoons$	$2NO_2(g)$
I	1.0 atm		0.10 atm
C			
E			

$Q_p = \frac{P^2_{NO_2}}{P_{N_2O_4}} = \frac{0.10^2}{1.0} = 0.010$

$\Delta G = +2.9 + (0.008314 * 298 * \ln(0.010))$

$= -8.5\ kJ$

spontaneous ⟶ non-spontaneous

$\Delta G = \Delta G^\circ + RT \ln Q$

At equilibrium, $\Delta G = 0$

$0 = \Delta G^\circ + RT \ln K$ K_p for gases

$\Delta G^\circ = -RT \ln K$ K_c for solutions

$+2.9\ kJ = -\frac{0.008314\ kJ}{K} * 298\,K * \ln K_p$

$\boxed{K_p = 0.31}$

$e^{-2.9/(0.008314 \times 298)}$

Estimate the vapor pressure of water at 298 K?

03-24-2017

$H_2O\ (\ell) \rightleftharpoons H_2O\ (g)$ $\quad K_p = P_{H_2O}$

$\Delta G^\circ = -RT \ln K_p$

ΔG°_{vap} ← constants

$H_2O\ (\ell) \rightleftharpoons H_2O\ (g)$

ΔG°_f $\quad -237.2 \quad -228.6$ kJ/mol

$\times -1$ mol $\quad \times 1$ mol

ΔG°_{vap} $\quad 237.2$ kJ $- 228.6$ kJ

$= 8.6$ kJ

$\Delta G^\circ_{vap} = 8.6$ kJ

$+8.6\ kJ = -0.008314 \times 298 \times \ln K_p$

$K_p = 0.0311$

$P_{H_2O} = 0.0311$ atm ⟶ 23.62 mmHg

760 mmHg = 1 atm