exothermic - releases heat ΔH -

endothermic - gains heat ΔH +

ΔS favors product

$+\Delta S$

increase in disorder

- ΔG is a

Spontaneous rxn

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

800°C

1073 K

4. $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

$$\Delta H_{rxn} = (2(NH_3)) - (1(N_2) + 3(H_2))$$

$$\Delta H_{rxn} = (2(-46.11)) - (0 + 3(0))$$

$$\Delta H_{rxn} = -92.22 \text{ KJ}$$

$$\Delta S_{rxn} = -198.94 \text{ J/K}$$

$$\Delta S_{rxn} = -.19894 \text{ KJ/K}$$

$$\Delta G = -92.22 - ((1073)(-.19894))$$

$$\Delta G =$$

121.24 KJ

not spontaneous

$$\Delta G = -RT\ln(K)$$

← temp (K)

8.3145 J/K·mol

equilibrium

$$-\frac{\Delta G}{RT} = \ln(K)$$

$$K = e^{-\Delta G/RT}$$

5.

$$e^{-\left(\frac{121.24\,kJ}{\left(.0083145\,\frac{kJ}{K}\right)(1073\,K)}\right)}$$

13.590

$$8.3145 \frac{J}{K \cdot mol} = .0083145 \frac{kJ}{mol\,K}$$

$$K = 1.25296 \times 10^{-6}$$

favors the reactants b/c K is small.

6. $Na_{(l)} \rightleftarrows Na_{(g)}$

ΔG at boiling pt is at equilibrium $\Delta G = 0$

$$\Delta H_{rxn} = \Delta H(Na_{(g)}) - \Delta H(Na_{(s)})$$

$$\Delta H = 107.68 - 2.41$$

$$\Delta H = 105.27\ kJ$$

$$\Delta S = \Delta S(Na_{(g)}) - \Delta S(Na_{(l)})$$

$$\Delta S = 153.61 - 57.85$$

$$\Delta S = 95.76\ J/K$$

$$\Delta S = .09576\ kJ/K$$

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

$0 = (105.27) - x(.09576)$

$T = 1099.3\ K$

$T = 826°C$

HW 7, 12

12. $3H_{2(g)} + N_{2(g)} \rightarrow 2NH_{3(g)}$

$\Delta H_{rxn} = -92.22\,KJ$

$\Delta S_{rxn} = -.19894\,KJ/K$

$$\Delta G = -92.22 - (T(-.19894))$$

T = 398 K

$$\Delta G = -92.22 - ((398)(-.19894))$$

$$\Delta G = -13.0418 \text{ KJ}$$

$\Delta G = -13.0418$ KJ

$\Delta G = -RT\ln(K)$

$K = e^{-\Delta G/RT}$

$$K = e^{-\left(\frac{-13.0418}{(.0083145)(398)}\right)}$$

$K = e^{-(-3.94)}$

$K = 51.48 = 51.5$

$K = \frac{\text{products}}{\text{reactants}}$

$K \neq 0$ products are favored

8.

$$3H_{2(g)} + N_{2(g)} \rightarrow NH_{3(g)}$$

$$\Delta H_{rxn} = -92.22\,kJ$$

$$\Delta S_{rxn} = -.19894\,\frac{kJ}{K}$$

$$300 + 273 = 573\,K$$

$$\Delta G = (-92.22) - ((573)(-.19894))$$

$$\Delta G = (-92.22) - (-113.99262)$$

$$\Delta G = 21.77 \text{ KJ}$$

Not spontaneous

573 K, 1073 K

$$3H_2 + N_2 \rightarrow 2NH_3 + energy$$

Decrease Temp!! :)

9.

$$\underset{1.6\,M}{\overset{\text{lot}}{3H_2}} + \underset{0.4\,M}{N_2} \longrightarrow \underset{4.3\times10^{-4}\,M}{\overset{\text{little}}{2NH_3}}$$

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

$$Q = \frac{\text{products}}{\text{reactants}}$$ = testing for equilbrium

$$\Delta G^\circ = \Delta H_{rxn} - T\Delta S_{rxn}$$

at that temp.

$$\Delta G = 21.77 + (1.0083145)(573)$$

$$\ln\left(\frac{(4.3\times10^{-4})^2}{(1.6)^3(.4)}\right)$$

$$\ln(\ 1.13 \times 10^{-7})$$

$$-15.997$$

HW 10, 13

Quiz Fri

1. ΔH_{rxn}

2. ΔS_{rxn}

3. ΔG spontaneous or not

$$\Delta G = 21.77 + ((.0083145)(573) \wedge (-15.997$$

$$\Delta G = -54.44 \text{ KJ}$$

favors product side

to little product has been formed.

$N_2 + 3H_2 \rightarrow 2NH_3 + \text{ener}$

$\Delta G = \Delta H_{rxn} + T\Delta S_{rxn}$

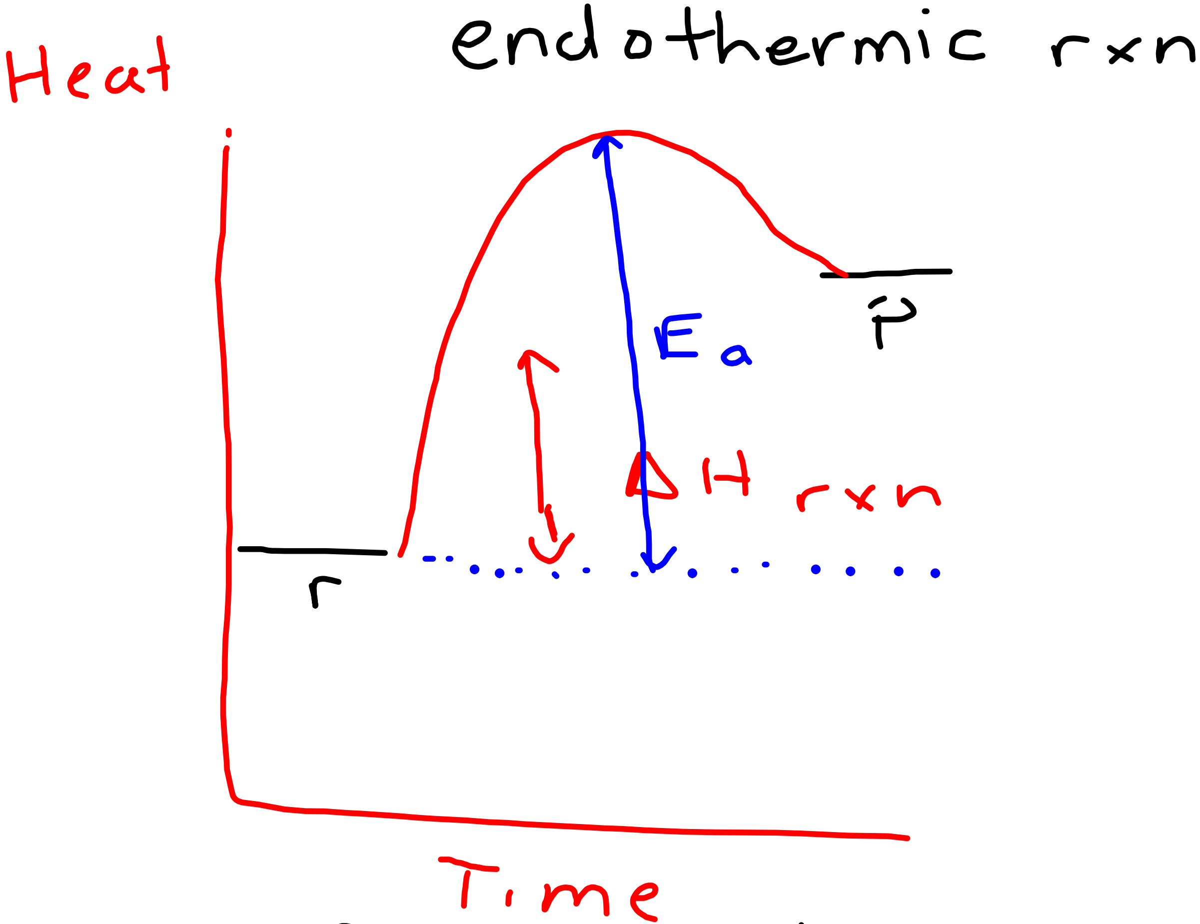
$0 = -92.22 - x(-.19894)$

$92.22 = -x(-.19894)$

$\frac{92.22}{.19894} = \frac{x(\cancel{.19894})}{\cancel{.19894}}$

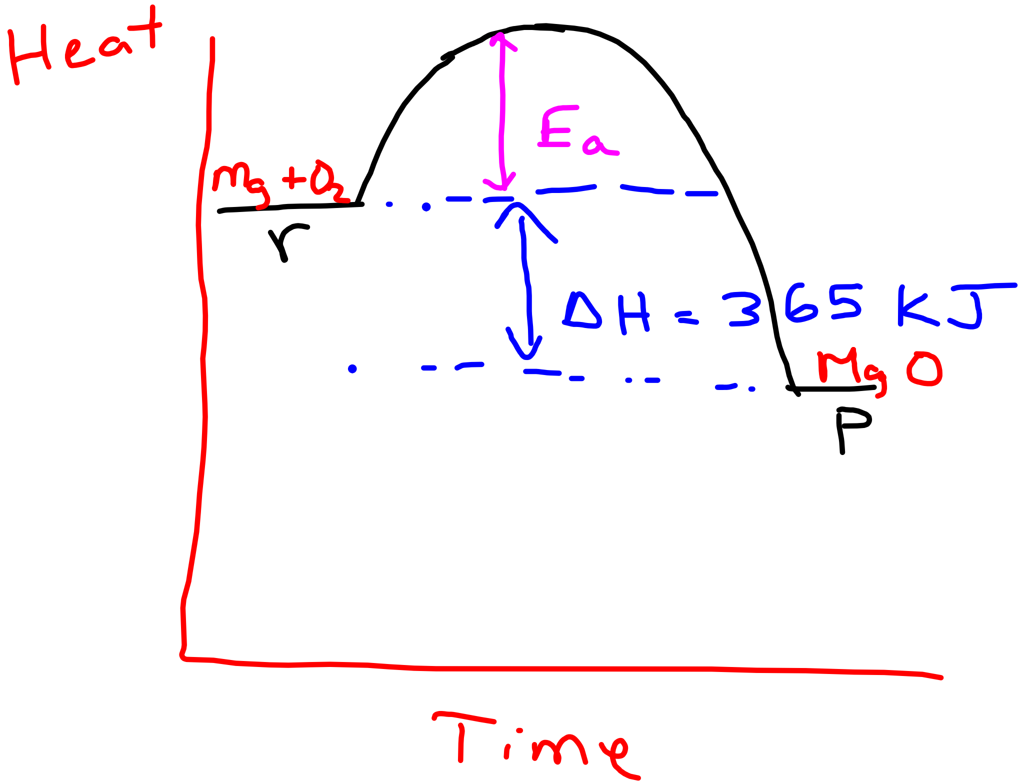
$463.56\ K = x$

$190.5°C$



r = reactants
p = product

Ea = energy of activation



$CO + N_2O \rightarrow CO_2 + N_2 + 365$ KJ

exothermic

$\Delta H = -$

E_a = energy of activation

HW

15, 16, 17, 18

28.

$$CO_{2(s)} \longrightarrow CO_{2(g)}$$

$\Delta S = +$

increase in disorder

$$I_{2(s)} \longrightarrow I_{2(g)}$$

b.

$$CO_{2}(g) \rightarrow CO_{2}(g)$$

1.05 atm 0.25 atm

$\Delta S = +$

Increase in disorder

C.

$$\overset{6}{C_6H_{12}O_{6(s)}} + 6O_{2(g)} \rightarrow \overset{12}{6CO_{2(g)}} + 6H_2O$$

$$\Delta S = +$$

d.

$$\overset{4\,mol}{3H_{2(g)} + N_2} \rightleftharpoons \overset{2\,mol}{2NH_3}$$

$\Delta S = -$

decreasing in disorder

e.

$$\overset{2\,mol}{H_2 + Cl_2} \rightleftharpoons \overset{2\,mol}{2HCl}$$

$\Delta S = 0$

no change

$\Delta H_{rxn} = -498\ KJ$

$\Delta S_{rxn} = -116.7\ J \quad -117\ J$

$-.1167\ KJ$

$\Delta G = -431\ KJ$

15

$$H_2 + Cl_2 \rightleftharpoons 2HCl$$

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

$$\Delta H_{rxn} = ((2)(-92.31)) - (0)$$

$$\Delta H_{rxn} = -184.62\ kJ$$

$$\Delta S_{rxn} = (2(186.8)) - (222.96 + 130.68)$$

$$\Delta S_{rxn} = 19.96\ J = .01996\ kJ/K$$

$$\Delta G = -184.62 - (400(.01996))$$

$$\Delta G = -192.604\ kJ$$

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

$$\ln\left(\frac{(.0043)^2}{(.35)(6.38)}\right)$$

-11.7

$$\Delta G = -192.60 + ((400)(0.008314)(-11.7))$$

$$\Delta G = -192.60 + (-38.9)$$

$$\Delta G = -231.52\ \text{KJ}$$

still moving towards product side.

17.

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

$$\Delta G = -429.09 + ((.0083145)(548))\ln Q$$

$$\ln\left(\frac{(1.61)^2}{(1.55)^2(0.378)}\right)$$

1.0488

$$\Delta G = -429.09 + (4.7787)$$

$$\Delta G = -424.32\ \text{kJ}$$

HW

19, 20, 21

21. $\Delta G = -RT\ln(K)$

$= -(.008315)(308)\ln(50.3)$

$= -(.008315)(308)(3.918)$

$= -10.03\ kJ$

$\approx -10.0\ kJ$

$$\Delta G = -RT\ln(K)$$

$$-\frac{\Delta G}{RT} = \ln(K)$$

$$K = e^{-\Delta G/RT}$$

$pH = 4.0$

10^{x} $10^{-4.0}$

Quiz Wed.

1. Calculate ΔG
2. ΔS prediction

23 $\Delta G = -25 J$ $55°C$

$K?$

$$\Delta G = -RT \ln K$$

$$K = e^{-\Delta G/RT}$$

$$= e^{-\left(\frac{(-.025 kJ)}{(.0083145)(328)}\right)}$$

$$= e^{(.009167)}$$

$$= 1.0092$$

$$= 1.0$$

26.

$$\left(\frac{80.0\,cal}{g}\right)\left(\frac{4.18\,J}{cal}\right)\left(\frac{1\,kJ}{1000\,J}\right)\left(\frac{18\,g}{1\,mol}\right) =$$

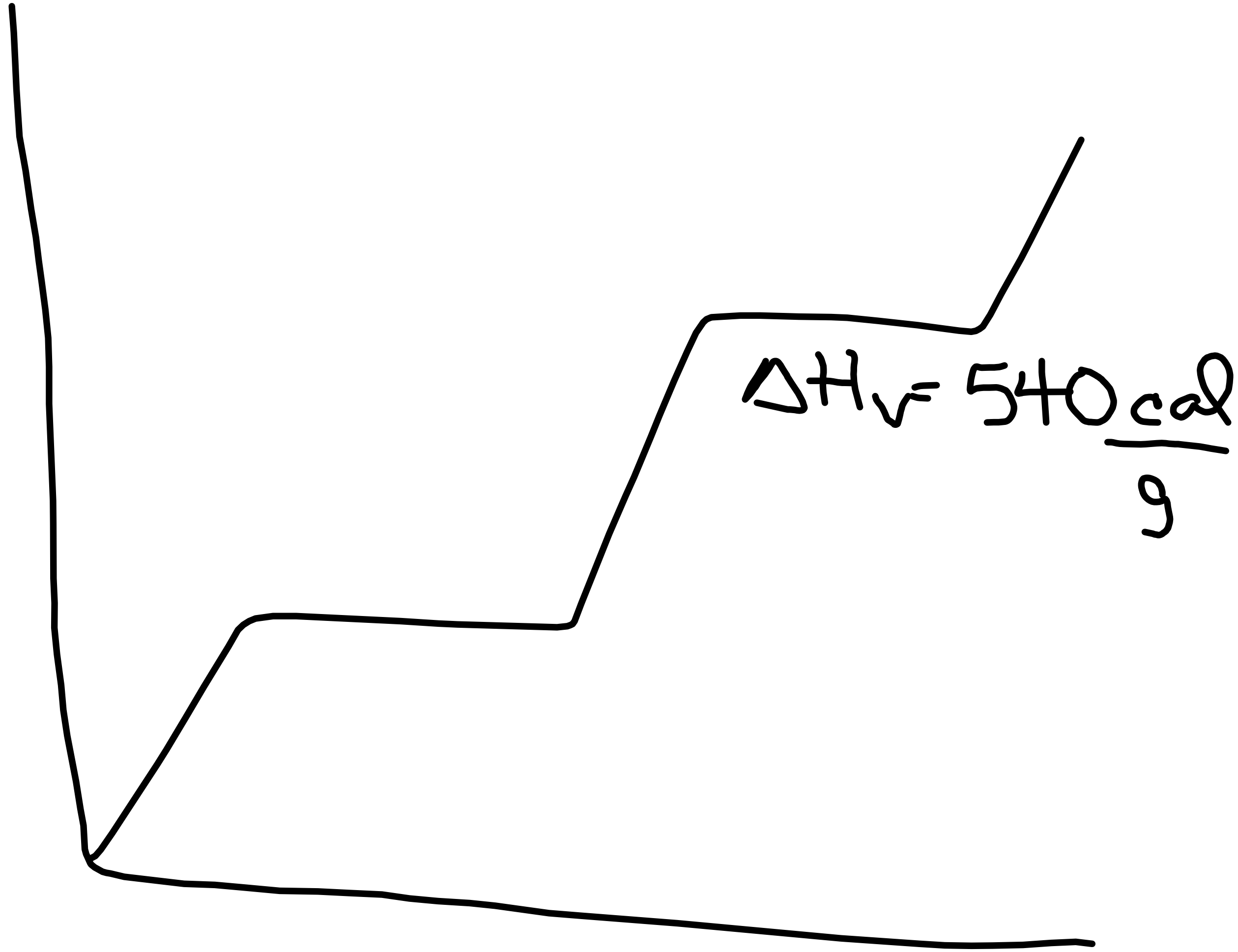
$$6.0192\,kJ/mol$$

$$6.02\,kJ/mol$$

27.

$$540.0\,\frac{cal}{g}\left(\frac{4.18\,J}{cal}\right)\left(\frac{1\,KJ}{1000\,J}\right)\left(\frac{18\,g}{1\,mol}\right) =$$

$40.63\,KJ/mol$


$\Delta H_v = 540 \frac{cal}{g}$

29.

$$BBr_{3(l)} \rightleftharpoons BBr_{3(g)}$$

$$\Delta G = 0$$

$$0 = \Delta H - T\Delta S$$

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

$$T = \frac{\Delta H}{\Delta S}$$

$$BrB_{3(l)} \rightleftharpoons BrB_{3(g)}$$

$$\Delta H_{rxn} = -186.43 + 220.7$$

$$\Delta H_{rxn} = 34.27\,KJ$$

$$\Delta S_{rxn} = 95.26\,J = .09526\,KJ/K$$

$$T_{boiling} = \frac{34.27\,KJ}{.09526\,KJ/K}$$

$$T_{boil} = 359.75\,K$$

$$86.75\,°C$$

$$\% = \frac{91.3 - 86.75}{91.3} \times 100 = 4.98\%$$

① D -

D -

D -

D -

D -

$\cancel{6CO_2}_{(g)} + 6H_2O_{(l)} \rightarrow C_6H_{12}O_{6(s)} + \cancel{6O_2}_{(g)}$

$\Delta G = -RT \ln K$

$\Delta G = \underline{80.7\ KJ}$ reactants

$K = 2.09 \times 10^{-14}$ reactants

$K > 1$ products

$K < 1$ reactants

$\frac{\text{Products}}{\text{reactants}} = .0000329$

33

$\Delta H_{rxn} = 15.65 \text{ KJ}$

$\Delta S_{rxn} = 221.76 \text{ J/K} =$

$.22176 \text{ KJ/K}$

$\Delta G_{rxn} = \Delta H - T\Delta S$

$\Delta G rxn = 15.65 - 1193(.22176)$

$\Delta G = -248.9 \text{ KJ}$

b. Yes $- \Delta G$

c. Products ΔG

30. $I_{2(s)} \rightarrow I_{2(g)}$

$\Delta H_{rxn} = 62.24\,KJ$

$\Delta S_{rxn} = 143.85\,J/K = .14385\,KJ/K$

$\Delta G_{rxn} = 19.3727\,KJ$

$K = e^{-\Delta G/RT}$

$K = e^{-19.372/(.0083145)(298)}$

$K = e^{-7.8188}$

$K = 4.02 \times 10^{-4}$ atm

vapor press.

$$CO_{2(g)} \rightarrow CO_{(g)}$$

3.2 atm   5.6 atm

$$K = \frac{5.6\,\text{atm}}{3.2\,\text{atm}}$$

31. energy + $CH_3OH_{(l)} \rightarrow CH_3OH_{(g)}$

$\Delta G = 0$

$\Delta H_{rxn} = -201.2 - (-238.64)$

$\Delta H_{rxn} = 37.44\ kJ$ endothermic

$\Delta S_{rxn} = 238 - 127$

$\Delta S_{rxn} = 111\ J/K = .111\ kJ/K$

$$T = \frac{\Delta H}{\Delta S} = \frac{37.44\ kJ}{.111\ kJ/K}$$

$T = 337.30\ K$

$T = 64.3\ °C$

24. $H_2O_{(l)} \longrightarrow H_2O_{(g)}$

$\Delta H_{rxn} = 46.65\ KJ/mol$

$\Delta S_{rxn} = 118.85\ J/k \cdot mol$

$$\left(\frac{6000\,KJ}{hr}\right)\left(\frac{1\,mol}{46.56\,KJ}\right) = \frac{128.62\,mol}{hr}$$

$$\left(\frac{128.62\,mol}{hr}\right)\left(\frac{18\,g}{1\,mol}\right) = \frac{2315.1\,g\ H_2O}{hr}$$

$$\left(\frac{2315\,g\ H_2O}{hr}\right)\left(\frac{1\,mL}{1\,g}\right)\left(\frac{1\,L}{1000\,mL}\right)$$

$\frac{2.315\,L}{hr}$ $\quad \frac{2\,L}{hr}$