Monday, March 23rd

Learning objective 5.13: *The student is able to predict whether or not a physical or chemical process is thermodynamically favored by determination of (either quantitatively or qualitatively) the signs of both ΔH° and ΔS°, and calculation or estimation of ΔG° when needed.*

As you enter...(Write down the learning objective, the question and your answer.)

What do you think it means for a reaction to occur spontaneously?

What factors contribute to the spontaneity of a reaction?

Homework: 17.1 = p.808 #28, 29, 30, 32, 35 (text p. 772-786)

Big Idea 6: Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.

1st period:

- Notes: Free Energy (20 min)
- Free Energy Worksheet (25 min)

Tix out the door (Write your name on the paper.)

What does it mean for a reaction to be spontaneous?
What factors determine the spontaneity of a reaction?

ΔS°

$Mg(s) = 33$ J/k

$MgCl_2(s) = 90$

$Cl_2(g) = 223$

$\Delta S = (90) - [33 + 223] = -166$ J/k

b)

$N_2(g) = 153$

$H_2(g) = 131$

$NH_3(g) = 193$

$\Delta S = 2(193) - [153 + 3(131)] = -160$

Tuesday, March 24th

Learning objective 5.14: *The student is able to determine whether a chemical or physical process is thermodynamically favorable by calculating the change in standard Gibbs free energy.*

As you enter... (Write down the learning objective, the question and your answer.)

At what temperatures is the following process spontaneous at 1 atm?

$$Br_2(l) \longrightarrow Br_2(g)$$

$\Delta H^\circ = 31.0\ kJ/mol$ and $\Delta S^\circ = 93.0\ J/K \cdot mol$

What is the normal boiling point of liquid Br_2? T = 333 K

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

$\Delta G < 0$

$0 < 31000\ J/mol - T(93\ J/K \cdot mol)$

$T > 333\ K$

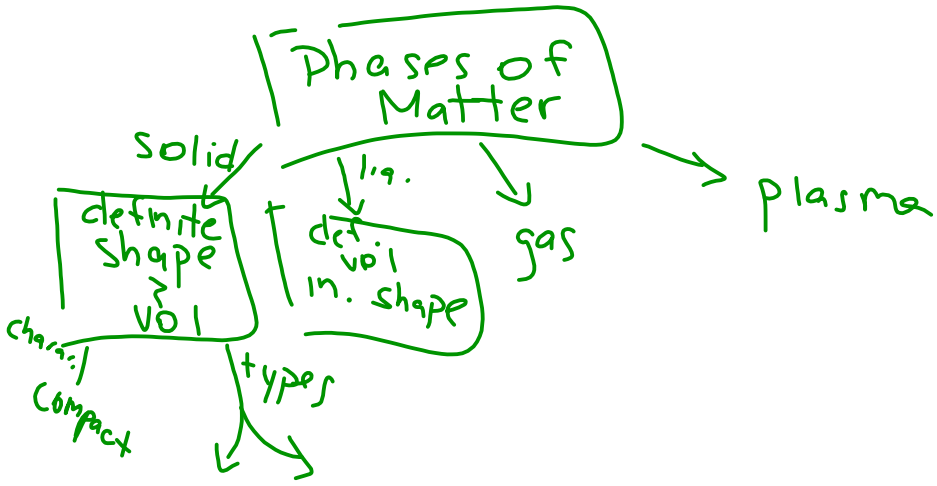
Homework:
Due today... 17.1 = p.808 #28, 29, 30, 32, 35 (text p. 772-786)
Due Thursday... 17.2 = p.808 #50, 53, 57, 59, 69 (text p.786-806)
Friday... Thermo Quiz

Big Idea 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.

1st period:
- Review Homework 17.1 (20 min)
- Concept Map (45 min)

2nd period:
- Thermo Practice Questions (30 min)

Concept Map Pointers...



Tix out the door (Write your name on the paper.)

How does free energy, enthalpy, and entropy relate to each other?

Solution

The vaporization process will be spontaneous at all temperatures where ΔG° is negative. Note that ΔS° favors the vaporization process because of the increase in positional entropy, and ΔH° favors the *opposite* process, which is exothermic. These opposite tendencies will exactly balance at the boiling point of liquid Br_2, since at this temperature liquid and gaseous Br_2 are in equilibrium ($\Delta G^\circ = 0$). We can find this temperature by setting $\Delta G^\circ = 0$ in the equation

$$\begin{aligned} \Delta G^\circ &= \Delta H^\circ - T\Delta S^\circ \\ 0 &= \Delta H^\circ - T\Delta S^\circ \\ \Delta H^\circ &= T\Delta S^\circ \end{aligned}$$

Then
$$T = \frac{\Delta H^\circ}{\Delta S^\circ} = \frac{3.10 \times 10^4 \text{ J/mol}}{93.0 \text{ J/K} \cdot \text{mol}} = 333 \text{ K}$$

At temperatures above 333 K, $T\Delta S^\circ$ has a larger magnitude than ΔH°, and ΔG° (or $\Delta H^\circ - T\Delta S^\circ$) is negative. Above 333 K, the vaporization process is spontaneous; the opposite process occurs spontaneously below this temperature. At 333 K, liquid and gaseous Br_2 coexist in equilibrium. These observations can be summarized as follows (the pressure is 1 atm in each case):

1. $T > 333$ K. The term ΔS° controls. The increase in entropy when liquid Br_2 is vaporized is dominant.
2. $T < 333$ K. The process is spontaneous in the direction in which it is exothermic. The term ΔH° controls.
3. $T = 333$ K. The opposing driving forces are just balanced ($\Delta G^\circ = 0$), and the liquid and gaseous phases of bromine coexist. This is the normal boiling point.

Wednesday, March 25th

Learning objective 5.9: *The student is able to make claims and/or predictions regarding relative magnitudes of the forces acting within collections of interacting molecules based on the distribution of electrons within the molecules and the types of intermolecular forces through which the molecules interact.*

(A) $\Delta H > 0$, $\Delta S > 0$
(B) $\Delta H > 0$, $\Delta S < 0$
(C) $\Delta H < 0$, $\Delta S > 0$
(D) $\Delta H < 0$, $\Delta S < 0$
(E) $\Delta H = 0$, $\Delta S < 0$

12. Must be true for a reaction that is spontaneous at all temperatures

13. True for the evaporation of water at 25°C and 1 atm

14. True for the combustion of liquid pentane, $C_5H_{12}(l)$, to form $H_2O(g)$ and $CO_2(g)$ at 1 atm

ing objective, the question and your answer.)

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

C

C

Homework:
Due yesterday... 17.1 = p.808 #28, 29, 30, 32, 35 (text p. 772-786)
Due tomorrow... 17.2 = p.808 #50, 53, 57, 59, 69 (text p.786-806)
Friday... Thermo Quiz

Big Idea 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.

1st period:
- Thermodynamics of a Rubber Band (30 min)
- Exit Tix (15 min)

Concept Map Pointers...

Tix out the door (Write your name on the paper.)

AP Question

Thursday, March 26th

Learning objective 5.15: *The student is able to explain how the application of external energy sources or the coupling of favorable with unfavorable reactions can be used to cause processes that are not thermodynamically favorable to become favorable.*

As you enter... (Write down the learning objective, the question and your answer.)

Assess how you did on yesterday's exit tix.

Homework:
Due already... 17.1 = p.808 #28, 29, 30, 32, 35 (text p. 772-786)
Due today 17.2 = p.808 #50, 53, 57, 59, 69 (text p.786-806)
Tomorrow... Thermo Quiz

Big Idea 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.

1st period:
- Review yesterday's work (25 min)
- Homework Questions? (15 min)

2nd period:
- Practice Thermo Questions (35 min)
- Exit Tix (20 min)

+ ΔH endo
contract
- ΔG spont.
+ ΔS · ↑ entropy

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

Tix out the door (Write your name on the paper.)

AP Question

(59) $\Delta G = ?$

$NO_{(g)} + O_{3(g)} \rightarrow NO_{2(g)} + O_{2(g)}$

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

STP; R = 8.31 J/K·mol; T = 298 K

prod − reac.

$\Delta G^\circ = -198$ kJ/mol → Appendix 4

$K_p = \frac{P_{NO_2} \cdot P_{O_2}}{P_{NO} \cdot P_{O_3}} = 50$

$\Delta G = -198000 + (8.31)(298)\ln 50 = \boxed{-1.88 \times 10^5 \text{ J/mol}}$

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

kJ/mol

J/mol + (J/K·mol)(K)

J/mol + J/mol = J/mol

(69) $N_{2(g)} + 3F_{2(g)} \rightarrow 2NF_{3(g)}$

T = 800 K

equilibrium: $P_{N_2} = .021$ $P_{F_2} = .063$ $P_{NF_3} = .48$

$\Delta G^\circ = ?$

$\Delta G = \Delta G^\circ + RT \ln K$ $\quad K_p = \frac{P_{NF_3}^2}{P_{N_2} \times P_{F_2}^3}$

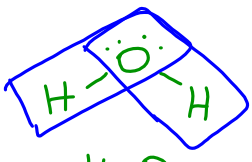
$0 = \Delta G^\circ + (8.31)(800)(10.689)$ = 4388.7

$\Delta G^\circ = -7.11 \times 10^4$ J/mol $\times \frac{1\text{ kJ}}{1000\text{ J}} =$

$= -71$ kJ/mol

71.100

(13) Bond Energy



H-H :Ö::Ö:

$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$

$\Delta H = ?$

$-4(464) + [2(436) + 499]$

-415

Friday, March 27th

Learning objective 5.1373905: *The student is able to get his/her peers to guess a chemistry concept through pictures. (Aka. Play pictionary.)*

As you enter... (Write down the learning objective)

Prepare for Quiz.

Homework for due Monday after break:
1. Organic chemistry packet.
2. Diagnostics exam.
3. Chapter 18 open notes quiz Tuesday after break.

Big Idea 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.

1st period:

- Quiz (20 min)
- Chemistry Pictionary (25 min)