Unit4Day5-LaBrake

Monday, November 18, 2013
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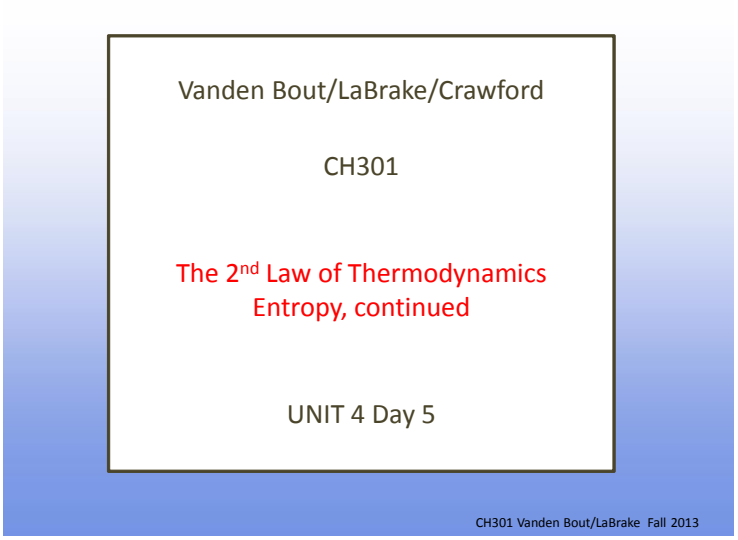

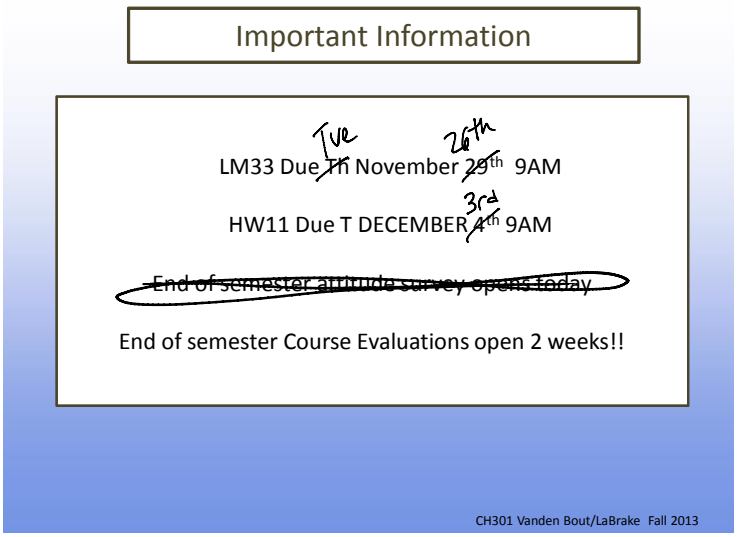

What are we going to learn today?

Second & Third Law of Thermodynamics

Quantify change in Entropy

QUIZ: iClicker Question 1

Which of the following has the highest positional probability? most microstates

a) 1 mole N_2 gas at 1 atm
b) 1 mole N_2 gas at .001 atm
c) No difference

same T

$PV = nRT$

$P_1V_1 = P_2V_2$

QUIZ: iClicker Question 2

Which of the following has the higher entropy?

a) 1 mole N_2 gas at 1 atm
b) 1 mole N_2 gas at .001 atm
c) No difference

QUIZ: iClicker Question 3

Predict sign for the for ΔS_{sys} for sugar dissolving in water.

a) -
b) +
c) No difference

sugar + water → sugar dissolved in water

$Sugar_{crystal} \rightarrow Sugar_{soln}$

QUIZ: iClicker Question 4

Predict the sign for the for ΔS_{sys} for iodine vapor condensing on a cold surface.

a) -
b) +
c) No difference

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

$\Delta S_{total} =$

stretched bond → relaxed bond

ΔS_{sys} ? a) + b) - c) 0

Entropy

What affects the entropy of the system?

Volume Change ↑ ↑

Mixing ↑

Phase Change S → l → g ↑

Temperature Change ↑ ↑

Chemistry ?

Entropy of the Surroundings

We typically define heat from the perspective of the system. Therefore, when we look at changes for the surroundings, we see the relationship is

$$\Delta S_{surroundings} = \frac{-q}{T} = \frac{\Delta H_{rxn}}{T}$$

$\Delta H_{rxn} < 0$ Exothermic $\Delta S_{surroundings} > 0$

$\Delta H_{rxn} > 0$ Endothermic $\Delta S_{surroundings} < 0$

Entropy and Temperature

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

$$dS = \frac{C\,dT}{T}$$

$$\Delta S = C \ln\frac{T_f}{T_i}$$

Entropy and Temperature

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

$$dS = \frac{dq}{T}$$

$$q = C\Delta T$$
$$dq = C\,dT$$

$$dS = \frac{C\,dT}{T}$$

$$d\int S = C\int \frac{dT}{T}$$

$$d\int S = C\int_{T_i}^{T_f} \frac{dT}{T}$$

$$\Delta S = C \ln\frac{T_f}{T_i}$$

Entropy for a Phase Change

During a phase change, the heat is the reversible heat and the temperature is constant

"trans" – a phase transition (i.e. vaporization, melting)

$$\Delta S_{trans} = \frac{q_{rev}}{T} = \frac{\Delta H_{trans}}{T_{trans}}$$

Entropy for a Chemical Change

During a chemical change, the heat is NOT the reversible heat and the temperature is constant

Reactants ⟶ Products

$$\Delta S = S_{final} - S_{initial} = S_{products} - S_{reactants}$$

We need to be able to find the entropy of a substance

The Third Law of Thermodynamics

The entropies of all perfect crystals approach zero when the absolute temperature approaches zero.

$$\boldsymbol{S = k \ln \Omega = k \ln 1 = k(0) = 0}$$

We can then use entropy change from temperature change and phase change to find the entropy of any substance at any temperature

Absolute Entropies

Substance	S_m°	Substance	S_m°	Substance	S_m°
Gases		**Liquids**		**Solids**	
ammonia, NH_3	192.4	benzene, C_6H_6	173.3	calcium oxide, CaO	39.8
carbon dioxide, CO_2	213.7	ethanol, C_2H_5OH	160.7	calcium carbonate, $CaCO_3$†	92.9
hydrogen, H_2	130.7	water, H_2O	69.9	diamond, C	2.4
nitrogen, N_2	191.6			graphite, C	5.7
oxygen, O_2	205.1			lead, Pb	64.8

NOTE: This is not the same as enthalpy of formation. All elements in their standard states have values

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(l)$$

$$\Delta S_r^\circ = \sum nS_{products}^\circ - \sum nS_{reactants}^\circ$$

Entropy

What affects the entropy of the system?

Volume Change - only qualitative
Mixing - only qualitative

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

Temperature Change $\Delta S = Cln\frac{T_f}{T_i}$

Chemistry $\Delta S_r^\circ = \sum nS_{products}^\circ - \sum nS_{reactants}^\circ$

Activity

Please open your course pack to page 109
Thermo Unit- Entropy of Physical and Chemical Changes

QUIZ: iClicker Question 5

Given that $\Delta H_{fus}^{\circ} = 6.02$ kJ mol^{-1} and that the heat capacity for water is 4.184 J g^{-1} °C^{-1}. How much heat flows into the system for this process?

a. 12 kJ
b. 16 kJ
c. 3770 kJ
d. 3790 kJ

QUIZ: iClicker Question 6

Which is the larger entropy change?

a. $\Delta S_{melting}$
b. $\Delta S_{warming}$
c. They are the same

$= \frac{q}{T} = \frac{\Delta H_{fus} \cdot n}{T} =$

$mC_{sp} \ln\left(\frac{T_f}{T_i}\right) =$

$\Delta S_{syst} = \Delta S_{melt} + \Delta S_{warm}$

QUIZ: iClicker Question 7

Did heat flow into or out of the surroundings during this change?

a. into
b. out
c. No heat flow

QUIZ: iClicker Question 8

What is the entropy change for the surroundings?

a. 42 J/K
b. -42 J/K
c. 53 J/K
d. -53 J/K

$$\Delta S_{surr} = \frac{-q}{T} = \frac{-15.81\ kJ}{298\ K}$$

$\Delta S_{surr} = ?$

a) 0 $\frac{kJ}{mol\ K}$
b) 7 $\frac{kJ}{mol\ K}$
c) 2 $\frac{kJ}{mol\ K}$
d) 42 $\frac{kJ}{mol\ K}$
e) 1 $\frac{kJ}{mol \cdot K}$

QUIZ: iClicker Question 9

What is the total change in entropy per mole of solid ice that melts under these conditions?

a. -55 J/K mol
b. 55 J/K mol
c. -2.1 J/K mol
d. 2.1 J/K mol
e. 0 J/K mol

$$\Delta S_{total} = \Delta S_{sys} + \Delta S_{surr}$$

$$\Delta S_{total\ this\ system\ @\ 2\ mol} = 4.2\ \frac{J}{K}$$

$H_{2(s)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(s)}$

$\Delta S_{rxn} = \sum_n S^\circ_p - \sum_n S_R$

$\Delta S_{rxn} = (70) - (131 + \frac{1}{2}205)$

$\Delta S_{rxn} =$

a) $+163\ \frac{J}{mol \cdot K}$
b) $-163\ \frac{J}{mol \cdot K}$
c) $+326\ \frac{J}{mol \cdot K}$

Learning Outcomes

Calculate change in entropy of a system for physical change at constant temperature and with a change in temperature, and for a chemical change using tabulated standard molar entropy data.

Calculate change in entropy for the surroundings for a physical change and a chemical change.