Chemistry 102 2018 Discussion #5, Chapter 12

Student name___________________ TA name________________ Section_______________

Things you should know when you finish the Discussion hand out:

R = 8.314 [J/(mol·K)] = 8.314 [(L·kPA)/(mol·K)] = 0.08206 [(L·atm)/(mol·K)] = 0.08314 [(L·bar)/(mol·K)]

1. ΔH_{soln}, $\Delta_{lattice}H$, $\Delta_{aq}H$
2. Units of concentrations
   a. Molality, m (mol/kg)= $\dfrac{moles(solute)}{mass(solvent)kg}$
3. Colligative property where *i* is a *van't Hoff factor*
   a. Osmotic Pressure: $\Pi = MRT \cdot i$; M(mol/L) is Molarity
   b. Freezing Point Lowering : $\Delta T_{fp} = -|k_{fp}| \cdot m \cdot i$
      $\Delta T_{fp} = T_{fp}(solution) - T_{fp}(solvent) < 0$
   c. Boiling Point Elevation : $\Delta T_{bp} = +|k_{bp}| \cdot m \cdot i$
      $\Delta T_{bp} = T_{bp}(solution) - T_{bp}(solvent) > 0$
   d. Vapor Pressure Lowering: $p_{solvent} = \chi_{solvent} \cdot p^{\circ}_{pure\ solv}$; $\Delta p_{solvent} = \chi_{solute} \cdot p^{\circ}_{pure\ solv}$

1. Dissolving an unknown compound in water is a slightly exothermic process. Which of the following applies?

   a. $|\Delta_{lattice}H| = |\Delta_{aq}H|$
   b. $|\Delta_{lattice}H| > |\Delta_{aq}H|$
   c. $|\Delta_{lattice}H| < |\Delta_{aq}H|$
   d. Need more information

2. Silver Chloride is not soluble in water. Which of the following applies?

   a. $\Delta_{sol}H^{\circ} > 0$
   b. $\Delta_{sol}H^{\circ} < 0$
   c. $|\Delta_{lattice}H| < |\Delta_{aq}H|$
   d. Need more information

3. Place the following compounds in order of increasing magnitude of *enthalpy of aquation*. Explain why. (Hint: Think about Coulomb's law: Energy $\propto \dfrac{q_+ q_-}{\text{separation}}$)

   i. NaCl vs. NaBr vs. NaI

   ii. NaCl vs. LiCl vs. KCl

   iii. MgS vs. $MgCO_3$ vs. $MgCl_2$

4. Place the following compounds in order of increasing magnitude of *lattice enthalpy*. Explain why.

   a. NaCl vs. NaBr vs. NaI

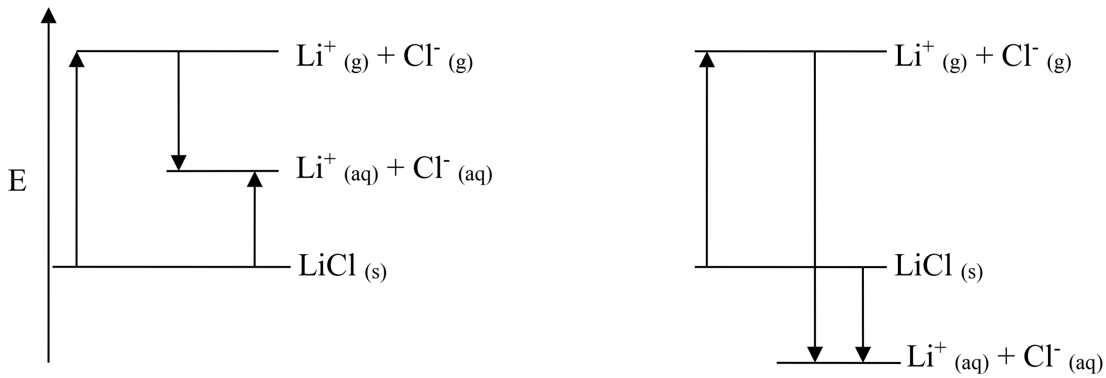
   b. NaCl vs LiCl vs. KCl

   c. MgS vs. $MgCO_3$ vs. $MgCl_2$

   d. NaCl vs. Na_2S vs. MgS

5. Does having a bigger magnitude of *lattice enthalpy* mean that *enthalpy of aquation* will also be bigger?

6. If dissolving LiCl is exothermic, which energy diagram explains this process? Label the arrow using $\Delta_{soln}H°$, $\Delta_{aq}H$, $\Delta_{lattice}H$.



a. If $\Delta_{soln}H°$ for LiCl (s) is -37 kJ/mol and $\Delta_{lattice}H$ is 850 kJ/mol, what is $\Delta_{aq}H$?

b. **(at home)** If you dissolve 0.848 g of LiCl in 100 ml of water at 300 K, what will the final solution temperature be? (Heat capacity of water is 4.2 J/g K)(Answer:301.8)

7. Rank the *van't Hoff factor i* from the lowest to highest for the following componds if we add 1 mol of each of them to 1 kg of water . $C_6H_{12}O_6$, AgCl, HCl, CH_3COOH(acetic acid), Na_3PO_4.

8. At 300 K, the osmotic pressure of a sugar solution is measured as 0.25 bar. What is the concentration of the solution?(Answer:0.010)

a. How would osmotic pressure differ if the same number of moles of NaCl(s) was dissolved in the solution?

9. What mass of sucrose (342.3 g/mol) needs to be added to 1L of water (K_b = 0.50°C/mol) to raise the boiling point by 10.°C?(Answer: 6.8kg)

a. Will you need more or less of NaCl to do the same?

b. What mass of NaCl needs to be added to 1L of water to raise the boiling point by 10ºC?(Assume when dissolved in water sodium chloride breaks into ions completely)(Answer:580grams)

c. Is it easy to change the boiling point or freezing point significantly by using a non-volatile solute?

10. The vapor pressure of water at 32 ºC is 4.76 kPa. A glass of water in sealed in a 1.00 L container filled with air at 32 ºC. After the water comes to equilibrium with the air in the container, the total pressure is 1 bar and there is 500. g of liquid water in the glass.

    a. What will be the partial pressure of water vapor in the container?

    b. If 35.0 g of ethylene glycol is dissolved in the water. Will the vapor pressure increase or decrease?

    c. If 35.0 g of ethylene glycol ($C_2H_6O_2$ with molar mass of 62.1g/mol) is dissolved in the water. Will the mass of liquid water be decreased or increased?

    d. Calculate change in the mass of the liquid water after it has returned to equilibrium.(Answer:0.000335g)

11. When salt is stirred into ice, the mixture turns to slush, because the salt lowers the freezing point of the ice, and the temperature of the slush drops well below 0°C. The following questions guide you to account for how this cooling is able to occur.
    If you dissolve 1.0 mol of sodium chloride in 200. grams of ice initially at 0°C what will be the final temperature of the solution? When sodium chloride is dissolved in ice at 0°C the final solution looks like a slush of ice and water.(Useful information: c_{water}=4.2 J/(K·g) c_{ice}=2.1 J/(K·g) ΔH_{fus}=333J/g).

    a. Write a process (a reaction) of transferring ice in to the water.

    b. How much heat is involved if all 200grams of ice is melted in to the water?

    c. How much heat is involved if only 50% ice is melts in to water

d. How much heat is involved if only 10% ice is melts in to water?

e. Write a process (a reaction) representing dissolving 1 mol of sodium chloride?

f. How much heat is involved when 1 mol of sodium chloride is dissolved?(hint look up necessary enthalpies in the table at the end of handout)

g. What is the total amount of heat involved if you dissolve 1 mol of sodium chloride in 200 grams of ice if all 200 grams of ice transferred in to the water? (assuming that all of sodium chloride dissolves in the amount of the water present) What will be the final temperature of the solution?

h. What is the total amount of heat involved if you dissolve 1 mol of sodium chloride in 200 grams of ice if only 50% of ice melts in to water? What will be the final temperature of the solution? (assuming that all of sodium chloride dissolves in the amount of the water present)

i. What is the total amount of heat involved if you dissolve 1 mol of sodium chloride in 200 grams of ice if only 10% of ice melts in water? What will be the final temperature of the solution? (assuming that all of sodium chloride dissolves in the amount of the water present)

j. Assuming that all 1 mol of sodium chloride dissolves in 20 grams of water, what is a concentration of the NaCl ? Compare you result to the figure 12.7 on page 465 of your book. Is it possible?

(Answers:67kJ, 33kJ,6.7kJ, 3.0kJ, -82,-58, -21)

12. Dissolving sodium chloride in water is a slightly endothermic process. Draw an energy diagram that explains this process. Label the arrow using $\Delta_{soln}H°$, $\Delta_{aq}H$, $\Delta_{lattice}H$.

13. Which one of the following has the largest magnitude of *lattice enthalpy*: LiF, NaF, CaF_2, AlF_3?
    Compare your prediction to the table on page 5.

14. What is the vapor pressure of a solution made of 1.2 g of a non-volatile solute (12 g/mol) and 18 mL of water (assume d_{water} = 1g/mL) at 25°C. The vapor pressure of pure water at 25°C is 24 mmHg. (Answer:21.8)

15. The Van't Hoff Coefficient for acetic acid is 1.01. What is the percent dissociation of acetic acid? Is this a strong acid or a weak acid?(Answer:1%)

16. If 1.0 mg of a substance dissolved in 10 mL of water generates an osmotic pressure of 1 kPa at 300K, what is the molar mass of the substance?(Assume i=1)(Answer: 250)

Compound	$\Delta_{lattice}H$(kJ/mol)	$\Delta_{aq}H$(kJ/mol)
LiCl	861	-898
NaCl	787	-784
KCl	717	-701
NaBr	751	-753
NaI	700	-708
MgS	3406	-3480
$MgCO_3$	3122	-3148
MgCl	2524	-2679

In preparation for Chapter 13:

1. Define reaction *Q*uotient (*Q*):

2. What kind of information you can get if only reaction *Q*uotient (*Q*) is given? (choose all that apply)
    i. How fast reaction proceeds
    ii. The reaction will be spontaneous
    iii. The reaction will be nonspontaneous
    iv. The reaction is at equilibrium
    v. Reactants are favored at equilibrium
    vi. Products are favored at equilibrium
    vii. Reactants and products are equally favored at equilibrium
    viii. Currently, the reaction has more products than reactants or currently, the reaction has more reactants than products

3. Define equilibrium constant (K):

4. What kind of information you can get if only equilibrium constant(K) is given? (choose all that apply)
   i. How fast reaction proceeds
   ii. The reaction will be spontaneous
   iii. The reaction will be nonspontaneous
   iv. The reaction is at equilibrium
   v. Reactants are favored at equilibrium or Products are favored at equilibrium
   vi. Reactants and products are equally favored at equilibrium
   vii. Currently, the reaction has more products than reactants or Currently, the reaction has more reactants than products

5. Write the expression for Reaction *Q*uotient (Q) for the following reactions:

   $\mathbf{C_2H_5OH_{(aq)} + 3\ O_{2(g)} \leftrightarrows 2\ CO_{2(g)} + 3\ H_2O_{(l)}}$ $Q=$

   $\mathbf{H_3O^+_{(aq)} + OH^-_{(aq)} \leftrightarrows 2\ H_2O_{(l)}}$ $Q=$

6. Aluminum reacts with nitric acid is: $\mathbf{Al_{(s)} + 6\ H_3O^+_{(aq)} + 3\ NO_3^-_{(aq)} \Longleftrightarrow 3\ NO_{2(g)} + 9\ H_2O_{(l)} + Al^{3+}_{(aq)}}$. The initial value of the reaction quotient is $Q_{initial}$. If the concentration of $NO_3^-{}_{(aq)}$ is exactly tripled by adding $NaNO_{3(s)}$, what will be the ratio of $Q_{initial}$ to the final value, Q_{final} (nothing else is changed)?

$Q_{initial} / Q_{final} =$ ______

7. What is true about the Reaction *Q*uotient (Q) when the reaction proceeds forward (assume constant temperature)?

   It will increase   It will decrease   It will stay constant.

8. What is true about the Reaction *Q*uotient (Q) when the reaction proceeds in reverse (assume constant temperature)

   It will increase   It will decrease   It will stay constant.

9. What is true about the Equilibrium Constant K during a reaction (assume constant temperature)?

   It will increase   It will decrease   It will stay constant.

10. If a reaction is spontaneous going forward, what must be true?

   a. Reaction proceeds towards product (net gain of product)
   b. Reaction proceeds towards reactants (net gain of reactants)
   c. Reaction is at equilibrium (no net change)

11. For a reaction that begins with all reactants and no products, what must be true?

$K << 1$ $K >> 1$ $Q < K$ $Q > K$ $Q = K$

12. For a reaction that has reached equilibrium and where only a **very small** amount of product was formed what must be true?

$K << 1$ $K >> 1$ $Q < K$ $Q > K$ $Q = K$

For a reaction that has reached equilibrium and where a ***large*** amount of product was formed what must be true?

$K << 1$ $K >> 1$ $Q < K$ $Q > K$ $Q = K$

Important properties of logarithms to know:

1. *ln* x=2.3log x
   a. If x>1 *log* x>0
   b. If x=1 *log* =0
   c. If x<1 *log* x<0
2. *log* a·b = *log* a + *log* b
3. *log* a^b=b·log a
4. $log(\frac{a}{b}) = \log a - \log b$

13. What is true if a forward reaction is spontaneous? (Chose all that apply)

$Q < K$ $Q > K$ $Q = K$ $\frac{Q}{K} > 1$ $\frac{Q}{K} = 1$ $\frac{Q}{K} < 1$

$\ln\frac{Q}{K} > 0$ $\ln\frac{Q}{K} < 0$ $\ln\frac{Q}{K} = 0$

14. If a reaction is non-spontaneous going forward what must be true?

   a. Reaction proceeds towards product (net gain of product)
   b. Reaction proceeds towards reactants (net gain of reactants)
   c. Reaction is at equilibrium (no net change)

15. What is true if a forward reaction is non-spontaneous? (Chose all that apply)

$Q < K$ $Q > K$ $Q = K$ $\frac{Q}{K} > 1$ $\frac{Q}{K} = 1$ $\frac{Q}{K} < 1$

$\ln\frac{Q}{K} > 0$ $\ln\frac{Q}{K} < 0$ $\ln\frac{Q}{K} = 0$

16. What is true for a reaction at equilibrium? (Chose all that apply)

$Q < K$ $Q > K$ $Q = K$ $\frac{Q}{K} > 1$ $\frac{Q}{K} = 1$ $\frac{Q}{K} < 1$

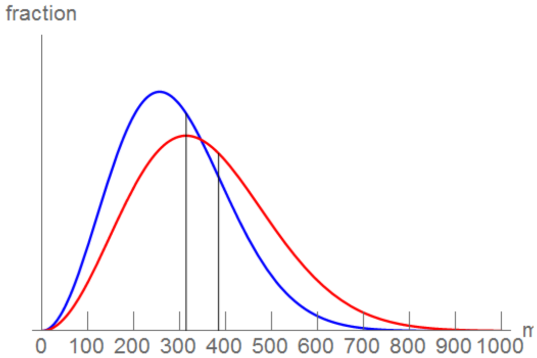
$\ln\frac{Q}{K} > 0$ $\ln\frac{Q}{K} < 0$ $\ln\frac{Q}{K} = 0$

Exam 1 Answers:

1.

a. 314m/s

b.



2.

a. Ne
b. The same

c. 1
d. 0
e. Higher than

3. $9.43*10^{-3}$mol

4.

a. $\frac{84.6g}{1mol} \cdot \frac{1mol}{0.1424L} \cdot \frac{1L}{10^3\,ml}$=0.5910g/ml

b. $P_{obs} = P_{ideal} - a(n/V)^2$; where: $a = 23.11$ bar L^2/mol^2 and $(n/V)^2 = (0.03453\,\frac{mol}{L})^2$

$P_{ideal} = P_{obs} + a(n/V)^2 = 1.0164 + (23.11\text{ bar }L^2/mol^2) \cdot (0.03453\text{ mol/L})^2 = 1.04395\text{bar} = 1.04\text{bar}$

5. The π_n orbital is localized on the O atoms. The π^* orbital is localized across all three atoms. This means excitation of one electron from π_n to π^* will decrease the electron density on the O atoms and increase the electron density on the N atom. Therefore, the dipole moment will decrease.

O_{left} = $\mathbf{(4e^-)_{\sigma\text{-frame}} + (1/2\ e^-)_{\pi\ nonbonding} + (1/3\ e^-)_{\pi^*} = 4 \cdot (5/6)e^-}$ (originally O_{left}=5 **e**$^-$)

O_{right} =$\mathbf{4 \cdot (5/6)e^-}$ (originally O_{right}=5 **e**$^-$)

N= $\mathbf{(2e^-)_{\sigma frame} + (1/3\ e^-)_{\pi^*} = 2 \cdot (1/3)\ e^-}$ (originally N=2 **e**$^-$)

Less separation of the charge will **<u>decrease</u>** dipole moment.

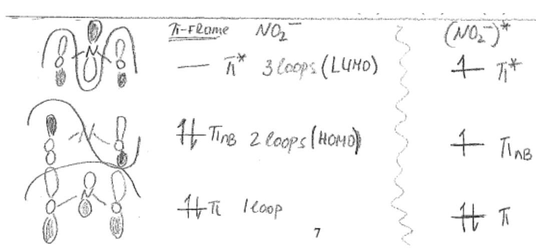
a. Removal of an electron from the π_n orbital will reduced the electron charge localized on each O atom from 1 to 1/2. Therefore, the dipole moment will be decreased.

O_{left} = $\mathbf{(4e^-)_{\sigma\text{-frame}} + (1/2\ e^-)_{\pi\ nonbonding} = 4.5e^-}$ (originally O_{left}=5 **e**$^-$)

O_{right} =$\mathbf{4.5e^-}$ (originally O_{right}=5 **e**$^-$)

N= $\mathbf{(2e^-)_{\sigma frame} = 2e^-}$ (originally N=2 **e**$^-$)

Less separation of the charge will **<u>decrease</u>** dipole moment.



6. A container is filled with Ne at 18 °C and 8.95 bar. Due to a small hole in the container, the pressure of the container drops by half in 55 minutes. If the container had instead been filled with Xe at 18 °C and 8.95 bar, what would the pressure of the Xe be after 35 minutes? Express your answer in bar.

a. $|\Delta P_{Ne}|=0.50-8.95bar=4.475bar$

drops by 50% $\Delta P = P_f - P_{in} = 4.475 - 8.95 = -4.475 bar$

b. $\frac{rate(Ne)}{rate(Xe)} = \frac{\frac{4.475bar}{55min}}{\frac{|\Delta P(Xe)|}{35min}} = \frac{u(Ne)}{u(Xe)} = \sqrt{\frac{M(Xe)}{M(Ne)}}$

c. $|\Delta P(Xe)| = \frac{35}{55} \cdot 4.475 \cdot \sqrt{\frac{M(Ne)}{M(Xe)}} = 1.165$; $\Delta P(Xe) = -1.165$ because pressure of the container drops

d. $P_{Xe} = P_{in} + \Delta P = (8.95bar + (-1.165))bar = 7.83bar$

7. The chemical reaction 3 A(g) + 2 B(g) ⇄ 2 C(g) is carried out in a rigid container at a constant temperature of 28.7 °C. At the start of the reaction, 6.00 bar of A and 5.00 bar of B are added to the empty container, for a total pressure of 11.00 bar. At the end of the reaction, the total pressure in the container is 6.50 bar. Calculate the percent yield of the reaction.

$P = n^* \frac{RT}{V}$; **P~n**; $\frac{RT}{V}$ - constant

	3 A(g)	+ 2 B(g)	⇄ 2 C(g)	
Initially:	6.00bar	5.00 bar		$P_{initial\_total} = 11.00bar$
Used/formed:	$-x$	$-\frac{2}{3}x$	$+\frac{2}{3}x$	
End:	6.00bar$-$x	$5.00-\frac{2}{3}x$	$\frac{2}{3}x$	$\mathbf{P_{final\_total} = (6.00bar - x) + (5.00 - \frac{2}{3}x) + \frac{2}{3}x = 6.50bar}$

If B is a limiting reagent: $5.00barB \cdot \frac{2molC}{2molB} = 5molC$ will form

If A is a limiting reagent: $6.00barA \cdot \frac{2molC}{3molA} = 4molC$ will form

<u>A is a limiting Reagent</u>

$$(6.00bar - x) + (5.00 - \frac{2}{3}x) + \frac{2}{3}x = 6.50bar; \quad x = 4.50bar\text{(actual amount used)}$$

$$\%yeld = \frac{4.5bar}{6.00bar} \cdot 100\% = 75.0\%$$

8.

a. 7 eV
b. 1Ev

9.

molecule — a (atm L^2/mol^2) and b (L/mol)

Ethanol, C_2H_5OH → 12.56 and 0.08710
Hydrogen chloride, HCl → 3.700 and 0.04061
Hydrogen iodide, HI → 6.309 and 0.05303
Hydrogen bromide, HBr → 4.500 and 0.04415

10.

a. 4
b. 18
c. 8/3
d. 0
e. 0