EXAM 1 Free Response
Vanden Bout/LaBrake
CH302 Spring 2013

Name: ________________________
EID: __________________________
Version Number: ________________

Questions are on front and back of this FR exam. Only responses inside the provided boxes will be graded.

I. (16 points) Thinking Like a Chemist About Dissolution: Consider the following:

1.03 g of NaBr is dissolved enough water to bring the solution volume up to 500 mL. In a separate beaker 0.332 g of $Pb(NO_3)_2$ is dissolved in enough water to bring the solution volume up to 500 mL.

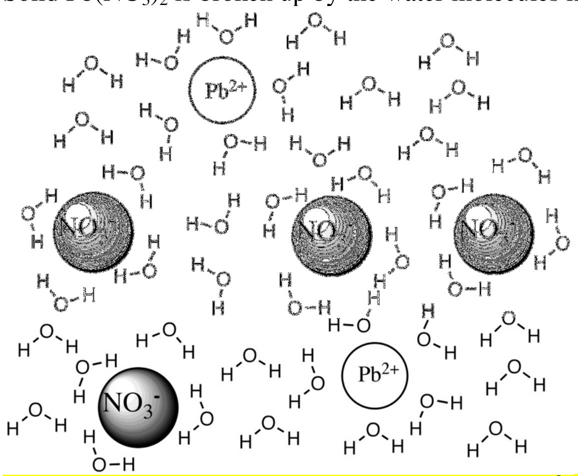
a. Fully describe the process ***of the nitrate salt*** dissolving in water using the following three ways

1. Macroscopically (words) (1 point)

Solid $Pb(NO_3)_2$ is added to water, where the salt "disappears" as it dissolved away. (+1 pt)

2. Microscopically (words + picture) (3 points)

Solid $Pb(NO_3)_2$ is broken up by the water molecules into one Pb^{2+} ion and two NO_3^- ions.



(+1 pt for word description, +1 2:1 ratio of NO_3^-:Pb^{2+}, +1 for showing water surrounds the ions)

3. State the sign (+, -, or zero) for each of the values in the below table (4 points)
(1 point a piece for ΔH, 1 point for ΔS and ΔG)

Thermodynamic Quantity	$\Delta H_{solution}$	$\Delta H_{lattice}$	$\Delta H_{hydration}$	$\Delta S_{solution}$	$\Delta G_{solution}$
Sign	+	+	-	+	-

b. Mix the two solutions together. Write out the formula unit equation, the total ionic equation *and* the net ionic equation that describes the change that occurs when the two solutions are mixed together. (3 points)
1 point a piece, no credit if the equations were not balanced.

$2NaBr\ (aq) + Pb(NO_3)_2\ (aq) \rightarrow PbBr_2\ (s) + 2NaNO_3\ (aq)$

$2Na^+\ (aq) + 2Br^-\ (aq) + Pb^{2+}\ (aq) + 2NO_3^-\ (aq) \rightarrow PbBr_2\ (s) + 2Na^+\ (aq) + 2NO_3^-\ (aq)$

$2Br^-\ (aq) + Pb^{2+}\ (aq) \rightarrow PbBr_2\ (s)$

c. Determine the molar concentration of each ion in solution at the first instant when mixed together. (3 points)

1 point for Na^+ and Br^-, 1 point for Pb^{2+}, 1 point for NO_3^-

(1.03 g NaBr)*(1 mol NaBr/102.89g NaBr)*(1mol Na^+/1 mol NaBr)= 0.010 moles Na^+

(1.03 g NaBr)*(1 mol NaBr/102.89g NaBr)*(1mol Br^-/1 mol NaBr)= 0.010 moles Br^-

(0.332 g $Pb(NO_3)_2$)*(1mol $Pb(NO_3)_2$/331.2g Pb^{2+})*(1 mol Pb^{2+}/1 mol $Pb(NO_3)_2$)= 0.001 moles Pb^{2+}

(0.332 g $Pb(NO_3)_2$)*(1mol $Pb(NO_3)_2$/331.2g Pb^{2+})*(2 mol NO_3^-/1 mol $Pb(NO_3)_2$)= 0.002 moles NO_3^-

New Volume: 500 mL + 500 mL = 1000 mL = 1 L

$[Na^+]$ = (0.010 moles)/1L = 0.010 M

$[Br^-]$ = (0.010 moles)/1L = 0.010 M

$[Pb^{2+}]$ = (0.001 moles)/1L = 0.001 M

$[NO_3^-]$ = (0.002 moles)/1L = 0.002 M

d. The K_{sp} for $PbBr_2$ is 6.3 X 10^{-6}. The solubility of $NaNO_3$ is 87 g/ 100 g H_2O. Calculate the value of Q_{sp} for the insoluble salt and predict if a precipitate will be formed. (2 points)

1 point for calculating Q correctly (if you miscalculated the concentrations in "c" and used them in "d," we double checked your calculations and gave full credit if all you did was put in wrong numbers.

1 point for determining if a precipitate was formed

$Q_{sp} = [Pb^{2+}][Br^-]^2$

$Q_{sp} = (0.0012)(0.01)^2 = 1.2 \times 10^{-7}$

No precipitate will be formed because $Q_{sp} < K_{sp}$ ($1.2 \times 10^{-7} < 6.3 \text{ X } 10^{-6}$)

II. Consider two containers with expandable walls (similar to balloons) separated by a semi permeable membrane. Container A contains 100 mL of a 0.2 M aqueous solution of potassium nitrate and Container B contains 100 mL of 0.4 M aqueous solution of potassium nitrate. The containers are at room temperature, 25 °C.

a. Initially, what is the difference in osmotic pressure between the two solution? (3 points)

Container A: $\Pi = i\Delta MRT$

i = 2, R = 0.08206 L*atm/mole*K, ΔM = 0.4-0.2M = 0.2M, T = 298 K

$$2 \times \frac{0.2moles}{L} \times \frac{0.08206L*atm}{mole*K} \times 298K = 9.8atm$$

For Full Credit:

Either solve separately and subtract, final answer of 9.8 atm

OR

Do ONE calculation using the difference between the containers, 0.2M to give 9.8 atm (most correct way)

Partial credit (not full credit) was given if there was only a verbal description of the difference.

Parital credit was given if you had the correct equation

Partial credit was given if you used the equation correctly but used the wrong value of R

b. Which direction do you expect the water to flow (if at all)? Explain this change in terms of free energy. (3 points)

The water will flow from container A to container B. (1 point)

Solutions with higher concentrations have lower free energy. (2 points)

Some explanation:

Container B has a higher concentration of ions initially and therefore has a lower free energy. The water will have a net movement across the membrane towards container B to equalize the concentrations of the two solutions and therefore reach equilibrium (free energy equal in both solutions and a dynamic equilibrium of water movement across the membrane).

c. What will be the final KNO_3 concentration(s) for Container A and Container B? (2 points)

[KNO_3] = 0.3M (For full credit, all you needed was the number)

Equilibrium will be reached when the two concentrations are the same. This is as if you had mixed the two solutions together to get a final volume. Mixing 100mL of 0.2M with 100mL of 0.4M will yield a solution with a concentration of 0.3 M.

OR

$$\frac{0.2moles}{L} \times \frac{1L}{1000mL} \times 100mL = 0.02moles$$

$$\frac{0.4moles}{L} \times \frac{1L}{1000mL} \times 100mL = 0.04moles$$

$$100mL + 100mL = 200mL = 0.2L$$

$$\frac{0.06moles}{0.2L} = 0.3M$$

d. What will be the final volume(s) for Container A and Container B (BONUS)? (2 points)

To get full credit, all you needed were the final volumes (no calculations required)

$M_{1A}V_{1A} = M_{2A}V_{2A}$

0.2M*100 mL = 0.3M*x

x = 66.7 mL for Container A

$M_{1B}V_{1B} = M_{2B}V_{2B}$

0.4M*100 mL = 0.3M*x

x = 133.3 mL for Container B