CHEM 1423 - Exam 2 – March 3, 2016

Constants and Conversion Factors

R = 0.082 L-atm/mol-K

R = 8.31 J/mol-K

1 atm. = 760 torr

Molar Masses:

$C_6H_{12}O_6$ - 180.	$C_{12}H_{22}O_{11}$ - 342.	C_2H_6O - 46.
H_2O - 18.	$Al(NO_3)_3$ - 213.	
NaOH - 40.	HNO_3 - 63.	$HClO_4$ - 100.5

Beer-Lambert Law: $A = \log\left(\frac{I_o}{I}\right) = \varepsilon bc$

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Name Solutions

(60) **PART I. MULTIPLE CHOICE (Circle the ONE correct answer)**

1. Consider the equilibrium, $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$. This is an endothermic reaction with ΔH^o = +180 kJ/mol. The value of the equilibrium constant is $K_c = 7.0 \times 10^{-10}$ at 650 °C. What is the approximate value of K_c at 550 °C?

   (A) 4.0×10^{-11} (A) 1.6×10^{-12} (A) 3.0×10^{-7} (A) 1.2×10^{-8}

2. The solubility of a gas in a liquid solvent generally ________ with increasing temperature because the solution process is ________

   (A) increases , endothermic (B) decreases , endothermic
   (C) increases , exothermic (D) decreases , exothermic

3. The solubility of a solid in a liquid solvent generally ________ with increasing temperature because the the entropy change for the solution process is ________

   (A) increases , negative (B) decreases , negative
   (C) increases , positive (D) decreases , positive

For #4 - #5: A sample of drinking water contains 650 ppt of Te (by mass).

4. The **mass fraction** of Te in the sample is:

   (A) 6.5×10^{-12} % (B) 6.5×10^{-10} (C) 6.5×10^{-8} % (D) 6.5×10^{-7}

5. How many ng of Te are contained in a 400 g sample of the drinking water.

   (A) 0.65 ng (B) 1.6×10^{-3} ng (C) 2.6×10^{4} ng (D) 260 ng

For #6 - #7: When 45 grams of glucose [$C_6H_{12}O_6$] is added to 90 grams of water, the density of the solution is 1.25 g/mL.

6. The **Molarity** of the above solution is

   (A) 2.3 Molar (B) 1.9 Molar (C) 2.6 Molar (D) 2.8 Molar

7. The **molality** of the above solution is

   (A) 2.3 molal (B) 1.9 molal (C) 2.8 molal (D) 2.1 molal

8. Approximately how many grams of sucrose, $C_{12}H_{22}O_{11}$, are required to prepare 3.0 L of a 0.40 Molar sucrose solution?

(A) 410 grams (B) 205 grams (C) 164 grams (D) 342 grams

9. Approximately how many grams of ethanol (C_2H_6O) must be added to 450 grams of water, H_2O, to prepare a solution in which the ethanol mole fraction is 0.20 ?

(A) 73 g (B) 113 g (C) 288 g

(D) Cannot be determined without the density of the solution

10. When 90 grams of glucose ($C_6H_{12}O_6$) is added to 144 g of water (H_2O), the vapor pressure **above the solution** is 132 torr at 60 °C. What is the approximate vapor pressure of **pure water** at 60 °C?

(A) 148 torr (B) 140 torr (C) 124 torr (D) 7.8 torr

11. A sample of glucose is dissolved in 400 grams of water (K_f = 1.86 °C/m). The freezing point of the solution is -1.60 °C. Approximately how many moles of glucose are dissolved in this sample?

(A) 0.19 mol (B) 0.26 mol (C) 1.15 mol (D) 0.34 mol

12. When 20 grams of an unknown compound is dissolved in 150 grams of water (K_f = 1.86 °C/m), the freezing point of the solution is -3.5 °C. What is the approximate Molar Mass of the unknown compound?

(A) 112. g/mol (B) 89 g/mol (C) 56. g/mol (D) 71 g/mol

13. What is the approximate osmotic pressure, **in torr**, when 1.6×10^{-3} mol of the strong electrolyte, magnesium phosphate [$Mg_3(PO_4)_2$] , is dissolved in 720 mL of aqueous solution at 25 °C?

(A) 206 torr (B) 14 torr (C) 107 torr (D) 41 torr

14. Which of the following solutions has the **lowest boiling point**?

(A) 0.35 m $C_6H_{12}O_6$ (B) 0.10 m $Mg(NO_3)_2$

(C) 0.17 m KCl (D) 0.09 m Na_3PO_4

15. A sample of the strong electrolyte, aluminum nitrate [$Al(NO_3)_3$], is dissolved in 300 g of H_2O (K_b = 0.51 °C/m). The boiling point of the solution is 101.3 °C. Approximately how many grams of $Al(NO_3)_3$ are contained in the solution?

(A) 28.4 g (B) 136. g (C) 40.7 g (D) 163. g

16. Rank the following three solutions in order of **increasing acidiity**

(1) $[OH^-] = 2.0 \times 10^{-9}$ M (2) $[H^+] = 2.0 \times 10^{-6}$ M (3) pOH = 8.9

(A) 1 < 3 < 2 (B) 2 < 1 < 3 (C) 1 < 2 < 3 (D) 2 < 3 < 1

17. The **pH** of a solution prepared by dissolving 7.0×10^{-4} grams of the base, NaOH, in 800 mL of aqueous solution is approximately

(A) 9.3 (B) 10.7 (C) 4.7 (D) 8.6

18. Approximately how many grams of nitric acid, HNO_3, must be dissolved in 25. L of aqueous solution to prepare a solution with **pOH** = 8.4 ?

(A) 7.4×10^{-3} g (B) 6.3×10^{-6} g (C) 4.0×10^{-3} g (D) 6.3×10^{-5} g

19. Which of the following **are not** conjugate acid/base pairs?

(i) H_2CO_3/CO_3^{2-}
(ii) $CH_3CH_2NH_3^+/CH_3CH_2NH_2$
(iii) HPO_4^{2-}/PO_4^{3-}
(iv) NH_4^+/NH_5

(A) ii & iii (B) iv only (C) i & ii & iv (D) i & iv

20. What is the acid dissociation equilibrium equation for the Hydrogen Phosphate ion, HPO_4^{2-} ?

(A) $K_a = \frac{[H^+][HPO_4^{2-}]}{[PO_4^{3-}]}$ (B) $K_a = \frac{[H^+][PO_4^{3-}]}{[HPO_4^{2-}]}$

(C) $K_a = \frac{[H^+][HPO_4^{2-}]}{[H_2PO_4^-]}$ (D) $K_a = \frac{[H^+][HPO_4^{2-}]}{[H_2PO_4^-]}$

PART II. FOUR (4) PROBLEMS ON FOLLOWING PAGES:

REMEMBER TO SHOW YOUR WORK FOR CREDIT

(10) 1. Consider the aqueous solution equilibrium, 2A(aq) ⇌ B(aq) + 2 C(aq).
The product, B, has an absorption in the UV range of the spectrum at 450 nm, with a Molar Absorptivity, $\varepsilon = 3{,}700\ M^{-1}\ cm^{-1}$

A solution is prepared in a 0.50 cm cell with an initial concentration of the reactant, A, $[A]_o = 1.00\times10^{-4}$ M, and the solution is allowed to reach equilibrium.
1.00×10^{-3}

At equilibrium, the percent transmission of product, B, is %T = 44.0%.

Calculate the equilibrium constant, K_c, for this reaction.

Calc $[B]_{eq}$

$\%T = 44 = 100\ I/I_0 \rightarrow I_0/I = 100/44$

$A = \log\left(\frac{I_0}{I}\right) = \log\left(\frac{100}{44}\right) = 0.357$

$[B]_{eq} = \frac{A}{\varepsilon b} = \frac{0.357}{(3700\ M^{-1}cm^{-1})(0.5\ cm)} = 1.93\times10^{-4}\ M$

ICE Table

	2A	⇌ B	+ 2C
init	1×10^{-3}	0	0
chg.	$-2X$	$+X$	$+2X$
Equil	$1\times10^{-3}-2X$	X	$2X$

$[B]_{eq} = X = 1.93\times10^{-4}\ M$

Conc:
$[B]_{eq} = X = 1.93\times10^{-4}\ M$

$[A]_{eq} = 1\times10^{-3} - 2X = 6.14\times10^{-4}\ M$

$[C]_{eq} = 2X = 3.86\times10^{-4}\ M$

Kc

$K_c = \frac{[B]_{eq}[C]_{eq}^2}{[A]_{eq}^2} = \frac{(1.93\times10^{-4})(3.86\times10^{-4})^2}{(6.14\times10^{-4})^2}$

$= \boxed{7.63\times10^{-5}}$

(10) 2. Concentrated aqueous Perchloric Acid, $HClO_4(aq)$, has a Molarity of 11.6 M, and a density of 1.67 g/mL.

Calculate the weight percent of $HClO_4$ in the concentrated Perchloric Acid solution.

Assume 1L = 1000 mL solution

$n_{HClO_4} = 11.6\ mol/L \times 1L = 11.6\ mol.$

$m_{HClO_4} = 11.6\ mol \times 100.5\ g/mol = 1166\ g.$

$m_{tot} = 1000\ mL \times \frac{1.67\ g}{1\ mL} = 1670\ g.$

$W\% = \frac{m_{HClO_4}}{m_{tot}} \times 100 = \frac{1166}{1670} \times 100 = 69.8\ \%$

$\approx$ **70 %**

$mass_{Rib} = 1.5\ g$

$V = 0.40\ L$

(10) 3. 1.5 grams of a sample of Ribonucleus A is dissolved in 400 mL of aqueous solution. The measured Osmotic Pressure of the solution at 35 °C is 5.2 torr.

Calculate the Molar Mass of this sample of Ribonucleus A.

Calc C_{Rib}

$$\Pi = 5.2\ torr \times \frac{1\ atm}{760\ torr} = 6.84 \times 10^{-3}\ atm$$

$$C_{Rib} = \frac{\Pi}{RT} = \frac{6.84 \times 10^{-3}\ atm}{\left(0.082\ \frac{L \cdot atm}{mol \cdot K}\right)(308\ K)} = 2.71 \times 10^{-4}\ mol/L$$

Calc n_{Rib}

$$n_{Rib} = 2.71 \times 10^{-4}\ mol/L \times 0.40\ L$$
$$= 1.08 \times 10^{-4}\ mol$$

Calc. M_{Rib}

$$M_{Rib} = \frac{mass_{Rib}}{n_{Rib}} = \frac{1.5\ g}{1.08 \times 10^{-4}\ mol}$$

$$= 1.38 \times 10^{4}\ g/mol$$
$$= 13{,}800\ g/mol$$

Soln. A

(10) 4. 15. L of an aqueous Nitric Acid, $HNO_3(aq)$, solution with pH = 4.70 are mixed with 25. L of an aqueous Potassium Hydroxide, KOH(aq), solution with pH = 9.20.

Soln B →

Calculate the pH of the resulting solution.

Calc. n_{H^+} (Soln A)

$[H^+] = 10^{-pH} = 10^{-4.70}$
$= 2.00 \times 10^{-5}$ mol/L

$n_{H^+} = 2.00 \times 10^{-5}$ mol/L $\times$ 15 L
$= 2.99 \times 10^{-4}$ mol H^+

Calc. n_{OH^-} (Soln B)

pOH = 14 − 9.20 = 4.80
$[OH^-] = 10^{-pOH} = 10^{-4.80} = 1.58 \times 10^{-5}$ mol/L

$n_{OH^-} = 1.58 \times 10^{-5}$ mol/L $\times$ 25 L
$= 3.96 \times 10^{-4}$ mol OH^-

Calc. net n_{OH^-}

$n_{OH^-} = n_{init}(OH^-) - n_{H^+}$
$= 3.96 \times 10^{-4} - 2.99 \times 10^{-4} = 9.7 \times 10^{-5}$ mol OH^-

Calculate $[OH^-]$, pOH, pH

V = 15 + 25 = 40 L

$[OH^-] = \frac{n_{OH^-}}{V} = \frac{9.7 \times 10^{-5} \text{ mol}}{40 \text{ L}} = 2.43 \times 10^{-6}$ M

$pOH = -\log[OH^-] = 5.62$

pH = 14 − 5.62 = 8.38 ≈ **8.4**