Version A

CHEM 1423 - Exam 2 – March 2, 2017

Constants and Conversion Factors

R = 0.082 L-atm/mol-K

R = 8.31 J/mol-K

1 atm. = 760 torr

Molar Masses: $C_2H_6O_2$ - 62. H_2O - 18. $C_6H_{12}O_6$ - 180.

NH_3 - 17, $C_6H_5C_2H_5(l)$ - 106

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

Version A

CHEM 1423 - Exam 2 – March 2, 2017

Name Solutions

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

For #1 - #3: Consider he gas phase reaction, $2\ Br_2(g) + 4\ NO(g) \rightleftharpoons 4\ NOBr(g)$, $K_c = 50.$ at 400 K. The enthalpy change for this reaction is $\Delta H = +75$ kJ

1. For the above equilibrium reaction, if NO(g) is added to the mixture, the ratio $[NOBr]/[Br_2]$ will _____ and K_c will _____.

   (A) decrease , remain constant (B) increase , decrease
   (C) increase , remain constant (D) decrease , decrease

2. For the above equilibrium reaction, if the temperature is **decreased**, the ratio $[NOBr]/[Br_2]$ will _____ and K_c will _____.

   (A) decrease , remain constant (B) increase , decrease
   (C) increase , remain constant (D) decrease , decrease

3. For the above reaction, if Ar(g) is added to the mixture in a container at fixed **total pressure**, the ratio $[NOBr]/[Br_2]$ will _____ and K_c will _____.

   (A) decrease , remain constant (B) increase , decrease
   (C) remain constant , remain constant (D) increase , remain constant

4. Consider the equilibrium, $H_2(gas) + I_2(solid) \rightleftharpoons 2\ HI(gas)$
   If the volume of the container is **decreased**, the ratio, $[HI(g)]/[H_2(g)$, will _____ and K_c will _____

   (A) decrease , decrease (B) decrease , remain constant
   (C) remain constant , remain constant (D) increase , remain constant

For #5-#6: Consider the aqueous solution equilibrium, $A(aq) \rightleftharpoons 3\ B(aq)$.
The product, B, has an absorption in the UV range of the spectrum at 450 nm, with a Molar Absorptivity, $\varepsilon = 50.\ M^{-1}\ cm^{-1}$

A solution is prepared in a 1.5 cm cell with an initial concentration of the reactant, A, $[A]_o = 0.005$ M, and the solution is allowed to reach equilibrium.
At equilibrium, the % transmittance of B is 30%.

5. What is the approximate concentration of B at equilibrium?

   (A) 0.021 M (B) 0.0023 M (C) 0.0070 M (D) 0.00023 M

Version A

6. What is the approximate value of the equilibrium constant for the above reaction?

(A) 1.3×10^{-4} (B) 2.6 (C) 1.2×10^{-8} (D) 3.7×10^{-2}

7. Which of the following statements is/are **NOT correct**.

(i) the solubility of most solids in a liquid increases with rising temperature.

(ii) the solubility of most gases in a liquid increases with rising temperature.

(iii) when a solid is dissolved in a liquid, the entropy increases.

(iv) ΔH_{soln} must be negative for a solid to dissolve in a liquid.

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

8. A sample of water contains of Arsenic in a sample of water is 16 ppb (parts per billion) of Arsenic. Therefore, the Weight Percent of Arsenic in the sample is:

(A) 1.6×10^{-10} % (B) 1.6×10^{-6} % (C) 1.6×10^{-9} % (D) 1.6×10^{-8} %

For #9 - #10: When 124 grams of Ethylene Glycol ($C_2H_6O_2$), is added to 600 grams of water, the density of the solution is 0.80 g/mL.

9. The **Molarity** of Ethylene Glycol in the above solution is approximately:

(A) 3.3 M (B) 2.7 M (C) 2.2 M (D) 3.5 M

10. The **mole fraction** of Ethylene Glycol in the above solution is approximately:

(A) 0.21 (B) 0.057 (C) 0.060 (D) 0.17

11. You want to prepare a 1.5 **molal** solution of Ethylene Glycol ($C_2H_6O_2$) in water. Approximately how many grams of Ethylene Glycol would you have to add to 600 grams of water to prepare this solution?

(A) 56 g (B) 65 g (C) 80 g (D) 41 g

12. What is the approximate weight % of Glucose $C_6H_{12}O_6$ in an aqueous solution containing 0.80 **molal** Glucose?

(A) 0.14 % (B) 1.4 % (C) 14.4 % (D) 12.6%

13. What is the approximate NH_3 **Molarity** in a solution in which the NH_3 mass percent is 10% (solution density = 0.92 g/mL)?

(A) 6.5 M (B) 5.4 M (C) 3.7 M (D) 5.9 M

14. When 60 grams of an unknown compound is dissolved in 500 g of water (K_f=1.9 °C/m), the freezing point of the solution is -2.20 °C. The Molar Mass of the compound is approximately

(A) 52 g/mol (B) 104 g/mol (C) 70 g/mol (D) 86 g/mol

15. What is the osmotic pressure, **in torr**, when 9.5×10^{-4} mol of the strong electrolyte, aluminum nitrate [$Al(NO_3)_3$] , is dissolved in 600 mL of aqueous solution at 25 °C?

(A) 0.16 torr (B) 29 torr (C) 118 torr (D) 105 torr

16. When 2.0 grams of an Enzyme are dissolved in 600 mL of aqueous solution, the osmotic pressure at 25 °C is 9.5 torr. The Molar Mass of the Enzyme is approximately:

(A) 6.5×10^3 g/mol (B) 4.4×10^3 g/mol (C) 2.3×10^3 g/mol

(D) Cannot be determined without the Osmotic Pressure Depression Constant

17. The vapor pressure of pure water at 60 °C is 149 torr. What is the approximate vapor pressure of a solution prepared by adding 135 grams of glucose ($C_6H_{12}O_6$) to 300 grams of water at 60 °C?

(A) 137.4 torr (B) 102.8 torr (C) 6.4 torr (D) 142.6 torr

18. Consider the strong electrolytes, sodium sulfate, Na_2SO_4, and sodium phosphate, Na_3PO_4.

If 350 mL of 0.30 M Na_2SO_4(aq) is added to 250 mL of 0.50 M Na_3PO_4(aq), the sodium ion concentration (i.e Molarity) in the mixture, [Na^+], is approximately:

(A) 0.59 M (B) 0.98 M (C) 046 M (D) 0.35 M

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

(A) 0.10 m $Mg_3(PO_4)_2$ (B) 0.11 m K_3AsO_4

(C) 0.20 m Na_2SO_4 (D) 0.32 m NH_4Cl

PART II. TWO (2) PROBLEMS ON FOLLOWING PAGES:

REMEMBER TO SHOW YOUR WORK FOR CREDIT

Version A

(12) 1. Consider the equilibrium between $N_2(g)$, $H_2(g)$, $NH_3(g)$:
$N_2(g) + 3\ H_2(g) \rightleftarrows 2\ NH_3(g)$. The value of K_c at 30 °C is 8.0. The Enthalpy change for this reaction is $\Delta H = -92.0$ kJ.

Calculate the temperature, **in °C,** at which the equilibrium constant, K_c, is 1.00×10^{-4}..

$\Delta H^\circ = -92.0\ kJ$

$= -9.20 \times 10^4\ J$

$T_1 = 30^\circ C = 303\ K$

$K_{c1} = 8.0$

$T_2 = ?$

$K_{c2} = 1.00 \times 10^{-4}$

$$\ln\left(\frac{K_{c2}}{K_{c1}}\right) = -\frac{\Delta H^\circ}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$\frac{1}{T_2} - \frac{1}{T_1} = -\frac{R}{\Delta H^\circ}\ln\left(\frac{K_{c2}}{K_{c1}}\right)$$

$$\frac{1}{T_2} = \frac{1}{T_1} - \frac{R}{\Delta H^\circ}\ln\left(\frac{K_{c2}}{K_{c1}}\right)$$

$$= \frac{1}{303\ K} - \frac{8.31}{(-9.20 \times 10^4)}\ln\left(\frac{1.00 \times 10^{-4}}{8.0}\right)$$

$$\frac{1}{T_2} = 2.281 \times 10^{-3}\ K^{-1}$$

$$T_2 = 438\ K - 273$$

$$= 165^\circ C$$

EB = Ethylbenzene

Version A

(12) 2. The vapor pressure of pure Ethylbenzene, $C_6H_5C_2H_5(l)$ [M=106], is 74.0 torr at 70 °C. When 50 grams of an unknown non-volatile solute, X, is added to 265 grams of Ethylbenzene, the vapor pressure of the solution at 70 °C is 62.9 torr.

Calculate the Molar Mass of the unknown, X, in grams/mol

$$P_{EB} = X_{EB} P^{\circ}_{EB} \rightarrow X_{EB} = \frac{P_{EB}}{P^{\circ}_{EB}} = \frac{62.9}{74.0} = 0.85$$

$$n_{EB} = 265\,g \times \frac{1\,mol}{106\,g} = 2.5\,mol$$

$$X_{EB} = \frac{n_{EB}}{n_{EB} + n_X} = 0.85$$

$$n_{EB} = 0.85\,n_{EB} + 0.85\,n_X$$

$$\therefore \quad 0.85\,n_X = n_{EB} - 0.85\,n_{EB} = 0.15\,n_{EB}$$

$$\therefore \quad n_X = \frac{0.15\,n_{EB}}{0.85} = \frac{0.15(2.5)}{0.85} = 0.44\,mol\,X$$

$$M_X = \frac{mass\,X}{n_X} = \frac{50\,g}{0.441\,mol} = 113\,g/mol$$

Version B

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Molar Masses: $C_2H_6O_2$ - 62. H_2O - 18. $C_6H_{12}O_6$ - 180.

NH_3 - 17, $C_6H_5C_2H_5(l)$ - 106

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Version B

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Name Solutions

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

For #1-#2: Consider the aqueous solution equilibrium, A(aq) ⇌ 3 B(aq).
The product, B, has an absorption in the UV range of the spectrum at 450 nm, with a Molar Absorptivity, $\varepsilon = 50.\ M^{-1}\ cm^{-1}$

A solution is prepared in a 1.5 cm cell with an initial concentration of the reactant, A, $[A]_o = 0.005$ M, and the solution is allowed to reach equilibrium.
At equilibrium, the % transmittance of B is 30%.

1. What is the approximate concentration of B at equilibrium?

   (A) 0.0070 M (B) 0.0023 M (C) 0.021 M (D) 0.00023 M

2. What is the approximate value of the equilibrium constant for the above reaction?

   (A) 1.2×10^{-8} (B) 2.6 (C) 1.3×10^{-4} (D) 3.7×10^{-2}

For #3 - #5: Consider he gas phase reaction, $2\ Br_2(g) + 4\ NO(g) \rightleftharpoons 4\ NOBr(g)$, $K_c = 50.$ at 400 K. The enthalpy change for this reaction is $\Delta H = +75$ kJ

3. For the above equilibrium reaction, if the temperature is **decreased**, the ratio $[NOBr]/[Br_2]$ will _____ and K_c will _____.

   (A) increase , remain constant (B) increase , decrease
   (C) decrease , remain constant (D) decrease , decrease

4. For the above equilibrium reaction, if NO(g) is added to the mixture, the ratio $[NOBr]/[Br_2]$ will _____ and K_c will _____.

   (A) decrease , remain constant (B) decrease , decrease
   (C) increase , remain constant (D) increase , decrease

5. For the above reaction, if Ar(g) is added to the mixture in a container at fixed **total pressure**, the ratio $[NOBr]/[Br_2]$ will _____ and K_c will _____.

   (A) increase , remain constant (B) increase , decrease
   (C) remain constant , remain constant (D) decrease , remain constant

Version B

6. Consider the equilibrium, $H_2(gas) + I_2(solid) \rightleftharpoons 2\ HI(gas)$
If the volume of the container is **decreased**, the ratio, $[HI(g)]/[H_2(g)$, will _____ and K_c will _____

(A) decrease , decrease (B) increase , remain constant
(C) remain constant , remain constant (D) decrease , remain constant

7. Which of the following statements is/are **NOT correct**.

(i) the solubility of most solids in a liquid increases with rising temperature.
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(A) ii & iv (B) iv only (C) i & iii (D) ii only

For #8 - #9: When 124 grams of Ethylene Glycol ($C_2H_6O_2$), is added to 600 grams of water, the density of the solution is 0.80 g/mL.

8. **Molarity** of Ethylene Glycol in the above solution is approximately:

(A) 2.2 M (B) 2.7 M (C) 3.3 M (D) 3.5 M

9. The **mole fraction** of Ethylene Glycol in the above solution is approximately:

(A) 0.21 (B) 0.057 (C) 0.060 (D) 0.057

10. A sample of water contains of Arsenic in a sample of water is 16 ppb (parts per billion) of Arsenic. Therefore, the Weight Percent of Arsenic in the sample is:

(A) 1.6×10^{-10} % (B) 1.6×10^{-9} % (C) 1.6×10^{-6} % (D) 1.6×10^{-8} %

11. You want to prepare a 1.5 **molal** solution of Ethylene Glycol ($C_2H_6O_2$) in water. Approximately how many grams of Ethylene Glycol would you have to add to 600 grams of water to prepare this solution?

(A) 80 g (B) 65 g (C) 56 g (D) 41 g

12. What is the approximate NH_3 **Molarity** in a solution in which the NH_3 mass percent is 10% (solution density = 0.92 g/mL)?

(A) 6.5 M (B) 5.9 M (C) 3.7 M (D) 5.4 M

13. What is the approximate weight % of Glucose $C_6H_{12}O_6$ in an aqueous solution containing 0.80 **molal** Glucose?

(A) 12.6 % (B) 1.4 % (C) 14.4 % (D) 0.14%

Version B

14. When 2.0 grams of an Enzyme are dissolved in 600 mL of aqueous solution, the osmotic pressure at 25 °C is 9.5 torr. The Molar Mass of the Enzyme is approximately:

    (A) 4.4×10^3 g/mol (B) 6.5×10^3 g/mol (C) 2.3×10^3 g/mol

    (D) Cannot be determined without the Osmotic Pressure Depression Constant

15. What is the osmotic pressure, **in torr**, when 9.5×10^{-4} mol of the strong electrolyte, aluminum nitrate [$Al(NO_3)_3$] , is dissolved in 600 mL of aqueous solution at 25 °C?

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Version B

(12) 1. Consider the equilibrium between $N_2(g)$, $H_2(g)$, $NH_3(g)$:
$N_2(g) + 3\ H_2(g) \rightleftarrows 2\ NH_3(g)$. The value of K_c at 30 °C is 8.0. The Enthalpy change for this reaction is $\Delta H = -92.0$ kJ.

Calculate the temperature, **in °C,** at which the equilibrium constant, K_c, is 1.00×10^{-4}..

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$X_{EB} = \frac{n_{EB}}{n_{EB} + n_X} = 0.85$

$n_{EB} = 0.85\,n_{EB} + 0.85\,n_X$

$\therefore \quad 0.85\,n_X = n_{EB} - 0.85\,n_{EB} = 0.15\,n_{EB}$

$\therefore n_X = \frac{0.15\,n_{EB}}{0.85} = \frac{0.15(2.5)}{0.85} = 0.441\,mol\,X$

$M_X = \frac{mass\,X}{n_X} = \frac{50\,g}{0.441\,mol} = 113\,g/mol$