Notre Dame University
Faculty of Natural and Applied Sciences
Department of Sciences
Quantitative Analysis / CHM 215
Final Exam – Duration: 120 minutes
Spring 2009

Student Name:_____ **ID#:**_____

Key

This exam consists of three parts:

Part I: multiple-choice questions (2.5 points per questions); total points: 30 points
Part II: Problems (70 points)
Bonus question: 5 points

Part I: Multiple-choice questions

1– What does the ionization constant tell us about the strength of an acid?

a) **The larger the ionization constant, the stronger the acid**
b) The smaller the ionization constant, the weaker the acid
c) The ionization constant does not reflect the strength of an acid
d) The strength of an acid is inversely proportional to the ionization constant

2– Select the false statement about carbonic acid (H_2CO_3).

a) It is a diprotic acid
b) It is a weak acid
c) **Its neutralization includes 2 stages with 1 buffering regions**
d) Its half titration yield an amphiprotic species

3- Which solution will have the lowest pH value?

a) 0.1 M HCN ($Ka = 4.9 \times 10^{-10}$)
b) **0.1 M HNO_3**
c) 0.1 M NaCl
d) 0.1 M H_2CO_3
e) 0.1 M NaOH

4- Which one of the following statements on buffers is false?

a) The more the concentration of buffer components is large, the more the buffer capacity is important.
b) A buffer system is always composed from a weak acid and its conjugate weak Base
c) A buffer resists change in pH
d) The buffer capacity is the best when the concentration of the weak acid is equal to the concentration of its conjugate base
e) **All of the above are true**

5– Calculate the concentration of OH^- ions in a $1.4x10^{-3}$ M HCl solution.

a) 2.85
b) 1×10^{-7}
c) **7.14×10^{-12}**
d) 3×10^{-10}

6- Calculate the pH of the solution that results when 20.0 ml of 0.20 M formic acid are diluted to 45.0 ml with distilled water. (Ka for formic acid = 1.8×10^{-4})

a) 7
b) 4.7
c) 1.5
d) 3.8
e) **2.4**

7- Calculate the percent ionization of 0.0010 M CH_3COOH. (Ka = $1.75x10^{-5}$)

a) 10%
b) 15.5%
c) 20%
d) **12.5%**
e) 7%

8- In the Fajans method for signaling the end point in argentometric titration:

a) The indicator used is an adsorption indicator
b) The indicator used is fluoroscein
c) The end point is indicated by back titration
d) **Two of the above**
e) All of the above

9- Precipitation titration

a) Is based on weighing the mass of the precipitate obtained during precipitation
b) Is based on reactions that yield soluble complexes
c) **Is based on reactions that yield ionic compounds of limited solubility**
d) Includes EDTA titrations
e) None of the above

Questions 10 -12: During an argentometric titration where a 0.1 M $AgNO_3$ solution is used to titrate 50 mL of an NaBr solution:

10- Select the incorrect statement:

a) **pAg decreases as titration proceeds**
b) pAg increases as titration proceeds
c) At the equivalence point pAg = $pK_{sp}/2$
d) The equivalence point is characterized by a major change in pAg

11- If the equivalence point is obtained upon the addition of 100 mL of $AgNO_3$, this means that the initial concentration of NaBr is:

a) 0.1 M, since Ag+ react with sodium ion and with bromine ion with a 1:1 ration
b) **0.2 M**
c) 0.05 M
d) It is impossible to answer this question, since the [NaBr] is not given

12- Before the equivalence point, the Ag+ concentration can be computed from:

a) Ksp
b) Ksp and initial NaBr
c) **Ksp and excess NaBr**
d) Excess Ag+
e) Excess NaBr

Part II: Problems

1- Calculate the hydronium ion concentration in a solution that is 0.040 M in:
(H_3PO_4: $Ka_1 = 7.11 \times 10^{-3}$; $Ka_2 = 6.32 \times 10^{-8}$; $Ka_3 = 4.5 \times 10^{-13}$

a) Na_3PO_4 (7 points)

Answer: 1.18×10^{11}

3.35×10^{-13}

b) Na_2HPO_4 (7 points)

Answer: 2.4×10^{-10}

1.68×10^{-10}

2- Calculate the pH of a solution made by mixing 50.0 ml 0.2 M NH_4Cl (aq) and 75 mL of 0.1 M NaOH(aq). Kb (NH_3) = 1.8×10^{-5} at 25°C. (12 points)

Answer: 9.72

3- Calculate the potential of a platinum electrode immersed in a solution that is 0.0183 M in $K_3Fe(CN)_6$ and 0.00566 M in $K_4Fe(CN)_6$. (6 points)

E^o $Fe(CN)_6^{3-}/Fe(CN)_6^{4-}$ = 0.36 V

0.329 V

4- Calculate Ni^{2+} concentration in a solution that is buffered to a pH of 3 and prepared by mixing 50.0 ml of 0.025 M Ni^{2+} with: (K_{NiY}^{2-} = 4.2 x1018 ; α_4 at pH 3 = 2.51 x 10^{-11})

a) 25 mL of a 0.05 M EDTA solution (8 points)

Answer: 1.26 x 10^{-5}M

b) 50 ml of a 1.86% (m/v or g/100mL) EDTA (372.24 g/mol) solution. (8 points)

Answer: 9.52 x 10^{-9}

5- The solubility product constant for K_2PtCl_6 is 1.1×10^{-5} ($K_2PtCl_6 \Leftrightarrow 2K^+ + PtCl_6^{2-}$). What are the solubility of K_2PtCl_6 and the K^+ concentration of a solution prepared by mixing 50.0 ml of 0.4M KCl with 50.0 ml of:

a) water (3 points)

Answer: no solubility; K+ = 0.2 M

b) 0.4 M Pt Cl_6^{2-} (7 points)

Answer: 0.0105 M

6- Calculate the equilibrium constant for the reaction (10 points)

$$2MnO_4^- + 3Mn^{2+}\ 2H_2O \leftrightarrow 5MnO_2(s) + 4H^+$$

$E^o\ MnO_4^-/\ MnO_2 = +1.695$ V and $E^o\ MnO_2/\ Mn^{2+} = +1.23$ V

Hint: multiply equations by appropriate integers so that the numbers of electrons are equal.

Answer: 1.44×10^{47}

7- Concerning a redox titration in which 20 mL of 0.15 *M* Co^{3+} are titrated with 0.1 *M* Cu^+.

$Co^{3+} + Cu^+ \leftrightarrow Co^{2+} + Cu^{2+}$

$E°\ Co^{3+}/Co^{2+} = 1.8$ V; $E°\ Cu^{2+}/Cu^+ = 0.153$ V (12 points)

7 A- What is the electrode potential of the system after addition of 15 mL Cu^+? (6 points)

- **Answer: Dr. 1.8 V**
- **Remark $E°$ values have been changed to meet the values of the textbook**
- **Grading: similar distribution of points as before**

7 B- What is the electrode potential of the system at the equivalence point (30 mL Cu^{+})? (6 points)

- **Answer: Dr. 0.98 V**

- **Grading: similar distribution of points as before**

BONUS: A solution containing 4.48 ppm (or mg/L) $KMnO_4$ (158.04 g/mol) has a transmittance of 0.309 in a 1.0 cm cell at 520 nm. Calculate the molar absorptivity (ε) of KMnO4. (5 points)

ε= 18021 L/mol x cm