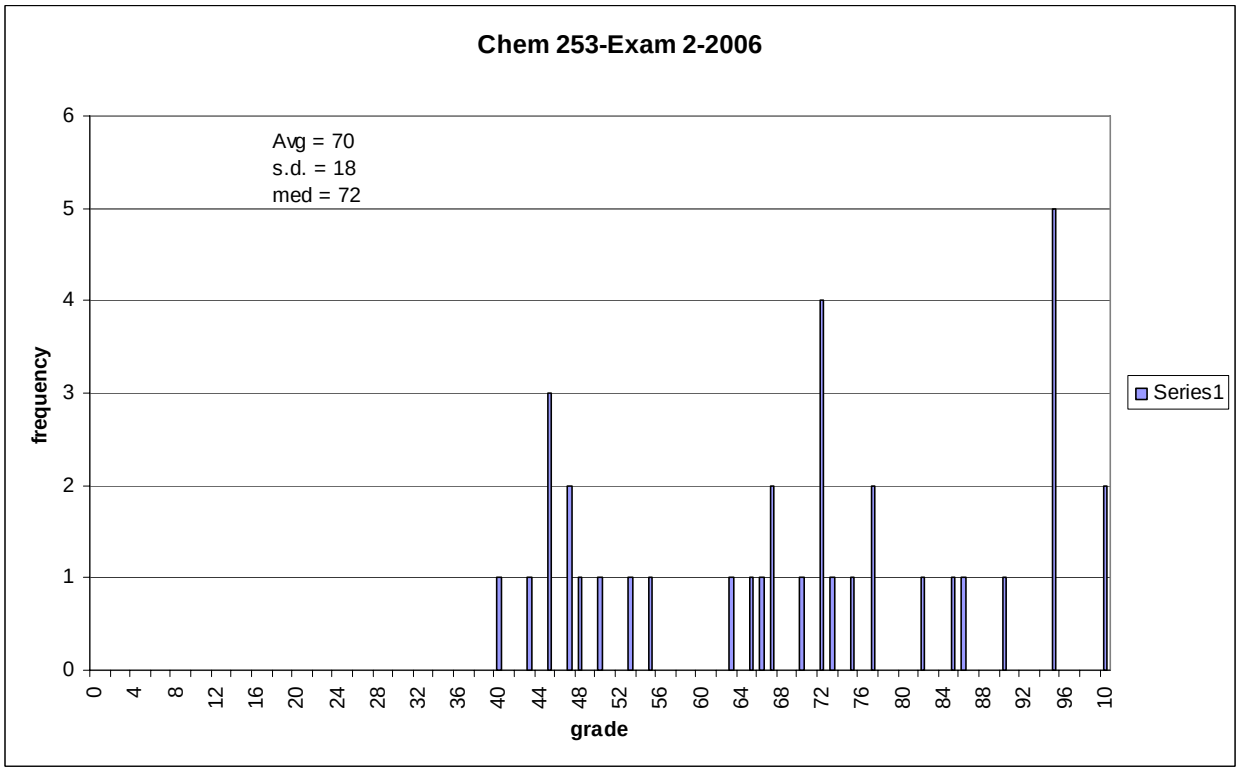
Chem 253 – Exam 2 – October 11, 2006



Read carefully

Use the scantron sheets to fill in your answers. Use the exam itself as scratch paper except for the last problem which you must turn in. Questions 1-15 are worth 5 points each. Question 16 is worth 25 points for a total of 100 on the entire exam. Question 16 is to be turned in with your scantron sheet at the end of the exam.

1] What is the pH of a solution that is initially 0.1 M Na_2HA?

$H_3A \rightleftarrows H_2A^- + H^+$ $\quad K_{a1} = 1.0\times10^{-4}$
$H_2A\text{-} \rightleftarrows HA^{2-} + H^+$ $\quad K_{a2} = 1.0\times10^{-7}$
$HA^{2-} \rightleftarrows A^{3-} + H^+$ $\quad K_{a3} = 1.0\times10^{-10}$

a) 8.5
b) 7.0
c) 6.5
d) 5.5
e) 10.0

2] What is the solubility of Hg_2Cl_2 ($K_{sp} = 1.2\times10^{-18}$) in 0.20 M NaCl?

a) 7.1×10^{-5} M
b) 3.0×10^{-17} M
c) 3.0×10^{-15} M
d) 8.0×10^{5} M
e) 1.0×10^{2} M

3] Calculate K_2 given K_1:

$A^- + H_2O \rightleftarrows HA + OH^-$ $\quad K_2 = ?$
$HA \rightleftarrows H^+ + A^-$ $\quad K_1 = 1.8\times10^{-7}$

a) 5.6×10^{-8}
b) 2.4×10^{-9}
c) 7.7×10^{-4}
d) 9.7×10^{-2}
e) 7.9×10^{-10}

4] Which of the following is the conjugate base for acetic acid?

a) CH_3COOH
b) $HCOOH$
c) CH_3COOCH_3
d) CH_3COO^-
e) $HCOO^-$

5] What is pH of a solution of a weak monoprotic acid that is initially 0.10 M (i.e. 0.10 F). Its K_a is 1.0×10^{-5}.

a) 3.0
b) 5.00
c) 3.00
d) 7.0
e) 9.01

6] What is the charge balance equation for a solution that is saturated with SrF_2?

K_{sp} (SrF_2) = 2.9×10^{-9} K_a (HF) = 6.8×10^{-4}

$SrF_2(s) = Sr^{2+} + 2F^-$
$F^- + H_2O = HF + OH^-$
$H_2O = H^+ + OH^-$

a) $2[Sr^{2+}] + [H^+] = [F^-] + [OH^-]$
b) $[Sr^{2+}] + [H^+] = 2[F^-] + [OH^-]$
c) $[Sr^{2+}] + [H^+] = [F^-] + [OH^-]$
d) $[Sr^{2+}] + [H^+] = 2[F^-] + 2[OH^-]$
e) $[F^-] = 2[OH^-] + [Sr^{2+}] + [H^+]$

7] 0.10 moles of MX_2 is dissolved in 1.00-L of water and undergoes the following reactions. What is the mass balance equation for this sequcnce? (problem 9-15 from Harris)

$M^{2+} + X^- = MX^+$ K_1
$MX^+ + X^- = MX_2(aq)$ K_2

a) $[MX_2] = [MX^+] + [M^{2+}]$
b) $[MX^+] + [M^{2+}] = [MX_2] + 2[X^-]$
c) $[MX^+] + [M^{2+}] = [MX_2] + [X^-]$
d) $[M^{2+}] + [MX^+] + 2[X^-] = [MX^+] + [MX_2]$
e) $0.10M = [MX_2] + [MX^+] + [M^{2+}]$

8] A diprotic acid H_2A has $K_{a1} = 1.0\times10^{-6}$, and K_{a2} 1.0×10^{-10}. Assume that the pH is 4.00. Which of the following would allow you to calculate the fraction (α)of this acid in the form of HA^- at pH 4.00?

a) $\dfrac{[H^+]^2}{[H^+]^2 + K_{a1}[H^+] + K_{a1}K_{a2}}$

b) $\dfrac{[H^+]}{[H^+]^2 + K_{a1}[H^+] + K_{a1}K_{a2}}$

c) $\dfrac{K_{a1}[H^+]}{[H^+]^2 + K_{a1}[H^+] + K_{a1}K_{a2}}$

d) $\dfrac{K_{a1}[H^+]}{[H^+]^2 + K_{a1}[H^+]^2 + K_{a1}K_{a2}}$

e) $\dfrac{K_{a1}K_{a2}}{[H^+]^2 + K_{a1}[H^+] + K_{a1}K_{a2}}$

9] What is pAg when 25.00 mL of 0.100 M $AgNO_3$ is added to 50.00 mL of 0.100 KCl?

K_{sp} (AgCl) = 1.8×10^{-8}

a) 12.42
b) 9.44
c) 1.75
d) 6.27
e) 1.11

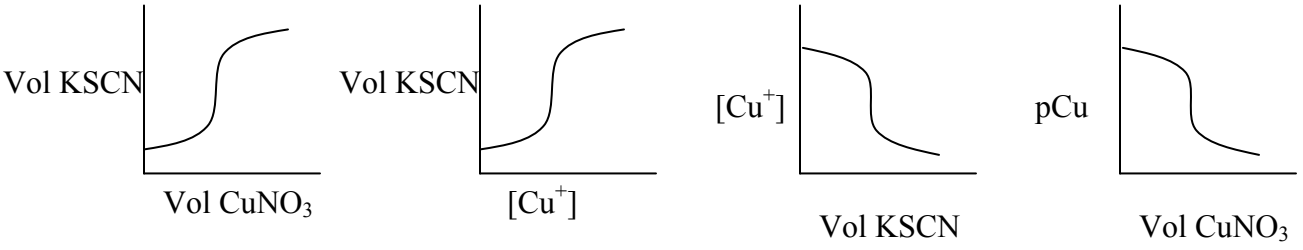
10] What is pAg when 50.00 mL of 0.100 M $AgNO_3$ is added to 50.00 mL of 0.100 KCl?

a) 3.87
b) 5.22
c) 8.43
d) 1.75
e) 3.23

11] What is pAg when 75.00 mL of 0.100 M $AgNO_3$ is added to 50.00 mL of 0.100 KCl?

a) 8.33
b) 5.91
c) 7.22
d) 1.70
e) 3.22

12] Which diagram best describes the curve for the titration of 50.0-mL of 0.100 M KSCN with 0.0500 M $CuNO_3$? The K_{sp} of CuSCN is 4.8e-15



I II III IV

a) I
b) II
c) III
d) IV

13] Why is it necessary to standardized solutions of NaOH titrant?

a) NaOH cannot be completely dried
b) NaOH reacts with HCl in the atmosphere
c) NaOH hydrolyzes and forms H_2O
d) NaOH is a primary standard and does not have to standardized.
e) NaOH reacts with H_2CO_3 and HCO_3^-

14] The useful pH buffer region for most weak acids is

a) $pK_a \pm 1$ pH
b) $pK_a \pm 0.5$ pH
c) $pK_a \pm 2$ pH
d) $pK_a \pm 0.1$ pH
e) $K_a \pm 1$ pH

15] The pH of solution of 0.10 M of a weak acid, HA is 4.67. What is K_a for this acid?

a) 2.1×10^{-5}
b) 4.6×10^{-9}
c) 5.7×10^{-7}
d) 1.2×10^{-11}
e) 7.3×10^{-8}

Name : _____

16] Problem 9-20 from the homework. Consider a saturated solution of $R_3NH^+Br^-$, where R is an organic group. Find the solubility of $R_3NH^+Br^-$ in a solution maintained at pH 9.50. (25 points)

$R_3NH^+Br^-(s) \rightleftarrows R_3NH^+ + Br^-$ $\quad K_{sp} = 4.0\times10^{-8}$
$R_3NH^+ \rightleftarrows R_3N + H^+$ $\quad K_a = 2.3\times10^{-9}$

Write down the correct MBE: _____ (5 points)

What should be solved for in order to obtain $R_3NH^+Br^-$ solubility? _____ (5 points)

Answer _____ (3 points)

Show work and reasoning for 12 points

Answers

1] a) pH = ½ (-log(1.0e-7) + -log(1.0e-10)) = 8.5

2] b)

Hg_2Cl_2	=	Hg_2^{2+}	+	$2Cl^-$
--		0		0.20
		+x		+2x
--		x		0.20+2x

$1.2\times10^{-18} = x(0.20+2x)^2$
$1.2\times10^{-18} \approx x(0.20)^2$
x = 3.0e-17

3] a)
$K_aK_b = K_w$
$K_b = K_w/K_a$ = 1.01e-14/1.8e-7 = 5.6e-8

4] d

5] c)

HA	=	H+	+	A-
0.10 M		0		0
-x		+x		+x
0.10-x		x		x

$1.0e\text{-}5 = x^2/(0.10-x)$
$1.0e\text{-}5 = x^2/0.10$
x = 1.0e-3
pH = 3.00

6] a) $2[Sr^{2+}] + [H^+] = [F^-] + [OH^-]$

7] e) $0.10M = [MX_2] + [MX^+] + [M^{2+}]$

8] c) $\dfrac{K_{a1}[H^+]}{[H^+]^2 + K_{a1}[H^+] + K_{a1}K_{a2}}$

9] d)
millimoles Ag^+ = 2.50
millimoles Cl^- = 5.00

excess Cl^- = 2.50 millimoles

$[Cl^-]$ = 2.50 mmoles/75.00 mL = 3.33e-2 M

$1.8\times10^{-8} = [Ag^+]$ 3.33e-2

$[Ag^+]$ = 5.4e-7
pAg = 6.27

10] a)
millimoles Ag^+ = 5.00
millimoles Cl^- = 5.00

equivalence point	$AgCl(s)$ =	Ag^+	+	Cl^-
	--	+x		+x

$x^2 = 1.8\times10^{-8}$
x = 1.34e-4
pAg = 3.87

11] d)
millimoles Ag^+ = 7.50
millimoles Cl^- = 5.00

excess Ag^+ = 2.50 mmoles
$[Ag^+]$ = 2.5 mmoles / 125.00 mL = 2.0e-2
pAg = 1.70

12] d

13] e

14] a

15] b $[H^+]$ = 2.13e-5 $K_a = [H^+][HA^-]/[HA] = (2.13e\text{-}5)^2/0.10 = 4.6e\text{-}9$

16] MBE: $[Br^-] = [R_3NH^+] + [R_3N]$ #1 (5 points)

$K_a = [H^+][R_3N]/[R_3NH^+]$ #2

$K_{sp} = [R_3NH^+][Br^-]$ #3

3 variables, 3 eqn

$[H+] = 10^{-9.50} = 3.2e\text{-}10$

If solve for $[Br^-]$ we find the solubility of $R_3NH^+Br^-$ (5 points)

Sub into MBE narrow it down to 2 variables

$[R_3N] = [R_3NH^+]\ K_a/[H^+] = 7.19\ [R_3NH^+]$

$[Br^-] = [R_3NH^+] + [R_3N]$

$[Br^-] = [R_3NH^+] + 7.19\ [R_3NH^+] = 8.19\ [R_3NH^+]$

$[R_3NH^+] = [Br^-] / 8.19$

Sub into Ksp

$K_{sp} = [R_3NH^+][\ Br^-] = 4.0\times10^{-8} = [Br^-]^2 / 8.19$

$[Br^-]= 5.7e\text{-}4$