Your Name: Key Section: ______

Chemistry 31 – Quantitative Analysis Exam #1, October 13, 2008 **Test Version #3**

Multiple Choice and Short Answer

Either circle the one correct answer from the choices listed, or enter the correct term on the blank line.

1 **(4 points).** In aqueous solution the sum of the pH and pOH is equal to:

a. $1x10^{14}$ (b.) 14
c. $1x10^{-14}$ d. 0

2 **(4 points).** What is the pH of a solution containing $1x10^{-5}$M NaOH?:

a. 5 (b.) 9
c. impossible to determine d. 7

3 **(4 points).** What is the correct answer with correct number of significant figures to the following calculation?

$$(2.667x10^{-6} * 45) + 1.24 \times 10^{-3}$$

→ $1.2x10^{-4}$
$+ 12.4x10^{-4}$
$13.6x10^{-4} = 1.36x10^{-3}$

(a.) $1.36x10^{-3}$ c. $1.360x10^{-3}$
b. $1.4x10^{-3}$ d. $1x10^{-3}$

4 **(4 points).** An ore sample contains 3.6735g of gold with an absolute uncertainty of 0.2mg. What is the relative uncertainty expressed in parts per million? ($1g = 10^3$mg)

$\frac{0.2}{3.6735x10^3} \times 10^6 = 50$ (1.5g/g)

a. $5x10^4$ppm d. 20ppm
(b.) 50ppm c. $5x10^{-5}$ppm

5 **(4 points).** Which solution has the highest concentration of hydroxide $[OH^-]$ ion?

Problem thrown out

~~a.~~ 0.10M solution of weak acid with $pK_a = 6$
b. 0.10M solution of weak acid with $pK_a = 3$
(c.) 0.10M solution of weak base with $pK_b = 9$
d. Cannot determine from the information given

6 **(4 points).** The major cause of experimental imprecision is random or indeterminate errors.

7 **(4 points).** For any population of data describing a Gaussian distribution, the probability that an additional data point will fall between ±2σ (standard deviations) from μ (the mean) is 95.5%. For a data set with μ = 48.63 and σ = 0.07, what is the chance that an additional data point will have a value greater than 48.77?

a. 4.5% b. 50%
d. 47.75% (c.) 2.25%

8 (4 points). Complex ion formation becomes an important effect at (a) lower or (b) higher ion concentrations relative to common ion effects? (circle a or b)

9 (4 points). A narrow Gaussian distribution indicates experimental data with (a) more or (b) less precision than a comparatively wider Gaussian distribution? (circle a or b)

Worked out Problems

It is your responsibility to work out your answers clearly. Unclear, or unreadable work will not be graded. If there is not enough space provided to show your work, continue on the back of the page and clearly mark the problem number. Be sure to show all of your work and report your final answer with the correct number of significant figures and units. Unless otherwise noted, an unreasonable number of significant figures in a final answer will be marked off 2 points. A correct answer without work shown will not receive credit. Circle or draw a box around your final answer.

10 (12 points). Given the following information:

$$C_6H_4(O)CO_{2(aq)}^{2-} + H_2O_{(l)} \xleftrightarrow{K_{b1}} C_6H_4(OH)CO_{2(aq)}^{-} + OH_{(aq)}^{-};\ pK_{b1} = 11.03$$
$$C_6H_4(OH)CO_{2(aq)}^{-} + H_2O_{(l)} \xleftrightarrow{K_{b2}} C_6H_4(OH)CO_2H_{(aq)} + OH_{(aq)}^{-};\ pK_{b2} = 1.3$$

should be switched

Give the correct balanced **chemical reaction** and **equilibrium expression** for when the acid $C_6H_4(OH)CO_2H$ is added to pure water. Only consider the dissociation of the first proton.

$$C_6H_4(OH)CO_2H_{(aq)} \rightleftharpoons C_6H_4(OH)CO_{2(aq)}^{-} + H^{+}_{(aq)}$$

~~pKa = ...~~ =

$$\frac{[C_6H_4(OH)CO_2^-][H^+]}{[C_6H_4(OH)CO_2H]} = K_{a1}$$

Due to switched pKb values in problem, any value for K, including Ka1, will be accepted.

11 (12 points). Determine the solubility (reported in moles/L) of $Ag_4Fe(CN)_{6(s)}$ in pure water if $K_{sp} = 8.5\times10^{-45}$ and:

$$Ag_4Fe(CN)_{6(s)} \longleftrightarrow 4Ag^{+}_{(aq)} + Fe(CN)_{6(aq)}^{4-}$$

$$[Ag^+]^4[Fe(CN)_6^{4-}] = 8.5\times10^{-45}$$

	Ag^+	$Fe(CN)_6^{4-}$
I	0	0
C	4x	x
E	+4x	+x

$$(4x)^4(x) = 8.5\times10^{-45}$$
$$256x^5 = 8.5\times10^{-45}$$
$$x = 5.0\times10^{-10}\ M$$

12 **(12 points)**. Calculate the following and report the answer with the absolute uncertainty (use the correct number of significant figures for full credit). Uncertainties given below are absolute.

$$\left(\frac{[4.97(\pm0.05) - 1.86(\pm0.03)] + 6.01(\pm0.04)}{21.2(\pm0.2)}\right)^2$$

abs $\left(\frac{9.12(\pm0.07)}{21.2(\pm0.2)}\right)^2$ $\sqrt{0.05^2+0.03^2+0.04^2} = 0.07$ abs

convert to relative

rel $\left(\frac{9.12(\pm7.7\times10^{-3})}{21.2(\pm9.4\times10^{-3})}\right)^2$ $\sqrt{(7.7\times10^{-3})^2+(9.4\times10^{-3})^2} = 0.012$ rel

rel $[0.430(\pm0.012)]^2$ $0.012\times2 = 0.024$ rel

rel 0.185 ± 0.024 rel

abs $0.185(\pm0.004)$ −2 pts for incorrect sig figs

13 **(12 points)**. What is $[SCN^-_{(aq)}]$ if we saturate a solution of 3.56×10^{-3}M Hg^{2+} with $Hg(SCN)_{2(s)}$? $K_{sp} = 2.8\times10^{-20}$

$$Hg(SCN)_{2(s)} \rightleftharpoons Hg^{2+}_{(aq)} + 2SCN^-_{(aq)}$$

$$[SCN^-]^2[Hg^{2+}] = 2.8\times10^{-20}$$

	Hg^{2+}	SCN^-
I	3.56×10^{-3}	0
C	$+x$	$+2x$
E	$3.56\times10^{-3}+x$	$2x$

$(2x)^2(3.56\times10^{-3}+x) = 2.8\times10^{-20}$ ← ignore x

$1.42\times10^{-2}x^2 = 2.8\times10^{-26}$

$x = 1.4\times10^{-9}$

$[SCN^-] = 2x = 2.8\times10^{-9}M$

14 (16 points). In a Kjeldahl titration, organic nitrogen is digested in sulfuric acid to convert all organic N into NH_4^+. The NH_4^+ is then converted into ammonia gas ($NH_{3(g)}$) and the ammonia gas is bubbled into a known volume of HCl with a known molarity.

$$NH_{3(g)} + H^+_{(aq)} \longrightarrow NH^+_{4(aq)}$$

Any left over $H^+_{(aq)}$ is then back titrated to the equivalence point by a known concentration of $OH^-_{(aq)}$.

$$OH^-_{(aq)} + H^+_{(aq)} \longrightarrow H_2O_{(l)}$$

The Kjeldahl procedure was used to analyze a sample containing 9.70 mg of protein. The liberated NH_3 was collected in 5.00mL of 0.0336M HCl. The remaining acid required 6.34mL of 0.010 M NaOH for complete titration. What is the weight percent of nitrogen in the protein? (the molecular weight of nitrogen is 14.01 g/mole)

moles H^+ added in forward titration:

$$5.00\,mL \left| \frac{0.0336\,mmol}{1\,mL} \right| = 0.168$$

moles H^+ needed to titrate NH_3

$$\begin{array}{r} 0.168 \\ -\,0.063 \\ \hline 0.105\,mmol \end{array}$$

moles OH^- added in back titration:

$$6.34\,mL \left| \frac{0.010\,mmol}{1\,mL} \right| = 0.063\,mmol$$

$$0.105\,mmol\ H^+ \left| \frac{1\,mmol\ NH_3}{1\,mmol\ H^+} \right| \frac{1\,mmol\ N}{1\,mmol\ NH_3} \left| \frac{14.01\,mg\ N}{1\,mmol\ N} \right| = 1.47\,mg\ N$$

$$\frac{1.47\,mg}{9.70\,mg} \times 100 = \boxed{15.1\%}$$

15 (Must be signed). I did not cheat on this test in any way. Signed: ____________