Your Name: Key Section: _____

Chemistry 31 – Quantitative Analysis Exam #1, March 4, 2009

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)**. For any weak acid HA and its conjugate base A^-, the sum of pK_a and pK_b equals:

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

2 **(4 points)**. What is the pH of a solution containing 1.0 M H^+?:

a. 1 b. 10
(c) 0 d. You cannot have $[H^+] = 1.0M$

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

$$(2.667x10^{-6} * 45.0) + 1.240 \times 10^{-3}$$ 1.204 x10⁻⁴

a. $1.36x10^{-3}$ (c) $1.360x10^{-3}$ 1.240x10⁻³
b. $1.4x10^{-3}$ d. $1x10^{-3}$ + 0.120 x10⁻³

4 **(4 points)**. An ore sample contains 3.674g of gold and has a *relative* uncertainty of 1.4 parts per thousand. What is the absolute uncertainty? ($1g = 10^3 mg$)

a. 5.1g d. 50mg
(b) 5mg c. 0.4mg

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

a. 0.10M solution of weak acid with $pK_a = 6$
(b) 0.10M solution of weak acid with $K_a = 1.0x10^{-3}$ 3
c. 0.10M solution of weak acid whose conjugate base has $pK_b = 9$ 5
d. Cannot determine from the information given

6 **(4 points)**. systematic errors lead to a decrease in accuracy.
determinate

7 **(4 points)**. In the absence of complex ion formation, the presence of a common ion will lead to:

a. an increase in solubility. d. no change in solubility.
(b) a decrease in solubility. c. none of the above.

8 **(4 points)**. The value 25.09874 ± 0.0793 should be reported as: 25.10 ± 0.08

9 **(4 points)**. In 2 complete sentences or less, describe what a confidence interval represents.

A confidence interval is a range of values that has a known probability of containing the true population mean.

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 for the weak acid H_2A:

$$H_2A_{(aq)} \xleftrightarrow{K_{a1}} HA^-_{(aq)} + H^+_{(aq)};\ pK_{a1} = 3.00$$
$$HA^-_{(aq)} \xleftrightarrow{K_{a2}} A^{2-}_{(aq)} + H^+_{(aq)};\ pK_{a2} = 9.00$$

Give the correct balanced **chemical reaction** and **equilibrium expression** (include the correct value for K_b) for when the base A^{2-} is added to pure water. Only consider the first association reaction.

$$A^{2-}_{(aq)} + H_2O_{(l)} \rightleftharpoons HA^-_{(aq)} + OH^-_{(aq)}$$

$$\frac{[OH^-][HA^-]}{[A^{2-}]} = 1 \times 10^{-5}$$

11 **(12 points)**. What is the solubility (reported in g/L) of BaF_2 in pure water? $K_{sp} = 1.5 \times 10^{-6}$, MW = 175.32g/mol, and:

$$BaF_{2(s)} \longleftrightarrow Ba^{2+}_{(aq)} + 2F^-_{(aq)}$$

$$[Ba^{2+}][F^-]^2 = 1.5 \times 10^{-6}$$

	Ba^{2+}	F^-
I	0	0
C	+x	+2x
E	x	2x

$$x(2x)^2 = 1.5 \times 10^{-6}$$
$$4x^3 = 1.5 \times 10^{-6}$$
$$x = 7.2 \times 10^{-3}\ \frac{mol}{L}\left(\frac{175.32g}{mol}\right) = \boxed{1.26\ g/L}$$

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.

$$\left(\frac{3.556(\pm 0.008)}{0.345(\pm 0.001)}\right)+\left(\frac{2.336(\pm 0.004)}{1.223(\pm 0.004)}\right)$$

$10.307 \pm \sqrt{(0.0022)^2+(0.0029)^2}$ (rel)

± 0.0036 rel

10.307 ± 0.038 abs

$1.910 \pm \sqrt{(0.0017)^2+(0.0033)^2}$ (rel)

± 0.0037 rel

1.910 ± 0.00707 abs

$12.217 \pm \sqrt{(0.038)^2+(0.00707)^2}$

12.217 ± 0.038

$\boxed{12.22 \pm 0.04}$

13 **(12 points)**. Consider the titration of 100.0mL of a solution containing 0.0945M Br^- with a solution of 0.165M Ag^+ as the titrant. What is the concentration of Ag^+ in the titration solution after 20.5mL of titrant have been added? The K_{sp} for AgBr is 5.0×10^{-13}.

titration rxn:

$Ag^+ + Br^+ \rightarrow AgBr_{(s)}$

equil rxn:

$AgBr_{(s)} \rightleftharpoons Ag^+ + Br^+$

$[Ag^+][Br^+] = 5.0\times10^{-13}$

	Ag^+	Br^-
I	0	0.0504
C	+x	+x
E	x	(0.0504+x)

moles of Br^-: $100.0\,mL \left|\frac{0.0945\,mmol}{1\,mL}\right| = 9.45\,mmol\,Br^-$

moles Ag^+ added: $20.5\,mL \left|\frac{0.165\,mmol}{1\,mL}\right| = 3.38\,mmol\,Ag^+$

mmol Br^- left over: $9.45 - 3.38 = 6.07\,mmol\,Br$

$\frac{6.07\,mmol\,Br}{120.5\,mL} = 0.0504\,M\,Br^-$

Ignore

$(x)(x+0.0504) = 5.0\times10^{-13}$

$x = \boxed{9.9\times10^{-12}\,M = [Ag^+]}$

14 (**16 points**). Limestone consists mainly of the mineral calcite, $CaCO_3$. The carbonate content of 0.5813g of powdered limestone was measured by suspending the powder in water, adding 10.00mL of 1.409M HCl, and heating to dissolve the solid and expel CO_2:

$$CaCO_{3(s)} + 2H^+_{(aq)} \longrightarrow Ca^{2+}_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$

The excess acid required 36.96 mL of 0.1004M NaOH for complete titration to a phenolphthalein end point. Find the weight percent of calcite in the limestone. The molecular weight of $CaCO_3$ is 100.087g/mole.

moles H^+ added: $10.00\,mL \left| \frac{1.409\,mmol}{1\,mL} \right| = 14.09\,mmol\ H^+$

moles OH^- added: $36.96\,mL \left| \frac{0.1004\,mmol}{1\,mL} \right| = 3.711\,mmol\ OH^-$

$14.09 - 3.711 = 10.38\,mmol\ H^+$ reacted with $CaCO_3$

$10.38\,mmol\ H^+ \left| \frac{1\,mmol\ CaCO_3}{2\,mmol\ H^+} \right| \left| \frac{1\,mol}{1000\,mmol} \right| \left| \frac{100.087\,g\ CaCO_3}{1\,mol\ CaCO_3} \right| = 0.5194\,g\ CaCO_3$

$$\frac{0.5194\,g\ CaCO_3}{0.5813\,g\ sample} \times 100 = \boxed{89.35\%}$$