Your Name: Key Section: _____

Chemistry 31 – Quantitative Analysis Exam #1, October 11, 2010

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 base B and its conjugate acid BH^+, the sum of pK_b and pK_a equals:

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

2 (**4 points**). What is the difference between the complex ion $PbI_{2(aq)}$ and the solid $PbI_{2(s)}$?:

a. no difference b. covalent versus ionic bonds
c. the empirical formula d. both c and b

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

$$35.969 - 18.0035 + 8.26x10^{-5}$$

a. 17.9656 c. 17.965
b. 18.0 d. 17.966

4 (**4 points**). Student A and B measured the percent chloride in the same solid sample. Student A's reported result was 53.55 (±0.03)%. Student B's reported result was 52.93 (±0.03)%. Reported precision represents 95% confidence intervals with n = 3. Which student has the more accurate result?

a. Student A d. They are equally accurate
b. Student B c. Impossible to know with the given information

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

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

6 (**4 points**). Systematic errors can be avoided by proper calibration and good experimental design.

7 (**4 points**). $AgI_{(s)}$ will have the greatest solubility in which solution? Do **not** consider complex ion formation or activities.

a. pure water d. a solution containing $1.0x10^{-4}$ M I^-
b. a solution containing $1.0x10^{-4}$ M Ag^+ c. b and d

8 **(4 points)**. Report with correct significant figures. 3.466344×10^2 (± 0.0062):

$346.634 (\pm 0.006)$ or $3.46634 (\pm 0.00006) \times 10^2$

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 base B:

$$B_{(aq)} \xleftarrow[+H_2O]{K_{b1}} BH^+_{(aq)} + OH^-_{(aq)};\ pK_{b1} = 6.00$$

$$BH^+_{(aq)} \xleftarrow[+H_2O]{K_{b2}} BH^{2+}_{(aq)} + OH^-_{(aq)};\ pK_{b2} = 13.00$$

Due to the mistake in the problem, this problem was counted as up to 6 points extra credit.

Give the correct balanced **chemical reaction** and **equilibrium expression** (include the correct value for K_a) for when the acid BH^+ is added to pure water. Only consider the acid dissociation.

$BH^+ \rightleftharpoons B + H^+$ or $BH^+ + H_2O \rightleftharpoons B + H_3O^+$

$$\frac{[H^+][B]}{[BH^+]} = 10^{-8}$$

11 **(12 points)**. What is the solubility (reported in mol/L) of $PbSO_{4(s)}$ in pure water? $K_{sp} = 6.3 \times 10^{-7}$, and:

$$PbSO_{4(s)} \longleftrightarrow Pb^{2+}_{(aq)} + SO^{2-}_{4(aq)}$$

$[Pb^{2+}][SO_4^{2-}] = 6.3 \times 10^{-7}$

	Pb^{2+}	SO_4^{2-}
i	0	0
C	+x	+x
E	x	x

$x^2 = 6.3 \times 10^{-7}$

$x = 7.9 \times 10^{-4}$ mol/L

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

$$\frac{4.97(\pm 0.05) - 1.86(\pm 0.01)}{21.1(\pm 0.2)}$$

$3.11 \pm \sqrt{0.05^2 + 0.01^2} = 0.05$, $\quad \frac{0.05}{3.11} = 1.64 \times 10^{-2}$

$\frac{0.2}{21.1} = 9.48 \times 10^{-3}$

$0.147 \pm \sqrt{(9.48 \times 10^{-3})^2 + (1.64 \times 10^{-2})^2} = 0.0189 = 2\%$

absolute $= 0.147(0.0189) = 0.003$

0.147 ± 0.003 absolute $\quad 0.147 \pm 2\%$ relative

13 **(12 points)**. What <u>minimum</u> mass (in grams) of $PbI_{2(s)}$ must be added to 2.0 liters of pure $H_2O_{(l)}$ to give a saturated solution of PbI_2? $K_{sp} = 7.9 \times 10^{-9}$, MW = 461.01 g/mole, and:

$$PbI_{2(s)} \longleftrightarrow Pb^{2+}_{(aq)} + 2I^-_{(aq)}$$

	Pb^{2+}	I^-
I	0	0
C	+x	+2x
E	x	2x

$[Pb^{2+}][I^-]^2 = 7.9 \times 10^{-9}$

$(x)(2x)^2 = 7.9 \times 10^{-9}$

$4x^3 = 7.9 \times 10^{-9}$

$x = 1.25 \times 10^{-3} \frac{mol}{L}(2L) = 2.51 \times 10^{-3} mol \left| \frac{461.01 g}{1 mol} \right|$

$= 1.16 g$

14 (**16 points**). Solution A contains 0.0450 M SO_4^{2-}. Solution B contains 0.500 M Ag^+. 15.00 mL of solution A are mixed with 15.00 mL of solution B. After equilibrium is reached, what is $[Ag^+]$ and $[SO_4^{2-}]$ in the final solution? The K_{sp} for $Ag_2SO_{4(s)}$ is 1.5×10^{-5}.

$$Ag_2SO_{4(s)} \rightleftharpoons 2Ag^+ + SO_4^{2-}$$

$$[Ag^+]^2[SO_4^{2-}] = 1.5 \times 10^{-5}$$

$$15.00\,mL\ A \left| \frac{0.0450\ mmol\ SO_4^{2-}}{1\,mL} \right| = 0.675\ mmol\ SO_4^{2-}\ (\text{limiting}) \left| \frac{2\ mmol\ Ag^+}{1\ mmol\ SO_4^{2-}} \right| = 1.35\ mmol\ Ag^+\ \text{used}$$

$$15.00\,mL\ B \left| \frac{0.500\ mmol\ Ag^+}{1\,mL} \right| = 7.50\ mmol\ Ag^+ - 1.35\ mmol\ Ag^+ = \frac{6.15\ mmol}{30\,mL}\ \text{left over}$$

$$= 0.205\,M\ Ag^+$$

	Ag^+	SO_4^{2-}
I	0.205	0
C	+2x	+x
E	0.205+2x	x

ignore

$$(0.205+2x)^2(x) = 1.5 \times 10^{-5}$$

$$2(3.6 \times 10^{-4}) << 0.205$$

$$x = \boxed{3.6 \times 10^{-4}\,M = [SO_4^{2-}]}$$

$$\boxed{[Ag^+] = 0.204\,M}$$