

Chem 303 Exam 1. March 8, 2007. In-Class Test

Name _____

Useful Information: , FW of iron(II) chloride = 126.9 g/mol, $\text{pH} = -\log[\text{H}_3\text{O}^+]$,

$$\text{pH} = \text{pK}_a + \log \frac{[\text{base}]}{[\text{acid}]} . \text{K}_a \cdot \text{K}_b = \text{K}_w, \text{ See problem 5 for color indicator information.}$$

(1) (30 pts) Little Suzy Perfect carefully measured 50.00 mL of 0.100 M (standardized) H_2SO_4 into a clean 250 mL beaker. She filled a buret to the 0.00 mL mark with standardized KMnO_4 solution that she had diluted so that it was 0.01000 M. She weighed 0.0500 g of a FeCl_2 -containing powder into a weigh boat and poured in into the beaker with H_2SO_4 . She titrated dropwise to the endpoint which was carefully measured to be at 6.55 mL of KMnO_4 .

She took the volume of KMnO_4 and multiplied by the molarity to find the moles of iron.

$$0.01000 \frac{\text{moles}}{\text{L}} \times 0.00655 \text{L} = 6.55 \times 10^{-5} \text{ moles}$$

Then, she converted the moles of iron to mg of FeCl_2

$$6.55 \times 10^{-5} \text{ moles Fe} \times 126.8 \frac{\text{g}}{\text{mol}} = 8.43 \times 10^{-3}$$

and then to mg

$$= 8.43 \text{ mg.}$$

The percentage of FeCl_2 was found to be

$$\frac{8.43 \text{ mg}}{50.0 \text{ mg}} \times 100\% = 19.6\%$$

Then, Big Joe Sloppy put ~50 mL of roughly 0.100 M H_2SO_4 into a clean 250 mL beaker. He filled a buret to the 0.56 mL mark with 0.01223 M KMnO_4 . He weighed 0.0577 g of a FeCl_2 -containing powder into a weigh boat and poured in into the beaker with H_2SO_4 . He reweighed the used weigh boat and subtracted the extra mass (0.0041 g) from his mass (for a final mass of 0.0536 g powder). He used 7.80 mL of KMnO_4 to titrate the sample.

He found that he used 9.53×10^{-5} mole of KMnO_4 and that is equal to 1.91×10^{-5} moles of Fe^{2+} .

$$0.00780 \text{L} \times 0.01223 \text{M} = 9.53 \times 10^{-5} \text{ moles}$$

He converted the moles of Fe^{2+} into mass of FeCl_2 .

$$(1.91 \times 10^{-5} \text{ moles Fe}) \times 126.8 \text{ g / mole} = 2.42 \times 10^{-3} \text{ g}$$

and this into mg (2.42 mg). The percentage of FeCl_2 in the powder was found to be 4.51%.

(a) List all of the determinant errors in the above procedures.

(b) List 3 instances with indeterminate error in the above procedure and state what the indeterminate error is.

(c) Explain how you could correct two of the determinant errors above.

(d) Who's value for the purity of the powder was most correct?

(2)(20 points) Analyses are often reported to the 95% confidence limit. What does that mean? In problem 1, if the two students listed their values at the 95% CL as $\pm 0.2\%$, could they both be right? Why or why not

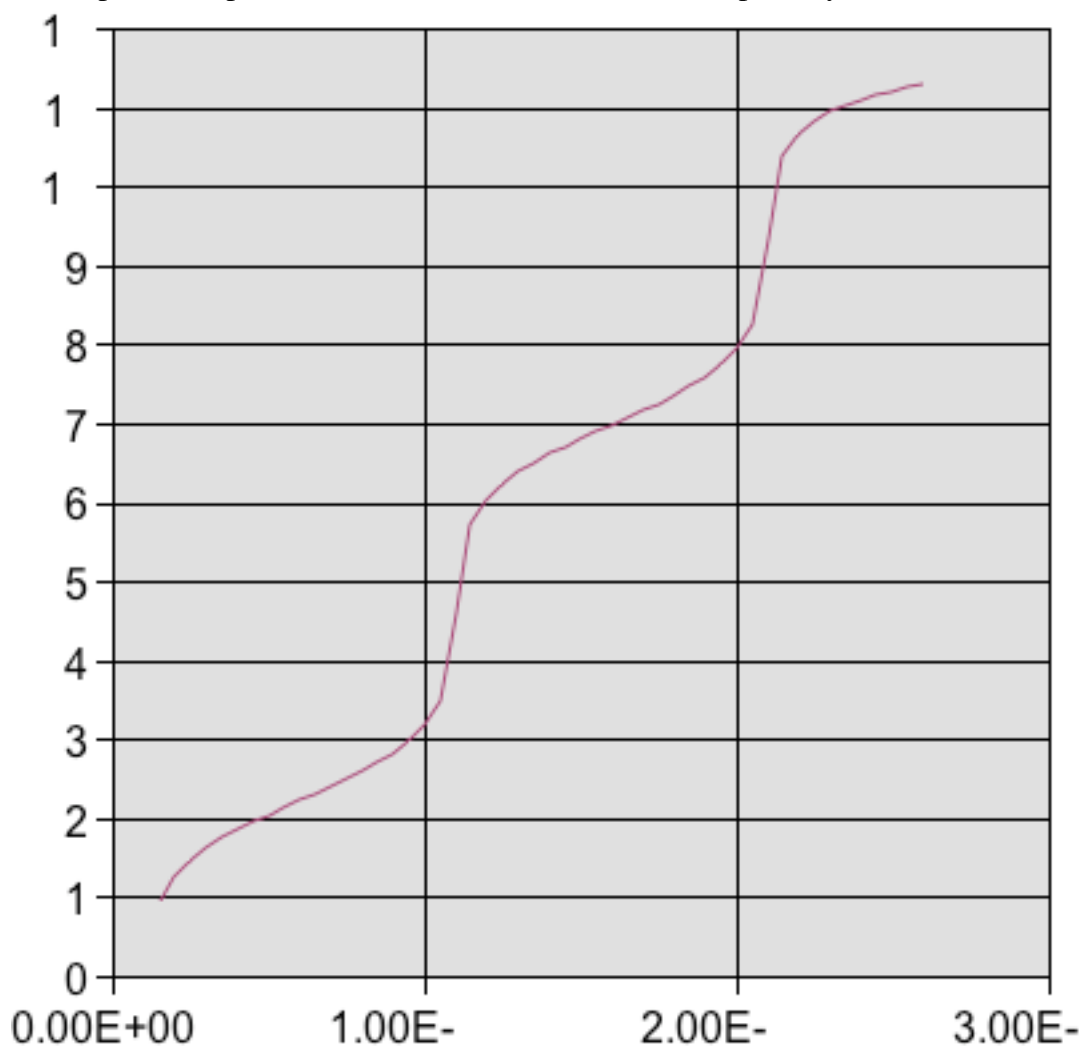
(3)(20 points) When is the “activity” of an ion significant (what are some of the factors or some situations)? When can the activity be accurately predicted and when can't it?

(4)(a) (15 points) If you wanted to make a pH 5.5 buffer, which of the following systems would be the best to use? Why?

Buffer System	K_a of the acid
$\text{NH}_3/\text{NH}_4^+$	5.6×10^{-10}
$\text{CH}_3\text{CO}_2\text{H}/\text{CH}_3\text{CO}_2^-$	1.8×10^{-5}
$\text{HONH}_2/\text{HONH}_3^+$	1.1×10^{-6}
$\text{HPO}_4^{2-}/\text{H}_2\text{PO}_4^-$	6.32×10^{-8}

(b)(15 pts) If 5.0 mL of 0.100 M HCl is added to 95.0 mL of distilled water (pH = 7.00), what is the change in pH? If 5.0 mL of 0.100 M HCl is added to 95.0 mL of a pH = 7.0 buffer (0.0500 M KH_2AsO_4 /0.0500 M K_2HAsO_4 K_{a2} for $\text{H}_3\text{AsO}_4 = 1.0 \times 10^{-7}$), what is the change in pH?

(5)(15 points) A pH monitored titration is shown below (pH on y-axis)



Indicator	pH of Transition
Crystal Violet	0.1-2.0
Congo Red	3.0-5.0
Bromcresol Green	3.8-5.3
Methyl Red	4.8-6.0
Phenol Red	6.4-8.0
Thymolphthalein	8.3-10.5
Alizarin Yellow	10.1-12.0

Given the data above, choose a set of color indicators that will let you determine the two endpoints for the titration. Explain why these are the best indicators and how you would use them (how would you find the endpoints).

Chem 3034 Exam 1. February 26, 2007. Take-Home Test

Name _____

You may use your textbook, and notes on this part of the exam. You may not work with other people on this part of the exam. You may use a spreadsheet to determine the activity coefficients, but you must include the spreadsheet (an understandable version) with your exam. Show ALL work for credit. This portion is due by 4:00 PM Friday, February 26.

(1) Statistics

Student Group 1 tests jars of Brand X peanut butter for Pb^{2+} level using Atomic Absorption Spectroscopy. Their results from their trials are: 95 ppb, 120 ppb, 124 ppb, 121 ppb, and 123 ppb

Student Group 2 tests a different brand (Brand Y) of peanut butter with the following result: 126 ppb, 126 ppb, 126 ppb, and 127 ppb.

(a)(5 points) Can a point be discarded by the Q test for either of the two samples above (if yes, show the work and discard the point for all other parts of this question)?

(b)(15 points) Calculate the means, standard deviations, and the error at 95% CL for the two samples

(c) (10 points) Can you say that one peanut butter brand is lower in lead than the other based on the data?

(d)(10 points) Use the F test to determine if there is a significant difference in the precision of the two tests (at the 95% CL).

(2) Calculate the $[\text{Pb}^{2+}]$ in each of the following solutions when saturated with barium fluoride ($K_{\text{sp}} = 3.0 \times 10^{-4}$).

(a)(5 pts) PbF_2 in distilled water (neglect activities)

(b)(15 pts) PbF_2 in distilled water (do NOT neglect activities). Use the Debye-Hückel equation for activities.

(3)(20 points) (Note: You may neglect activity for this problem) The students are trying to analyze tap water for Ca^{2+} content by adding NaF to precipitate CaF_2 . Using a F^- selective electrode, they can monitor the fluoride concentration in the solution.

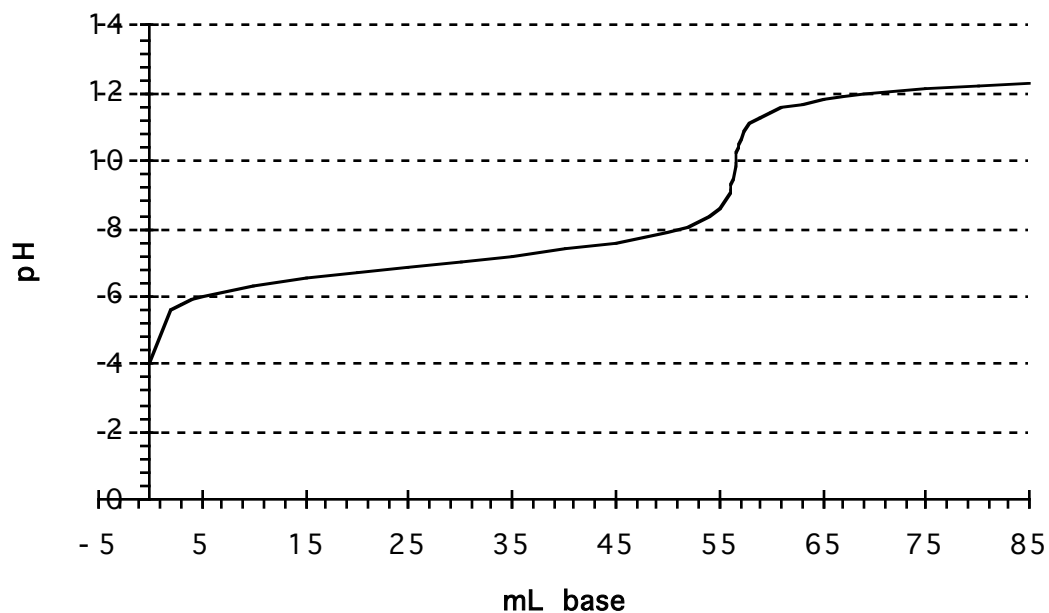
(a) At what $[\text{F}^-]$ should they stop the addition of NaF if they wish to precipitate at least 99% of the Ca^{2+} and the $[\text{Ca}^{2+}]$ in the water is expected to be between 1×10^{-5} and 1×10^{-3} ?

(b) If the water samples also contain 0.001 M Mg^{2+} , would this cause a problem?

(4) (10 points) How would you prepare a 1.00 L solution of pH = 10.00 buffer from Na_2CO_3 and NaHCO_3 with an ionic strength of 0.200?

(5) A 50.0 mL sample of a 0.100 M weak acid was titrated with NaOH.

Weak Acid/Strong Base Titration



pH	Volume
9.14	56.10
9.21	56.15
9.93	56.60
10.22	56.70
10.49	56.87
11.09	58.00

Indicator	pH of Transition
Congo Red	3.0-5.0
Methyl Red	4.8-6.0
Cresol Purple	7.6-9.2
Thymolphthalein	8.3-10.5
Alizarin yellow	10.1-12.0

(a)(5 points) What is the K_a of this acid (1 sig fig)?

(b)(5 points) If an indicator whose transition (blue to yellow) is between pH 6 and 7.5 was used, what problem would this cause? What would be observed in the titration as the transition was approached?

(c)(10 points) If one group used Cresol purple as an indicator and noticed the endpoint at 9.21 mL and the second group used thymolphthalein as the indicator and the endpoint was noted at pH = 10.49 what is the difference (in mL of NaOH) between the two groups? If their precision in titrating multiple samples was $\pm 2\%$, would the difference be statistically significant(why or why not)?

(6)(25 points) Construct the titration curve for a weak acid H_2SO_3 with a $K_{a1} = 1.2 \times 10^{-3}$ and $K_{a2} = 6.6 \times 10^{-8}$. Use a spreadsheet and plot the curve as in Problem 5 above. Use a 40.0 mL sample of the 0.100 M acid to start with and titrate it with 0.0885 M NaOH. List explicitly the initial pH and the equivalence point and its pH. Calculate the point for every 0.5 mL (on the mL). Include the worksheet as well as the graph (please explain it so it is easy to understand). Do you think a color indicator would work well with this titration?

(7)(10 points) Find the fractional composition of all species for a sample of phthalic acid in a pH = 8.00 buffer. See pages 216-217 in your textbook for some ideas.