Directions: 
(1) Put your name and signature on the free response part of the exam where indicated.
(2) Each multiple choice question is actually 2 questions on your scanning sheet. If you are sure of an answer, put the same answer down for both questions for 5 pts. If you cannot decide between two answers, put one answer down for one question and the other answer down for the other question. If you get one correct you'll get half credit for 2.5 pts. If there is an ambiguous multiple choice question, use the last page to explain your answer.
(3) Do NOT write on the envelope.
(4) Bubble in OPTION A on the scanning sheet IF you want your grade posted.
(5) When finished, put the free response answers in the envelope with the scanning sheet. You can keep the multiple choice part - the answers will be given to you as you leave.
(6) There are a total of 30 questions (18 actual questions).

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PART 1

1&2. ALL saturated solutions of CaCO₃ MUST have:

(1) Ksp = [Ca²⁺] + [CO₃²⁻]  
(2) [Ca²⁺] = [CO₃²⁻]  
(3) Ksp = [Ca²⁺][CO₃²⁻]

(a) 1 only  
(b) 1, 2  
(c) 1, 3  
(d) 2 only  
(e) 3 only

3&4. Which of the following salts has a pH greater than 7?

(a) Ba(NO₂)₂  
(b) (CH₃)₂NH₂Cl  
(c) KClO₄  
(d) NaCl  
(e) NH₄NO₃

5&6. The hydrolysis constant used when finding the pH of a solution of NH₄Cl is:

(a) \( \frac{K_w}{K_c} \) for Cl⁻  
(b) \( \frac{K_a}{K_w} \) for NH₄⁺  
(c) \( \frac{K_a}{K_c} \) for NH₄⁺  
(d) \( \frac{K_b}{K_w} \) for NH₄⁺  
(e) \( \frac{K_w}{K_b} \) for NH₃

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7&8. What will happen when equal volumes of 0.20 M of Pb(NO$_3$)$_2$ and 0.0020 M of NaCl are mixed?

(a) a precipitate will occur because Qsp > Ksp
(b) a precipitate will occur because Qsp < Ksp
(c) no precipitate will occur because Qsp > Ksp
(d) no precipitate will occur because Qsp < Ksp
(e) the mixture will explode

9&10. Calculate the number of moles of Sn(OH)$_4$ that will dissolve to make 1 liter of saturated solution at 25°C.
(Hint: Find the molar solubility.)

(a) 5 x 10$^{-20}$  (b) 6 x 10$^{-10}$  (c) 89 x 10$^{-30}$  (d) 1 x 10$^{-12}$  (e) 2 x 10$^{-9}$

11&12. The pH of a 0.0020 M solution of an unknown weak base is 8.10. What is the K$_b$ of the unknown base?

(a) 2.4 x 10$^{-9}$  (b) 7.9 x 10$^{-10}$  (c) 4.9 x 10$^{-11}$  (d) 6.0 x 10$^{-12}$  (e) 1.5 x 10$^{-9}$
13&14. What is the percent dissociation of HF in a 2.00 M solution of HF(aq)?

(a) 8.4%  (b) 7.0%  (c) 4.2%  (d) 0.52%  (e) 1.9%

15&16. To prepare a buffer solution using 100 mL of 0.10 M HCl, you can add to the solution:

(a) 50 mL of 0.10 M NaOH  (b) 100 mL of 0.10 M NaOH
(c) 150 mL of 0.10 M NH₃  (d) 100 mL of 0.10 M NH₃
(e) 50 mL of 0.10 M NH₃
17&18. CaF\textsubscript{2} is LEAST soluble in

(a) 0.10 M Ca(NO\textsubscript{3})\textsubscript{2}  
(b) 0.10 M NaNO\textsubscript{3}  
(c) 0.10 M NaF  
(d) pure water  
(e) it is equally soluble in all of these solutions

19&20. A solution is prepared by mixing 1.00 mol of NH\textsubscript{3} and 2.00 mol of NH\textsubscript{4}Cl in 1.00 liter of solution. To 300 mL of this solution is added 180 mL of 0.500 M NaOH. What is the pH of this solution?

(a) 8.54  
(b) 9.14  
(c) 9.71  
(d) 9.32  
(e) 8.78
The following 5 questions deal with a single titration:

**21&22.** A 100.0 mL sample of 0.200 \( M \) nitrous acid, \( \text{HNO}_2 \) (a weak acid), is titrated with 0.300 \( M \) NaOH. Calculate the initial pH before the titration is begun.

(a) 2.02  
(b) 2.27  
(c) 2.36  
(d) 2.49  
(e) 2.84

**23&24.** A 100.0 mL sample of 0.200 \( M \) nitrous acid, \( \text{HNO}_2 \) (a weak acid) is titrated with 0.300 \( M \) NaOH. Calculate the pH after 50.0 mL of 0.300 \( M \) NaOH has been added.

(a) 2.84  
(b) 3.51  
(c) 3.82  
(d) 3.97  
(e) 4.37
PART 2

(6 pts) **25.** A 100.0 mL sample of 0.200 M nitrous acid, HNO₂ (a weak acid) is titrated with 0.300 M NaOH. Calculate the pH at the equivalence point.

Will the solution be ACIDIC, BASIC, or NEUTRAL? (Circle the correct answer)

(5 pts) **26.** A 100.0 mL sample of 0.200 M nitrous acid, HNO₂ (a weak acid) is titrated with 0.300 M NaOH. Calculate the pH after 100.0 mL of 0.300 M NaOH is added.
(5 pts) **27.** A 100.0 mL sample of 0.200 M nitrous acid, HNO$_2$ (a weak acid) is titrated with 0.300 M NaOH. Using the answers to Questions 21-26, sketch the titration curve with pH on the vertical axis and milliliters of base added on the horizontal axis. Label the axes and plot your 4 points. Point out the buffer region and the equivalence point. If you cannot complete the calculations, sketch what the curve should look like for partial credit.

(3 pts) **28.** (a) Draw the particle view of a solution of HClO (aq).

(2 pts) (b) What is the strength of the acid: STRONG or WEAK? (Circle the correct answer)

(2 pts) (c) What is the size of the $K_a$ for the acid: LARGE or SMALL? (Circle the correct answer)
29. (a) Give an example of a salt derived from a weak base and a strong acid.

(b) Will an aqueous solution of the salt be ACIDIC, BASIC or NEUTRAL (circle the correct answer).

(c) Explain why. Include any relevant reactions and equilibria pertinent to your salt.

30. (a) All solutions of soluble salts and bases will become saturated if the concentrations are high enough. Write the equilibrium and the $K_{sp}$ expression for Ca(OH)$_2$(s).

(b) What will the pH be of a saturated solution of Ca(OH)$_2$ at 25°C if the [Ca$^{2+}$] is 0.10 M? You can find the $K_{sp}$ value on the chart.