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).

PART 1

1&2. Which of the following salts has the highest molar solubility?
(a) PbCl₂ (b) PbBr₂ (c) CaF₂ (d) BaF₂ (e) MgF₂

3&4. A 0.1 M solution of an electrolyte has a pH of 9. The electrolyte is a ________________ .
(a) strong acid (b) strong base (c) weak acid (d) weak base (e) neutral

5&6. Which of the following solutions is a buffer?
(a) 0.1 M HF and 0.2 M NaF
(b) 0.1 M NH₃ and 0.2 M NaCl
(c) 0.1 M KOH and 0.1 M KCN
(d) 0.1 M HCl and 0.3 M NaCl
(e) 0.1 M HClO₄ and 0.3 M NaClO₄
7&8. PbS would be least soluble in

(a) 0.10 M Pb(NO₃)₂
(b) 0.10 M Na₂S
(c) 0.10 M PbClO₃
(d) 0.10 M K₂S
(e) It is equally soluble in all of these solutions.

9&10. The pH of a 0.300 M solution of an unknown monoprotic weak acid is 4.25. What is the $K_a$ of the unknown acid?

(a) 5.9 x 10⁻⁶    (b) 3.9 x 10⁻⁹    (c) 1.1 x 10⁻⁸
(d) 4.0 x 10⁻⁵    (e) 6.3 x 10⁻⁷

11&12. What is the approximate pH of a solution that is 0.30 M in NH₃ and 0.10 M in NH₄Cl?

(a) 8.97    (b) 9.61    (c) 9.25    (d) 9.73    (e) 9.88
13&14. One liter of $2.0 \times 10^{-4}$ M NaF and one liter of $2.0 \times 10^{-5}$ M Ca(NO$_3$)$_2$ are mixed. What is the value of $Q_{sp}$ for CaF$_2$ in the final solution and will a precipitate form?

(a) $Q_{sp} = 1.0 \times 10^{-9}$; yes, a precipitate will form
(b) $Q_{sp} = 1.0 \times 10^{-13}$; no, a precipitate will not form
(c) $Q_{sp} = 4.0 \times 10^{-13}$; no, a precipitate will not form
(d) $Q_{sp} = 4.0 \times 10^{-9}$; yes, a precipitate will form
(e) $Q_{sp} = 3.9 \times 10^{-11}$; no, a precipitate will not form

15&16. Which of the following acid solutions (all at 0.10 M) has the lowest concentration of anion?

(a) HClO
(b) HCN
(c) HNO$_2$
(d) CH$_3$COOH
(e) CHO$_2$H
17&18. Suppose you have 100 mL of a 0.0010 M Mg(NO₃)₂ solution. If solid sodium hydroxide, NaOH, is slowly added to the beaker, at what pH would precipitation begin?

(a) 8.13  (b) 7.00  (c) 10.08  (d) 7.85  (e) 6.11

19&20. What is the pH of 0.25 M (CH₃)₃NHCl?

(a) 5.10  (b) 5.65  (c) 5.82  (d) 5.31  (e) 5.23
The following 5 questions deal with a single titration:

21&22. A 100.0 mL sample of 0.200 M formic acid, HCOOH, is titrated with 0.100 M NaOH. Calculate the initial pH before the titration is begun.

(a) 3.11  (b) 1.58  (c) 2.22  (d) 2.78  (e) 4.41

23&24. A 100.0 mL sample of 0.200 M formic acid, HCOOH, is titrated with 0.100 M NaOH. Calculate the pH after 50.0 mL of 0.100 M NaOH has been added.

(a) 3.57  (b) 3.90  (c) 3.74  (d) 3.34  (e) 3.27
(5 pts) **25.** A 100.0 mL sample of 0.200 \( M \) formic acid, HCOOH, is titrated with 0.100 \( M \) 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 \( M \) formic acid, HCOOH, is titrated with 0.100 \( M \) NaOH. Calculate the pH after 225 mL of 0.100 \( M \) NaOH is added.
(5 pts) **27.** A 100.0 mL sample of 0.200 M formic acid, HCOOH, is titrated with 0.100 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.

(5 pts) **28.** A buffer is prepared by mixing 2.00 mole of NH₃ and 1.00 moles of NH₄Cl in 1.00 liter solution. To 200. mL of this solution is added 30.0 mL of 3.00 M NaOH. What is the pH of the resulting solution?
(5 pts) **29.** What is the pH of a solution of NH₄Cl? (<7, =7, or >7)? Explain using an appropriate equilibrium.

(3 pts) **30.** (a) Explain what is happening in the beaker when a saturated solution of Au(OH)₃ is prepared by adding solid gold(III) hydroxide to pure water. Draw what is happening in solution to illustrate your point.

(5 pts) (b) Write the equilibrium and the K_{sp} expression for this system.

(2 pts) (c) Define molar solubility.

(5 pts) (d) Calculate the molar solubility, s, at 25°C, for Au(OH)₃.