CHE 226 **ANALYTICAL CHEMISTRY** **Fall 2004**

EXAM III – December 2, 2004

Name _____

WRITE YOUR NAME ON EACH EXAM PAGE NOW. THERE ARE 8 QUESTIONS AND 103 *PERCENT* TOTAL IN THIS EXAM.

Show clearly all work on these pages. ***Use the proper number of significant figures and the correct units in all final answers***. You must show your calculations and/or reasoning, ***including equations***, on a question to obtain any credit; no credit for answers appearing out of the blue. ***Your work must be understandable at the time it is being graded to obtain any partial credit.***

You do not have to do the *final* arithmetic on a question unless you need to have a numerical value for the next part of a question, *as long as the answer is expressed in its final form and all algebraic manipulations have been made*. Very little will be subtracted for routine arithmetic errors, but all numerical answers must be shown to the proper number of significant figures. Programmable calculators must have all memory erased. A calculator may be used, but not shared with anyone else. Tables of data and other information that may be useful are appended to the back of the exam. Use the backs of the pages as scrap paper. Anything written on the backs will be ignored unless you add an explanatory note on the front of the page.

Unless otherwise stated, assume all solutions are aqueous, density = 1.0000 g/mL; activity coefficients are unity (*i.e.*, activity = concentration); temperature, $T = 298$ K; $K_w = 1.008 \times 10^{-14}$.

QUESTION 1	_____ /6	QUESTION 7	_____ /14
QUESTION 2	_____ /8	QUESTION 8	_____ /34
QUESTION 3	_____ /6	QUESTION 9	_____ /
QUESTION 4	_____ /10	QUESTION 10	_____ /
QUESTION 5	_____ /10	QUESTION 11	_____ /
QUESTION 6	_____ /15	**TOTAL**	_____ /103

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Phosphoric acid, H_3PO_4, is very important in biological systems, even though it is a relatively simple inorganic acid. Often referred to as "inorganic phosphate" or "monophosphate", P_i, it is involved in a myriad of enzymatic and other biological reactions. Phosphate is a vital constituent of nucleotides and nucleic acids and a major component of calcium hydroxyapatite, $Ca_{10}(PO_4)_6(OH)_2$, which forms teeth and bones. Although the carbonate buffer primarily controls physiological pH in most mammals, phosphate also contributes to the buffering action.

The **pK_a's** for phosphoric acid, H_3PO_4, are 2.15, 7.20, and 12.15. **Questions #1-6** following immediately below deal directly with phosphoric acid and its acid-base properties.

1. (6 Points) Calculate the values of the **K_a's** for phosphoric acid.

2. (8 Points) The pH of blood is normally about 7.40 in healthy humans. Identify the two **predominant** chemical forms of phosphoric acid (or, "the phosphate system") at this pH, and calculate the concentration **ratio** of the basic to the acidic form.

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3. (6 Points) Calculate the theoretical pH of a 0.0500 M solution of Na_2HPO_4. Assume that **all** the simplifying assumptions that are typically used to reduce an acid-base system to *one controlling equilibrium* when calculating pHs are valid.

4. (10 Points) Now, calculate the theoretical pH of 0.0500 M Na_2HPO_4 using the full equation derived when none of the simplifying assumptions is made. [See the last page.]

5. (10 Points) Using the hydrogen ion **concentrations** obtained from Questions 3 and 4 above, calculate the **relative error in the hydrogen ion concentration** obtained in Question 3. [This assumes that the more extensive equation provides the "true value", or at least a better estimate of it.] Does the simple approach provide an *acceptable* level of error?