

FINAL EXAM – December 14, 2004

Name _____

WRITE YOUR NAME ON EACH EXAM PAGE NOW. THERE ARE 11 QUESTIONS AND 145 POINTS TOTAL IN THIS EXAM. FINAL % SCORE = # POINTS/135.

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 or for a statistical test, 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, $T = 298 \text{ K}$; $K_w = 1.008 \times 10^{-14}$.

QUESTION 1 _____ /20

QUESTION 7 _____ /5

QUESTION 2 _____ /10

QUESTION 8 _____ /10

QUESTION 3 _____ /10

QUESTION 9 _____ /15

QUESTION 4 _____ /10

QUESTION 10 _____ /10

QUESTION 5 _____ /30

QUESTION 11 _____ /10

QUESTION 6 _____ /15

TOTAL _____ /145

1. (20 Points) Tripolyphosphoric acid, $\text{H}_5\text{P}_3\text{O}_{10}$ was a common ingredient in high-phosphate detergents as its penta-sodium salt. It was relatively cheap, would make the washing solution quite basic, and was also a good complexing agent for sequestering ions in the tap water used and those extracted from the soiled clothes. It has largely been replaced in modern detergents because of concerns about excessive phosphate pollution of natural waters. For simplicity, designate the fully protonated acid as H_5TPP . The acid's five $\text{p}K_a$'s are listed as ~ 1 , ~ 2 , 2.79, 6.47, and 9.24, respectively.

(a) (10 Points) What would be the predominant chemical form of H_5TPP in natural waters, assuming the $\text{pH} = 7.00$? What fraction of the total TPP-containing forms present would this form constitute? [Remember, you do not need to do the *final* arithmetic.]

(b) (10 Points) It was stated that the penta-sodium salt of TPP makes a clothes-washing solution quite basic. Assume that you have a 0.50 M solution of Na_5TPP . Calculate the pH of that solution.

