WRITE YOUR NAME ON EACH EXAM PAGE NOW. THERE ARE 7 QUESTIONS AND 105 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, as long as the answer is expressed in its final form and all algebraic manipulations have been made. Little will be subtracted for routine arithmetic errors. A calculator may be used, but not shared with anyone else.

A sheet of scrap paper is at the back of the exam booklet. Tear it off now.

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 ___________ /21   Question 7 ___________ /18

QUESTION 2 ___________ /6   Question 8 ___________ /

QUESTION 3 ___________ /12   Question 9 ___________ /

QUESTION 4 ___________ /6   Question 10 ___________ /

QUESTION 5 ___________ /18   Question 11 ___________ /

QUESTION 6 ___________ /24   TOTAL ___________ /105
1. (21 points) Assume anhydrous calcium phosphate, Ca$_3$(PO$_4$)$_2$, molar mass = 310.18, is a "primary standard" compound. A 1.00-g sample of pure, dried calcium phosphate is dissolved carefully in excess dilute HCl, which essentially converts the phosphate ion into several of its protonated forms. The resultant solution is diluted to exactly 500.0 mL. Calculate the –

(a) Moles of calcium phosphate taken.

(b) Molar concentration of calcium ion in the final solution

(c) Parts per million (ppm) of phosphorus (P) in the final solution (NOT phosphate, but phosphorus). Atomic mass of phosphorus = 30.9737
2. (6 points) List two characteristics of indeterminate or random error.

3. (12 points) Define the following terms.
   a. Accuracy
   b. (Solvent) Autoprotolysis
   c. The median
4. (6 points) You are trying to estimate the total uncertainty in the level of nitrogen in the soil of a large test plot. A number of soil samples are randomly taken from different locations in this plot and prepared for analysis. From a series of experiments, you determine that the relative standard deviation in the sampling step itself is ±12% and that for the measurement step is ±5%. Calculate the overall relative standard deviation for the whole process.

5. (18 points) Calculate the absolute standard deviation for each of the following. Express the calculated result given for \( y \) and its standard deviation to the same significant digit. The numbers in parentheses are absolute standard deviations.

(a) \[ y = 10.2(\pm 0.2) - 3.54(\pm 0.2) = 6.66 \pm ? \]

(b) \[ y = 10.2(\pm 0.2) \times 3.54(\pm 0.2) = 36.108 \pm ? \]
6. (24 points) The following replicate values were obtained for the concentration of magnesium in a sample of river water:

36, 31, 37, and 40 µg/mL

Calculate the –

(a) Average or arithmetic mean, \( \bar{x} \).

(b) Standard deviation, \( s \).

(c) Standard error (or deviation) of the mean, \( s_m \).

(d) Can any of the values be rejected by the Q-test (at the 90% confidence level)? [Q Table is on p. 6]
7. (18 points) Calcium fluoride, CaF\textsubscript{2}, is a sparingly soluble salt with a $K_{sp} = 3.9 \times 10^{-11}$.

(a) Calculate its molar solubility in a saturated solution.

(b) Calculate its molar solubility in a saturated aqueous solution that is also 0.050 M in fluoride ion, F\textsuperscript{-}.

<table>
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<th>$Q_{\text{crit}}$ (Reject if $Q_{\text{calc}} &gt; Q_{\text{crit}}$)</th>
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