You may use your personal hand-calculator and an unmarked copy of your blue Statistical Handout.Helper and of your Periodic Table, but NO extra “scratch paper” (the backs of these test-pages should suffice).

LECTURE: (3.5 pts each)
For each question, choose the BEST answer and write the letter in the left margin next to the question.

1. In the weighing out of your KHP primary standard during the standardization process of your NaOH titrant, what did the TARE weight refer to in physical terms:
   a) the weight of the empty weighing bottle
   b) the weight of the weighing bottle plus KHP contents
   c) the zeroing of the balance, after carefully checking to be sure the balance is level
   d) the weight of the KHP sample used for analysis

2. What is special about a primary standard?
   a) It is something with Acid/Base properties
   b) It permits determination of the number of moles of species to high quality merely by drying and weighing
   c) It will always react 1:1 with the titrant
   d) It will always be an ionic species, as molecular species cannot be titrated.
   e) all of the above

3. In calculating the % analyte for a single sample which is analyzed by a titration process, how many high-quality pieces of measurement data are needed? (NOTE the word “single”; we are NOT talking about replicate measurements here.)
   a) 1
   b) 2
   c) 3
   d) 4
   e) 5

4. What is it that distinguishes a measurement from a number?
   a) the presence of a numeric interval caused by systematic error
   b) a numeric interval attributable to a poor quality instrument
   c) gross error
   d) a numeric interval attributable to random error
   e) a numeric interval attributable to careless work

5. The result of the operation (0.4042g - 0.4022g) has how many significant figures?
   a) 1
   b) 2
   c) 3
   d) 4
   e) 5

6. What’s the fundamental distinction between the absolute uncertainty and the sample standard deviation?
   a) the absolute uncertainty refers to accuracy; the sample standard deviation refers to reproducibility.
   b) the sample standard deviation has units of measurement; the absolute uncertainty does not.
   c) absolute uncertainty refers to one measurement; sample standard deviation refers to a replicate set of measurements.
   d) the absolute uncertainty will not be influenced by systematic error; the sample standard deviation will be influenced by systematic error.

(continued next page)
7. You have heard a number of time in this course the statement “Given the fact that two values are numerically different, are they really different?”. What is meant by this statement, in statistical terms?
   a) Are you able to separate effects of Random Error from a real effect?
   b) Are you able to separate effects of Random Error from a Systematic Error?
   c) Are you able to separate effects of Gross Error from a Systematic Error?
   d) Are you able to separate and identify the 3 different kinds of Error?
   e) Is there an outlier present in your measurement values?

8. In your KHP determination instructions you read “... accurately (+/- 0.1 mg) weigh out a KHP sample whose 'target weight' is 0.7 g...”. What does this mean in terms of what you actually do in lab?
   a) Use a tenth-gram balance. Place the KHP on a piece of weighing paper on the balance and stop when the balance indicates 0.7 g.
   b) Use a tenths-gram balance. Tare the weighing bottle+KHP contents to zero. Transfer some KHP to your titrating flask and re-weigh. Continue process until the balance indicates -0.7 g.
   c) Use the analytical balance. Place the KHP on a piece of weighing paper on the balance and stop when the balance indicates a “7” in the tenths-place of the balance. Record all 4 decimal places.
   d) Use the analytical balance. Tare the weighing bottle+KHP contents to zero. Transfer some KHP to your titrating flask and re-weigh. Continue process until the balance indicates a “7” in the tenths-place of the balance. Record all 4 decimal places.

9. The true value of your KHP determination is 38.76% KHP. You hand in as your best estimate 38.55% KHP. What is the % Error?
   a) (38.55)/(38.76)
   b) (100)(38.76 - 38.55)/38.76
   c) (100)(38.76 - 38.55)/38.55
   d) None of the above. The true answer is: ______________________ (Insert your own calcn)

10. Suppose the true weight of some object is 1.260 g. You see a statement that says “... the sample mean was 1.234 g with a 95% confidence interval of 0.016 g”. This may be interpreted as which of the following:
   a) You are 95% sure that the actual sample mean is to be found within the range 1.218 g to 1.250 g.
   b) You are 95% sure of the effect of random error on the value of your sample mean.
   c) You may be 95% sure that there is a real systematic difference between the true value and your measurements.
   d) All of the above
   e) None of the above

11. In the question immediately above, suppose that you wished to change the confidence interval from 95% to 99%. Which of the following is true?
   a) The value of the mean would remain unchanged, but the value of the C.I. would increase.
   b) The value of the mean would remain unchanged, but the value of the C.I. would decrease.
   c) The value of the mean would increase, and the value of the C.I. would increase.
   d) The value of the mean would decrease, but the value of the C.I. would increase.
   e) The change of confidence level from 95% to 99% is to be accomplished by increasing the number of replicate measurements.

12. If you wish to compare a single measurement of weight with a single measurement of volume to see which is the better measurement, what must you do?
   a) Perform a Q-test; the measurement which gives the smaller calculated Q value is the better measurement.
   b) Calculate the % Relative Standard Deviation for both; the measurement with the lower %RSD will be the better measurement.
   c) Calculate the % Relative Uncertainty for both; the measurement with the lower % Relative Uncertainty will be the better measurement.
   d) Determine the absolute uncertainty for both; the measurement with the smaller absolute uncertainty will be the better measurement.
SHORT ANSWERS:

A. (6 pts) For each below, give the equilibrium equation and the \( K \) expression as specified:

\[ K_{\text{sp}} \text{ for } \text{Ag}_3\text{PO}_4 \]

\[ K_a \text{ for } \text{C}_6\text{H}_5\text{COOH} \]

B. (12 pts) If \( K_b \) for \( \text{CH}_3\text{NH}_2 = 5.0 \times 10^{-4} \), \( pK_b = \quad \), conjugate is \quad .

If \( pK_a \) for \( \text{HPO}_4^{2-} = 12.67 \), \( K_a = \quad \), conjugate is \quad .

If \( \text{pH} = 6.75 \), \( [\text{H}_3\text{O}^+] = \quad \), \( \text{pOH} = \quad \).

If \( [\text{OH}^-] = 0.15 \text{ M} \), \( [\text{H}_2\text{O}^+] = \quad \), \( \text{pH} = \quad \).

PROBLEM SOLVING:

1. (10 pts) You’ve standardized your NaOH solution, obtaining as your average value 0.1088 for the molarity of NaOH (MW = 40.00). But you’re a bit cautious and decide to do a couple of more “just to be sure”. You’ve learned that the slowest part of the whole process is the weighing step. Using your NaOH titrant, what is the largest weight of primary standard KHP (MW = 204.2) that you can weigh out without getting into trouble in the resulting titration? (Note: “getting into trouble” means needing more than 50.00 mL of titrant to reach the end point for the titration.) SHOW A ONE-LINE SET-UP FOR THE CALCN.
2. (10 pts) The “0.4% rule” says that for the first set of titrations you do, if your %RSD (for the sake of this problem, calculated using the Sum of Squares Method) is 0.4% or less, no more titrations need be done, but the average value of these results can be used immediately. In standardizing your NaOH solution, you get the following values for the NaOH molarity:

0.1032, 0.1040, 0.1041, 0.1031 \quad (\bar{y} = 0.1044; \bar{y}^2 = 0.01090036)

Do you need to do any more titrations? EXPLAIN WITH A SENTENCE SHOWING YOUR REASONING. A SIMPLE “YES” OR “NO” WILL EARN YOU NO CREDIT.

3. (20 pts) In cleaning your buret you notice what appears to be a flaw in the buret at about the 35-mL mark. Cleaning the buret fails to make any difference, and others tell you this flaw is of no consequence, but you decide to check the buret’s calibration. You do this in the following fashion: You adjust the meniscus to the 30-mL mark, let out water and stop when the meniscus reaches the 40-mL mark. You make these readings and adjustments as exactly as you can, of course. By weighing the water delivered and knowing water’s density you can determine how many mL of water you actually delivered. Performing this operation 6 times yields the following data in mL: 9.57, 9.51, 10.00, 10.01, 10.01, 9.56 \quad (\sum y = 58.66; \sum y^2 = 5738.8188)

a) Using statistics to make decisions depends on having replicate measurements. SHOW how you, in fact, know that these are replicates.

b) What is the decision limit you will be using in this work?

c) At the 95% level of confidence, is the buret accurate? SHOW ALL YOUR WORK AND EXPLAIN YOUR REASONING WITH A COHERENT SENTENCE. A SIMPLE “YES” OR “NO” WILL EARN YOU NO CREDIT.

Honor Pledge: I have neither given nor received any unacknowledged help on this test.
Signed, ________________________________