Allow two consecutive hours (but not at a time when you have another scheduled class) for taking this test. You may use your personal hand-calculator and your blue Statistical Handout-Helper page, but NO extra scratch paper (the backs of these test-pages should suffice).

LECTURE: 48 pts. (3 pts each)
For each question, choose the BEST answer and write the letter in the left margin next to the question.

1. 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

2. What is it that distinguishes a Real Effect from a Systematic Error?
   a) the former will be of a larger magnitude than the latter
   b) the latter is apt to have a negative impact while the former is apt to have a positive impact
   c) knowledge on the part of the person doing the work
   d) a Confidence interval can deal with the latter but not the former
   e) none of the above

3. 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?

4. 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 difference between the true value and your measurements.
   d) All of the above
   e) None of the above

5. What is special about a primary standard?
   a) It is something with Acid/Base properties
   b) It permits determination of the number of mmoles of species to high quality merely by drying and weighing
   c) It always react 1:1 with the titrant
   d) It always be an ionic species, as molecular species cannot be titrated.
   e) all of the above
6. When preparing the NaOH titrant solution, why do you have to boil the water?
   a) to sterilize the solution
   b) to remove CO₂ because the CO₂ can react with the OH⁻ and raise the OH⁻ concentration.
   c) to remove CO₂ because the CO₂ can react with the HP⁻ in the flask and change the number of millimoles of HP⁻ before any OH⁻ is even added.
   d) to add O₂ to the solution by agitating the solution. The added O₂ provides a sharper color change.
   e) to remove CO₂ because the CO₂ ultimately could form carbonate and possibly interfere with the indicator’s action.

7. 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) \(\frac{38.55}{38.76}\)
   b) \(100\frac{38.76 - 38.55}{38.76}\)
   c) \(100\frac{38.76 - 38.55}{38.55}\)
   d) None of the above. The true answer is: __________________________ (Insert your own calcn)

8. Of the contributing influences which determine the value of a measurement, where is a TARE weight to be found?
   a) in the zeroing process
   b) in the Real Effect stage
   c) as a contributor to Random Error
   d) as an unknown systematic error
   e) none of the above

9. What is it that is the distinguishing characteristic of a Controlled Major Reaction:
   a) the reactants are mixed together a mL at a time (or less)
   b) the concentrations of each reactant are known to a high level of quality
   c) the Bulk Formulae of the reactants are specified throughout the reaction
   d) the reaction is carried out so that both reactants are Limiting Reagents
   e) none of the above.

10. You wish to check your balance for the presence of systematic error. You zero the balance and place a known weight on the pan. You repeat this process a number of times. What are the values you get going to look like, assuming the balance is actually correctly calibrated?
    a) the values you get will all be the value of the known weight; after all, you are measuring a standard
    b) you will get a range of values to one side (the right or left) of the known weight value
    c) you will get a range of values centered on the known weight value
    d) until you perform the operation, it is impossible to predict what will happen, because of the presence of systematic and random error.
11. This course began the discussion of measurements with the concept of a “numeric interval”. Later the discussion included the Gaussian Distribution. In Gaussian terms, what is the “numeric interval” most usefully related to:
   a) Confidence Limits
   b) The theoretical standard deviation for the Gaussian Distribution, $F$.
   c) The uncertainty associated with the instrument performing a single measurement.
   d) The Range of measurement values obtained from a set of replicates.

12. You carry out a determination for %KHP by titrating 5 samples to a %RSD of 0.33%. You obtain and report a mean value of 45.67 %KHP. A 95% CI for your data is 0.06 %KHP. You later learn that the true value for this sample has a value of 45.62 %KHP. What are you entitled to conclude?
   a) There was no gross error present in your work
   b) There was no systematic error present in your work
   c) The system was under statistical control in your work
   d) The % error for your work was 0.11%
   e) All of the above
   f) Only 2 of the above

13. If solid CaC$_2$O$_4$ is mixed into a liter of pure water, and $x$ mmoles of the compound dissolves at equilibrium, it is also true that
   a) the solubility of calcium oxalate = $10^{-3} \times x$ mmol/mL
   b) the concentration of dissolved oxalate ions = $10^{-3} \times x$ M
   c) the value of the $K_{sp}$ for CaC$_2$O$_4$ = $10^{-6} \times x^2$
   d) all of the above
   e) none of the above
   f) only two of the above

14. If solid calcium fluoride is added to a liter of pure water, the salt dissolves to a very small extent. At equilibrium, $[F^-] = 4.2 \times 10^{-4}$ M. What is the solubility of CaF$_2$, and what is the $K_{sp}$ for CaF$_2$?
   a) $4.2 \times 10^{-4}$ M, and $1.8 \times 10^{-7}$
   b) $4.2 \times 10^{-4}$ M, and $8.8 \times 10^{-8}$
   c) $4.2 \times 10^{-4}$ M, and $3.7 \times 10^{-11}$
   d) $2.1 \times 10^{-4}$ M, and $3.7 \times 10^{-11}$
   e) $2.1 \times 10^{-4}$ M, and $8.8 \times 10^{-8}$

15. Several drops of 0.10 M AgNO$_3$ solution are added to an insoluble mixture of Ag$_2$SO$_4$ in water. Which of the following consequences is true?
   a) The added AgNO$_3$ decreases the solubility of Ag$_2$SO$_4$, because more Ag$^+$ ions are in the solution.
   b) The added AgNO$_3$ increases the solubility of Ag$_2$SO$_4$, because more Ag$^+$ ions are in the solution.
   c) The solubility of Ag$_2$SO$_4$ is not affected, because the $K_{sp}$ of Ag$_2$SO$_4$ does not change.
   d) The solubility of Ag$_2$SO$_4$ is affected but in an unpredictable way, because we do not know how the $K_{sp}$ value has changed.
16. If a substance (which we shall symbolize \( RXH_2 \) in “generic” fashion) has a \( K_b \) value = \( 3 \times 10^{-5} \) when in aqueous solution, it is also true that
a) element X is a nitrogen atom
b) the conjugate is \( RXH_2^+ \)
c) the conjugate is a weak acid with a \( K_a \)
d) the conjugate can itself be a weak base in water
e) all of the above
f) only 2 of the above.

(27 pts) Fill in appropriate values or formulas to complete the following table:

If \( K_b \) for \( CO_3^{2-} = 2.1 \times 10^{-4} \),  \( pK_b = \) _______; its conjugate is _______

If \( pK_a \) for \( H_2PO_4^- = 7.21 \), \( K_a = \) _______; its conjugate is _______

If \([OH^-] = 0.00012 \text{ M}, \)  \( pOH = \) _______, \( pH = \) _______, and \([H_3O^+] = \) ____________

If \( pOH = -0.82, \) \([OH^-] = \) ___________, \( pH = \) __________, and \([H_3O^+] = \) ____________

If \( pOH = 5.53, \) \( pH = \) __________, and \([H_3O^+] = \) ____________

In a mixture containing 0.30M KI and solid AgI (\( K_{sp} = 8.5 \times 10^{-17} \)), \( pK_{sp} = \) _______

and \([Ag^+] = \) ____________

Within an aqueous mixture of HNO\(_3\) and CH\(_3\)CO\(_2\)H\(_2\), what is the counter ion? __________

If \( K_a \) for HCOOH = \( 1.8 \times 10^{-4} \), what is the \( K_a \) expression?

and what is the reaction equation?

In the H\(_3\)PO\(_4\) “family” at equilibrium, what family member has a \( K_b \) value but no \( K_a \) value? __________

PROBLEMS (53 pts): Show All Work; Method must be clear; Sig Figs and Units count.

1. (8 pts) Part I. In these days of cold and ice, you’re getting very tired of having to chip ice off your windshield every day. You find yourself attracted to an ad for MAGICMELT, a product which is being promoted which will not only free your windshield of ice, it will also clear up your windshield from dirt and grease. This sounds so good you buy a bottle and you talk 6 of your friends into each buying a bottle. When you open it, your chemistry knowledge tells you that you’ve been had (and you had better hope your friends have no chemistry knowledge). What you smell is nothing more than the unmistakable aroma of regular ammonia (\( NH_3, \) \( MW = 17.00, \) specific gravity = 0.987, \( K_b = 1.8 \times 10^{-5} \)). When you get over your frustration at having been suckered, you read the label more carefully and find that yes, indeed, the magic ingredient is a 3.4% (by weight) solution of ammonia.
What is the Molarity of this product as it comes out of the bottle?

(12 pts) Part II. Having been made suspicious of the whole MAGICMELT corporation, you decide that maybe you’d better to check to see if they actually are putting in as much ammonia as is stated on the label. You go and collect all 7 bottles and carry out an analysis for ammonia employing your newly-acquired Chem 112 acid/base titration skills. What you obtain as % NH$_3$ values is the following: 3.38, 3.41, 3.21, 2.86, 3.26, 3.37, and 3.33.

With 95% confidence, can you state whether the MAGICMELT corporation can be held accountable for having put too little ammonia in their product? SHOW ALL YOUR WORK, COMPLETE WITH REASONING, AND STATE YOUR CONCLUSION IN A COHERENT SENTENCE (A simple “Yes” or “No” will cause a reduction in credit).

2. This whole MAGICMELT experience has given you a case of heartburn, so you turn to old reliable Tums for relief. It turns out that what gives you your relief is another acid/base reaction. The active ingredient in Tums is Calcium Carbonate (CaCO$_3$, MW = 100) where the CO$_3^{2-}$ ion is capable of neutralizing two H$_3$O$^+$ particles. It turns out to be possible to analyze for the amount of CaCO$_3$ in Tums through an acid/base titration. Suppose you take 5 tablets of Tums, whose total weight is 5.2367 g, dissolve them completely, and titrate the resulting solution with an HCl titrant which has been standardized to a value of 0.1024 M. The titration is carried out so that the carbonate ion is completely neutralized. If the volume needed to reach the equivalence point is 36.88 mL

a) (8 pts) What is the % CaCO$_3$ present in Tums?

b) (5 pts) Assuming that each tablet weighs the same, how much Calcium (Ca, MW = 40.00) in mg, do you ingest when you chew up one Tums tablet?
3. Given these $K_{sp}$ values: $\text{Ag}_2\text{SO}_4 = 1.2 \times 10^{-5}$, $\text{AgCl} = 1.8 \times 10^{-10}$, $\text{AgSCN} = 1.0 \times 10^{-12}$

An aqueous solution contains $3.0 \times 10^{-3}$ of each of these anions: $\text{SO}_4^{2-}$, $\text{Cl}^-$, and $\text{SCN}^-$. A concentrated solution of $\text{AgNO}_3$ is added in tiny portions (negligible volume affect) to cause precipitation to occur.

a) (8 pts) SHOW by calculations and thorough understanding statement what concentration of $[\text{Ag}^+]$ would be best for separating $\text{SO}_4^{2-}$ from the other anions. (Explain how this is a separation.)

b) (6 pts) What would be the concentration of $\text{Ag}^+$ in the solution at the moment that $\text{AgCl}$ just begins to start precipitating?

c) (6 pts) At the moment that $\text{AgCl}$ just begins to start precipitating, what will be the concentration of $\text{SCN}^-$ and of $\text{SO}_4^{2-}$ in the solution?

Pledge: I have neither given nor received any unacknowledged aid on this test.
Signed: ______________________________