Lecture: Multiple Choice -- (33 pts) 3 points each.
Choose the BEST answer and write the letter in the left margin next to the question.

1) The warped “bell-curve-like” shape which was generated for the distribution curve of densities for your 1st lab exercise can be said to be a consequence of:
   a) the presence of systematic error in your measurements
   b) the presence of no systematic error in your measurements
   c) the presence of gross error in your measurements
   d) the presence of no gross error in your measurements
   e) the presence of random error in your measurements
   f) the presence of no random error in your measurements’
   g) answers a) and e)
   h) answers a), c) and e)

2) A solution contains HP⁻ ions which are to be titrated. If an additional 25 mL of water is added before the titration process begins, which of the following is true:
   a) The conc of HP⁻ will change, introducing a systematic error into the titration process.
   b) An extra 25 mL of water needs to be added to the titrant to counterbalance that added to the titration flask.
   c) The number of mmoles of HP⁻ is unaffected by the dilution process, but the greater total volume will require the addition of greater amount of titrant.
   d) The number of mmoles of HP⁻ is unaffected by dilution so the same number of mmoles of OH⁻ will be needed. There is no resulting systematic error.

3) In this course, you have been posed the question, “Given the fact that two values are numerically different, are they really different?”. What is meant by this question 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) 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.
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 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

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.

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) (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)

8). If you were to see the phrase, “. . . 95% confidence limits are 5.50 cm to 6.50 cm . . .”, what are you 95% sure of?
a) The true length lies in the range 5.50 cm to 6.50 cm.
b) The confidence interval is +/- 0.50 cm
c) The best estimate of the true value is 6.00 cm
d) A value outside this range has only a 5% chance of occurring because of presence of random error.
e) All of the above.

9) You decide you wish to check your balance for the presence of any systematic error. You obtain from the National Institute of Standards and Technology an official weight whose certified value is given as 50.0723 g. You weigh the NIST weight on your balance 6 times, carefully using the prescribed proper set of instructions. How are you going to decide if no systematic error is present?
a) If any of your measurement values are 15.0723, then the balance is OK.
b) If the % RSD for your measurements is < 0.4% then the balance is OK
c) After a satisfactory Q-test, if a 95% C.I. around the mean of your 6 values excludes the value 50.0723, then you will conclude the balance is free from systematic error.
d) After a satisfactory Q-test, if a 95% C.I. around the mean of your 6 values includes the value 50.0723, then you will conclude the balance is free from systematic error.
e) You need to get a mean value of 50.0723 in order to conclude that the balance is free from systematic error.
10) We’ve introduced the phrase “. . . by Professional Agreement . . . “ in this course. What do we mean by this expression?

a) The % Relative Uncertainty for any measurement value is assumed to be +/- 0.1% if no other information is available.

b) The Absolute Uncertainty for any measurement value is assumed to be +/- 1 in the last recorded digit if no other information is available.

c) It is necessary to eliminate systematic errors from all measurements before calculating a confidence interval, and that responsibility falls on the person doing the experimental work.

d) We will accept either the use of a mean or a median as our measure of central tendency, as either measure is equally valid.

e) It is necessary to perform a Q-test before starting in on any statistical manipulation of replicate measurements.

11) Which of the following statements apply to both a major rxn and a minor rxn?

a) can be characterized by a $K_{eq}$ expression

b) implies the presence of a limiting reagent

c) can be used as a titration reaction

d) rxn takes place at the particle level

e) all of the above

Lecture – (60 pts) Short answers. Be precise and concise

1. (9 pts) a) Define what is meant by the term measurement.

   b) Identify the three component parts that constitute a measurement.

2. (11 pts) Given the generic chemical reaction: $aA + bB \leftrightarrow cC + dD$

   a) write the expression implied by the symbol $K_{eq}$, the equilibrium constant

   b) Write the expression implied by the symbol $Q$, the reaction quotient

   c) Explain (an example would help) how $K_{eq}$, $Q$, and the Principle of Le Chatlier are interrelated.
3. (12 pts) Write the balanced equilibrium reaction and appropriate \( K \) expression, for each of these:

a) \( K_w = 1.00 \times 10^{-14} \)

b) \( K_a \) for \( HPO_4^{2-} = 2.2 \times 10^{-13} \)

c) \( K_b \) for \( HPO_4^{2-} = 1.6 \times 10^{-7} \)

d) What is the relationship between \( K_a \) for \( HPO_4^{2-} \) and \( K_b \) for \( HPO_4^{2-} \) ?

4. (10 pts) a) Draw and identify all components (regions and junctions) of the pH line.

b) Without doing any calculations, indicate HOW (by means of what kind of calculation) the pH is to be determined for a system which can be described as:

   i) a Type V system

   j) a Type II system

5. (18 pts) Fill in appropriate values or formulas to complete the following table.

<table>
<thead>
<tr>
<th>( HOAc ), ( K_a = 1.8 \times 10^{-5} )</th>
<th>Conjugate =</th>
<th>( pK_a = )</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH(_3)CH(_2)NH(_2), ( pK_b = 10.81 )</td>
<td>Conjugate =</td>
<td>( K_b = )</td>
</tr>
<tr>
<td>HNO(_3) ( [H_3O^+] = 0.0010 ) M</td>
<td>Counter ion =</td>
<td>( pOH = )</td>
</tr>
</tbody>
</table>
1. (10 pts) With the recent snow and ice, you had to make use of the deicing feature present in your windshield washer, but it didn’t work as well as you’d like. You find out that the important ingredient that does the deicing in your windshield washer fluid is ethylene glycol and that it is supposed to be present in the windshield washer fluid to an amount of 3.4% by weight. You’re suspicious that the windshield washer fluid is low in ethylene glycol, so you decide to employ your newly-acquired analytical/decision-making skills. You carefully sample your windshield fluid 7 times and analyze each sample for % ethylene glycol by weight (never mind how; you’ll find out probably next year). What you obtain are the following values for % ethylene glycol: 3.41, 3.21, 2.86, 3.38, 3.26, 3.37, and 3.33

With 95% confidence, what do you decide regarding whether the % ethylene glycol in your windshield washer fluid is lower than it should be? SHOW ALL WORK, COMPLETE WITH REASONING, AND STATE YOUR CONCLUSION IN A COHERENT SENTENCE. (Merely answering “yes” or “no” will cause a reduction in credit)

2. (8 pts) In your working in the laboratory, maybe in performing the analysis for % ethylene glycol mentioned above, you find a recipe which needs 0.50 L of a 0.15 M HCl (MW = 36.50) solution. When you approach the Kindly Old Professor and politely inquire as to how you can get this solution, that churlish hound hands you a bottle of concentrated HCl, whose concentration of HCl = 12.0 M, and tells you that you need to prepare it yourself. Muttering about the incivility of “some people”, you go about the task on your own.

a) How much, in ml, of the concentrated HCl are you going to need to do the job?

b) What lab equipment (i.e., balances, glassware, etc.) do you decide will be appropriate to do the job? Explain your reasoning for full credit.
3. (8 pts) All this lab work has made you sick to your stomach, so you decide to take some medication for relief. A suggested remedy is Milk of Magnesia, whose active ingredient is Mg(OH)$_2$ (MW = 58.34). But now you’re wondering what the % by weight of Mg(OH)$_2$ is in Milk of Magnesia (this analytical stuff is like a sickness), so you decide to analyze for %Mg(OH)$_2$ by titrating with a HCl titrant whose concentration has been standardized to a value of 0.1195 M HCl. You carefully weigh out a sample of Milk of Magnesia whose weight is 2.7720 g and titrate so that complete titration is achieved. It takes you 42.38 mL of the HCl titrant to get to the equivalence point. What is the % Mg(OH)$_2$ in the sample?

4. (6 pts) You perform the one titration above, and you’d like to do replicate determinations for %Mg(OH)$_2$, but you’ve run out of standardized HCl titrant, and when you approach the Kindly Old Professor and ask for more, he tells you you’ll have to standardize your own (he’s not very helpful). It turns out that 4-aminopyridine (MW = 94.12) is a primary standard that reacts with HCl in a 1:1 molar ratio. You weigh out .4764 g of this dried primary standard, and you find it takes 40.17 mL to achieve a satisfactory titration for a solution of HCl which you’ve prepared. What is the molarity of the HCl solution?

Please write and sign the pledge.