CHEM 3451 Quantitative Analysis
Fall 2011

Course Description: CHEM 3451 is designed to introduce students to the theory and practice of the quantitative aspects of the basic analytical chemistry. Topics to be discussed in lecture include solution preparation, statistical analysis, equilibrium calculations, titration analysis, electrochemistry, spectrophotometry, and introductory instrumental analysis. (Quant. Lab. CHEM 3452 is a separate course)

(Notice: CHEM 3451 requires extensive calculations based on chemical equilibriums)

Course Objectives:
• Introduce QA as a measurement science that bridges wide range of scientific disciplines.
• Enhance understanding of statistical terminology and its QA applications.
• Provide practices of volumetric and gravimetric analysis.
• Introduce modern instrumental analysis.

Instructor: Dr. Oliver Chyan,
Voice (940)565-3463 , Chemistry Building, room 156
E-mail: Chyan@unt.edu


Class Schedule: Tuesday/Thursday, 9:30 - 10:50 AM.
At the Chemistry Building, room 106

Office Hours: (Tuesday & Thursday, 11 -12:30 AM) (or by arrangements if need extra help.)

Exams: Three terms exams will tentatively be held on Tuesdays of Sept. 20, Oct. 11, and Nov. 15. Please plan accordingly. The average of three exams will be counted as 75% toward final grade. Your lowest term exam score may be dropped provided you take ALL three exams and receive >45% on EVERY exam. Then, the other two higher exam grades will be counted 37.5 % each toward the final grade. Final exam (25% grade) will be comprehensive.

Missing Exam: Plan your schedule accordingly. If you must miss an exam, permission (with proper documentation) must be obtained in advance. Medical absence requires proper doctor’s statement.

Homework: Working the problems is very important to achieve better understanding of materials taught and good grade in the class. A copy of the solution manual (UNT Eagle Commons library reserved # STR 19733) with detailed answers to the problems is reserved in
the science library. *Note: the solution manual is not errors free.* Extra credit will be given for the completed homework submitted in time, see following section.

**Attendance Policy:** Class attendance is highly recommended and will be monitored periodically. Students who miss the class are responsible for all the missed class materials that may not be addressed by the instructor in a subsequent class.

**Grading Scale:**

<table>
<thead>
<tr>
<th>Final percent Average</th>
<th>Letter Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 - 100 %</td>
<td>A</td>
</tr>
<tr>
<td>80 - 89 %</td>
<td>B</td>
</tr>
<tr>
<td>70 - 79 %</td>
<td>C</td>
</tr>
<tr>
<td>60 - 69 %</td>
<td>D</td>
</tr>
<tr>
<td>Below 60 %</td>
<td>F</td>
</tr>
</tbody>
</table>

*Note:*

*I reserve the right to make changes/modifications of the syllabus if needed.*

The Chemistry Department believes in reasonably accommodating individuals with disabilities and complies with university policy established under Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act (1990) to provide equal access and opportunity. Please communicate with your professor as to your specific needs and/or the office of Disability Accommodation (ODA) (Room 321, Union, 565-4323).

**Academic Ethics:** A high level of ethical conduct will be maintained in this course. Any evidence of an act of academic dishonesty during the exams will result in an automatic F and expulsion from this course. Please adhere to University policies and the UNT Code of Conduct and Discipline with respect to academic ethics and honesty.

[http://www.unt.edu/csrr/development/dishonesty.html](http://www.unt.edu/csrr/development/dishonesty.html)
[http://vpaa.unt.edu/academic-integrity.htm](http://vpaa.unt.edu/academic-integrity.htm)

**NOTICE FOR CHEM 3452 (QUANT LAB)**

Lab starts on the week of August 29:
1st lab: Check in/Lab Safety.

No lab on the Labor Day Week.
Extra credit: 0.5 point bonus for each completed homework handed in. You are also welcomed to discuss with TAs for help on the homework problems. You can earn maximum of 6 bonus points added to your final grade. [For example, 75(C) becomes 81(B)]. Important! No extra credit for late homework or direct copy from the solution manual.

Where to hand in: Chemistry room 174

When: due each Friday 12 PM as scheduled below.

<table>
<thead>
<tr>
<th>Week of</th>
<th>Due date</th>
<th>Chapters</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd week /Labor day</td>
<td>Sept 9 (#1)</td>
<td>Chapters 1, 2</td>
</tr>
<tr>
<td>3rd week</td>
<td>Sept 16 (#2)</td>
<td>Chapter 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>1st exam: Sept. 20 (Tuesday) Chapter 1 to 4</strong></td>
</tr>
<tr>
<td>4th week</td>
<td>Sept 23 (#3)</td>
<td>Chapter 4</td>
</tr>
<tr>
<td>5th week</td>
<td>Sept 30 (#4)</td>
<td>Chapter 5</td>
</tr>
<tr>
<td>6th week</td>
<td>Oct 7 (#5)</td>
<td>Chapter 6,7</td>
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<tr>
<td></td>
<td></td>
<td><strong>2nd exam: Oct. 11 (Tuesday) Chapter 5 to 8</strong></td>
</tr>
<tr>
<td>7th week</td>
<td>Oct 14 (#6)</td>
<td>Chapter 8</td>
</tr>
<tr>
<td>8th week</td>
<td>Oct 21 (#7)</td>
<td>Chapter 9, 10</td>
</tr>
<tr>
<td>9th week</td>
<td>Oct 28 (#8)</td>
<td>Chapter 11</td>
</tr>
<tr>
<td>10th week</td>
<td>Nov 4 (#9)</td>
<td>Chapter 12</td>
</tr>
<tr>
<td>11th week</td>
<td>Nov 11 (#10)</td>
<td>Chapter 14</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>3rd exam: Nov. 15. (Tuesday) Chapters 9-12, 14</strong></td>
</tr>
<tr>
<td>12th week</td>
<td>Nov 18 (#11)</td>
<td>Chapter 15</td>
</tr>
<tr>
<td>13th week</td>
<td>Nov 25 (#12)</td>
<td>Chapter 16</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Final exam: Dec. 13 (Tuesday) 8-10 AM, Comprehensive</strong></td>
</tr>
</tbody>
</table>
### Assigned Homework Problems

**Solution Manual (Eagle Commons Library reserved # STR 19733)**

**Fundamental Skills**
- **Ch. 0** The Analytical Process
- **Ch. 1** Measurements
- **Ch. 2** Tools of the Trade
- **Ch. 3** Experimental Error
- **Ch. 4** Statistics
- **Ch. 5** QA and Calibration
- **Ch. 6** Chemical Equilibrium

**Assigned Problems**
- 3, 4, 5, 12, 13, 14, 17, 20, 22, 23, 24, 28, 29, 31, 32, 34

**Titrimetric Methods of Analysis**
- **Ch. 7** Let the Titrations Begin
- **Ch. 8** Activity & Systematic Treatment
- **Ch. 9** Monoprotic Acid-Base Equilibria
- **Ch. 10** Polyprotic Acid-Base Equilibria
- **Ch. 11** Acid-Base Titrations

**Assigned Problems**
- 2-5, 8-12, 14, 16, 18, 19, 21, 22, 24, 28
- 1-4, 6, 8, 10, 12, 15-20, 22, 24-26
- 1-3, 5-8, 11-13, 15, 18, 21-23, 26-28, 30
- 32, 34, 37, 38, 40
- 4-6, 11-18, 20, 23, 25, 29, 30
- 1-4, 6, 8, 12-14, 19, 23, 29, 31, 36, 37, 42, 45, 49, 50
- 1-3, 5, 6, 13, 22, 23, 26, 28, 31, 32

**Electroanalytical Methods of Analysis**
- **Ch. 14** Fundamentals of Electrochemistry
- **Ch. 15** Electrodes and Potentiometry
- **Ch. 16** Redox Titrations

**Assigned Problems**
- 5-10, 12, 14, 15, 16-21, 24-28, 32, 34, 35, 37, 41, 44, 46
- 1, 2, 6, 8, 9, 13, 20, 21, 24, 29, 30, 32, 34, 38
- 1, 4, 7-11, 13, 14, 17, 18, 19, 21-27

**Spectroscopic Methods of Analysis**
- **Ch. 19** Fundamentals of Spectrophotometry
- **Ch. 20** Applications of Spectrophotometry
- **Ch. 21** Spectrophotometers
- **Ch. 22** Atomic Spectroscopy

**Assigned Problems**

**Chromatographic Methods of Analysis**
- **Ch. 23** Introduction to Analytical Separations
- **Ch. 24** Gas Chromatography
- **Ch. 25** High-Performance Liquid Chromatography
- **Ch. 26** Chromatographic Methods and Capillary Electrophoresis
Tips on How to do well in CHEM 3451

1. **Team study** is a proven effective way to do well in this class. Make friends and work together now!

2. **Pre-view** (i.e. read ahead) the chapter(s) before attending the class, especially for new concepts like statistical analysis, etc. Get familiar with your textbook! Look what is included in the appendixes.

3. To excel in Analytical Chemistry requires 1) understanding the important concepts 2) apply them to “hand-on” problem solving exercises that often requires calculations with chemical equilibrium concepts.

4. Our lecturing time is rather limited. Both important concepts and selected examples will be covered in the class. However, do not expect all types of questions tested will be covered exactly in the class. It is simply **NOT** possible to cover all types of calculations and problems within the limited class time. **It is your responsibility to work on all problems as described in 5 and 6 below.** We will be happy to provide as much help possible per requests.

5. **What will be tested from textbook?** Study *chapter examples* (covered the answer, verify your understanding of the problem, *Do you know how to solve the problems?*), then, Do the *Exercises* and verify the answers at the end of the book. Work on *Assigned Problems* and verify with answers from solution manual (reserved STR 19733) and Harris’s 7ed Texrbook (reserved QD101.2.H37.2007) -- Mark/collection those problems you have difficulty with for the quick review/practice right before the exam.
6. **What will be tested other than textbook?** Study “online quizzes” from [http://bcs.whfreeman.com/qca7e/](http://bcs.whfreeman.com/qca7e/)

   **Example 3.** The Great Salt Lake, located in the state of Utah, is approximately eight times saltier than the ocean. The salinity of the lake is said to occasionally be as high as 27 parts per thousand sodium chloride. Calculate the molarity of the sodium ion in the Great Salt Lake. *(Chapter 1)*

   *(a) 4.6 x 10^-4 Molar*

   *(b) 0.46 Molar*

   *(c) 1.2 Molar*

7. **Most of exam problems (80-90%) will be taken form 5 and 6.** Exam questions may not copy exactly, but will be rather similar. Remaining 10-20% will be from lecture examples or other sources.

8. **Practice before exam:** Before the exam, make up a simulated exam (put in some of those marked problems you have difficulty earlier) and give yourself one hour and half on the simulated exam.

9. After each exam, make sure you understand the relevant subjects and can really do the old exam problems. Make good correction notes for comprehensive final exam.

10. **Helpful tip!** The >60% of old term exams questions will be reused in final exam questions with slight modifications (like changing numbers etc.).
Part I. Multiple Choice Questions (30 points)

1. Define the term precision.
   
   (a) Precision refers to how close a measured value is to the "true" value.
   (b) Precision refers to how accurately a given measurement is made.
   (c) Precision can be evaluated by standard deviation.
   ( "online quizzes" http://bcs.whfreeman.com/qca7e/ )

2. The degrees of freedom used to calculate the confidence interval are:
   
   (a) the number of data points which are being evaluated.
   (b) the number of data points - 1.
   (c) The value associated with the number of data points used to determine the value of t.
   ( "online quizzes" http://bcs.whfreeman.com/qca7e/ )

3. A government chemist has performed a gravimetric analysis for chloride ion (in percent % concentration) on a sample submitted to the laboratory. The following results were obtained: Given the following data:

<table>
<thead>
<tr>
<th>Sample no.</th>
<th>Percent chloride ion</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>27.46</td>
</tr>
<tr>
<td>6</td>
<td>27.52</td>
</tr>
<tr>
<td>7</td>
<td>27.48</td>
</tr>
<tr>
<td>8</td>
<td>27.10</td>
</tr>
</tbody>
</table>

Using t-values from the table provided. What is the 95% confidence interval for this set of data? (4 points)

   (a) ± 0.31%
   (b) ± 0.56  ( "online quizzes" http://bcs.whfreeman.com/qca7e/ )
   (c) ± 0.69%

4. When an analytical chemist uses the word accuracy when referring to the data obtained from an analysis, the chemist is talking about:
(a) how close the mean obtained from a set of data is to the true value of the composition of the sample analyzed.
(b) relative error calculated from the mean of a set of data.
(c) how close the individual data points obtained from a set of data are to each other.
(d) how close the individual data points obtained from mean value.

(“online quizzes” http://bcs.whfreeman.com/qca7e/)

5. A student was presented with a sample of vinegar for analysis. After analyzing the sample four times, the student was faced with the following set of data:

<table>
<thead>
<tr>
<th>Analysis no.</th>
<th>Percent acetic acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.06%</td>
</tr>
<tr>
<td>2</td>
<td>4.15%</td>
</tr>
<tr>
<td>3</td>
<td>4.35%</td>
</tr>
<tr>
<td>4</td>
<td>4.09%</td>
</tr>
</tbody>
</table>

Given the following values of Q for rejection of data, which decision is appropriate?

<table>
<thead>
<tr>
<th>Q 90% confidence</th>
<th>No. of observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.941</td>
<td>3</td>
</tr>
<tr>
<td>0.765</td>
<td>4</td>
</tr>
<tr>
<td>0.642</td>
<td>5</td>
</tr>
</tbody>
</table>

(a) Reject the value 4.06%.
(b) No values may be rejected.
(c) Reject the value 4.35%

(“online quizzes” http://bcs.whfreeman.com/qca7e/)

6. Any diluted aqueous solution has a density near 1.00 g/mL. Suppose the solution contains 1 ppb of the solute, please identify which of following alternative concentration expression of solute is correct?

(a) 1 ng/L
(b) 1 µg/L
(c) 10⁻² µg/mL
(d) 1 pg/mL

7. A solution is prepared by dissolving 25.8 grams on magnesium chloride (MgCl₂) in water to produce 250.0 mL of solution. Calculate the molarity of the chloride ion in the solution. (Mg = 24.305 g/mol. Cl = 35.452 g/mol)

(a) 0.217 Molar
(b) 1.08 Molar
(c) 2.17 Molar
8. The ethyl alcohol content of many beers produced in the United States is 4.05% (vol/vol). If the density of ethyl alcohol at room temperature is 0.7893 grams per mL, what is the percent of ethyl alcohol in beer expressed as percent (wt/vol)?
(a) 3.20 % ethyl alcohol (wt/vol)
(b) 5.13 % ethyl alcohol (wt/vol)
(c) 7.80 % ethyl alcohol (wt/vol)

9. Write the answer to the following calculation to the proper number of significant figures. 3.86 + 9.1 - 0.231 = 12.7290
(a) 12.7
(b) 12.73
(c) 12

10. Fine the absolute uncertainty of the following calculation, and express the answer to the proper number of significant figures. 12.34(±0.04) + 178.1(±0.2) - 18.493(±0.002) = 172.010
(a) 172.01(± 0.2)
(b) 172.0(±0.2)
(c) 172.010(±0.242)

11. The density of concentrated reagent HCl (aq) (37.0 wt%) is 1.19 g/mL, Molecular weight for HCl is 36.46 g/mol. Find the correct concentration conversion(s) based on this information
(a) The Molarity (M) of concentrated reagent HCl (aq) is 16.1
(b) The Molality (m) of concentrated reagent HCl (aq) is 12.1
(c) The Molarity (M) of concentrated reagent HCl (aq) is 12.1

12. In medicine, blood sugar is a term used to refer to levels of glucose (C₆H₁₂O₆, 180.16 g mol⁻¹) in the blood. The common unit for blood sugar reading is expressed in mg/dl. Normally, blood glucose levels stay within narrow limits throughout the day: (70 to 150 mg/dl). Find the correct statement(s)
(a) the normal range blood glucose level is 3.9 to 8.3 mmol/l
(b) the normal range blood glucose level is 5 to 9 mmol/l
(c) a high blood glucose level reading (which indicates diabetic condition) is above 200 mg/dl, that converts into as 10.8 mmol/l

(From Lecturing Example)

13. High level of gastric acid (stomach acid, mainly HCl) is one of the main causes of sour stomach/heartburn. Antacid tablet is often used to neutralize the stomach acid. Typical active ingredient in an anacid tablet contains 100 mg of Mg(OH)₂. To neutralize 100 mL of 0.1 M HCl, one needs M.W. Mg(OH)₂ = 58.3 g/Mol

(a) 1    (b) 2    (c) 3    (d) 4 tablets

14. Calculate the absolute or relative uncertainty of the following calculation; pick the correct expression of the following answers with the proper number of significant figures.

(a) 9.23 (±0.03) + 4.21 (±0.02) – 3.26 (±0.06) = 10.18 ± (0.71 %)
(b) [4.97 (±0.05) – 1.86 (±0.01)] / 21.1 (±0.2) = 0.17 (±0.03)
(c) 2.0164 (±0.0008) + 1.233 (±0.002) + 4.61 (±0.01) = 7.85 (±0.01)
(d) Log [3.14 (±0.05)] = 0.49 ± 0.07  (For y = log x, ey = 0.43429 e,y/x)

15-16 Traces of organic, man-made hexachorohexanes in sea sediments were extracted by a know process and by two new procedures, then followed by measuring with chromatography. (Exercise 4-F)

(From Textbook Exercises & Problems)

<table>
<thead>
<tr>
<th>Methods</th>
<th>Concentration found (mean value), (pg/g)</th>
<th>Standard deviation (pg/g)</th>
<th>Number of replications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>34.4</td>
<td>3.6</td>
<td>6</td>
</tr>
<tr>
<td>Procedure A</td>
<td>42.9</td>
<td>1.2</td>
<td>6</td>
</tr>
<tr>
<td>Procedure B</td>
<td>51.1</td>
<td>4.6</td>
<td>6</td>
</tr>
</tbody>
</table>

15. Are the concentrations (pg/g)
(a) parts per thousand, (b) parts per million (c) parts per billion (d) parts per trillion

16. Pick the correct statement(s)
(a) Standard deviation for procedure B is significantly different from that of conventional procedure
(b) The mean concentration found by procedure B is significantly different from that of conventional procedure
(c) Standard deviation for procedure A is not significantly different from that of conventional procedure
(d) The mean concentration found by procedure A is not significantly different from that of conventional procedure

**Important! Please fill in your Correct Answers here, Your score for Section I will be graded solely from these answers below.**

1. ____________
2. ____________
3. ____________
4. ____________
5. ____________
6. ____________
7. ____________
8. ____________
9. ____________
10. ____________
11. ____________
12. ____________
13. ____________
14. ____________
15. ____________
Part II. Definition or Essay questions (30 points)

Chapter 0: Please describe general steps involved in the typical Chemical Analysis. (10 points)

2-15 Describe how to prepare 250.0 mL of 0.1500M NaCl (MW: 58.443 g/mol) with a 250 ML volumetric flask. (10 points)

3-11 Considering a target shooting practice of ten shots, please draw ten dots on the following target in such a way to represent the result is (10 points)

A) Accurate but not precise. B) Precise but not accurate

Note the inner most circle = “True Value” i. e. your target.

Part III. Work out details questions. (Important!! show all calculation details to get full credit) (40 points)

3-B You have a bottle labeled “53.4 wt% NaOH – density = 1.52 g/mL”, how many milliliters of 53.4 wt% NaOH will you need to prepare 2.000 L of 0.169 M NaOH solution? (20 points)

Problem 4-13 (see Textbook) (20 points)