CHEM 4373-5331
Quantitative Chemical Analysis
Spring 2015
T 6:00 – 9:50 pm, Bayou 3506

UHCL Quality Enhancement Plan (QEP): Applied Critical Thinking (ACT) for Lifelong Learning and Adaptability

Applied Critical Thinking Statement:

This course has been authorized by UHCL as an Applied Critical Thinking (ACT) Course which means that in addition to learning about the specified course content, students will be engaged with some or all of the Elements of Thought and Universal Intellectual Standards of critical thinking. The objective of an ACT course is to develop the student's ability to become skilled at analysis and evaluation by applying a set of intellectual tools that may be effectively used across all disciplines (as well as to the student's personal life). Based on the Foundation for Critical Thinking (http://www.criticalthinking.org/), critical thinking involves thinking for a *purpose*, asking *questions*, using *information*, applying *concepts*, drawing *inferences* and *conclusions*, identifying *assumptions*, anticipating *implications* and *consequences*, and recognizing *points of view*. The Universal Intellectual Standards that are applied to these *Elements of Thought* of critical thinking in order to develop Intellectual Traits include *clarity, accuracy, precision, relevance, depth, breadth, logic, significance, and fairness.*

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Office Hours: Tuesday 10:00 -11:30 pm, or by appointment
Teaching Assistant: Shankarampet, Fanendargoud
Prerequisite: Analytical Chemistry or equivalents
Textbook: Daniel C. Harris, ***Exploring Chemical Analysis***, New York; W. H. Freeman & Co (5th edition)
Blackboard: will be used to accommodate syllabus, lab procedure instructions and other course-related materials, instructor comments and emergent notifications, etc.

Critical Thinking in Quantitative Chemical Analysis

Analytical Chemists use Critical Thinking in solving chemical quantitative problems that require systematic solutions with high accuracy and precision. Specifically, such solutions require analytical methods and operations that focus on assumptions, information, and consequences. Analytical

Chemist focus on understanding the principles that connect unknown samples with analysis methods to provide an infrastructure for problem solution. All of this begins with clearly understanding a question that needs a solution. Specific questions addressed in this course are:

- How to select a fair quantitative analysis method for an unknown sample in order to obtain the most reliable data for the task?
- How to conduct the data analysis for the task, i.e. an evaluation on how accurate and precision the data would be, and within how much confidence range that we can trust the data we obtained?

Student Learning Outcomes (SLOs)

Upon completion of this course, students will be able to:

1. Gain *in-depth* understanding of the basic *concepts* of quantitative chemical analysis *clearly* and *precisely*, and master basic principles underlying all the types of quantitative chemical analysis.
2. *Clearly* identify the *purpose* of the major task of quantitative chemical analysis. Not only know what, how but also why.
3. *Clearly* understand how important the accuracy and precision are in a specific quantitative chemical analysis, and know *in depth* how to achieve a reliable analysis.
4. Develop *accurate* methods for data evaluation for the *information* collected from a specific quantitative chemical analysis, and *logic and fair* error analysis for experimental *inference*.
5. Acquire *relevant* laboratory skills via hands-on practices of quantitative chemical analysis, aimed at accuracy and precision of the data.
6. Develop *significant* collaborating skills with the awareness of *implication* and *consequences* by engaging in various lab analysis tasks with lab partners.
7. *Logically* design a *relevant* practical quantitative analysis method for an unknown sample based on the *concepts* learned in the course.

Fundamental and Powerful Concepts (FPC) of the Course

In ACT vocabulary, *fundamental and powerful concepts* form the foundation that permeates and unites a course. In this course, the FPC are the followings:

1. Accuracy and precision of the data collection
2. Relationships between of moles-mass, and moles-molarity-volume
3. Coefficient relationship between reactants and products within a specific analysis

Vocabulary of Critical Thinking: In this course, we will learn and use the vocabulary of critical thinking. Our critical thinking vocabulary will include an understanding and use of both 8 elements of thought and 9 universal intellectual standards.

- **Elements of Thought**

1. **Purpose** – goals, objectives
2. **Question at Issue** – problem, issue
3. **Information** – data, facts, reasons, observations, experiences, evidence
4. **Interpretation and Inference** – conclusions, solutions
5. **Concepts** – theories, definitions, laws, principles, models
6. **Assumptions** – presuppositions, axioms, taking for granted
7. **Implications and Consequences**
8. **Point of View** – frames of reference, perspectives, orientations

- **Universal Intellectual Standards**

1. Clarity
2. Accuracy
3. Precision
4. Relevance
5. Depth
6. Breadth
7. Logic
8. Significance
9. Fairness

The UHCL Quality Enhancement Plan (QEP) endorsed by the university accrediting body is a plan to promote applied critical thinking (ACT) for lifelong learning and adaptability. In particular, the key learning outcomes of the UHCL applied critical thinking plan involve 4 C's: *Curiosity*, *Connections*, *Creativity*, and *Communication*. In this course, we will primarily focus on *Connections*.

Critical Thinking Activities and Assessment

A semester-end project on the quantitative determination of an unknown sample will be assigned to the students in an earlier time of the semester. The students are encouraged to work in groups (freedom on combination, but no more than 4 students per group). The evaluation of the activities is used to assess how well critical thinking is incorporated into the course. These assessments will be used as input to the UHCL Critical Thinking database for internal assessment of Critical Thinking, and will not affect your grade of the course.

1. With the given information, student is required to *logically* design a relevant analysis procedure for an unknown sample based on the concepts learned in the course, and conduct the experiments on their own which will be due right before the final exam. (SLO #2, 7)
2. Student will perform *accurate* data evaluation for the *information* collected by developing *logic and fair* error analysis for experimental *inference*. Student will also develop *significant* collaborating skills with the awareness of *implication* and *consequences* by engaging in independent lab analysis tasks with lab partners. (SLO #4, 6)

This project will be graded on a 10-point basis to assess students' applied critical thinking for their conceptual understanding and making application for unknown quantitative analysis process.

The outcome of this assessment will be separately recorded for the purpose of data collection and monitoring the students learning outcomes for Applied Critical Thinking. The project will assess **SLOs 2, 4, 6, 7** described earlier and the scores will be categorized in three levels: unacceptable (score < 7.0), acceptable (score between 7.0 and 9.0) and excellent (score > 9.0).

Course Description

Laboratory. This course consists primarily of laboratory sessions which are intended to cover a variety of analytical techniques as illustrated in experiments.

Lecture. Five additional short lectures (Class Note 1-5) will be offered prior to the lab session, which are intended to provide theoretical background for the experiments by supplementing the relevant course material in Analytical Chemistry. Major topics to be covered in lecture will be *selected* from among the following chapters:

1. Introduction to chemical analysis (Chapters 0 - 2)
2. Basic math and statistics tools (Chapters 3 - 5)
3. Gravimetric analysis (Chapter 7)
4. Volumetric analysis and precipitation titrations (Chapter 6)
5. Chemical equilibria and Acid-Base titrations (Chapters 1, 8 - 10)
6. Complex ion formation and equilibria, EDTA titrations (Chapter 13)

Self-study. No extra homework assignment in this course. An online self-study site is provided for you for self-check purpose: http://bcs.whfreeman.com/exploringchem4e/

Quizzes. Short quizzes (1 short question based on previous lab experiment, 10 minutes) will be given to the class before the lab session, which starts from the third week.

Grading Scheme

Exam 1	15 %
Exam 2	15 %
Lab reports	55 %
Quizzes	5 %
End of semester Project	5 %
Lab Evaluation and Lab Notebook	5 %

The overall grade distribution will approximately follow the grading system below. +/- grading scale will be used:

90-100	A	78-80	C+
88-90	A-	70-78	C
86-88	B+	60-70	C-
82-86	B	55-60	D
80-82	B-	<55	F

Grading rules

1. A notebook is mandatory required for laboratory data records. Be neat and organized! They will be checked by the end of the semester, and will worth **5%** of final grade with lab performance evaluation.
2. Individual experiment reports are graded on a **100** point scale, typically **75** points for the analytical results/calculations; **15** points for the conclusion; **5** points for persistence with significant figures and neatness of the report, etc. A copy of original data sheet is required to attach to the report, which worth **5** points.
3. All reports must be compiled using Microsoft Word and submitted as hard copies. Fail to do this will lose **10** points from that report grade.
4. The laboratory grade is mainly based on the accuracy of determination of unknowns. The analysis error within **± 0.5%** will be generally satisfactory unless specifically indicated; whereas **± 0.3%** is required for **CHEM 5331** students.
5. Each student will work with a partner through the semester; however, each student is required to submit his/her own report. Never copy your lab partner's work otherwise your grade will be **zero** with no excuse (refer to Honesty Policy).
6. Students must turn in hardcopy lab report on the due day before the lab session starts. **1** point will be deducted if turn in after the lab. There will be **2** points/day deduction for late submission (including weekend)! For late-submissions over 1 week, the report won't be accepted anymore. For any reason fail to submit the lab report within a week, a grade **zero** will be given even you have done the lab.
7. Student must attend all the lab sessions to get a PASS for the course, otherwise a final grade F will be issued.
8. No make-up laboratory and exam for this lab course. However, you may have a chance to do the makeup with acceptable excuses (refer to Attendance Policy). The full credit for the make-up is **80%** of the original. Laboratories and/or exams missed due to unexcused absences will be given a grade of **zero**.
9. Short quizzes (1 calculation question based on previous lab experiment, 10 minutes) will be given to the whole class before the lab starts, which worth **5%** of the final grade. Puncture attendance is highly expected. The quizzes will start at 19:00 and end at 19:10 sharp. If you miss, you miss.

LAB SAFETY

Laboratory safety is of primary importance! All students must take an online safety training session and pass the test, and must carefully read and sign a copy of the **Laboratory Safety Rules** before being allowed in lab. Students who fail to wear approved **safety glasses and lab coats** or otherwise violate important safety rules will be dismissed from lab with a grade of zero for that experiment.

E-mail POLICY

Although most of time instructor will post all information onto the Blackboard, such as files, reminders, etc. during the semester, you are recommended to check your UHCL e-mail in a regularly way or better check it again before class in case there is last-minute emergency call. Since UHCL security system will spam most outsider emails, the instructor will use your registered UHCL email

address as the recipients for communication purpose. **Please use your UHCL emails all the time in this course**; otherwise, you will be the one responsible for any message delay caused by spam.

Tentative Lab Schedule
Spring 2015 (Jan.20~May 04)

Weeks	Date	Lectures / Experiments	Quizzes	Report Due
1	Jan 20	Lab Check-In and preparation Class Note 1: Intro topics and Gravimetric Analysis	-------	
2	Jan 27	Lab 1: Calibration of Glassware	-------	Feb 03
3	Feb 03	Lab 2: Gravimetric Cl	Quiz 1	Feb 17
4	Feb 10	Class Note 2: Volumetric Analysis and Precipitation Titrations Lab 3: Volumetric Cl (Fajans Method)	Quiz 2	Feb 17
5	Feb 17	Lab 4: Volumetric Cl (Volhard Method)	Quiz 3	Feb 24
6	Feb 24	Class Note 3: Acid-Base Titrations Lab 5: Acid-Base Titration (Soda Ash Unknown)	Quiz 4	Mar 03
7	**March 03**	**Exam 1**		
8	**March 10**	**Spring Break**		
9	March 17	Lab 6: KHP Determination (Acid-Base titration)	Quiz 5	Mar 31
10	March 24			
11	March 31	Class Note 4: Complex ion and EDTA titrations Lab 7: EDTA Titration (Mg Unknown)	Quiz 6	Apr 07
12	Apr 07	Lab 8: EDTA Titration (Ca and Mg in tap water)	Quiz 7	Apr 14
13	Apr 14	Class Note 5: Oxidation-Reduction Titrations Lab 9: $KMnO_4$ Determination of Ca	Quiz 8	Apr 21
14	Apr 21	**End of Semester Project:** unknown sample analysis		Apr. 28
15	**Apr 28**	**Exam 2**		

- Lecture class sessions are highlighted in pink
- The tentative schedule is subjected to be changed during the semester. Pay attention to any updates.

ATTENDANCE POLICY

The only acceptable excuses for missing class or laboratory are:

1. An Official University Absence
2. A written medical excuse including the physician's name and contact information
3. A written notice from the Office of Student Life about a major personal problem such as a death in the family

Please notify the course instructor of your excused absence in advance if possible in order to schedule a makeup in another laboratory session. Laboratories or exams missed because of excused absences will be made up as arranged with the course instructor.

UHCL HONESTY POLICY

The Honesty Code is the university community's standard of honesty and is endorsed by all members of the University of Houston-Clear Lake academic community. It is an essential element of the University's academic credibility. It states: "I will be honest in all my academic activities and will not tolerate dishonesty." You should be aware that academic misconduct and failure to perform within the bounds of these ethical standards is sufficient grounds to receive a failing grade on assigned tasks and for recommendation for suspension from UHCL. Specific examples include, but are not limited to:

1. Cheating: copying from another student's test paper; using programmable calculators, portable computers and cell phones during the test without permission; collaborating with or seeking aid from another student during a test without permission; substituting for another student or permitting another student to substitute for oneself.
2. Plagiarism: the appropriation, theft, purchase or obtaining by any means another's work, and the unacknowledged submission or incorporation of that work as one's own offered for credit.
3. Collusion: the unauthorized collaboration with another in preparing work offered for credit.

6 DROP RULE LIMITATION

Students who entered college for the first time in Fall 2007 or later should be aware of the course drop limitation imposed by the Texas Legislature. Dropping this or any other course between the first day of class and the census date for the semester/session does not affect your 6 drop rule count. Dropping a course between the census date and the last day to drop a class for the semester/session will count as one of your 6 permitted drops. You should take this into consideration before dropping this or any other course. Visit www.uhcl.edu/records for more information on the 6 drop rule and the census date information for the semester/session.

Appendix:

Summary of lab report requirements

For lab experiments in this course, a written report is due one week after the experiment is performed. The report will be turned in at the beginning of class. You will be evaluated on the accuracy and precision of your analytical results and the quality of your report (which includes neatness, spelling,

and grammatical correctness of sentences). Although the exact requirements may vary from lab to lab, generally reports must be typed, and include the following:

(1) Cover sheet and title. The title page should be the first page of your report. It should be separate and stand-alone by itself. Your lab report must have the title page cover containing your name, partner's name(s) and section number, the experiment number and name, date that the experiment was conducted, and date of report. Your title page should also include the following signed and dated statement:

> Rule of Academic Responsibility:
>
> "It is the responsibility of every student at the University of Houston at Clear Lake to adhere steadfastly to truthfulness and to avoid dishonesty, fraud, or deceit of any type in connection with any academic program."
>
> I have fulfilled the Rule of Academic Responsibility.
>
> _____ _____
>
> Signature Date

(2) Abstract. The abstract should be a short paragraph describing the purpose, technique, and results of the experiment—think of the abstract as a concise summary (no need to be more than half page).

(3) Introduction. This short section should be 1 paragraph at most. It should briefly describe the technique(s) employed in the experiment (in your own words) and provide justification as to why it works. Cite any sources used.

(4) Experimental. The experimental section of your report should describe briefly the procedures and apparatus used in the experiment. Do not repeat the all the information in the lab handout provided but provide sufficient information so that someone should be able to repeat your experiment. If modifications were required, the statement should read: "The procedure in the laboratory handout was followed, with the following changes:" (list and describe).

(5) Data and results. Present all your raw data using tabular and, if appropriate, graphical form. Graphs and tables should be clearly captioned. Axes should be clearly labeled. Units must be clearly stated and consistency of significant figures maintained. Intermediate results should be also given if any. This should not be simply a photocopy of your lab notebook. Report relevant raw data or information, which was conclusive and supportive. You should not just report "good" data, but you don't need to report all the "bad" data either. *E.g.*, if you perform a large number of experimental trials, you might exclude a measurement using the *Q*-test. Do not panic if your data is not perfect every time. Understanding your mistakes is just as important as understanding what should have happened. Keep in mind, however, that it is true that someone with better results might do a little better than someone with completely wrong results, but understanding those mistakes will count more than if the person with correct results doesn't understand why.

(6) Sample calculations. Any calculations and/or graphs made of the data should be presented in this section. Show all steps, including units, in your calculations. Show an example of each calculation performed. Pay attention to significant figures.

- Results should be expressed to the correct number of significant figures and in the correct units. If you have performed triplicate analyses, it is not necessary to show your calculations for all three results, but an example for one result should be given.
- Estimate the precision, expressed as the standard deviation and relative standard deviation of replicate results. You may exclude a result and report the remaining data if justified by a *Q*-test at the 95% level or for another good reason (*e.g.*, if you have an assignable cause for the mistake). Explain!
- Graphs should be produced using Microsoft Excel and printed legibly. Remember to label all graphs with appropriate title, units, axes clearly numbered and labeled, and legends.

In the last, this section should contain a clear tabular and/or graphical report of the outcome of your calculations.

(7) Conclusion. An at least 1- page long conclusion is required for all lab reports. This section should explain your results and how they support (or not) the concepts of the experiment. Include observations noted during the experiment. Explain why the lab was done and make valid conclusions based on the observations and collected data. Were there any problems with the experiment? How did these factors impact your experiment? How can the experiment be improved? Define any terms or concepts you use. Finally, describe problems encountered with the experiment. You should discuss the sources of errors and uncertainties, those due to errors in technique in the lab and those due to imprecision, as well as those implicit in the assumptions and theory on which the experiment was based. In discussing any major errors you encountered, propose why they happened. Don't just say, "I messed up". Be more descriptive. How did errors arise and why? Report any suggestion for improvement to avoid these errors. Answer any questions asked of you in the laboratory manual at the end of the lab report.

Additional requirements.

- The lab reports must be typed in Microsoft Word.
- **Format of the report:**
  - **4-way margins: 1";**
  - **Font size: 12**
  - **Line spacing: 1.0-1.15**
- If you work with a partner and/or share data with someone, that is as far as the relationship goes. Don't copy anything else. All the calculations, graphs, conclusions, procedure, purpose, *etc*., should be your own work.
- Keep in mind these lab reports are also exercises in learning how to communicate in a formal written scientific paper. Use complete sentences, coherent statements, and consistent tense throughout the report. Use the third person passive tense in your writing. E.g., do not use the first or second person tenses:

  First person: "I weighed out 10 g of NaOH."

  Second person: "You weigh out 10 g NaOH."

  Also do not write instructions in the imperative tense: "Weigh out 10 g NaOH."

Instead, use the third person passive tense: "10 g of NaOH was weighed out."

In normal writing, third person passive is often considered weak, since action is done to an object instead of that object actually doing the action. For scientific writing, however, this tense is perfectly satisfactory since it is assumed the lab has already been done (past tense action) and the reader knows who did the lab (your name was on the paper).