2013

CHEM 109: General Chemistry I—A Peer Review of Teaching Project Benchmark Portfolio

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Peer Review of Teaching Benchmark Portfolio
CHEM 109: General Chemistry I

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Table of Contents

I. Abstract

This portfolio has been developed for CHEM 109 – General Chemistry I. The course is the first of a freshman level two semester sequence in general chemistry taken by students with majors in a wide variety of technical and scientific disciplines. CHEM 109 is a high enrollment course, with class sizes for individual sections nearing 200 students. The development of this portfolio was conducted with the following objectives:

1. *Clearly identify, justify, and codify the major learning objectives for this course*

2. *Describe and rationalize the course structure and learning assessment methods*

3. *Analyze and reflect on student achievement in the context of these objectives and assessments*

Reflections on the portfolio development outcomes and potential changes for future iterations of the course are also discussed.

II. Course Description and Goals

A. Course Subject Matter

CHEM 109 (General Chemistry I) is the first course in a two semester general chemistry sequence here at the University of Nebraska – Lincoln. The present official course description characterizes CHEM 109 as follows:

> *"Lecture and laboratory exercises serving as an introduction to chemical reactions, the mole concept, properties of the states of matter, atomic structure, periodic properties, chemical bonding, and molecular structure." [CHEM 109 Course Description, University of Nebraska – Lincoln Undergraduate Bulletin 2013-2014]*

The overall course subject matter is typical of equivalent courses taught at other universities, and is also well-aligned with the topics covered by the First Term General Chemistry cumulative assessment commissioned by the Division of Chemical Education Examinations Institute of the American Chemical Society. Overall, the content and breadth of the course is consistent with current standards in the field.

B. Course Learning Objectives

Although a complete listing of specific concepts covered in CHEM 109 would be rather lengthy, in the process of developing this portfolio I've come to better appreciate that most of the course content revolves around a relatively few unifying themes. Indeed, upon deeper reflection regarding the "big picture" objectives for the course, I find that essentially all of the concepts mentioned in the official course description (and a number of others which are not mentioned in the official course description) can be considered individual components of two interrelated and overarching course learning goals:

(i). Establish a fundamental working knowledge of the structure of matter at the atomic and molecular levels

(ii). Develop a foundational understanding of some physical and chemical changes that matter can undergo, and the relation of these changes to energy

Furthermore, fostering an understanding of the structure of matter and changes which matter undergoes also requires the cultivation of quantitative problem solving skills – both "on paper" and "hands on." A third, supporting course learning goal is thus identified:

> *(iii). Build basic skills in problem solving, calculation, and measurement necessary to quantitatively address the structure of matter and changes which matter undergoes*

These considerations led me to develop a new course summary for use in my CHEM 109 syllabus:

> *"This four-credit course (3 cr lecture; 1 cr laboratory) is the first in a two-semester sequence which serves as an introduction to fundamental principles of chemistry for students in scientific and technical disciplines. Course topics include atomic theory, chemical quantities, solutions, thermochemistry, gases, quantum theory, chemical bonding, and molecular structure. Over the course of CHEM 109, students will develop an understanding of matter at the atomic and molecular levels, including the structure of matter, the chemical and physical changes which matter undergoes, and the relation of these transformations to energy." [CHEM 109 Syllabus, Spring Semester 2013 (Appendix A)].*

C. Course Enrollment Demographics

1. Majors

CHEM 109 primarily serves students majoring in various scientific (*e.g.*, Animal Sciences, Biological Sciences; Biochemistry; Chemistry; Environmental Sciences; Nutrition and Health Sciences, Psychology), engineering (*e.g.*, Agricultural Engineering; Biological Systems Engineering; Chemical Engineering; Civil Engineering; Computer Engineering; Electrical Engineering; Mechanical Engineering), and pre-professional (*e.g.*, Pre-Health; Pre-Medicine, Pre-Veterinary) disciplines. The major fields listed above do not constitute an exhaustive list; nevertheless, the listing does give a reasonable representation of the majors being pursued by CHEM 109 enrollees. CHEM 109 also fulfills the ACE 4 general requirement:

> *"Use scientific methods and knowledge of the natural and physical world to address problems through inquiry, interpretation, analysis, and the making of inferences from data, to determine whether conclusions or solutions are reasonable." [From the University of Nebraska – Lincoln Achievement-Centered Education Institutional Objectives and Student Learning Outcomes]*

In order to fulfill the ACE 4 requirements, a small population of non-scientific / non-technical majors also enroll in CHEM 109. A description of how CHEM 109 addresses the ACE 4 objectives is provided in the course syllabus (Appendix A).

2. Class Standing

In my previous experience teaching CHEM 109 during two Fall semesters (Fall 2010 and Fall 2011), approximately 75% of CHEM 109 enrollees were in their freshman year, with about 15% in their sophomore year of study. Juniors and seniors comprised the remaining 10%. However, during the Spring semester of this portfolio development (Spring 2013), the enrollment demographics were quite different with freshmen constituting only about 45% of the course enrollment, sophomores constituting approximately 35%, and juniors and/or seniors accounting for the balance

(20%). These differences are not unexpected for "off sequence" sections of CHEM 109 (*i.e.*, during Spring semesters) as compared to those held "on sequence" (*i.e.*, during Fall semesters).

3. Preparation

Regardless of major or class standing, virtually all CHEM 109 students are gaining their first university-level exposure to chemistry. Although some CHEM 109 participants have previously taken a high school course in chemistry, prior coursework in chemistry is not required. The only prerequisite for CHEM 109 is completion of MATH 103 (College Algebra and Trigonometry), or a mathematics placement test score indicating preparedness for at least MATH 104 (Calculus for Managerial and Social Sciences) or MATH 106 (Analytic Geometry and Calculus I). Thus, it seems that all CHEM 109 students should thus have some core competency in mathematics. The prerequisite notwithstanding, my experience working with CHEM 109 students thus far suggests that the quantitative and mathematical reasoning skills among these students is highly heterogeneous. In the absence of a chemistry prerequisite for CHEM 109, the prior familiarity of students with chemical concepts is perhaps even more varied.

D. Course Curricular Context

Based on the enrollment demographics discussed above, CHEM 109 clearly serves a broad cross section of students with respect to their major programs. For some fraction of students taking CHEM 109 simply to satisfy the ACE 4 requirement, CHEM 109 is a terminal course in chemistry. However, many CHEM 109 these students will go on to take CHEM 110 – General Chemistry II. This direct curricular progression from charges CHEM 109 instructors with the responsibility of preparing students for the subject matter of CHEM 110:

> *"Lecture and laboratory exercises serving as an introduction to intermolecular forces, kinetics, chemical equilibrium, thermodynamics, and electrochemistry." [CHEM 110 Course Description, University of Nebraska – Lincoln Undergraduate Bulletin 2013-2014]*

Many of the major topics of CHEM 110 build very directly and quite vertically on material introduced in CHEM 109; therefore, success in CHEM 110 is unlikely in the absence of a reasonably strong command of CHEM 109 subject matter.

For some students in scientific and / or technical majors, the general chemistry sequence will be their only requirements in chemistry. However, many programs require some chemistry coursework beyond the General Chemistry sequence. For example, some majors will require one or two semesters of organic chemistry coursework. On another extreme, some CHEM 109 students will go on to take extensive chemistry coursework beyond the General Chemistry sequence, including chemistry majors pursuing Bachelor of Arts degrees. Mirroring the diverse course enrollment demographics, the subsequent curricular paths of CHEM 109 students are rather eclectic, ranging from no additional chemistry coursework to the completion of a chemistry major.

E. Course Portfolio Rationale and Objectives

1. Course Selection

My reasons for choosing CHEM 109 as the focus of a benchmark portfolio in part stem from the high potential for impact. The Department of Chemistry currently offers nine sections of CHEM 109 per academic year (six during the Fall semester; three during the Spring semester) with a total enrollment capacity of approximately 1,750 students (about 195 students per section). Given the high enrollment and the previously mentioned breadth of participating majors, I believe this teaching assignment is an ideal platform for development of a portfolio with potential to affect teaching and learning in heavily subscribed course.

I would also reiterate that the Spring 2013 semester was my third turn at teaching a section of CHEM 109. I had thus reached a point where many core components of the course were in place, and where I had developed some experience in conducting and managing a high-enrollment class. I felt this placed me in a strong position to dedicate more effort towards the refinement, documentation, and assessment of teaching and learning in this course.

2. Challenges

Some other reasons for selection of CHEM 109 relate to what I perceive as the major challenges associated with teaching the course. One of these challenges is in maintaining pedagogical flexibility in the context of a large, coordinated multi-section course. Our general chemistry program is a closely coordinated enterprise, involving multiple staff members, a faculty member who serves as general chemistry coordinator (my colleague Prof. Jason Kautz), and numerous faculty members, lecturers, recitation teaching assistants, and laboratory teaching assistants.

While the having a closely coordinated program affords a number of benefits, this also means that many decisions which an instructor of record would typically have the freedom to make unilaterally are decided through consensus of a group of faculty. Thus, this portfolio development is an opportunity for me to reflect on the merits of policies and approaches which I currently practice but did not select for myself.

Because the Department of Chemistry gauges the success of our general chemistry program in part based on the outcomes of standardized final exams commissioned by the American Chemical Society (for CHEM 109, the First Term General Chemistry assessment), there is a certain prescribed breadth of content which must be covered. This means that my course outline and some aspects of pacing are other areas in which my maneuverability is somewhat limited.

Other challenging aspects of teaching CHEM 109 (and similar courses) lies both the size and the heterogeneity of the participating student population. The large classroom setting makes maintaining student engagement a significant task. Moreover, I find that the uneven preparation and wide ranging academic goals among the students make presenting the course in a manner well suited to at least a majority of the participants to be challenging.

3. Portfolio Goals

My objectives in compiling this portfolio are to document the total process of teaching CHEM 109 (including course preparation and assessment), and to establish some initial baselines regarding student learning in CHEM 109. Specifically, I aim to:

1. *Clearly identify, justify, and codify the major learning objectives for this course*
2. *Describe and rationalize the course structure and learning assessment methods*
3. *Analyze and reflect on student achievement in the context of these objectives and assessments*

I hope this will give me the opportunity to develop a more thoughtful approach to what I am teaching, how I am teaching, how I assess student achievement, and how this relates to student learning. I hope this line of inquiry will also serve to suggest modifications and new approaches to teaching this course in the future.

III. Course Structure and Activities

A. Lecture Component

1. General Description

The lecture component of CHEM 109 is described in the course syllabus as follows:

> *"Presentation of course material, example exercises, clicker questions, and demonstrations by the instructor… Students are encouraged to study the relevant textbook sections in advance." [CHEM 109 Syllabus, Spring Semester 2013 (Appendix A)].*

As articulated above, the lecture component of the course has four facets. Each of these will be separately discussed in the sections which follow.

2. Lecture Presentations

One aspect of in-class contact time is fairly traditional lecture-based presentation of course material. I use PowerPoint slides as visual aids to communicate the material and to pose example problems and clicker questions. The slides for each class meeting are posted in PDF format to Blackboard the day before class, although the posted versions of the slides do not include solutions to example problems, clicker questions, or other material that I want to encourage students to write down or to think about more spontaneously. Many of my students follow along with these slides and take notes on them, either electronically or in hard copy.

3. Example Problems

Example problems are woven throughout my lectures, and I work through these examples on paper with the aid of a document camera. Through the choice of example problems and the manner of approaching them, I make an effort to emphasize the *reasoning* involved in approaching a problem (*What are we being asked to determine? What information are we given? What strategy will allow us to bridge the gap between the two?*). We also take some time to ask whether we have arrived at a *sensible* result (*Can we have less than a molecule of H_2O? Did we expect for pressure to increase when volume decreases?*).

4. Clicker Questions

I use clicker questions in two principal respects: to complement example problems by asking students to apply existing knowledge in new ways; and to serve as a refresher on an important concept which precedes the presentation of new but related information. Students are encouraged to work collaboratively on the clicker questions, and most do. The discussion of clicker questions can become quite lively. After revealing the correct answer, we work through the solution in a similar manner to example problems with a level of detail that depends on how well the class seems to "get it" based on their responses. I've found this very helpful for stirring up discussions among students and for stimulating questions, and for ferreting out misconceptions.

5. Demonstrations

Chemical demonstrations are also shown during lecture. These range from fairly mundane to rather spectacular. In any case, I only use demonstrations which have some substantial connection to the concepts at hand and can serve to reinforce course material (rather than to merely serve as a diversion).

6. Associated Outside Activities

To encourage students to hone and practice problem-solving and active learning outside of class, online homework assignments are given on a weekly basis in CHEM 109. The content of each homework assignment covers the material presented in the previous week's lectures. The homework system – which is furnished by the publisher of our textbook - allows students to make multiple attempts at answering various questions, and provides hints and feedback regarding common misconceptions or mistakes. Students are encouraged to work on these assignments in small groups.

7. Associated Assessments

The majority of the course assessments are directly associated with the lecture component of CHEM 109. These include four mid-semester examinations (each worth 100 of the 1,000 possible course points), a final examination (the previously mentioned American Chemical Society standardized exam for first-semester general chemistry, worth 150 of the 1,000 possible course points), the weekly online homework assignments (collectively worth 100 of the 1,000 possible course points)) and clicker questions (two points awarded per correct response up a maximum of 50 course points out of 1,000 possible; I typically offer about 30 clicker questions over the course of a semester).

I feel that, for a large enrollment class, we give a fairly high number of exams in CHEM 109 (five in all over the course of the semester). This requires substantial effort on the part of the teaching team (coauthoring common exams; grading free response questions; returning the hundreds of graded exams to students within 12 hours of the exam completion). The advantage of giving exams with this frequency is that we are able to provide regular feedback and assessment (approximately every three weeks). I believe this is important given the fast pace of the course. The use of the American Chemical Society exam as the final exam is useful; this enables us to compare the performance of our students relative to the national statistics on an exam compiled by experts in chemical education. This is a useful metric in comparing the effectiveness of our course, by an external and nationally recognized standard.

Aside from exams, the other graded components associated with the lecture are the clicker questions and the online homework assignments. In my experience these are critical to encouraging engagement in the course, both during class and beyond. The online homework is especially helpful in instigating questions from students based on their efforts outside of the classroom. While I also post suggested problems from the textbook, because it is not practical to collect and grade these problems, some students find the incentive to complete them to be rather low. Using graded online homework gets the class solving problems that I doubt would be completed if no course credit were associated with the activity.

B. Recitation Component

The recitation component of CHEM 109 is described in the course syllabus as follows:

> *"Review of lecture topics in smaller groups led by the recitation teaching assistant. Students are encouraged to study the relevant sections of the recitation manual in advance." [CHEM 109 Syllabus, Spring Semester 2013 (Appendix A)].*

The recitation sessions provides reinforcement of the course material in a smaller group setting (approximately 30 students). This is also an opportunity for course participants to hear another "take" on the material from a different instructor. To ensure some continuity, recitation TAs do attend the course lectures; however, these TAs are given a good deal of latitude and flexibility regarding how they conduct their recitation sessions.

To encourage attendance, clicker-based quizzes are also given in recitation. This accounts for 50 of the 1,000 possible course points. Because students come to recitation having already been given some conceptual background in lecture, the recitation TA will often pose more challenging questions during the recitation. This also seems helpful in drawing out questions.

C. Laboratory Component

The laboratory component of CHEM 109 is described in the course syllabus as follows:

> *"Experiments performed under the instruction of a laboratory teaching assistant. Students should become familiar with the experiment prior to each laboratory meeting." [CHEM 109 Syllabus, Spring Semester 2013 (Appendix A)].*

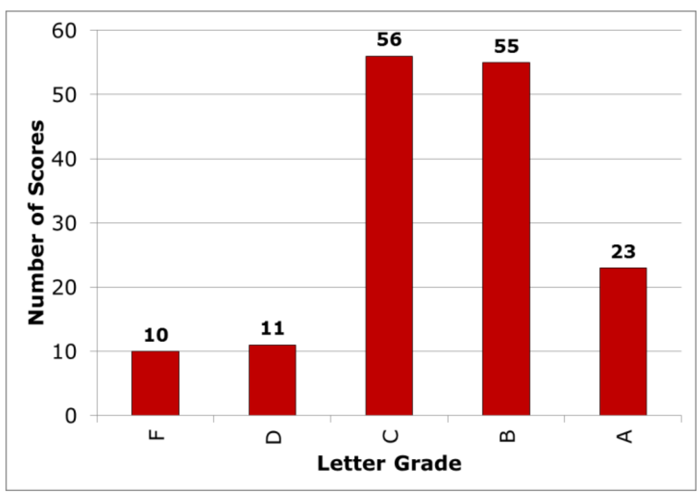
In the laboratory setting, CHEM 109 students have the opportunity to apply course concepts and develop rudimentary laboratory skills. The laboratory curriculum for our general chemistry program was recently updated (by my colleague Prof. Eric Malina) to make the exercises less formulaic or "cook book" than some traditional approaches to general chemistry laboratory. The majority of the laboratory experiments are now presented as paired exercises which are completed over two consecutive weekly lab meetings. The first "tool building" exercise is well guided and provides instructions for carrying out an experiment or procedure with the intent of conferring students with some specific laboratory skill. The second week follow up "problem solving" experiment asks the lab participants to make use of the tools and concepts learned previously to address a more open ended question. The students are not given detailed procedures on how to accomplish the "problem-solving" assignment, and indeed there are usually multiple possible approaches.

Assessment of the laboratory component of CHEM 109 is primarily based on weekly short-form lab reports. One longer, written report is also completed each semester.

IV. Analysis of Student Learning

A. Overview of Outcomes

In the Spring 2013 semester, my section of CHEM 109 initially had 186 students enrolled. Ultimately, 23 students formally withdrew from the course (87.6% retention). This retention rate is slightly lower than my previous experience (92.3% in Fall 2010; 91.8% in Fall 2011), but not alarmingly so. I also suspect that a slightly higher number of withdrawals is uncommon for an "off sequence" Spring semester offering.



At the end of the semester I gave 163 final grades; all of the grades given in the A-F range (155 students) are plotted above. For clarity, the grades are not broken down into "plus" and "minus" ranges in the plot; thus, the "A" range including 23 students encompasses the grades of "A-", "A" and "A+." Not appearing on the plot are seven grades for students who opted for pass / no pass grading (three P; four N) and one grade of "I." The incomplete was given due to the death of an immediate family member. The overall grade point average for the 155 letter-graded students was 2.45 (*i.e.*, middle "C+"). For the 145 of these who attempted every exam, the GPA was 2.59 (*i.e.*, upper "C+"). The average scores for each assessment type are tabulated below. On the whole, these outcomes are consistent with my previous experience with CHEM 109 and with departmental norms. Noting that the laboratory, online homework, clicker questions, and recitation quizzes all averaged above 80%, it seems clear that students are being distinguished on the basis of the exams. This will be explored in more detail in the following sections. For reference, the complete mid-semester examinations are provided in Appendices B-E.

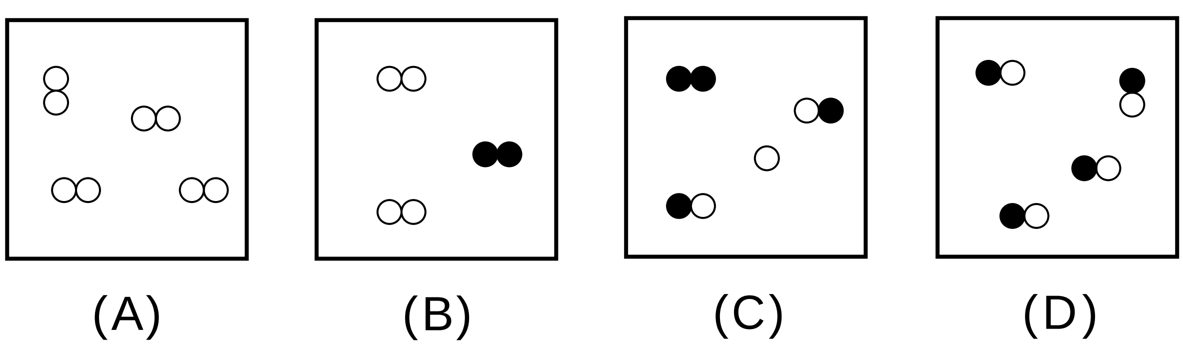
Assessment	**Possible Points**	**Average Points**	**Average %**
Exams 1-4	400	267.6	66.9
Final Exam	150	115.2	76.8
Laboratory	250	225.4	90.1
Online Homework	100	86.0	86.0
Clicker Questions	50	40.4	80.8
Recitation Quizzes	50	46.5	93.0
TOTAL	1000	770.5	77.1

B. Case Studies

1. Mid-Semester Examinations

In my experience, a common assertion among CHEM 109 students is that they "get the concepts" but find the mathematically–oriented problem-solving to be daunting and chemical notation to confuse their understanding of given question. One of my interests in studying student responses on the mid-semester examinations was to explore whether there is a disconnect between student performance on questions using extremely simple, diagrammatic representations of a concept as opposed to those written using chemical formalism or those requiring quantitative reasoning. One interesting comparison is found on Exam 1. In the "fill-in-the-blanks" question below, students were asked to classify types of matter (correct answers shown in the blanks):

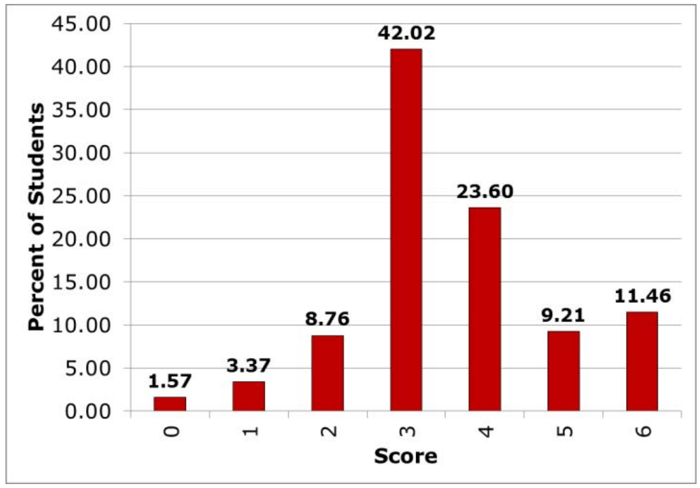
Q1. Write the letter of the illustration that represents each classification of matter (there can be more than one letter for each classification). 6 points.



Pure element(s): ___***A***______ ***Pure molecule(s):*** _***A, D***_____

Pure compound(s): __***D***_____ ***Mixture(s):*** _______***B, C***_______

For each correct classification, one point was awarded. The distribution of scores is shown at right. Approximately 44% of students received at least four points.



Since the distinctions being asked for (molecule versus compound; mixture versus pure substance) are rather rudimentary, I was surprised that less than half of the class earned four points or more. I did note that in some cases, points were lost because students were reluctant to apply more than one classification to a given diagram. Combining the concepts in this way does increase the difficulty level somewhat.

Interestingly, on the same exam students were asked to make a similar distinction in a multiple choice format, but using actual chemical symbols:

1. Which one of the following is a molecule, but **not** a compound?

A. He ***(41.12% - Incorrect)***

B. CO_2

C. N_2O_5

D. Cl_2 ***(54.61% - Correct)***

E. KBr

As shown above, only a little over half of the students correctly identified elemental chlorine as a molecule which is not a compound. Interestingly, the second most frequent response identified helium as a molecule but not a compound. Helium is actually an example of an atom, and represents neither a molecule nor a compound. I am again surprised that more students are not able to make these basic distinctions, particularly since we covered an entire unit on the classification of matter.

It is interesting to note that regardless of whether this understanding was probed using cartoons or using chemical symbology, the resulting student performance was similar. The two ways of asking the question seem to reveal the same understanding.

An interesting example of paired quantitative and conceptual question set is found on Exam 2 in the following two consecutive multiple choice questions:

5. At 41°C, the root mean square velocity of H_2 (g) molecules is:

A. 62.3 m/s ***(47.68% – Incorrect)***

B. 71.2 m/s

C. 196 m/s

D. 225 m/s

E. 1,970 m/s ***(36.67% - Correct)***

6. Which of the following most accurately represents the motion of gas molecules? Each circle represents one molecule of the same substance, and the arrows indicate their velocities.

A. B. C. ***(19.32% - Correct)*** D. ***(37.41% - Incorrect)***

E. All of the above reasonably depict the motion of gas molecules. ***(33.25% - Incorrect)***

On question 5, the nearly 37% arrived at the correct answer. The most common incorrect response (option A, nearly 48%) is the result that is obtained when the correct operations were carried out, but with application of the incorrect value of the universal gas constant (this indicates a lack of attention to the detail regarding dimensional analysis).

Question 5 was also intended to serve as a primer for Question 6. By asking examinees to calculate a root mean squared velocity of a sample of gas molecules, it was hoped that students would be reminded that gaseous molecules are in constant random motion and have a distribution of velocities at a given temperature (the situation depicted by option C in question 6). For question 6, the selection of option D indicates a conceptual problem: this diagram depicts all molecules having velocities which are equal in magnitude. I frankly have no idea why anyone would choose option E, or why D was a far more popular response than the similarly flawed A. Less than 20% of the class chose the correct representation.

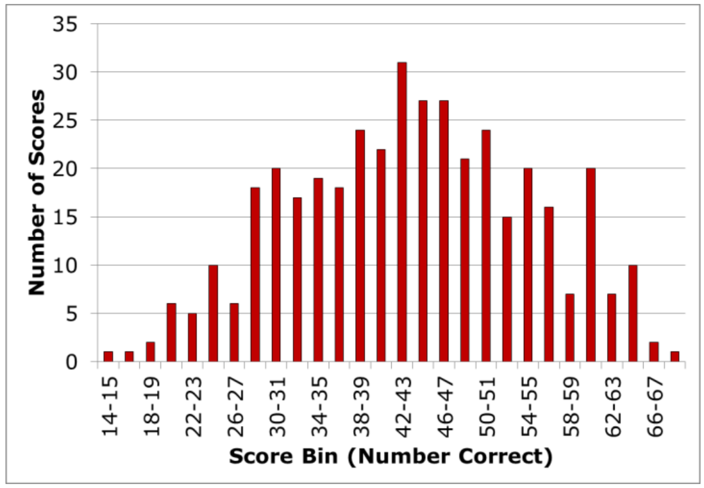
On the whole, this indicates that significantly population of students were able to calculate the root mean squared velocity of a gas, but evidently a much smaller fraction of participants were able to appreciate the meaning of what they had calculated (that is, a measure of central tendency for a distribution of velocities).

Further analysis of exam responses provides numerous other examples similar to the two I have reflected on here. Overall, I have been able to draw a couple of preliminary conclusions. Firstly, similar levels of conceptual understanding are indicated, regardless of whether a question is posed diagrammatically or using chemical formalisms. Secondly, in some situations students are able to flawlessly (or with one flaw) complete a calculation, but in the immediately succeeding question fail to demonstrate a conceptual understanding of what had been calculated. This leads me to question the oft-recurring student self-assessments which indicate their challenges are related to the mode of questioning; ultimately, everything seems to boil down to conceptual foundation, and the ability to produce a "correct" number through a series of calculations does not indicate understanding.

2. Final Exam

As mentioned previously, the final examination for CHEM 109 is a standardized test compiled by the American Chemical Society. The exam is comprehensive with respect to the content which is expected to be covered in a first semester university level general chemistry course. The exam consists of 70 multiple choice questions (four options each). Each question is intended to probe the student's understanding of one and only one concept. 110 minutes are allotted to complete the exam, and the score is based strictly on the number of correct responses (*i.e.*, there is no "guessing penalty").

According to national norms, the 50th percentile is found in the 42-43 correct bin in the figure shown at right. My class average was 43.1 correct, corresponding to a class average percentile of 52.2. This is a solid performance, although I note that the class average on this exam is a bit lower than it has been in previous semesters (my Fall 2010 section averaged at the 62.9 percentile; my Fall 2011 course averaged at the 60.4 percentile). I am at a bit of a loss to explain this, except to again note that this is not the only respect in which the Spring class is an outlier relative to my Fall classes. By this external standard, overall student performance seems acceptable.



V. Course and Portfolio Reflection

In CHEM 109 as a whole, I am pleased that my students are on average able to turn in a solid performance on a standardized exam. This gives me confidence that they are picking up at least some understanding of the topics deemed most crucial by the American Chemical Society. However, close examination of my mid-term exam data gives me some concern about the level of understanding that my students are able to achieve, even when they are clearly able to "plug and chug" through calculations. While I feel that the quantitative aspects of chemistry are tremendously important, it is possible that I have overemphasized this aspect in my teaching. This insight will undoubtedly influence how much time I spend in lecture working through example problems versus making conceptual links to the examples. This will also influence the design of my exams (I am now quite interested in further exploring student responses to paired quantitative and conceptual questions).

I feel that the development of this portfolio has been an exceedingly valuable exercise for me. I really appreciate the way that the Peer Review of Teaching program provides a blueprint for self-evaluation and documentation of teaching efforts. Engaging in the process has provided me with useful insights about my course and encouraged me to give deeper consideration to my teaching approaches and objectives of my course, and how I evaluate student conceptual understanding. This will have a direct impact on how I approach CHEM 109 in the future, particularly with respect to how I write assessments and how I advise students who insist they are not struggling with concepts, but formalism (it seems this is often not an accurate self-assessment on the part of students). To be sure, I will be sharing these thoughts with my colleagues, and I look forward to applying what I've learned here to all of my courses!

VI. Appendices

Appendix A:
CHEM 109 Course Syllabus, Spring 2013

Course Syllabus
CHEM 109: General Chemistry I
Spring Semester 2013, Section 110

Instructor and Contact Information

Instructor: Prof. Eric D. Dodds

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Office hours: Mo We Fr 12:30 - 1:30 pm, and by appointment

Course Description

This four-credit course (3 cr lecture; 1 cr laboratory) is the first in a two-semester sequence which serves as an introduction to fundamental principles of chemistry for students in scientific and technical disciplines. Course topics include atomic theory, chemical quantities, solutions, thermochemistry, gases, quantum theory, chemical bonding, and molecular structure. Over the course of CHEM 109, students will develop an understanding of matter at the atomic and molecular levels, including the structure of matter, the chemical and physical changes which matter undergoes, and the relation of these transformations to energy.

Course Meetings

Lectures are given Mo We Fr, 11:30 am - 12:20 pm, in 110 Hamilton Hall. Note that mid-semester exams will be given on Thursday evenings, and in different locations. Recitation and laboratory sessions are held various days and times.

Prerequisites

MATH 103, or a math placement test score for MATH 104 or MATH 106. *Students are strongly advised to observe this prerequisite. Proper math preparation is essential for success in CHEM 109.*

Required Materials

Textbook: Chemistry - The Science in Context, 3rd Edition, by T. R. Gilbert, R. V. Kirss, N. Foster, and G. Davies. W. W. Norton and Company, 2012. Available at the campus bookstore.

Recitation Manual: Chemistry 109 Recitation Manual, by J. A. Johnson and J. A. Kautz. Available at the campus bookstore.

Laboratory Manual: Chemistry 109 Laboratory Manual – Laboratory Techniques and Science Reasoning Skills, by E. Malina. Available at the campus bookstore.

Calculator: Scientific or graphing calculator. *Note that a TI graphing calculator (TI-83 or higher) is required for CHEM 110.*

Personal response system: i>Clicker2 remote. Available at the campus bookstore.

Laboratory safety eyewear: Available through PLU.

Suggested Materials

Solutions manual: Student Solutions Manual for Chemistry – The Science in Context, 3rd Edition, by K. S. Brewer, W. W. Norton and Company, 2011. Available at the campus bookstore.

Online Materials

Blackboard: Announcements, grades, and other materials will be posted at http://my.unl.edu.

SmartWork: Graded homework assignments will be completed at http://smartwork.wwnorton.com.

Chemistry Resource Center

The Chemistry Resource Center is located in 16-18 Hamilton Hall (telephone: 402-472-3514; http://www.chem.unl.edu/buckyball). The Center houses a collection of textbooks, computers for student use, and plentiful study space. Teaching assistants hold office hours at the Center, and are available to answer questions. Exam seating assignments and other important information will be posted at the Center. Graded assignments from lecture, recitation, and laboratory will be available for pick-up at the Center. *Students are encouraged to take advantage of the Resource Center.*

Course Structure

Lecture: Presentation of course material, example exercises, clicker questions, and demonstrations by the instructor. Lecture attendance will not be formally monitored; however, if an attendance record is requested, the instructor will consider clicker participation to be representative of attendance. *Students are encouraged to study the relevant textbook sections in advance.*

Recitation: Review of lecture topics in smaller groups led by the recitation teaching assistant. *Students are encouraged to study the relevant sections of the recitation manual in advance.*

Laboratory: Experiments performed under the instruction of a laboratory teaching assistant. *Students should become familiar with the experiment prior to each laboratory meeting.*

Grading

Final grades will be based on combined performance in the lecture, recitation, and laboratory components of the course. A grade of "incomplete" (I) will only be given if a documented illness, emergency, or obligation prevents a student from completing the course requirements.

Apportionment of points.

Assessment	Points
Exam 1	100
Exam 2	100
Exam 3	100
Exam 4	100
Final Exam (ACS standardized exam)	150
Laboratory (normalized total)	250
Online Homework (normalized total)	100
Clicker Questions (2 pts per correct)	50
Recitation Quizzes (5 pts per quiz)	50
TOTAL	**1000**

Letter grading scale.

Points Earned	Percent	Letter Grade
970 – 1000	≥ 97.0	A+
930 – 969	≥ 93.0	A
900 – 929	≥ 90.0	A-
870 – 899	≥ 87.0	B+
830 – 869	≥ 83.0	B
800 – 829	≥ 80.0	B-
770 – 799	≥ 77.0	C+
730 – 769	≥ 73.0	C
700 – 729	≥ 70.0	C-
670 – 699	≥ 67.0	D+
630 – 669	≥ 63.0	D
600 – 629	≥ 60.0	D-
< 600	< 60.0	F

Exam Times and Locations

The exam dates and times listed below cannot be changed. *All students should immediately make any necessary arrangements to attend the exams.*

Exam 1: Thursday, January 31, 5:45 pm

Exam 2: Thursday, February 21, 5:45 pm

Exam 3: Thursday, March 14, 5:45 pm

Exam 4: Thursday, April 18, 5:45 pm

Final Exam: Thursday, May 2, 6:00 pm

Each mid-semester exam period will be 90 minutes. The exams will be given in various classrooms across campus. Seating assignments will be posted at the Resource Center. *Students should review the seating assignments prior to each exam, as the assignments are modified from exam to exam.*

Exam Data Sheets

Five copies of an "Exam Data Sheet", or "Silent Test Partner" (STP), can be found at the back of the laboratory manual. Students may bring one of these sheets to each mid-semester exam. Notes may be added to these sheets, *provided that they are handwritten and fit entirely within the boxed space provided*. Each sheet must be labeled with the student's name and laboratory section. The sheets are collected with the exams and are inspected by the teaching staff. Violation of the STP sheet policy will result in a score of zero for the exam. STP sheets are not returned.

The final exam will be a standardized exam from the American Chemical Society. STP sheets cannot be used during this exam; however, the exam includes useful data similar to an STP sheet.

Exam Regrades

To prevent exam scores from being negatively impacted by minor grading errors, each student will be granted an error buffer of three points towards the total score of each mid-semester exam. However, in order to obtain a regrade the examinee must forfeit the error buffer. Thus, a regrade can only result in an improved score if the corrections are greater than three points in value. This policy applies to all regrade requests that require reevaluation of student work. Trivial grading mistakes (*e.g.*, an obvious arithmetic error) can be corrected without loss of the error buffer.

Regrade requests will only be accepted until 5:00 pm the day after the exam, and must be submitted directly to the instructor. Note that graded exams may be photocopied prior to release. The score for a mid-semester exam cannot exceed 100 points.

Academic Dishonesty

Academic dishonesty is a serious offense and will result in failure of the course. Do not submit work that is not your own. Do not plagiarize any source. Do not bring unauthorized materials to exams. Do not alter graded exams or assignments. University policies regarding academic dishonesty are set forth in the Student Code of Conduct and Disciplinary Procedures (Section 3.4.2; http://stuafs.unl.edu/ja/code). *Academic dishonesty will be met with the fullest disciplinary action provided by university policies.*

Collaboration with fellow students on graded homework and clicker questions is permitted and encouraged; however, each student must submit only their own work and assume responsibility for their own answers. Exams and laboratory reports must be exclusively each student's own work.

Missed Work

Failure to complete any graded exercise without an acceptable excuse will result in a score of zero for the missed work. There are only three acceptable reasons for missing graded work:

1. *Illness:* a signed letter from a physician or other health care professional is required.

2. *Official university business:* a signed letter from a coach, advisor, or supervisor is required.

3. *Documented emergency or obligation:* documentation corroborating the emergency (*e.g.*, death in the immediate family) or obligation (*e.g.*, court subpoena) is required.

A student who misses an exam but is excused for reasons described above may be able to schedule a make-up exam. Make-up exams are given solely at the discretion of the instructor.

E-mail

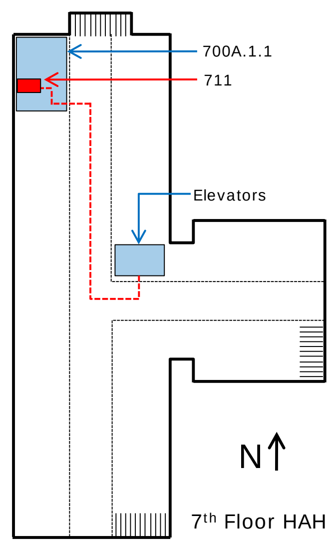
Students are welcome to e-mail the instructor with questions regarding course administration or to schedule an appointment for an office visit. Please mention CHEM 109 in the subject line. The instructor will make every effort to respond to e-mails within 24 hours. *Do not e-mail the instructor with questions regarding course subject matter; these questions should be posed in person.*

Questions concerning laboratory should be directed to the appropriate laboratory teaching assistant. Questions concerning recitation should be directed to the appropriate recitation teaching assistant. Questions concerning SmartWork online homework assignments should be directed to Brent Turner, the SmartWork administrator (unlwebquiz@gmail.com).

Office Hours

The instructor's office hours will be held in 711 Hamilton Hall. Please note that room 711 can be found inside of room 700A.1.1 (see map at right). Regular office hours will be held Mo We Fr, 12:30 - 1:30 pm. Consultation with the instructor is also possible by appointment, which can be scheduled by e-mail or telephone.

The instructor will only be available for consultation during regular office hours or by scheduled appointment. *The instructor will be unable to entertain impromptu office visits.*



Map to 711 HAH.

Lecture Slides

To facilitate note-taking, lecture slides will be posted on Blackboard prior to class meetings; however, some course material will be absent from these slides (*e.g.*, solutions to example problems worked in class, clicker questions and solutions, information on demonstrations, *etc.*). *Thus, these slides should not be considered a substitute for class attendance.*

Time Commitment

As a general guideline, a university student should dedicate two to three hours of study per week to each credit in which they are enrolled. Because CHEM 109 is a four credit course, students are advised to commit 8 - 12 hours per week to the study of lecture, recitation, and laboratory materials; to completion of laboratory reports and assigned homework; and to working additional problems from the textbook. *Consistent study and problem-solving practice are essential for success in CHEM 109.*

Tentative Course Schedule

Date	Lecture Topic	Text	Recitation/Laboratory Topic
Jan 7	Course introduction; properties of matter	1: 1-6	*Reci:* Matter; measurement *Lab:* Nuts & bolts of chemistry
Jan 9	Course policies; scientific measurements	1: 7-10	
Jan 11	The development of modern atomic theory	2: 1	
Jan 14	Isotopes and atomic mass	2: 2-3	*Reci:* Atomic theory; compounds *Lab:* Are you dense or what?
Jan 16	The periodic table and types of compounds	2: 4-7	
Jan 18	The mole and mole calculations	3: 1-2	
Jan 21	*No class – Martin Luther King Day*		*Reci:* Mole; chemical equations *Lab:* Are you dense or what?
Jan 23	Chemical equations and stoichiometry	3: 3-5	
Jan 25	Empirical and molecular formulas	3: 6-8	
Jan 28	Limiting reactant and stoichiometry	3: 9	*Reci:* Limiting reactant *Lab:* Get charged up
Jan 30	Limiting reactant and percent yield	3: 9	
Jan 31	***EXAM 1 - 5:45 PM – CHECK SEAT ASSIGNMENT***		
Feb 1	Solutions and electrolytes	4: 1-4	
Feb 4	Acid-base reactions	4: 5-6	*Reci:* Solutions; reactions *Lab:* Get charged up
Feb 6	Precipitation reactions	4: 7	
Feb 8	Oxidation-reduction reactions	4: 9	
Feb 11	Balancing oxidation-reduction reactions	4: 9	*Reci:* Thermochemistry I *Lab:* Proof it
Feb 13	Energy, enthalpy, heating, and cooling	5: 1-4	
Feb 15	Calorimetry: measuring heat	5: 5	
Feb 18	Enthalpies of formation and reaction	5: 6-7	*Reci:* Thermochemistry II *Lab:* Proof it
Feb 20	Enthalpies of reaction and Hess's Law	5: 8	
Feb 21	***EXAM 2 - 5:45 PM – CHECK SEAT ASSIGNMENT***		
Feb 22	Pressure and gas laws	6: 1-3	
Feb 25	The ideal gas law and gas density	6: 4-6	*Reci:* Gases *Lab:* Get charged up – Part II
Feb 27	Partial pressures and gas stoichiometry	6: 7	
Mar 1	Kinetic theory of gases	6: 8	
Mar 4	Effusion / diffusion and real gases	6: 8-9	*Reci:* Light; quantum theory *Lab:* Get charged up – Part II
Mar 6	The electromagnetic spectrum	7: 1-3	
Mar 8	Quantum theory and the Bohr model	7: 4	
Mar 11	Electrons as particles and waves	7: 5	*Reci:* Electron configurations *Lab:* See the light
Mar 13	Quantum numbers and atomic orbitals	7: 6-7	
Mar 14	***EXAM 3 - 5:45 PM – CHECK SEAT ASSIGNMENT***		
Mar 15	Electron configurations of atoms and ions	7: 8-9	
	Mar 18, Mar 20, Mar 22: No class – Spring Vacation		
Mar 25	Sizes of atoms and ions	7: 10-12	*Reci:* Lewis structures *Lab:* See the light
Mar 27	Introduction to chemical bonding	8: 1	
Mar 29	Lewis symbols and Lewis bonding theory	8: 2	
Apr 1	Electronegativity and bond polarity	8: 3-4	*Reci:* Molecular geometry *Lab:* Molecular modeling
Apr 3	Resonance and formal charge	8: 5-6	
Apr 5	Exceptions to the octet rule	8: 7	
Apr 8	Covalent bond energy and length	8: 8	*Reci:* Valence bond theory *Lab:* Molecular modeling
Apr 10	Molecular geometry and VSEPR theory	9: 1-2	
Apr 12	VSEPR theory and larger molecules	9: 2	
Apr 15	Molecular geometry and molecular polarity	9: 3	*Reci:* Bonding theories
Apr 17	Valence bond theory: small molecules	9: 4	
Apr 18	***EXAM 4 - 5:45 PM – CHECK SEAT ASSIGNMENT***		
Apr 19	Valence bond theory: larger molecules	9: 5	
Apr 22	Molecular orbital theory	9: 7	*Reci:* Course review
Apr 24	*Topic to be announced*	TBA	
Apr 26	*Topic to be announced*	TBA	
May 2	***FINAL EXAM - 6:00 PM - CHECK SEAT ASSIGNMENT***		

Laboratory Safety

Safety is of utmost importance in the chemistry laboratory. For this reason, teaching assistants will highlight safety procedures for each experiment and will instruct students in the proper handling, labeling, and disposal of chemicals. For the safety of all laboratory participants, students must give the safety instructions their full attention and must follow all prescribed safety procedures.

Services for Students with Disabilities

It is the policy of the University of Nebraska - Lincoln to provide flexible and individualized accommodation to students with documented disabilities that may affect their ability to fully participate in course activities or to meet course requirements. To receive accommodation services, students must be registered with Services for Students with Disabilities (telephone: 402-472-3787; http://www.unl.edu/ssd). Students are also free to discuss any concerns with the instructor.

Achievement-Centered Education (ACE)

CHEM 109 satisfies the ACE Student Learning Outcome 4:

Use scientific methods and knowledge of the natural and physical world to address problems through inquiry, interpretation, analysis, and the making of inferences from data, to determine whether conclusions or solutions are reasonable.

The learning outcome is embedded in the course through lectures, lecture demonstrations, and laboratory explorations. Lecture topics convey the content knowledge that relates observable phenomena with trends, laws, and theories as established through use of the scientific method. The students are taught to see phenomena as vehicles for inquiry into the natural world. Homework and quizzes further help students learn to interpret, analyze, and make inferences from data. They learn multiple ways to arrive at the same conclusions and, therefore, how to determine whether conclusions are reasonable. The laboratory explorations were selected to complement the lecture topics. This hands-on experience provides the opportunity for students to engage in guided inquiry of the scientific method.

Student understanding and application of content knowledge is assessed through ten laboratory reports, quizzes using the personal response system, four hourly exams and a final exam. Laboratory reports are used to assess the student's achievement of the scientific method component. They gauge the student's ability to understand the purpose of a testable hypothesis; ability to describe the data they collected; present, assess and analyze their data sets; identify appropriate conclusions; relate their findings to the literature; and effectively communicate their findings. Exams consist of problem questions about the lecture material and short answer questions. On the final exam, specific questions about the scientific method and its use to understand chemical principles will be used assess student achievement of this learning outcome.

To assess student achievement of this outcome, the Chemistry Curriculum Committee will collect and assess a reasonable sample of students' work each semester. At the end of each academic year, the curriculum committee and the instructor will provide feedback on students' achievement of the learning outcome.

Appendix B: CHEM 109 Exam 1, Spring 2013

PRINT NAME**____** ***Room*** ___________
(Last) ***(First)*** ***(MI)***

NU ID# ____ ***Bldg*** ____________

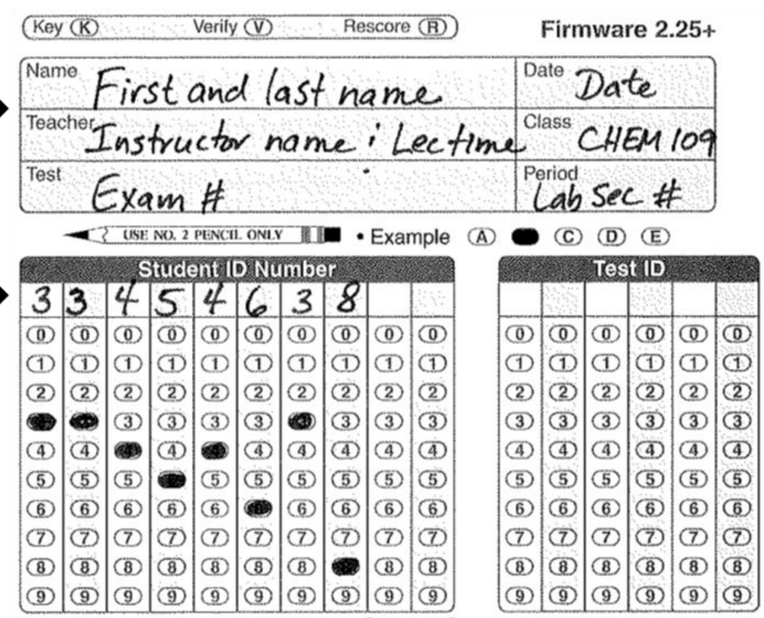
Signature _______________________________________ ***Seat #***____________

Lecture Section (circle): ***110*** ***120*** ***130*** ***Lab Section***_______

BE SURE YOU HAVE 11 DIFFERENT PAGES IN THIS EXAM PACKET
PLUS 1 ACCUSCAN FORM

FILL OUT THE ACCUSCAN FORM AS SHOWN BELOW
EXAMS WILL NOT BE GRADED IF THIS INFORMATION IS INCORRECT OR INCOMPLETE

Name: FULL NAME
Teacher: Instructor name / lecture time
Test: Exam 1
Date: Jan 31, 2013
Class: CHEM 109
Period: LAB SECTION NUMBER



Fill in AND bubble in your NU ID number.
START with the left-most box

NU ID number

These boxes should be BLANK **LOOK!**

SHOW ALL WORK - NO WORK, NO CREDIT

REPORT ALL ANSWERS WITH CORRECT UNITS AND SIGNIFICANT FIGURES

- *Sit in assigned seat*
- *All cell phones (or other 2-way mobile devices) must be turned off and cannot be used as a calculator.*
- *You may use a calculator and an exam data sheet.*
- *Raise your hand if you have a question.*
- *Keep your eyes on your own paper; several exam forms may be in use. It is a code violation if data from another exam form appears on your paper.*
- *Keep all required exams as part of your records.*

REQUEST FOR REGRADE

To prevent exam scores from being negatively impacted by minor grading errors, each student will be granted an error buffer of three points towards their total exam score. However, in order to have an exam regraded, the examinee must forfeit the error buffer. Therefore, a regrade can only result in an improved score if the corrections are greater in value than the error buffer. The maximum score is 100 pts. When submitting a regrade request, do not write on exam pages. Additional questions or comments are to be placed on a separate and turned in with your test.

Regrade requests must be submitted by 5:00 pm the day following the Exam

Please regrade question_____ because____

____

____

Please regrade question_____ because____

____

____

Please regrade question_____ because____

____

____

You must sign your regrade request, or it will not be considered a valid request

I accept responsibility for all answers contained herein. _________________________________

Signature

PART 1: MULTIPLE CHOICE

Choose the one best answer for each question, and record it on the provided AccuScan form (3 points each; no partial credit).

1. Which one of the following is a molecule, but ***not*** a compound?

A. He

B. CO_2

C. N_2O_5

D. Cl_2

E. KBr

2. If exactly two moles of substance "A" (molar mass = 125 g/mol) react completely with exactly one mole of substance "B" (molar mass = 55 g/mol) to form exactly one mole of substance "C," then what mass of "C" is produced by the reaction shown below?

$$\mathbf{2\,A + B \rightarrow C}$$

A. 55 g

B. 125 g

C. 180 g

D. 305 g

E. Cannot be determined from the information given

3. Which experiment led to the discovery of the nucleus?

A. Thomson's cathode ray experiment, which measured the mass-to-charge ratio of particles in a negatively charged beam

B. Millikan's oil drop experiment, which measured the amount of charge carried by the droplets in a chamber irradiated with x-rays

C. Rutherford's gold foil experiment, which measured the scattering angles of alpha particles directed at a thin layer of gold

D. Aston's positive ray experiment, which measured the mass-to-charge ratios of positively charged neon ions

E. None of these experiments led to the discovery of the nucleus

4. 0.550 g of magnesium burns in air to form 0.912 g of magnesium oxide according to the chemical equation below:

$$\mathbf{2\ Mg\ (s) + O_2\ (g) \rightarrow 2\ MgO\ (s)}$$

What mass of magnesium oxide would be formed if 0.375 g of magnesium were burned?

A. 0.226 g

B. 0.275 g

C. 0.456 g

D. 0.622 g

E. None of the above

5. Which one of the following is ***not*** true regarding the nucleus of an atom?

A. The nucleus contains the majority of the mass of an atom

B. The nucleus occupies most of the volume of an atom

C. The nucleus of an atom can contain protons and neutrons

D. The number of protons in a nucleus is the same for all atoms of a given element

E. Isotopes of a given element have different numbers of neutrons in their nuclei

6. Which one of the following has three significant figures?

A. 0.021

B. 0.210

C. 2.100

D. Both A and B above

E. None of the above

7. Which of the following results is ***not*** reported to the correct number of significant figures?

A. (0.125)(0.27) = 0.034

B. 356 + 20 = 380

C. $(1.2 \times 10^{-3}) - (3.9 \times 10^{-4}) = 8 \times 10^{-4}$

D. 985 / (3.1 + 9.0) = 81

E. 985 + 27 = 1012

8. Identify which one of the following represents a chemical change.

A. A change in the density of liquid water as temperature changes

B. The production of water from hydrogen and oxygen

C. The conversion of water from the solid to liquid state

D. The conversion of water from the liquid state to the gaseous state

E. None of the above are chemical changes

9. Which one of the following statements about arsenic is ***not*** true?

A. An atom of ^{75}As has 42 protons and 33 neutrons

B. The mass of one mole of arsenic atoms is 74.92 g

C. The As^{3+} ion has 30 electrons

D. The atomic number of arsenic is 33

E. Arsenic behaves as both a metal and a non-metal

33
As
arsenic
74.92

10. Which of the following is a compound of an alkaline earth metal and a halogen?

A. BaI_2

B. KBr

C. $MnCl_2$

D. $SrNe_2$

E. More than one of the above is a compound of an alkaline earth metal and a halogen

11. Which of the following elements is most likely to have the same chemical properties as calcium (Ca)?

A. K

B. Sc

C. Sr

D. Both K and Sc

E. None of these is likely to have the same chemical properties as calcium

12. Which one of the following is an ionic compound?

A. NaN_3

B. CH_4

C. N_2O_4

D. SO_3

E. CO_2

13. The molar mass of $(NH_4)_3PO_4$ is:

A. 95 g/mol

B. 113 g/mol

C. 131 g/mol

D. 149 g/mol

E. 242 g/mol

14. Which of the following contains the smallest number of atoms?

A. 1.0 g of Li

B. 1.0 g of Na

C. 1.0 g of K

D. 1.0 g of Rb

E. 1.0 g of Cs

15. Which one of the following is an empirical formula?

A. C_2H_4

B. C_2H_2

C. C_2H_6O

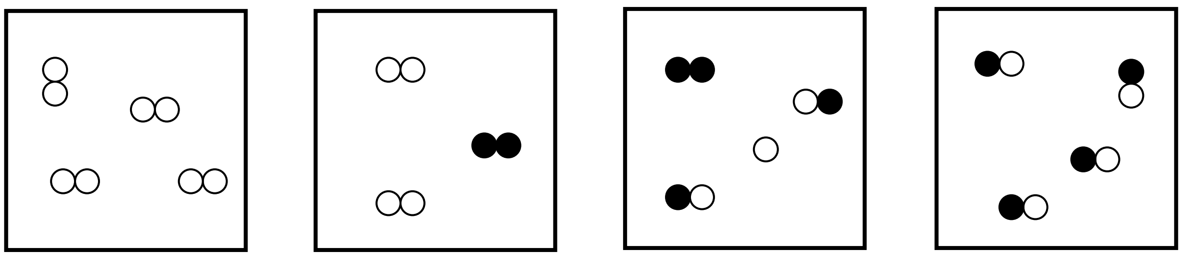
D. H_2O_2

E. $C_2H_2Cl_2$

PART 2: FREE RESPONSE

Show all work; no work, no credit. Give all numeric answers with the correct number of significant figures. Write final answers in the provided spaces.

Q1. Write the letter of the illustration that represents each classification of matter (there can be more than one letter for each classification). 6 points.



(A) (B) (C) (D)

TA Use Only	
Points	Initials

Pure element(s): ___________ ***Pure molecule(s):*** ___________

Pure compound(s): _________ ***Mixture(s):*** _________________

Q2. The masses of gemstones are often measured in carats, with 1.00 carat = 0.200 g. What volume of water would be displaced if a 15.05 carat sapphire were submerged in water? Sapphire has a density of 4.03 g/mL. Express your answer with the correct number of significant figures. 4 points.

TA Use Only	
Points	Initials

Volume: __________________ **mL**

Q3. Fill in the blanks in the table below. Also, circle the type(s) of bond(s) present in each substance. 5 points.

Formula	**Name**	**Type of bond present (circle)**		
NH_4Br		Ionic	Covalent	Both
	manganese (IV) oxide (manganese is Mn)	Ionic	Covalent	Both
P_2O_5		Ionic	Covalent	Both
	zinc phosphate	Ionic	Covalent	Both
H_2S (aq)		Ionic	Covalent	Both

TA Use Only	
Points	Initials

Q4. For the reaction below, determine the limiting reagent if 20.00 g of methane gas (CH_4; 16.04 g/mol) and 94.30 g of chlorine gas (Cl_2; 70.91 g/mol) are allowed to react. 6 points.

$$\mathbf{CH_4\ (g) + 2\ Cl_2\ (g) \rightarrow CCl_4\ (g) + 2\ H_2\ (g)}$$

TA Use Only	
Points	Initials

Limiting reagent: ________________

Q5. Antimony (Sb) has two isotopes. The average atomic mass of antimony is 121.760 amu. Given the tabulated data, find the fractional abundance of each individual isotope. Express your answers with the correct number of significant figures. 8 points.

Isotope	**Isotope Mass (amu)**
^{121}Sb	120.9038
^{123}Sb	122.9042

TA Use Only	
Points	Initials

Fractional abundance, ^{121}Sb: ________________

Fractional abundance, ^{123}Sb: ________________

Q6. Balance the following chemical equations by filling in the missing coefficients. 8 points.

___ Fe (s) + ___ O_2 (g) → ___ Fe_2O_3 (s)

___ $(NH_4)_2SO_4$ (aq) + ___ NaOH (aq) → ___ Na_2SO_4 (aq) + ___ NH_3 (aq) + ___ H_2O (l)

TA Use Only	
Points	Initials

Q7. Assume 26.96 g of potassium chlorate ($KClO_3$; 122.55 g/mol) ends up producing 7.01 g of potassium chloride (KCl; 74.55 g/mol) according to the reaction below. Determine the percent yield for the reaction and the mass of oxygen gas (O_2; 32.00 g/mol) produced. Express your answers with the correct number of significant figures. 8 points.

$$2\ KClO_3\ (s) \rightarrow 2\ KCl\ (s) + 3\ O_2\ (g)$$

TA Use Only	
Points	Initials

Percent yield: ________________ **%**

Mass of O_2: ________________ **g**

Q8. Calculate the number of hydrogen atoms in 15.5 g of NH_3. Express your answer with the correct number of significant figures. 5 points.

TA Use Only	
Points	Initials

Number of H atoms: ________________

Q9. Calculate the empirical formula of a compound composed of 25.9% N and 74.1% O by mass. 5 points.

TA Use Only	
Points	Initials

Empirical formula: ________________

Appendix C:
CHEM 109 Exam 2, Spring 2013

PRINT NAME____ **Room** __________

(Last) *(First)* *(MI)*

NU ID# ____ **Bldg** __________

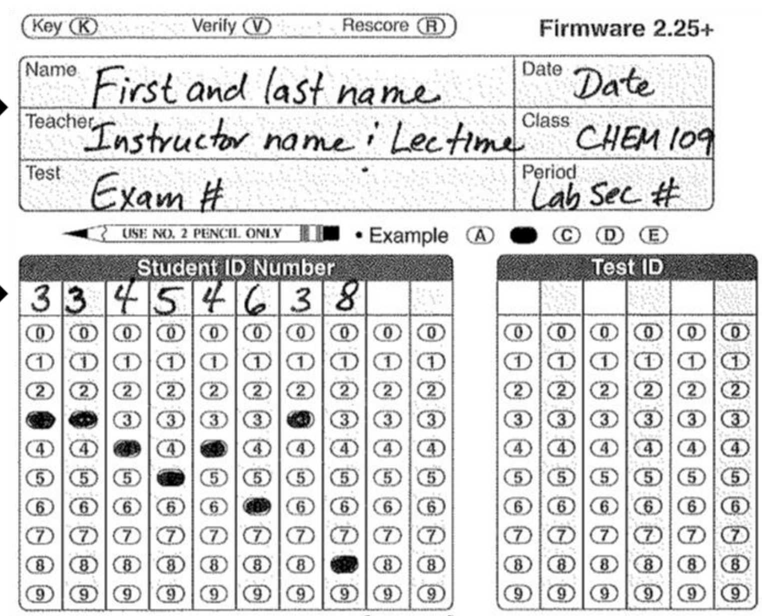
Signature ____ **Seat #**__________

Lecture Section (circle): 110 120 130 **Lab Section**_______

BE SURE YOU HAVE 11 DIFFERENT PAGES IN THIS EXAM PACKET
PLUS 1 ACCUSCAN FORM

FILL OUT THE ACCUSCAN FORM AS SHOWN BELOW
EXAMS WILL NOT BE GRADED IF THIS INFORMATION IS INCORRECT OR INCOMPLETE

Name: FULL NAME
Teacher: Instructor name / lecture time
Test: Exam 2
Date: Feb 21, 2013
Class: CHEM 109
Period: LAB SECTION NUMBER



Fill in AND bubble in your NU ID number.
START with the left-most box

NU ID number

These boxes should be BLANK **LOOK!**

SHOW ALL WORK - NO WORK, NO CREDIT

REPORT ALL ANSWERS WITH CORRECT UNITS AND SIGNIFICANT FIGURES

- *Sit in assigned seat*
- *All cell phones (or other 2-way mobile devices) must be turned off and cannot be used as a calculator.*
- *You may use a calculator and an exam data sheet.*
- *Raise your hand if you have a question.*
- *Keep your eyes on your own paper; several exam forms may be in use. It is a code violation if data from another exam form appears on your paper.*
- *Keep all required exams as part of your records.*

REQUEST FOR REGRADE

To prevent exam scores from being negatively impacted by minor grading errors, each student will be granted an error buffer of three points towards their total exam score. However, in order to have an exam regraded, the examinee must forfeit the error buffer. Therefore, a regrade can only result in an improved score if the corrections are greater in value than the error buffer. The maximum score is 100 pts. When submitting a regrade request, do not write on exam pages. Additional questions or comments are to be placed on a separate and turned in with your test.

Regrade requests must be submitted by 5:00 pm the day following the Exam

Please regrade question______ because____

____

____

Please regrade question______ because____

____

____

Please regrade question______ because____

____

____

You must sign your regrade request, or it will not be considered a valid request

I accept responsibility for all answers contained herein. ________________________________

Signature

PART 1: MULTIPLE CHOICE

Choose the one best answer for each question, and record it on the provided AccuScan form (3 points each; no partial credit).

1. A sample of 169.9 g of silver nitrate ($AgNO_3$; 169.9 g/mol) is dissolved in a solution of sodium chloride (NaCl; 58.44 g/mol) containing 584.4 g of NaCl in 2.00 L of solution. How many grams of solid silver chloride (AgCl; 143.3 g/mol) would be produced?

A. 0 g

B. 143.3 g

C. 169.9 g

D. 754.3 g

E. 1433 g

2. The ice inside a Styrofoam cooler with the lid open would be considered what type of system?

A. Closed

B. Isolated

C. Open

D. None of these would describe the system

Use the following description to answer the next three multiple choice questions. Dissolving solid sodium nitrate ($NaNO_3$) into liquid water (H_2O) causes the sodium nitrate solution to become colder than the solid sodium nitrate and liquid water used to make the solution.

3. The reaction $NaNO_3$ (s) → $NaNO_3$ (aq) would be considered what type of reaction?

A. Endothermic

B. Exothermic

4. The ΔH^o_{rxn} for $NaNO_3$ (s) → $NaNO_3$ (aq) would have what value?

A. Negative value

B. Positive value

5. What substance(s) would be absorbing the heat in the reaction $NaNO_3$ (s) → $NaNO_3$ (aq)?

A. H_2O

B. $NaNO_3$

C. The beaker, air, and rest of surroundings

D. The water, beaker, air, and rest of surroundings

6. When 10.0 g of a solid is added to 90.0 mL of water at 25.0ºC, only 6.0 g of the solid dissolves (remaining 4.0 g will not dissolve no matter how long solution is mixed). When an additional 60.0 mL of 25.0ºC water is added (total volume of 150.0 mL), the remaining 4.0 g of solid dissolves. What classification can be given to the final 150.0 mL solution?

A. Saturated

B. Supersaturated

C. Unsaturated

D. None of these classifications can be determined from the information given

7. How many grams of NaOH (40.00 g/mol) must be dissolved in water to make 100.0 mL of a 0.100 M NaOH solution?

A. 0.0400 g

B. 0.400 g

C. 4.00 g

D. 40.0 g

8. Which reaction below would be the net ionic equation for the following reaction?

$$\mathbf{2\ HC_2H_3O_2\ (aq) + Ba(OH)_2\ (aq) \rightarrow Ba(C_2H_3O_2)_2\ (aq) + 2\ H_2O\ (l)}$$

A. H^+ (aq) + OH^- (aq) → H_2O (l)

B. $HC_2H_3O_2$ (aq) + OH^- (aq) → $C_2H_3O_2^-$ (aq) + H_2O (l)

C. 2 $HC_2H_3O_2$ (aq) + $Ba(OH)_2$ (aq) → $Ba(C_2H_3O_2)_2$ (aq) + 2 H_2O (l)

D. 2 H^+ (aq) + 2 $C_2H_3O_2^-$ (aq) + Ba^{2+} (aq) + 2 OH^- (aq) → Ba^{2+} + 2 $C_2H_3O_2^-$ (aq) + 2 H_2O (l)

9. What is the oxidation number of N in N_2O_4?

A. -4

B. 0

C. +4

D. +8

E. None of the above would be the oxidation number of N in N_2O_4

10. Calculate ΔH^o_{rxn} for 2 CO (g) + 2 NO (g) → 2 CO_2 (g) + N_2 (g) given information below?

CO (g) + ½ O_2 (g) → CO_2 (g) **ΔH^o = —283 kJ**
N_2 (g) + O_2 (g) → 2 NO (g) **ΔH^o = —181 kJ**

A. —747 kJ

B. —464 kJ

C. —385 kJ

D. —102 kJ

11. What is the concentration of a solution made by adding enough water to 10.0 mL of 0.1165 M HCl to make a total volume of 0.500 L?

A. 0.00233 M

B. 0.00583 M

C. 0.0233 M

D. 2.33 M

E. 5.83 M

12. Using the information on your Exam Data Sheet, determine the heat of reaction for the reaction below?

CO_2 (g) + 4 H_2 (g) → CH_4 (g) + 2 H_2O (g)

A. +951.7

B. +164.7 kJ

C. +77.1 kJ

D. —164.7 kJ

E. —951.7 kJ

13. Which substance in the reaction below would be considered the Bronsted-Lowry base and why?

CH_3NH_2 (aq) + H_2O (l) $\rightleftharpoons$ $CH_3NH_3^+$ (aq) + OH^- (aq)

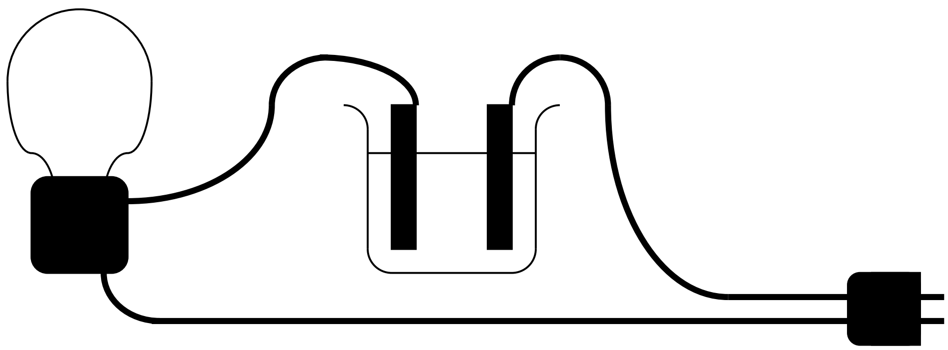
A. CH_3NH_2, because it accepts an H^+ in the reaction

B. CH_3NH_2, because it donates an H^+ in the reaction

C. H_2O, because it accepts an H^+ in the reaction

D. H_2O, because it donates an H^+ in the reaction

14. About 50 mL of pure water was put into a beaker. A light bulb is hooked up to an electrical outlet, but two metal rods are placed in the circuit (like the demonstration in lecture). When the rods are placed in water, the light bulb does **NOT** light up. When sample of solid compound is adding to the water and stirred thoroughly, the light bulb still does **NOT** light up? Which of the following statements would be true?



A. Compound could be a strong electrolyte

B. Compound could be an insoluble salt

C. Compound could be an non-electrolyte

D. Both B and C could be true

15. Which of the following could be reactants in a heat of formation reaction?

A. C (s)

B. CO_2 (g)

C. H_2O (l)

D. N_2 (g)

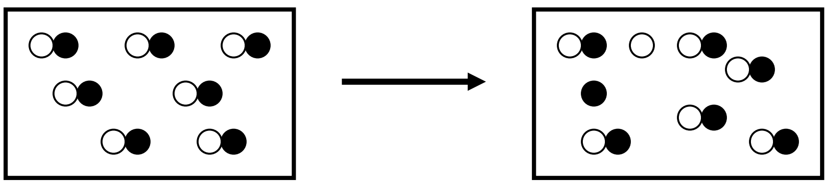
E. Both A and D could be reactants in a heat of formation reaction

PART 2: FREE RESPONSE

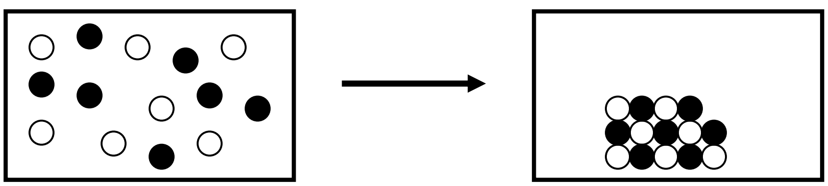
Show all work; no work, no credit. Give all numeric answers with the correct number of significant figures. Write final answers in the provided spaces.

Q1. Each illustration below represents a solution (water is the solvent, but not shown). The diagram to the left is a representation of the solution before any ionization or reaction is allowed to take place. The diagram to the right is the solution after any ionization or reaction has taken place. In each case, specify whether the compound is a strong electrolyte, weak electrolyte, nonelectrolyte, or insoluble salt. **NOTE:** White circles represent the cation (or hydrogen ion) and the black circles represent the anion. 8 points.

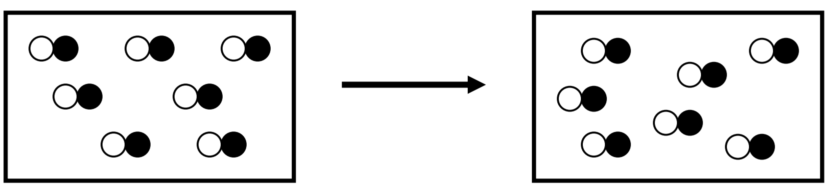
(A)



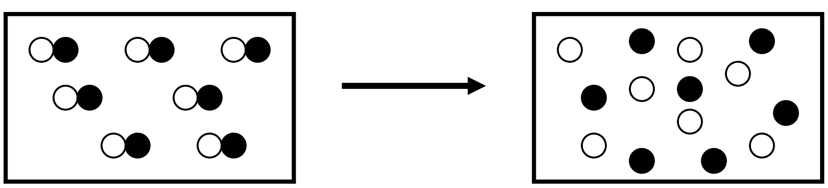
(B)



(C)



(D)



Place the letter of the representation in the correct blank.

Strong electrolyte: _______________ ***Weak electrolyte:*** __________________

Non-electrolyte: __________________ ***Insoluble salt:*** ____________________

TA Use Only	
Points	Initials

Q2. The following substances are dissolved in water as shown below. Indicate whether each substance is strong electrolyte, a weak electrolyte, or a non-electrolyte. 6 points.

Reaction	**Circle One**		
C_4H_9OH (s) → C_4H_9OH (aq)	Strong Electrolyte	Weak Electrolyte	Non-Electrolyte
$CaCl_2$ (s) → Ca^{2+} (aq) + 2 Cl^{-} (aq)	Strong Electrolyte	Weak Electrolyte	Non-Electrolyte
CH_3CH_2COOH (aq) ⇆ $CH_3CH_2COO^{-}$ (aq) + H^{+} (aq)	Strong Electrolyte	Weak Electrolyte	Non-Electrolyte

TA Use Only	
Points	Initials

Q3. For each case below, predict the products **and** indicate the type of reaction that takes place. Be sure the completed reaction is balanced and includes all states of matter. If no reaction would take place, write "No reaction" in the blank. 9 points.

A. __ **Rb_2SO_4 (aq) +** __ **$BaBr_2$ (aq) →**

Type of reaction: ______________________________

B. __ **HI (aq) +** __ **LiOH (aq) →**

Type of reaction: ______________________________

C. __ **NaCl (aq) +** __ **KOH (aq) →**

Type of reaction: ______________________________

TA Use Only	
Points	Initials

Q4. Consider the unbalanced oxidation-reduction reaction below. 10 points

$\mathbf{CrO_4^{2-}\ (aq) + S_2O_3^{2-} \rightarrow Cr(OH)_3\ (s) + SO_4^{2-}\ (aq)}$

A. What element is being oxidized?

Element oxidized: ____________________

B. What element is being reduced?

Element reduced: ____________________

C. Balance the reaction (assume acidic conditions)

Balanced reaction: ____

D. While this reaction is a redox reaction, it can also be classified as another type of reaction. What other type of reaction is taking place?

TA Use Only	
Points	Initials

Type of reaction: ____

Q5. A 72.5 g cube of solid copper (c_s = 0.385 J/g•°C) is heated to 89.7°C, and then deposited into a calorimeter containing 115 g of ethyl alcohol (CH_3CH_2OH) at 25.5°C. At thermal equilibrium, the combined copper / ethanol mixture reached a temperature of 31.2°C. What is the specific heat capacity (c_s) of CH_3CH_2OH **in J/g•°C**? Report your answer with the correct number of significant figures. 6 points.

TA Use Only	
Points	Initials

Specific heat: ____________________ **J/g•°C**

Q6. Acetic acid ($HC_2H_3O_2$) is responsible for the distinct odor and flavor of vinegar. Assume that 10.00 mL of vinegar was diluted with water to a new volume of 25.00 mL. This dilute vinegar solution was then titrated with a 0.09865 M solution of $Ba(OH)_2$. The balanced chemical equation for this reaction is given below.

$$\mathbf{2\ HC_2H_3O_2\ (aq) + Ba(OH)_2\ (aq) \rightarrow Ba(C_2H_3O_2)_2\ (aq) + 2\ H_2O\ (l)}$$

The equivalence point of the titration was reached when 20.82 mL of $Ba(OH)_2$ had been added. What is the molarity of acetic acid in the **original** vinegar solution? Report your answer with the correct number of significant figures. 6 points.

TA Use Only	
Points	Initials

Concentration: ____________________ **M**

Q7. Calculate the molarity of an HCl solution if 100.0 mL of the solution was reacted with 50.0 mL of 2.0 M NaOH causing both solutions to go from 23.4 ºC to 32.1 ºC. Assume all solutions have the same specific heat capacity and density as water (4.184 J/g•ºC; 1.00 g/mL). **HINT:** HCl is the limiting reagent. Report your answer with the correct number of significant figures. 10 points.

$HCl\ (aq) + NaOH\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)$ **$\Delta H^\circ = -110.3\ kJ$**

TA Use Only	
Points	Initials

Concentration: ____________________ **M**

Appendix D:
CHEM 109 CHEM 109 Exam 3, Spring 2013

PRINT NAME____ **Room** __________
(Last) (First) (MI)

NU ID# ____ **Bldg** __________

Signature ____ **Seat #**__________

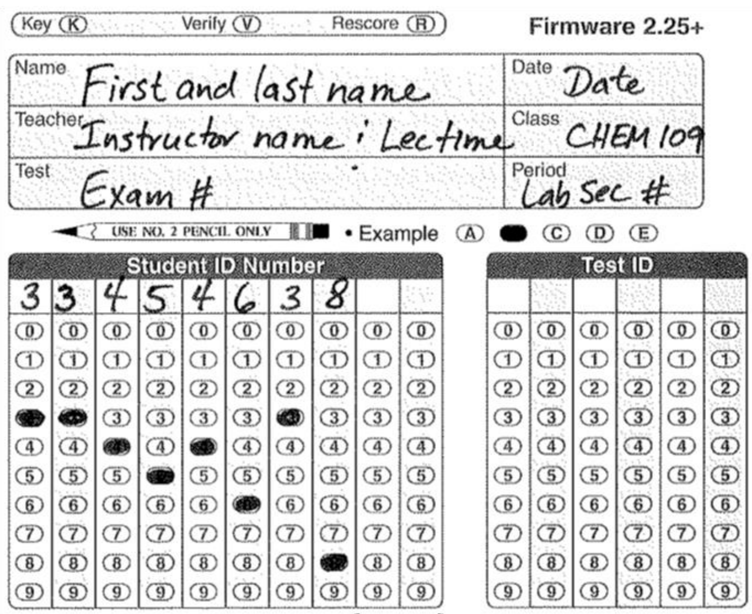
Lecture Section (circle): 110 120 130 **Lab Section**______

BE SURE YOU HAVE 11 DIFFERENT PAGES IN THIS EXAM PACKET
PLUS 1 ACCUSCAN FORM

FILL OUT THE ACCUSCAN FORM AS SHOWN BELOW
EXAMS WILL NOT BE GRADED IF THIS INFORMATION IS INCORRECT OR INCOMPLETE

Name: FULL NAME
Teacher: Instructor name / lecture time
Test: Exam 3
Date: Mar 14, 2013
Class: CHEM 109
Period: LAB SECTION NUMBER

Fill in AND bubble in your NU ID number.
START with the left-most box



These boxes should be BLANK **LOOK!**

NU ID number

SHOW ALL WORK - NO WORK, NO CREDIT

REPORT ALL ANSWERS WITH CORRECT UNITS AND SIGNIFICANT FIGURES

- *Sit in assigned seat*
- *All cell phones (or other 2-way mobile devices) must be turned off and cannot be used as a calculator.*
- *You may use a calculator and an exam data sheet.*
- *Raise your hand if you have a question.*
- *Keep your eyes on your own paper; several exam forms may be in use. It is a code violation if data from another exam form appears on your paper.*
- *Keep all required exams as part of your records.*

REQUEST FOR REGRADE

To prevent exam scores from being negatively impacted by minor grading errors, each student will be granted an error buffer of three points towards their total exam score. However, in order to have an exam regraded, the examinee must forfeit the error buffer. Therefore, a regrade can only result in an improved score if the corrections are greater in value than the error buffer. The maximum score is 100 pts. When submitting a regrade request, do not write on exam pages. Additional questions or comments are to be placed on a separate and turned in with your test.

Regrade requests must be submitted by 5:00 pm the day following the Exam

Please regrade question______ because____

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Please regrade question______ because____

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Please regrade question______ because____

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You must sign your regrade request, or it will not be considered a valid request

I accept responsibility for all answers contained herein. ___________________________________

Signature

PART 1: MULTIPLE CHOICE

Choose the one best answer for each question, and record it on the provided AccuScan form (3 points each; no partial credit).

1. A 0.010 mol sample of pure, gaseous helium (He) is held in a 150 mL container at 25°C. What is the pressure within the container?

A. 1.4×10^{-4} atm

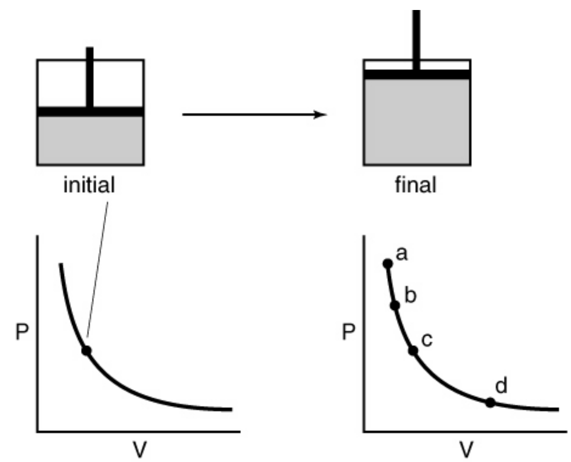
B. 1.6×10^{-3} atm

C. 1.4×10^{-1} atm

D. 1.6×10^{0} atm

E. None of the above

2. As shown in the accompanying figure, gas is contained in a piston assembly and allowed to expand. Which point(s) on the graph shows the correct pressure and volume after expansion?



A. a

B. b

C. c

D. d

E. Both c and d

3. A 1.50 L vessel at 298.15 K contains exactly one mole of gas. There is known to be 0.50 mol O_2 (g) and 0.15 mol N_2 (g). CO_2 (g) accounts for the remainder of the gas. What is the mole fraction of CO_2 (g) in this mixture?

A. 0.10

B. 0.35

C. 0.65

D. 0.90

E. The mole fraction of CO_2 (g) cannot be determined based on the given information

4. Which of the following statements are in agreement with kinetic theory of gases?

A. The pressure within a container depends on how often the gas molecules collide with the walls of the container

B. The pressure within a container depends on how energetically the gas molecules collide with the walls of the container

C. At standard temperature and pressure, the molecules of any gas will have the same root mean square velocity

D. Both A and B are in agreement with kinetic theory of gases

E. Both A and C are in agreement with kinetic theory of gases

5. At 41°C, the root mean square velocity of H_2 (g) molecules is:

A. 62.3 m/s

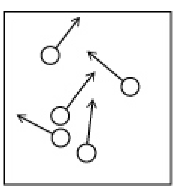
B. 71.2 m/s

C. 196 m/s

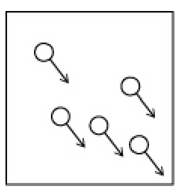
D. 225 m/s

E. 1,970 m/s

6. Which of the following most accurately represents the motion of gas molecules? Each circle represents one molecule of the same substance, and the arrows indicate their velocities.



A.



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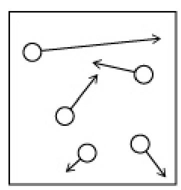

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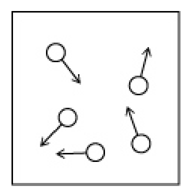


D.

E. All of the above reasonably depict the motion of gas molecules.

7. Which of the following lists the gases in order of ***lowest to highest*** rate of diffusion?

A. N_2O < NO_2 < NO < N_2O_4

B. NO < N_2O < NO_2 < N_2O_4

C. N_2O_4 < NO_2 < N_2O < NO

D. NO < NO_2 < N_2O < N_2O_4

E. N_2O_4 < N_2O < NO_2 < NO

8. What is the rate of diffusion of Kr (g) relative to Xe (g)?

A. 1.567

B. 1.252

C. 0.7989

D. 0.6383

E. None of the above

9. Under certain conditions, the ideal gas law fails to describe the behavior of real gases because:

A. At very high pressures, the number of moles of gas has no effect on the observed pressure

B. At very high pressures, the temperature has no effect on the observed pressure

C. At very high pressures, the volume of individual gas molecules must be accounted for

D. The ideal gas is only valid when PV/RT = 1

E. Both C and D are limitations of the ideal gas law

10. Which statement about electromagnetic radiation is ***not*** correct?

A. Electromagnetic radiation consists of oscillating electric and magnetic fields

B. The frequency and wavelength of electromagnetic radiation are related to each other

C. All electromagnetic radiation is visible to the eye

D. Electromagnetic radiation spans a very wide range of wavelengths

E. Both C and D are incorrect statements

11. Rank the following in order of increasing frequency of the light (***lowest to highest*** frequency):

1. A photon with 1.8×10^{-19} J of energy
2. Light with a wavelength of 850 nm
3. Light with a frequency of 1.0×10^{14} Hz

A. 1 < 2 < 3

B. 2 < 1 < 3

C. 2 < 3 < 1

D. 3 < 1 < 2

E. 3 < 2 < 1

12. Which of the following leads to increased kinetic energy of the electrons emitted when light shines on a metal surface?

A. Decrease in the light's wavelength

B. Increase in the light's wavelength

C. Decrease in the light's frequency

D. All of these will yield electrons with increased kinetic energy

E. None of these will yield electrons with increased kinetic energy

13. If the work function for chromium is 7.21 x 10^{-19} J, irradiating of the metal with which of the following wavelengths of light would produce a photoelectric effect?

A. 150 nm

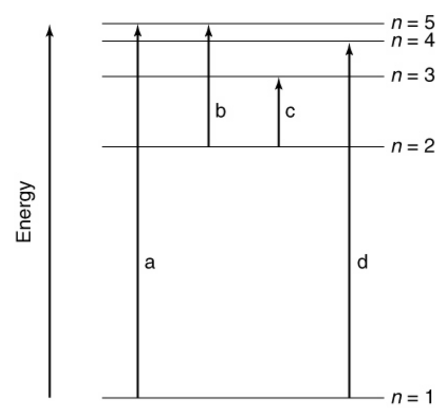
B. 300 nm

C. 450 nm

D. Both B and C would produce a photoelectric effect

E. None of the above would produce a photoelectric effect

14. Which of the transitions in this hydrogen atom energy-level diagram requires the longest wavelength photon?



A. a

B. b

C. c

D. d

E. All of the transitions require the same wavelength

15. Heisenberg's Uncertainty Principle helps us to understand that:

A. Electrons move around the nucleus in simple circular orbits

B. Electrons move around the nucleus at distances that produce a standing wave

C. The position and velocity of an electron cannot both be precisely determined; thus, we must describe electrons in atoms by the probabilities of their locations

D. A, B, and C are all related to Heisenberg's Uncertainty Principle

E. None of the above are related to Heisenberg's Uncertainty Principle

PART 2: FREE RESPONSE

Show all work; no work, no credit. Give all numeric answers with the correct number of significant figures. Write final answers in the provided spaces.

Q1. If a container is 255 L in volume and contains air at 0.950 atm at 25.0˚C, how many ***additional*** moles of gas must be pumped into the container to increase the pressure to 5.00 atm? Express your answer with the correct number of significant figures. 7 points.

TA Use Only	
Points	Initials

Moles of gas: **____________________ mol**

Q2. At a pressure of 1.25 atm and a temperature of 306.4 K, a certain gas has a density of 1.694 g/L. Under the conditions described, determine the root mean square velocity of these gas molecules. Express your answer with the correct number of significant figures. 8 points.

TA Use Only	
Points	Initials

Root mean square velocity: **________________ m/s**

Q3. A 25.0 L vessel initially contained 1.03 mol of He (g) and 2.47 mol Ar (g) at a temperature of 37.16°C. A very small opening in the container allowed some of the gaseous contents to effuse before the leak was discovered and sealed. During the leak, 0.29 mol of Ar (g) escaped the container; an unknown amount of He (g) was also lost. Answer the questions below. 10 points.

A. Calculate the partial pressure of Ar (g) remaining in the container after the leak. Express your answer with the correct number of significant figures.

Partial pressure of Ar (g): **_________________ atm**

B. Calculate the number of moles of He (g) lost from the container during the leak. Express your answer with the correct number of significant figures.

TA Use Only	
Points	Initials

Moles of He (g): **_________________ mol**

Q4. A self-contained breathing device uses KO_2 to convert CO_2 to O_2:

$$4\ KO_2\ (s) + 2\ CO_2\ (g) \rightarrow 2\ K_2CO_3\ (s) + 3\ O_2\ (g)$$

If the device contains 425 g of KO_2 (71.096 g/mol), then what volume of CO_2 can be converted to O_2 at 37.0˚C and 0.987 atm? Express your answer with the correct number of significant figures. 10 points.

TA Use Only	
Points	Initials

Volume of CO_2 (g): ____________________ **L**

Q5. Calculate the energy difference between radio wave of 0.10 m wavelength and a microwave of 55 GHz. 7 points.

TA Use Only	
Points	Initials

Energy difference: ____________________ **J**

Q6. Recently, the "buckyball" (C_{60}) became the largest object with a measured de Broglie wavelength. If the mass of a C_{60} molecule is 1.20×10^{-24} kg, what will be its de Broglie wavelength when moving at a speed of 220 m/s? 5 points.

TA Use Only	
Points	Initials

de Broglie wavelength: ____________________ **m**

Q7. The electron of a hydrogen atom transitions from $n = 3$ to $n = 1$, leading to emission of a photon. When this photon interacts with the surface of an unknown metal, an electron with a kinetic energy of 1.2×10^{-18} J is released. Find the work function of the unknown metal. Express your answer with the correct number of significant figures. 8 points.

TA Use Only	
Points	Initials

Work function: **_________________ J**

Appendix E:
CHEM 109 Exam 4, Spring 2013

***PRINT NAME*____ *Room* ___________**

(Last) ***(First)*** ***(MI)***

NU ID# ____ ***Bldg*** ____________

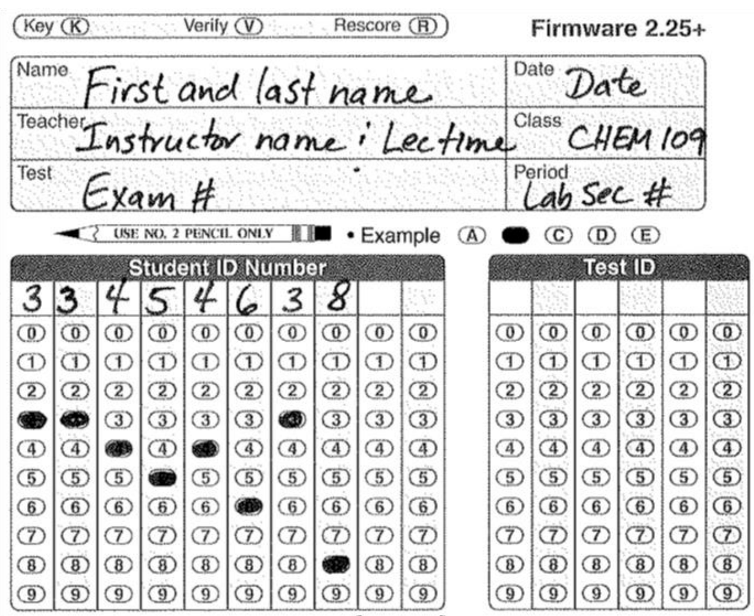
Signature ____ ***Seat #***____________

Lecture Section (circle): ***110*** ***120*** ***130*** ***Lab Section***_______

BE SURE YOU HAVE 10 DIFFERENT PAGES IN THIS EXAM PACKET
PLUS 1 ACCUSCAN FORM

FILL OUT THE ACCUSCAN FORM AS SHOWN BELOW
EXAMS WILL NOT BE GRADED IF THIS INFORMATION IS INCORRECT OR INCOMPLETE

Name: FULL NAME
Teacher: Instructor name / lecture time
Test: Exam 4
Date: Apr 18, 2013
Class: CHEM 109
Period: LAB SECTION NUMBER



Fill in AND bubble in your NU ID number.
START with the left-most box

NU ID number

These boxes should be BLANK **LOOK!**

SHOW ALL WORK - NO WORK, NO CREDIT

REPORT ALL ANSWERS WITH CORRECT UNITS AND SIGNIFICANT FIGURES

- *Sit in assigned seat*
- *All cell phones (or other 2-way mobile devices) must be turned off and cannot be used as a calculator.*
- *You may use a calculator and an exam data sheet.*
- *Raise your hand if you have a question.*
- *Keep your eyes on your own paper; several exam forms may be in use. It is a code violation if data from another exam form appears on your paper.*
- *Keep all required exams as part of your records.*

REQUEST FOR REGRADE

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Regrade requests must be submitted by 5:00 pm the day following the Exam

Please regrade question_____ because____

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Please regrade question_____ because____

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Please regrade question_____ because____

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You must sign your regrade request, or it will not be considered a valid request

I accept responsibility for all answers contained herein. __________________________________

Signature

PART 1: MULTIPLE CHOICE

Choose the one best answer for each question, and record it on the provided AccuScan form (3 points each; no partial credit).

1. Which quantum number is used to express the orientation of the orbital within a subshell?

A. l

B. m_l

C. m_s

D. n

E. Both m_l and m_s describe the orientation of the orbital

2. Which set of quantum numbers could apply to 10 different electrons in the same atom?

A. n = 2, l = 2

B. n = 3, l = 2

C. n = 3, l = 2, m_l = 2

D. Both A and B could apply the quantum numbers to 10 different electrons

E. All three options could apply the quantum numbers to 10 different electrons

3. A metal ion with a +1 charge has an electron configuration of [Kr]$5s^2 4d^{10}$. If the metal ion picks up one electron to become a neutral atom again, which of the following sets of quantum numbers could describe that electron assuming the neutral metal atom had a ground state electron configuration?

A. n = 4, l = 2, m_l = 2, m_s = - ½

B. n = 5, l = 0, m_l = 0, m_s = - ½

C. n = 5, l = 1, m_l = -1, m_s = - ½

D. n = 5, l = 2, m_l = -2, m_s = - ½

E. None of the above would work for that electron

4. Which of the following is the correct ranking of orbital energy (lowest energy to highest energy)?

A. 3d, 3p, 4s

B. 3p, 3d, 4s

C. 3p, 4s, 3d

D. 4s, 3d, 3p

E. 4s, 3p, 3d

5. Which are the following are isoelectronic?

Ca **Ti^{2+}** **V^{3+}**

A. Ca and Ti^{2+}

B. Ca and V^{3+}

C. Ti^{2+} and V^{3+}

D. Both A and B are isoelectronic

E. All three ions are isoelectronic

6. How many unpaired electrons in a chromium (Cr) atom?

A. 0

B. 2

C. 4

D. 5

E. 6

7. Which statement best describes the difference in size between a boron (B) and carbon (C) atom?

A. B is larger than C because B has a larger principal quantum number for its outermost electrons

B. B is larger than C because B has a larger effective nuclear charge

C. B is smaller than C because B has a smaller principal quantum number for its outermost electrons

D. B is smaller than C because B has a smaller effective nuclear charge

E. None of the above correctly describes the difference in size between boron and carbon

8. The second ionization energy for Ca would correspond to the energy required for which reaction below?

A. $Ca\ (g) \rightarrow Ca^{2+}\ (g) + 2\ e^-$

B. $Ca\ (g) + 2\ e^- \rightarrow Ca^{2+}\ (g)$

C. $Ca^+\ (g) \rightarrow Ca^{2+}\ (g) + 1\ e^-$

D. $Ca^+\ (g) + 1\ e^- \rightarrow Ca^{2+}\ (g)$

E. $Ca^+\ (s) \rightarrow Ca^{2+}\ (s) + 1\ e^-$

9. Which of the following would have four valence electrons?

A. S

B. Ge

C. Ti

D. Both Ge and Ti

E. All three atoms would have four valence electrons

10. Which of the following would have all electrons paired?

A. Ar

B. Ca

C. Si

D. Both Ar and Ca would have all electrons paired

E. All three atoms would have all electrons paired

11. Which would have the longest carbon-carbon bond length?

A. HCCH

B. H_2CCH_2

C. H_3CCH_3

D. All three would have the same carbon-carbon bond length

E. Both A and C have the same bond length, which is greater than that of B

12. Which would have the greatest bond polarity?

A. P—Cl

B. S—Cl

C. Cl—Cl

D. All three would have equal bond polarity

E. Both A and C have the same bond polarity, which is greater than that of B

13. Consider the molecules CH_4 (with H—C—H bond angle θ_1), NH_3 (with H—N—H bond angle θ_2), and H_2O (with H—O—H bond angle θ_3). Which of the following correctly orders the bond angles?

A. $\theta_1 > \theta_2 > \theta_3$

B. $\theta_1 > \theta_2 = \theta_3$

C. $\theta_1 = \theta_2 = \theta_3$

D. $\theta_1 = \theta_2 < \theta_3$

E. $\theta_1 < \theta_2 < \theta_3$

14. Which of the following best describes the space an electron is likely to be found in if that electron is in a 3s orbital?

A. A single spherical shape with a distance from the nucleus greater than a 2s orbital

B. A spherical shape within a spherical shape within a spherical shape

C. A dual lobe shape that has a node at the nucleus of the atom

D. A multi-lobed shape that has a node at the nucleus of the atom

E. None of the above describes a 3s orbital

15. Which of the following groups on the Periodic Table would have elements with atoms containing three unpaired electrons?

A. Group 13

B. Group 15

C. Group 17

D. Both Group 13 and Group 15

E. None of the above has atoms with three unpaired electrons

PART 2: FREE RESPONSE

Show all work; no work, no credit. Give all numeric answers with the correct number of significant figures. Write final answers in the provided spaces.

Q1. Draw the best Lewis structure for NI_3 (include resonance structures if needed). Based on your Lewis structure, what would be the electron geometry, molecular geometry, and polarity of NI_3? 8 points.

TA Use Only	
Points	Initials

Electron geometry: ______________________________

Molecular geometry: ______________________________

Molecular polarity (circle one): **Polar** **Non-polar**

Q2. Draw the best Lewis structure for IF_3 (include resonance structures if needed). Based on your Lewis structure, what would be the electron geometry, molecular geometry, and polarity of IF_3? 8 points.

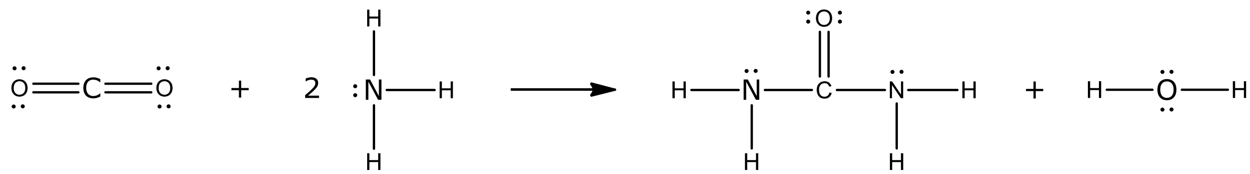
TA Use Only	
Points	Initials

Electron geometry: ______________________________

Molecular geometry: ______________________________

Molecular polarity (circle one): **Polar** **Non-polar**

Q3. Urea (NH_2CONH_2) is commonly used as a nitrogen source in agriculture. Urea can be produced by the reaction of carbon dioxide and ammonia.



Use the bond energies on your Exam Data Sheet, calculate the heat of reaction. Express your answer with the correct number of significant figures. 8 points.

TA Use Only	
Points	Initials

ΔH_{rxn}: ______________________ **kJ**

Q4. Using the Lewis Structures given in the reaction in the question above, answer the following questions. 6 points.

What is the approximate N—C—N bond angle in urea? Be as specific as possible.

N—C—N bond angle: ______________________

What is the molecular geometry around the C atom in urea?

Molecular geometry around C atom: ______________________

What is the molecular geometry around the N atom in urea?

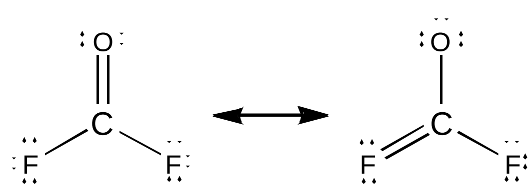
Molecular geometry around N atom: ______________________

TA Use Only	
Points	Initials

Q5. Draw the orbital diagram for a silicon (Si) atom. 6 points.

TA Use Only	
Points	Initials

Q6. Two possible resonance structures for carbonyl fluoride (COF_2) are shown below. Circle the better Lewis Structure and explain why it is the better structure. 6 points.



Why it is better Lewis structure:

TA Use Only	
Points	Initials

Q7. Based on minimized formal charges, draw the best Lewis Structure for AsO_4^{3-} (include resonance structures if needed). Determine the As—O bond order. 8 points.

TA Use Only	
Points	Initials

Bond order: ____________________

Q8. Draw the best Lewis structure for SCO and include arrows representing the polarity for all polar bonds. 5 points.

TA Use Only	
Points	Initials