Lehman College, CUNY

# General Chemistry 2: Spring ~~2018~~ 2019

Thursday 1:00pm – 2:50pm in Gillet 024

**Instructor:** Professor Donna McGregor (304 Davis Hall)
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Office Hours: TBA (or by appointment)

**Goal of the course:** This is the second semester of a 2-semester general chemistry sequence that begins to prepare you for a science-based career. CHE168 is a demanding course and to achieve success in this course you will need to organize large quantities of information in coherent ways so that you are able to recall and apply your knowledge. Organization of your time will be essential! And the mathematics is much more demanding than in CHE166!

Like in CHE166, we will once again be using a flipped classroom model of instruction. In this model you will watch videos and complete online homework at home and then come to class to 1) complete workshop assignments (during your 1-hour recitation section) and 2) participate in peer-learning activities using an iClicker (during our 2-hour class meeting every Thursday).

You should plan to spend ***at least* 10-15 hours per week** watching videos, doing online homework, engaging with your peers and learning material. It is your responsibility to prepare yourself for every topic before you come to class. We are here to support you in your learning, but you must keep up– it is unlikely that you will be able to catch up if you fall behind.

**Text:** For the purposes of this course you will be required to buy the General Chemistry 2 Let's Practice Workbook from the Lehman College Bookstore. You are not required to purchase a textbook. There is an e-book as part of your Sapling Homework (see below) but you should feel free to use ANY General Chemistry textbook. We will not be working through a textbook in a chapter-by-chapter fashion; rather we will cover 16 Chemistry topics and use the textbook as a reference. *If you feel the need to buy a recommended textbook Chemistry, 8th Ed., Zumdahl and Zumdahl is a wonderful choice.*

**Web Site:** As part of this course we will be using a new platform called GenChem. The GenChem platform will be ready for account registration on Tuesday, Jan 26th, 2016. You should log on to GenChem as soon as you can and register your account so that you can become familiar with the look and feel of the web interface. This is especially true if you did not complete CHE166 using the flipped model. It is imperative that when we meet on Thursday February 4th you are already registered on the GenChem platform.

*To claim your GenChem account:*

1. Log on to http://genchemlehman168 **on or after January 26th.**
2. Click Register and complete the registration process by entering your blackboard ID number, a working email address and a password that you create. It is very important that you use the same email address to claim your GenChem account and register both your iClicker and your Sapling homework account. This email address must be one that you check regularly as we will use it to communicate with you via the GenChem platform.

*To find your Lehman College Blackboard ID number:*

1. Log on to https://cunyportal.cuny.edu/cpr/authenticate/portal_login.jsp
2. Log into your account and Click on the Blackboard Tab in the "Applications/Resources" panel.
3. Click on the "Personal Information" tab on the top left side of the screen in the "Tools" panel.
4. Click on the "Edit personal Information" tab.
5. Here you will find your username followed by a 20-digit number. This 20-digit number is your Lehman College blackboard number.

The GenChem platform will be used in lieu of CUNY Blackboard and has been designed specifically for our course. This is where you will find ALL course documents including (but not limited to) the Learning Goal Analysis (LGA), Videos, Video PDF documents, iClicker sessions, links to online Sapling homework, Workshop assignments and old General Chemistry exams.

**Email:** Please make sure that you use the same email address to claim your GenChem account and register both your iClicker and your Sapling homework account. This should be an email address that you check frequently as we will be using email through the GenChem platform to communicate with the class. If you do not check your email regularly it is possible that you will miss important information - which is likely to have a negative impact your grade.

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**Grading policy:** Every component of this course earns you points towards your final grade, but to earn your points you must complete each component by its due date. Please see the GenChem platform for more information on assignment due dates.

To earn full credit in this course you must accumulate 1400 points. 400 points come from your TOPIC grade and 1000 points come from your EXAM grades.

| TOPIC | LGA[1] | Videos | Workshop[2] | i-Clicker[2] | Homework[2] | TOPIC TOTAL[3] | In-Class Exams[4] | Final Exam[4] |
|---|---|---|---|---|---|---|---|---|
| Topic 1 | 2 | 2 | W1: 10 | 0 | 5 | 19 | | |
| Topic 2 | 2 | 2 | W2: 10 | 11 | 5 | 30 | | |
| Topic 3 | 2 | 2 | - | 11 | 10 | 25 | Exam 1 (200 pts) | |
| Topic 4 | 2 | 2 | W3: 10 | - | 10 | 24 | | |
| Topic 5 | 2 | 2 | - | 11 | 10 | 25 | | |
| Topic 6 | 2 | 2 | W4: 10 | - | 10 | 24 | | |
| Topic 7 | 2 | 2 | W5: 10 | 11 | 10 | 35 | | |
| Topic 8 | 2 | 2 | - | - | 10 | 14 | | |
| Topic 9 | 2 | 2 | W6: 10 | 11 | 10 | 35 | Exam 2 (200 pts) | 400 pts |
| Topic 10 | 2 | 2 | - | 11 | 10 | 25 | | |
| Topic 11 | 2 | 2 | W7: 10 | - | 10 | 24 | | |
| Topic 12 | 2 | 2 | W8: 10 | 11 | 10 | 35 | | |
| Topic 13 | 2 | 2 | - | - | 10 | 14 | | |
| Topic 14 | 2 | 2 | W9: 10 | 11 | 10 | 35 | Exam 3 (200 pts) | |
| Topic 15 | 2 | 2 | W10: 10 | 11 | 10 | 35 | | |
| Topic 16 | 2 | 2 | W11: 10 | 11 | 10 | 35 | | |
| **TOTALS** | **32** | **32** | **110** | **110** | **150** | **434** | **600** | **400** |
| **Total Topic Grade Required = 400 out of a total of 434 possible points** | | | | | | | **Total Exam Grade = 1000** | |
| **Total number of points to be earned in the course: 400 + 1000 = 1400** | | | | | | | | |

1. The points for an LGA is an all or nothing score. 2 points are earned for completion of an assignment and zero points are earned for an incomplete assignment.
2. The points for each workshop, iClicker and homework assignment are scaled to the totals indicated.
3. The total score for each topic is computed by summing the topic components. There are 437 total TOPIC points, but only the first 400 points count. Think of the extra 37 points as extra points that you can accumulate and use if you miss an assignment. You cannot earn more than 400 TOPIC points. These extra points cannot be applied to your exam score.
4. If you miss an in-class exam the final exam will count for 600 points instead of 400 points. There are NO make-up exams.

The total number of points you earn will be normalized to a score out of 100.00 and then assigned a latter grade according to the table shown to the right. Letter grades will be determined based on a score to 2 decimal places. There will be no rounding of scores to determine letter grades.

| Letter Grade | Course Requirement |
|---|---|
| A+ | 97.50 |
| A | 92.50 |
| A- | 90.00 |
| B+ | 87.50 |
| B | 82.50 |
| B- | 80.00 |
| C+ | 77.50 |
| C | 70.00 |
| D | 60.00 |
| F | <60 |

**Exams:** There will be three equally weighted in-class exams (200 points each for a total of 600 points) given during the course of the semester. There will also be a Comprehensive Final Exam (400 points) given during finals week. If your final exam grade is higher than your lowest in-class exam grade your final grade will count for 600 points and your lowest in-class exam grade will be dropped.

For your exams you will be required to bring a pencil and a calculator to class. All other materials (e.g. periodic table and/or other necessary information such as a formula sheet) will be provided for you. Exams must be taken during the designated class period. *NO MAKE-UP EXAMS will be given.* If you miss one in-class exam you will earn a grade of zero for that exam. This grade will then be dropped as your lowest in-class exam grade and your final exam grade will automatically be counted for 600 points. If you miss more than one in-class exam you will receive a grade of ZERO for the second missed exam.

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**Exam schedule:**

- EXAM 1: **Thursday, March 10th**
  Think of this exam as a CHE168 placement exam. Your score determines whether or not you have gained the knowledge required to continue in the course. If you fail this exam you should consider withdrawing from the course. If you decide to remain in the course you should meet with us to discuss options for success. You will need to make a drastic change to your study habits!
- EXAM 2: **Thursday, April 7th**
  This exam is more difficult than exam 1. If you failed exam 1 and you also fail this exam you should definitely withdraw from the course. The last day to withdraw from the course is ***Monday April 11th*** and I will make sure you receive your exam 2 grades in time to make this decision.
- EXAM 3: **Thursday, May 12th**
  This is your last and most difficult in-class exam. In general student grades drop by 10% from exam 2 to exam 3 so make sure you put in enough time to prepare for this exam.
- FINAL EXAM: **TBA**

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**Required Learning Goal Analysis (LGA):** Before you begin a new topic you will be required to complete a Learning Goal Analysis on the GenChem platform. This analysis asks you to read each learning goal for that topic and assess how comfortable you feel with the content presented. There is no wrong answer to an LGA question. The goal is to help you begin accurately self-assessing your own content understanding and focus your attention on the learning goals to drive your learning. These learning goals serve as both an outline for the course and a tool to help you prepare for your exams. USE the LGA to study for your exams. Every single Exam question is based on at least 1 learning goal (although some will contain multiple learning goals). There is also an LGA document in the resources on GenChem for your review.

**Required 1-hour Recitation Workshop:** In addition to completing the videos and LGA assignments, you are responsible for submitting a weekly recitation assignment called a workshop. Workshops are to be completed in groups of 3 or 4 students and must be submitted to your recitation instructor. You may submit your workshop in person during your assigned recitation period or electronically (using the GenChem website) no later than 7:00pm every Sunday.

There are 11 required workshop assignments this semester. Each workshop is worth 10 points. You must attend the recitation section that you registered for every week in order to earn these points. If you miss a workshop you do not earn the points for that workshop. Remember that there are 34 extra points built into your topic grade so if you miss a workshop you can use 10 of these extra points to make up the loss. Please see the Workshop Grading Policy on GenChem for more Information.

During exam weeks recitation sections will be classed as "OPEN SECTION". This means that there will be no workshop due that week and recitation attendance is optional. During "OPEN SECTION" you may attend ANY workshop to ask questions or get individual help from one of the TA's.

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**Required iClicker:** As part of this course we will be making use of a personal response device called an iClicker. You will use the iClicker to respond to in-class questions during lecture every Friday. This will serve a dual purpose: 1) Your responses will provide me with real-time feedback about student understanding of course content and 2) Your participation will help you practice the material and grow as a chemistry student.

There will be 10 required 2 hour iClicker sessions, each worth a total of 11 points. You earn 1 point for attending a session and then 1 point for every question that you answer correctly during the session. Some sessions will have only 10 questions and some will have more than 10 questions. The maximum number of points you can earn per session is 11 so only 10 correct responses will be counted for each session. If your iClicker malfunctions or when you forget it at home you will not earn the points for that session. Please do NOT ask for points if you fail to have a functioning iClicker. Once again, remember that there are 34 extra points built into your topic grade so if you do not earn the points for an iClicker session you can use 11 of these extra points to make up the loss.

iClickers can be purchased at the Lehman College Bookstore. If you already own an iClicker from a previous course it can be used again for this course. Once you have your iClicker you will need to register it (even if you already registered it last semester). *To register your iClicker:*

1. Log on to http://www.iclicker.com/dnn/Support/RegisterYouriclicker/tabid/174/Default.aspx
2. Complete the registration questions. **Note:** You must register using your full first and last name and your Lehman College Blackboard ID number. Your blackboard number will be used to link your iClicker responses to our online student roster.

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**Required Homework**: This semester we will once again be using an on-line homework system called Sapling. While links to your homework will be provided in the GenChem platform, you will need to buy an access code through the Sapling Website and register for our course in order to access and complete your Sapling assignments. **Sapling will be available for registration on Tuesday, January 26th**

*To register for Sapling:*

1. Log on to https://www.saplinglearning.com/ibiscms/login/
2. Click on the blue "create an account" tab and follow the online instructions to create a user profile (choose a username and password) Please make sure that you use the same email address to claim your GenChem account and register for your Sapling homework account.
3. Select **CUNY, Lehman College** as your school
4. Select **CUNY Lehman - Chem 168 – Spring 16 - McGregor** as your course.
5. Follow the online instructions to purchase an Access Code.

The cost for ONE semester of access is $47.00, and the cost for TWO semesters of access is $78.00. If you plan to take both CHE 166 and CHE 168 we suggest you buy access for TWO semesters, as we will be using Sapling again in CHE 168.

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**Academic Dishonesty:** Lehman College regards acts of academic dishonesty (e.g., plagiarism, cheating on examinations, obtaining unfair advantage, and falsification of records and official documents) as serious offenses against the values of intellectual honesty. The college is committed to enforcing the CUNY Policy on Academic Integrity and will pursue cases of academic dishonesty according to the Lehman College Academic Integrity Procedures, see:

**http://www.lehman.edu/undergraduate-bulletin/academicintegrity.htm**

Students who are caught cheating on an exam in this course will automatically obtain a grade of ZERO for that exam and will be reported for Academic Dishonesty. This grade of ZERO cannot be used as your lowest exam score to be dropped in the course.

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**Accommodating Disabilities:** Lehman College is committed to providing access to all programs and curricula to all students. Students with disabilities who may need classroom accommodations are encouraged to register with the Office of Student Disability Services. For more information, please contact the Office of Student Disability Services, Shuster Hall Room 238, tel: 718-960-8441.

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# General Chemistry II: Learning Goal Analysis

Read each learning goal and assess how comfortable you feel with the content presented. **Remember:** The goal here is to help you begin accurately self-assessing your own content understanding and learn to focus your attention on the learning goals specific to each topic

Use the Leikert scale below to choose the appropriate responses to each question:

A. I feel very confident about his learning goal. I recognize the content and know that I could answer any questions about this subject.
B. I feel pretty confident about this learning goal. I recognize the words and know that I have worked problems about this learning goal in the past. I am sure that I could answer most questions about this subject.
C. I do not feel very confident about his learning goal. I recognize the words, but am not sure that I would be able to answer the questions about this topic.
D. I do not feel at all confident about this learning goal. I do not recognize the words and am sure that I would NOT be able to answer any questions about this topic.

## Topic 1: Equilibrium

| | | | | | |
|---|---|---|---|---|---|
| 1 | Use molarity formula to determine moles, volume, and concentration | A | B | C | D |
| 2 | Use the dilution formula to compute molarity and volume after dilution | A | B | C | D |
| 3 | Write molecular and net ionic equations for any reaction when appropriate | A | B | C | D |
| 4 | Be able to write sentences or use drawings to illustrate the difference between static and dynamic equilibrium as applied to chemical systems. (Be able to include the words macroscopic and microscopic in the definitions) | A | B | C | D |
| 5 | Graph concentration vs time for all species in a stoichiometric equation | A | B | C | D |
| 6 | Use an equilibrium graph (concentration vs time) to identify the equilibrium region, to identify the stoichiometric coefficients, and to identify the reactants and products | A | B | C | D |
| 7 | Write a general equilibrium expression in terms of activity from the stoichiometric equation using the law of mass action | A | B | C | D |
| 8 | Identify the appropriate units for each species in the stoichiometric equation (molarity, atm) | A | B | C | D |
| 9 | Write expressions for K for reactions that include aqueous species, gaseous species, and solids | A | B | C | D |
| 10 | Calculate a value of K from the known equilibrium concentrations or partial pressures | A | B | C | D |
| 11 | Use PV=nRT to find any variables and relate partial pressure to moles | A | B | C | D |
| 12 | Use the value of K for a given stoichiometry equation to obtain K for the same stoichiometric relationship but written forward or backward and written with a different set of stoichiometric coefficients | A | B | C | D |
| 13 | Write expressions for K for reactions that include aqueous species, gaseous species, and solids | A | B | C | D |

## Topic 2: Predicting Chemical Change

| | | | | | |
|---|---|---|---|---|---|
| 1 | Describe the equilibrium state of a chemical system using K if the system is at equilibrium or Q if the system is not at equilibrium | A | B | C | D |
| 2 | Obtain the value of Q from the concentrations or pressures of the species present if the system is not at equilibrium | A | B | C | D |
| 3 | Predict the direction of the shift of a reaction towards equilibrium by comparing Q to K | A | B | C | D |
| 4 | Use LeChatelier's principle to predict the shift of system that had its equilibrium perturbed. How does a reaction respond to a) an increase in mole number of one species, b) a decrease in mole number of one species, c) an increase or decrease in temperature, d) an increase or decrease in total pressure, e) an increase or decrease of reaction volume | A | B | C | D |
| 5 | Determine under what circumstances the actual value of K changes? Predict changes in K for all of the above perturbations. (In many cases K does not change – which cases?) | A | B | C | D |
| 6 | Recognize a noble gas and recognize an catalyst and realize that noble gases and catalysts do not perturb the equilibrium position | A | B | C | D |

## Topic 3: Acids and Base

| | | | | | |
|---|---|---|---|---|---|
| 1 | dentify Arrhenius acid/base reactions | A | B | C | D |
| 2 | identify Bronsted acid/base reactions | A | B | C | D |
| 3 | identify the conjugate acids and bases in Bronsted reactions | A | B | C | D |
| 4 | define amphoteric and recognize that water is amphoteric | A | B | C | D |
| 5 | determine relative acid strength from Ka values | A | B | C | D |
| 6 | memorize and identify strong acids and bases | A | B | C | D |
| 7 | write equilibrium reactions and associate the appropriate equilibrium constant to the reaction(for acid, $K_a$, base $K_b$ reactions) | A | B | C | D |
| 8 | use the pH scale to identify acidic or basic solutions | A | B | C | D |
| 9 | determine hydronium ion concentration from pH and pH from hydronium ion concentration | A | B | C | D |
| 10 | use the ICE table to solve for equilibrium concentrations for reactions with 1:1 stoichiometry | A | B | C | D |
| 11 | make appropriate approximations and use the 5% rule | A | B | C | D |
| 12 | solve the quadratic equation to obtain the equilibrium position | A | B | C | D |

## Topic 4: pH Calculations

| | | | | | |
|---|---|---|---|---|---|
| 1 | compute pH from hydrogen ion concentration | A | B | C | D |
| 2 | compute pOH from hydroxide ion concentration | A | B | C | D |
| 3 | compute relevant concentrations from pH or pOH | A | B | C | D |
| 4 | find pH from pOH or pOH from pH based upon the $K_w$ at 298 ($1x10^{-14}$) or other temperatures when a value for $K_w$ is known | A | B | C | D |
| 5 | identify strong acids and bases and calculate pH (and pOH) of strong acid or base solutions | A | B | C | D |
| 6 | use ICE to compute pH and pOH of weak acid and base solutions | A | B | C | D |
| 7 | use ICE to compute concentrations of all species in weak acid and base solutions | A | B | C | D |
| 8 | recognize a salt (ionic compound) from a chemical formula | A | B | C | D |
| 9 | identify the pH active species of salt solutions | A | B | C | D |
| 10 | identify an aqueous salt solution as acidic, basic, or neutral | A | B | C | D |
| 11 | obtain Kb from Ka or Ka from Kb using Kw | A | B | C | D |
| 12 | determine pKa from Ka and pKb and Kb (or vice versa) and relate pKa or pKb values to the strength of the acid or base compound | A | B | C | D |
| 13 | calculate the pH of salt solutions | A | B | C | D |

## Topic 5: Polyprotic Acids and Bases

| | | | | | |
|---|---|---|---|---|---|
| 1 | identify a polyprotic acid from its chemical formula and state how many acidic protons are in that compound | A | B | C | D |
| 2 | identify a polyprotic base from its chemical formula and identify the basic sites on the compound | A | B | C | D |
| 3 | link pKa1, pKa2, pKa3, etc values to the appreciate species and equilibrium reaction | A | B | C | D |
| 4 | obtain Kb1 and Kb2 values from the appropriate pKa values | A | B | C | D |
| 5 | Calculate pH and concentration of all species present in the solution for a polyprotic acid | A | B | C | D |
| 6 | Calculate pH and concentration of all species present in the solution for a polyprotic base | A | B | C | D |
| 7 | Calculate the pH for an amphoteric species | A | B | C | D |

## Topic 6: Buffers

| | | | | | |
|---|---|---|---|---|---|
| 1 | predict products of acid-base reactions | A | B | C | D |
| 2 | predict pH of solutions obtained when strong acids are mixed with strong bases in different stoichiometric ratios | A | B | C | D |
| 3 | predict pH of solutions obtained when mixing a strong acid with a weak base or strong base with a strong acid in different stoichiometric ratios | A | B | C | D |
| 4 | recognize that buffers contain weak acids and their conjugates or weak bases and their conjugates | A | B | C | D |
| 5 | identify a solution as a buffer solution from the species present in the solution and their relative concentrations | A | B | C | D |
| 6 | calculate the pH of a buffer solution using the Henderson-Haselbach equation. | A | B | C | D |
| 7 | identify the major species of aqueous solutions and identify which solutions are buffer solutions | A | B | C | D |
| 8 | calculate the pH of the buffer solution | A | B | C | D |
| 9 | use a table of Ka and Kb values and select from the table appropriate species to construct a buffer for a desired pH | A | B | C | D |
| 10 | select the best buffer for a particular situation based upon desired pH and buffering capacity | A | B | C | D |
| 11 | describe how to prepare a buffer of given concentration and pH from strong acid and weak base (or strong base and weak acid) | A | B | C | D |
| 12 | calculate the number of moles of acid and base in a buffer based on the buffer concentration and pH | A | B | C | D |
| 13 | know difference between buffer range (pH range) and buffer capacity(moles) | A | B | C | D |
| 14 | determine buffer capacity toward added acid or base | A | B | C | D |
| 15 | use all the buffer properties to predict concentrations of all species in a buffer solution | A | B | C | D |

## Topic 7: Titration Curves

| | | | | | |
|---|---|---|---|---|---|
| 1 | read a titration curve and identify the major species at each point on the curve. | A | B | C | D |
| 2 | identify key features of the curve including the end point, midpoint, buffering region | A | B | C | D |
| 3 | compute titrant volume required to reach the endpoint and compute pH of endpoint | A | B | C | D |
| 4 | determine the concentration of buffer species and pH at any point on the curve | A | B | C | D |
| 5 | recognize the characteristic s shape curve for strong-strong titrations and distinguish the curve from strong-weak titrations | A | B | C | D |
| 6 | recognize the buffer zone and determine the buffer range from the titration curve | A | B | C | D |
| 7 | find the pKa on a titration curve and guess the likely species based on the pKa using the table of Ka values | A | B | C | D |
| 8 | determine the buffer capacity from the titration curve for any pH in the buffer range | A | B | C | D |
| 9 | recognize a polyprotic titration curve and identify the major species in solution at any point on the curve | A | B | C | D |
| 10 | obtain major species at any pH from speciation graph | A | B | C | D |
| 11 | identify polyprotic buffer solutions from the curve and the pKa values | A | B | C | D |

## Topic 8: Heat and Work

| | | | | | |
|---|---|---|---|---|---|
| 1 | Articulate the difference between heat and work – work is a force acting over a distance and heat is dissipative energy | A | B | C | D |
| 2 | Identify the system and surroundings for various scenarios | A | B | C | D |
| 3 | Determine if energy is leaving or entering the system and the appropriate signs for these processes | A | B | C | D |
| 4 | Identify the sign of delta H for exo or endo reactions and articulate the movement of energy in these systems | A | B | C | D |
| 5 | use tables of bond energies to compute delta H of reaction | A | B | C | D |
| 6 | State the first law and explain how it is a statement of energy conservation (recognize that negative heat and work represent a loss of energy and positive heat and work represent a gain in energy) | A | B | C | D |
| 7 | Calculate the amount of work does to or by a gaseous system | A | B | C | D |
| 8 | Recognize the appropriate signs for heat ad work of any system (including gaseous systems) | A | B | C | D |
| 9 | Compute the heat of a reaction using calorimetry at constant pressure or constant volume | A | B | C | D |
| 10 | Compute the specific heat capacity or molar heat capacity from calorimetry | A | B | C | D |
| 11 | Calculate latent for any phase transition given delta H values | A | B | C | D |
| 12 | Compute the overall heat for a system undergoing changes in both temperature and phases as read from a heating curve | A | B | C | D |

## Topic 9: Enthalpy

| | | | | | |
|---|---|---|---|---|---|
| 1 | Enumerate the standard conditions in thermodynamics and in gases (STP) – clearly the indicate the differences | A | B | C | D |
| 2 | Recognize the relationship between energy and enthalpy | A | B | C | D |
| 3 | Use $\Delta H^{o}$ data and Hess's law to compute heats of reaction or formation | A | B | C | D |
| 4 | Relate Hess's law to the properties of a state function | A | B | C | D |
| 5 | Use Hess's law to combine the values of K for multiple reactions to find the value of K for a new reaction | A | B | C | D |
| 6 | Compute the $\Delta H^{o}$ for a reaction or $\Delta H^{o}_{f}$ from tabulated formation data and/or heats of reaction | A | B | C | D |

## Topic 10: Entropy

| | | | | | |
|---|---|---|---|---|---|
| 1 | define spontaneity from a scientific or chemical perspective and contrast that with the more colloquial definition | A | B | C | D |
| 2 | identify the system of greater entropy and predict entropy changes of a system | A | B | C | D |
| 3 | be able to relate $\Delta S$ and $\Delta H$ of the system to $\Delta S$ of the universe | A | B | C | D |
| 4 | know that $\Delta S$ is related to $\Delta H$ only for the surroundings or only when the system is at equilibrium | A | B | C | D |
| 5 | State the 2nd law of thermodynamics and recognize that the second law is not a conservation principle | A | B | C | D |
| 6 | rationalize the temperature dependence of entropy | A | B | C | D |
| 7 | identify all standard state conditions | A | B | C | D |
| 8 | relate the existence of an absolute entropy to the third law of thermodynamics | A | B | C | D |
| 9 | Interpret entropy as a measure of disorder and recognize that entropy is a consequence of systems with large numbers of particles | A | B | C | D |
| 10 | State the 3rd law of thermodynamics and recognize that the zero point for entropy is not arbitrary | A | B | C | D |
| 11 | compute $\Delta S°$ and $\Delta H°$ from thermodynamic tables | A | B | C | D |

## Topic 11: Free Energy

| | | | | | |
|---|---|---|---|---|---|
| 1 | predict spontaneity of chemical reactions from thermodynamic data using free energy | A | B | C | D |
| 2 | compute $\Delta G°$, $\Delta S°$, and $\Delta H°$ for chemical reactions from thermodynamic tables | A | B | C | D |
| 3 | relate $\Delta G$ for non-standard states to the standard state $\Delta G°$ | A | B | C | D |
| 4 | compute $\Delta G$ using $\Delta G°$ and the reaction quotient Q for any chemical reaction | A | B | C | D |
| 5 | Use $\Delta G°=\Delta H°-T\Delta S°$ to compute $\Delta G$ and predict spontaneity. | A | B | C | D |
| 6 | relate free energy changes to the equilibrium constant (K). Calculate K from $\Delta G°$ and $\Delta G°$ from K | A | B | C | D |
| 7 | understand that equilibrium constants that were important in previous topics, such as $K_w$, $K_a$ or $K_b$, and $K_{sp}$, can also be calculated from free energy values at 298K | A | B | C | D |

## Topic 12: Applications of Free Energy

| | | | | | |
|---|---|---|---|---|---|
| 1 | understand that equilibrium constants that were important in previous topics, such as $K_w$, $K_a$ or $K_b$, and $K_{sp}$, can also be calculated from free energy values at temperatures other than 298K | A | B | C | D |
| 2 | be able to estimate both normal boiling (or melting) points and boiling (or melting) points at atmospheric pressures other than 1 atm. | A | B | C | D |
| 3 | obtain equilibrium data (vapor pressure, boiling point) from thermodynamic data | A | B | C | D |
| 4 | calculate free energy changes for transport of a species from one concentration to another for both aqueous solutions and gases | A | B | C | D |
| 5 | compute thermodynamic parameters from the temperature dependence of the equilibrium constant, and conversely be able to predict the temperature dependence of K from thermodynamic parameters, including changes in vapor pressure with temperature | A | B | C | D |
| 6 | compare and/or rationalize bonding effects ($\Delta H$) with disorder ($\Delta S$) in solubility reactions | A | B | C | D |

## Topic 13: Redox Reactions

| | | | | | |
|---|---|---|---|---|---|
| 1 | determine the oxidation states of atoms in molecules | A | B | C | D |
| 2 | identify oxidizing and reducing agent | A | B | C | D |
| 3 | identify oxidized species and reduced species | A | B | C | D |
| 4 | count the number of electrons transferred from the oxidized species to the reduced species | A | B | C | D |
| 5 | identify half reactions and balance redox reactions | A | B | C | D |
| 6 | compute the standard cell potentials for redox reactions | A | B | C | D |
| 7 | use the relationships between the cell potential and work to relate potentials to free energy change in redox reactions | A | B | C | D |
| 8 | predict spontaneity for these reactions | A | B | C | D |
| 9 | predict best oxidizing and reducing agents based on standard cell potentials | A | B | C | D |

## Topic 14: Batteries

| | | | | | |
|---|---|---|---|---|---|
| 1 | draw diagrams for a galvanic cell identifying the cathode, anode, direction of electron flow, and ion flow within the salt bridge | A | B | C | D |
| 2 | sketch an "atomic" or "ionic" level diagram showing where the oxidation and reduction actually occurs | A | B | C | D |
| 3 | compute the standard cell potentials for galvanic cells and predict the spontaneous direction of galvanic cells | A | B | C | D |
| 4 | use and interpret line notation to describe a galvanic cell | A | B | C | D |
| 5 | use the Nernst equation to explore the temperature and concentration effects on galvanic cell potential | A | B | C | D |
| 6 | be able to compute cell potentials using thermodynamic data | A | B | C | D |
| 7 | draw an electrolytic cell and predict products of electrolysis | A | B | C | D |
| 8 | use q=it to compute current or time needed to plate metals | A | B | C | D |

## Topic 15: Chemical Kinetics

| | | | | | |
|---|---|---|---|---|---|
| 1 | understand a concentration vs time plot and use this graph to identify concentrations of species at any point in time and/or instantaneous reaction rates at any point in time | A | B | C | D |
| 2 | understand the notation for reaction rates, the units for reaction rates, and be able to relate reaction rates expressed in terms of any reactant or product | A | B | C | D |
| 3 | identify the order of a reaction from a rate law and be able to compute the rate constant from the rate law and appropriate data | A | B | C | D |
| 4 | compute the rate law using the method of initial rates | A | B | C | D |
| 5 | compute the rate law for first order reactions from graphs of concentration vs time | A | B | C | D |
| 6 | obtain the value of the rate constant from appropriate graphs for first order kinetics or from a half-life for the reaction | A | B | C | D |
| 7 | use first order kinetics to obtain half lives of radioactive decay, or to obtain the rate constant from the half-life | A | B | C | D |
| 8 | use the integrated first order rate equation to calculate concentration as a function of time | A | B | C | D |
| 9 | date materials using carbon-14 or uranium-238 (understand concept and perform calculations) | A | B | C | D |
| 10 | determine the half lives of reactions having 1st order kinetics from appropriate graphs or from the rate constant | A | B | C | D |

## Topic 16: Arrhenius Theory

| | | | | | |
|---|---|---|---|---|---|
| 1 | write rate laws corresponding to elementary reactions and simple reaction mechanisms | A | B | C | D |
| 2 | determine if a reaction mechanism is consistent with a given experimental rate law | A | B | C | D |
| 3 | use the Arrhenius equation for calculations of rate constant changes with temperature or activation energy | A | B | C | D |
| 4 | graph and interpret the Arrhenius equation | A | B | C | D |
| 5 | state the different between hetero- and homogeneous catalysts and know how a catalyst impacts the activation energy and its diagram | A | B | C | D |
| 6 | interpret and sketch reaction coordinate diagrams given appropriate information | A | B | C | D |

**NOTE:** Topic 17 is not a required part of GenChem2, but it is interesting to look at.

## Topic 17: Radioactive Decay

| | | | | | |
|---|---|---|---|---|---|
| 1 | read and interpret the island of stability graph. | A | B | C | D |
| 2 | identify the types of nuclear decay and write nuclear decay equations (alpha, beta, gamma and electron capture) | A | B | C | D |
| 3 | Review first order kinetics to obtain half lives of radioactive decay, or to obtain the rate constant from the half-life (dating materials using carbon-14 or uranium-238) | A | B | C | D |
| 4 | use the relationship between mass and energy to compute nuclear binding energies | A | B | C | D |
| 5 | identify the fusion and fission processes and compute the exothermicity of fusion or fission reactions | A | B | C | D |
| 6 | understand and be able to define the terms 'chain reaction' and 'critical mass' | A | B | C | D |