CHEMISTRY BC2001x **2008 GENERAL CHEMISTRY INFORMATION**

Lectures: **Professor Sally Chapman** Office: 802 Altschul Telephone: 4-2098
E-mail: schapman@barnard.edu Office Hours: Tu 2-4; W 4-6, Th 10:30-12, F 9-11
plus Monday 6–8 PM: problem-solving workshop in 804 Altschul (See page 5).

My office hours are for you; you are always welcome. Come to see me as soon and as often as you need to, with any and all questions or comments on lecture material or on problem solving. When several students need help, it is often most effective to answer questions in groups, so feel free to join in. If you have a situation that requires a private discussion, come at the beginning of my hours and tell me you need to see me privately, or make an appointment. If your schedule conflicts with all my office hours, I urge you to consider modifying your schedule!

While I can answer brief procedural questions by e-mail, I prefer to answer chemistry questions face-to-face. Do not expect e-mail responses late at night or on weekends.

Please see me during *scheduled hours*. If that is not possible, call to arrange an appointment.

LECTURE ROOM AND HOURS

The lectures are in **202 Altschul** (also called Lehman Auditorium) on Tuesdays and Thursdays, starting promptly at 9:10 AM. Exams start at 9:00, not 9:10 AM. Handouts are distributed and homework problems collected *before* the start of lecture. If you arrive late, please go upstairs to the 3rd floor and enter the room silently from the back. Cell phones must be **off**.

ATTENDANCE

You are expected to attend every lecture. While attendance is not checked, ***you cannot do well in this course unless you faithfully attend the lectures***. Lectures order and clarify the material, demonstrate interesting points, and show what topics the instructor feels should be stressed. Further, some important handout is picked up, or a problem handed in, or a problem or examination returned, or some combination of these, at the start of every lecture period. Do not miss lectures. Come early, come prepared, participate and ask questions if you have them, and you will help yourself to do well and to learn chemistry.

TEXTBOOK

The textbook is Raymond Chang, *General Chemistry: The Essential Concepts* (McGraw-Hill; *4th Ed.* 2006 or *5th Ed.* 2008), available at the Columbia Bookstore. Chang writes clearly, discusses chemistry at a good level, and has focused this shorter version of his textbook nicely. Chang's book will be supplemented with handouts on topics we cover in greater depth.

A solutions manual is available with answers to even-numbered problems in Chang's text: B. Cruickshank and R. Chang, *Problem-Solving Workbook to accompany General Chemistry*. Purchases is optional. I am not assigning problems from Chang, but the solutions manual might be useful if you do extra problems. This is available in the library or for purchase.

When trying to understand a particular topic, it is never a good idea to read the same explanation over and over. Adopt the habit now of consulting different sources; see the list below. One author may explain things in a way that is clearer for you; moreover different authors provide better treatments of different subjects.

LABORATORY

This course is carefully designed to integrate lecture and laboratory: topics are closely correlated, and material from both lecture and labs is included on examinations. For this reason, no one may take the lecture part of this course without the laboratory, or the laboratory part without the lecture, without compelling reasons and prior written permission from Prof. Chapman. ***Information about the laboratory is on separate pages***.

LECTURE SCHEDULE / READING ASSIGNMENTS / EXAMINATION SCHEDULE

Lectures will be of much more use to you if you have looked over the subject matter beforehand. The reading assignments refer to chapters and sections in Raymond Chang, *General Chemistry: The Essential Concepts, 5th Ed.* (McGraw-Hill 2008). We skip some topics that are probably familiar from high school (example: Ch. 7: atomic structure); others, like stoichiometry and bonding will be treated quite rapidly. The **lectures** and **assigned problems** should be your guide about the content and depth you will be expected to know for examinations.

#	TUESDAY LECTURE	READ	#	THURSDAY LECTURE	READ
1	*Sept. 2* / Introduction, overview. Atoms. Atomic weights.	Chapter 1; 2.1 – 2.4	**2**	*Sept. 4* / Avogadro's number. Moles. Chemical formulas.	2.5 – 2.8; 3.1 – 3.4
3	*Sept. 9* / Chemical equations. Stoichiometric calculations.	Sections 3.5 – 3.10	**4**	*Sept. 11* / Chemical elements. Structure of the periodic table.	[Chapt. 7]; Chapter 8
5	*Sept. 16* / Simple theory of covalent bonding: the octet rule.	Chapter 9	**6**	*Sept. 18* / More bonding theory. Molecular shapes. Polarity.	Chapter 10
7	*Sept. 23* / Properties of gases. The ideal gas law. Real gases.	Chapter 5	**8**	*Sept 25* / Gases, liquids, solids. Phase equilibria; phase diagrams.	Chapter 12
*	***Sept. 30* / EXAMINATION 1** Material from Lectures 1 – 6 and Problem Sets 1 – 3		**9**	*Oct. 2* / Solutions. Units of concentration. Henry's law.	Sects. 4.5; 13.1 – 13.5
10	*Oct. 7* / Solutions. Raoult's law. Distillation. Colligative effects.	Sect. 13.6; handout	**11**	*Oct. 9* / Ionic reactions in water. Salts, acids, bases. Electrolytes.	Sects. 4.1 – 4.2
12	*Oct. 14* / Chemical equilibrium. Q, K_{eq}. Gases. Solubility. K_{sp}.	Chapter 15; 17.5 – 17.6	**13**	*Oct. 16* / Self-ionization of H_2O. K_w. $[H^+]$, pH. Acids and bases.	4.1 – 4.3; 16.1 – 16.4
14	*Oct. 21* / Weak acids. K_a, pK_a. Weak bases. K_b, pK_b. Buffers.	16.5 – 16.9 17.1 – 17.2	*	***Oct. 23* / EXAMINATION 2** Material from Lecs. 7 – 12 (but *not* K_{sp}) and Prob. Sets 4 – 6	
15	*Oct. 28* / Titration: monoprotic acids and monobasic bases.	Sects. 4.6; 17.3 – 17.4	**16**	*Oct. 30* / Polyprotic acids. Effect of pH on solubility.	Sect. 16.5; handout
	***Nov. 4* / NO LECTURE: ELECTION DAY HOLIDAY**		**17**	*Nov. 6* / Binding of ligands to metals, esp. transition metals.	17.7 – 17.8; Chapter 20
18	*Nov. 11* / Oxidation states. Oxidation-reduction reactions.	Sects. 4.4; 19.1	**19**	*Nov. 13* / Electrochemistry. Galvanic cells. Cell voltage.	Sections 19.2 – 19.3
20	*Nov. 18* / Standard reduction potentials. The Nernst equation.	Sections 19.4 – 19.9	**21**	*Nov. 20* / Thermochemistry. Energy. Enthalpy. Calorimetry.	Chapter 6
*	***Nov. 25* / EXAMINATION 3** Material from Lecs. 12 – 17 (incl. K_{sp}) and Prob. Sets 7 – 9			***Nov. 27* / NO LECTURE: THANKSGIVING DAY HOLIDAY**	
22	*Dec. 2* / Thermodynamic data. Entropy. Spontaneous changes.	Sections 18.1 – 18.4	**23**	*Dec. 4* / Gibbs free energy and equilibrium at constant T and P.	Sections 18.5 – 18.7

Special office hours and informal review sessions will be scheduled between Friday, December 5 and Wednesday, December 17. The final examination, from 9:00 AM to noon on **Thursday December 18**, is comprehensive, covering the entire course, **including lab**. About one third will focus on the material of lectures 18–24. The final exam date and time cannot be changed.

PROBLEM SETS

Mastering chemistry means being able to solve chemistry problems. Every week a carefully selected set of practice problems is assigned; these are available on Courseworks. The first set is also available on the course web page. These practice problem sets, on topics listed on the next page, are designed to test your grasp of the key concepts in each block of material and your ability to apply them, and to improve your quantitative and analytic skills.

Do not expect to be able to solve all these problems right after reading and hearing about the material. Use the problems as a guide to what you must learn from the textbook and from the lectures, and what skills you need. Answers to these problems are ***not collected***. First work out complete answers, then check them yourself using the answers also found on Courseworks. Once you have mastered these problems, you should be prepared to do the hand-in problem, which is graded. The best way to become more proficient in chemistry is to do many problems!

I encourage you to work together on these study problems and on problem-solving methods. Forming a study group in which you help each other can be a very effective leaning technique. Ask each other questions and explain confusing points to each other. Make very sure that each member of the group understands all aspects of each problem thoroughly, not just a part.

In addition to the study problems, you will usually have a problem set **to be handed in**; the answers will be graded. Work out the solutions first on a separate sheet, then copy them neatly onto the pages provided, including all work and showing all your reasoning. Answers to problems must be submitted *on the original sheet*. *Extra pages may not be added*, since this would complicate grading. ***These pages must represent your own work only***. You may consult any book for help, but not ***any*** person. Discussion of these hand-in problems with anyone but Prof. Chapman before turning them in is a violation of the Barnard Honor Code. If you need help, see me: I will give you a hint to get you started.

Answers to hand-in problems are due by 9:10 AM on the date specified, and are collected before lecture begins. *Problems handed in between 9:10 and 11:00 the same day will receive 50% credit; no work will be accepted thereafter.* If for some reason you must miss class, you may bring your answers to my office in advance. If you are ill or suddenly seriously indisposed, speak to me; I will not penalize you for a missing set for which you offer a valid excuse.

EXAMINATIONS

There will be three in-term examinations, each 85 minutes long, and a 3-hour final examination.

First in-term Examination	**Tuesday September 30**	**9:00 – 10:25**
Second in-term Examination	**Thursday October 23**	**9:00 – 10:25**
Third in-term Examination	**Tuesday November 25**	**9:00 – 10:25**
Final Examination	**Thursday December 18**	**9:00 –12:00**

Each examination starts promptly at **9:00 AM**. Always get a good night's sleep before taking an examination. If you travel to school, allow extra time on those days. Each in-term examination ends at 10:25, and the final examination ends at 12:00, for everyone, even if you arrive late. The size of this class *absolutely precludes any rescheduling of any examinations* because of any conflicts with any other examinations, other work in any other class, or any travel plans.

You are entitled to a make-up examination only for one of three reasons: (1) a ***serious illness***, requiring a visit to the health service or bed rest; (2) a ***pressing personal or family emergency***; (3) a conflict with a ***religious observance***, which must be made known ***in advance***. If you must miss an examination, please speak to Professor Chapman, in advance when possible, but within 48 hours at most, to discuss scheduling a make-up test. If I don't hear from you, I will assume that you have dropped the course. *Do not make travel arrangements that conflict with the final!*

DUE DATES FOR HAND-IN PROBLEMS and STUDY PROBLEM ASSIGNMENTS

If you find these problems too challenging, start by doing some problems in Chang. Avoid looking at answers until you have made a serious effort to complete each problem on you own.

Set #	Topics covered in the practice problem set and the hand-in problems. For additional practice, work out other problems on the same topics.	HAND-IN SET DUE DATE
1	significant figures, units; elements, chemical symbols; atoms, molecules; Avogadro's number N_A, moles; atomic wts., molecular wts., formula wts.	Thurs Sept. 11
2	% composition, formulas; chemical reaction equations, stoichiometry; excess reagent(s), limiting reagent, maximum and actual yield of product	Thurs Sept. 18
3	the periodic table; types of compounds; bonding theory; molecular shapes	Thurs Sept. 25
THE FIRST EXAMINATION, ON TUESDAY SEPTEMBER 30, INCLUDES MATERIAL IN LECTURES AND READING ASSIGNMENTS 1 – 6 AND PROBLEM SETS 1 – 3		
4	properties of ideal and real gases, the gas laws; reactions involving gases; gases, liquids, and solids; phase changes, phase equilibria, phase diagrams	Thurs Oct. 2
5	solutions, concentration, dilution, volumetrics; Henry's law; Raoult's law	Thurs Oct. 9
6	colligative effects; reactions in aqueous solution; solubility rules; electrolytes; acids, bases; net ionic equations; chemical equilibrium; K_{EQ}.	Thurs Oct. 16
THE SECOND EXAMINATION, THURSDAY OCTOBER 23, INCLUDES MATERIAL IN LECTURES AND READING ASSIGNMENTS 7 – 12 AND PROBLEM SETS 4 – 6		
7	chemical equilibria in gases; solutions; solubility; solubility product K_{sp}	Thurs Oct 30
8	water; K_w; pH; acids and bases; K_a and K_b; acid-base reactions; buffers	Thurs Nov. 6
9	acid-base titrations; acid-base indicators; polyprotic acids, polybasic bases; simultaneous equilibria K_{eq}; pH and solubility	Thurs Nov. 13
THE THIRD EXAMINATION, ON TUESDAY NOVEMBER 27, INCLUDES MATERIAL IN LECTURES AND READING ASSIGNMENTS 12 –17 AND PROBLEM SETS 7 – 9		
10	simultaneous equilibria K_{eq}; binding of ligands to metals, especially transition metals; oxidation states; oxidation-reduction reactions	Thurs Nov. 20
11	electrochemical cells; standard reduction potentials; the Nernst equation	Thurs Dec. 4
12	energy; enthalpy; calorimetry; entropy; Gibbs free energy and equilibrium	----------
THE FINAL EXAMINATION, THURSDAY DECEMBER 18, INCLUDES MATERIAL IN LECTURES AND READING ASSIGNMENTS 18 – 23 AND PROBLEM SETS 10 – 12 (⅓ TO ½ OF THE EXAMINATION). IT WILL ALSO CONTAIN QUESTIONS ON THE OTHER MAJOR TOPICS OF THE COURSE, INCLUDING THE LABORATORY.		

STUDENTS WITH DISABILITIES

Any student taking this course who may need a disability-related accommodation in the lectures and/or examinations should inform Professor Chapman by Friday, September 26. You should also drop by the Office for Disability Services, 105 Hewitt, to register for support services.

GRADES

The weekly graded problems count 11%, each in-term examination 12%, the final examination 23%, and the grade for laboratory work 30% toward your overall course grade. You must pass both the lecture and laboratory parts of the course separately to receive an overall passing grade.

Numerical grades on each in-term examination will be converted to letter grades to give you an *approximate* idea of your standing. Grade distributions will be posted on the web. Please understand that I calculate final grades from *numerical* totals only: I do not use the approximate letter grades given for each in-term examination, so you should not be distressed if one particular numerical grade falls just below the assigned cutoff estimate for a certain letter grade equivalent. Since I work with numbers, you cannot combine letter grades to determine you final grade: for example, a B- average on exams and an A- average in lab could still result in a B- overall.

If you have any questions about the grading of problem sets or examinations, speak promptly to Prof. Chapman. While we try very hard to avoid errors, I want to correct any that might occur.

FAQ (Frequently asked question): **Do I grade on a curve?** The answer to this depends on what you mean by grading on a curve. One answer is *no*, in that there is **no** predetermined fraction of the class that gets each grade (e.g. 20% A's). I would be delighted to have no D's or F's in the class! Another answer is *yes*, in that I do **not** pre-assign a certain numerical grade to a letter grade (e.g. 85 = B). Exams differ in difficulty, and I do not believe it would be fair to penalize an entire class if I happened to give an exam that proved to be more difficult than usual!

CALCULATORS

This course involves considerable numerical computation, so you need an electronic calculator. Inexpensive calculators are fine if they can compute the values of logarithmic and exponential functions. If your calculator is powered by light, check that it works in 202 Altschul. Always bring a calculator to examinations; make sure the batteries are well charged. If you must borrow a calculator, be sure you are familiar with its use; different calculators may work very differently. All equations must be deleted from programmable calculators before examinations.

PROBLEM-SOLVING WORKSHOP: MONDAYS 6:00 – 8:00 PM 804 Altschul

Note: In place of Monday office hours, I hold a weekly **optional** workshop to give more help with problem-solving skills. The workshop is like office hours: what I do depends on who is present and what questions are asked. No new material will be presented, but I do go over various ways of thinking about and solving the problems raised by student questions. All students who attend are expected to participate. The atmosphere is always quite informal.

NOTICES

Information on the lecture part of the course and copies of most handouts are posted on the course web site*. The "Announcements" page includes last minute corrections and other announcements. Please check this regularly. Extra copies of handouts are generally available on the 8th floor, outside Prof. Chapman's office door. If you miss a class, ne sure to get all handouts promptly. You must ask me for a hand-in problem, I do not put out extras.

*Course home page: **http://bc.barnard.columbia.edu/~schapman/bc2001/index.htm**

SOME SUGGESTIONS AND ADVICE ON PROBLEM SOLVING

Success in this course requires you to be able to solve chemistry problems: not just exercises, where one plugs data into one equation, but real complex problems. A frustrated lament of some students is that they don't even know where to begin, so they feel overwhelmed. Beginning is sometimes the hardest part, but with practice you can learn how to proceed systematically.

1) A useful strategy in starting a problem is to *list what is given, what you know, and what you ultimately seek.* Define all symbols you use, using standard notation when possible (p for pressure, V for volume…). Always write out all units. Whenever appropriate, write down complete balanced chemical reaction equations or draw pictures to help clarify what is happening. Then, using any equations or relationships you know relevant to the problem, reason your way to the desired answer, step by step. Write out each step, especially if it involves a substitution, explicitly.

2) Always use dimensional analysis: *write out all units*; carry units through equations; check the answer for correct units. This is a quick and effective way to detect certain simple errors.

3) *Don't expect to see how to solve a problem right away, and don't expect to be able to reach the answer in one simple step.* Several steps of reasoning will almost always be needed. The key idea is to move forward, one step at a time. Don't be surprised if there seem to be several different ways of solving a given problem; there usually are.

4) *Thinking out the steps in a problem backward is often very useful*. Ask what you must know to be one step from the desired result; then ask what you must know to get that information, and so on, until you reach data that you do know and relationships that get you to the answer.

5) It is not sensible to do extensive numerical calculations before thinking the whole problem through. It is easier to work with symbols and keep track of the relations among quantities algebraically than it is to work with long chains of numbers. *Do calculations at the end*.

6) After solving a problem, look carefully at the calculated result. *Make sure it is reasonable* in sign, in magnitude, in dimensions. Many computational errors (for example, accidentally pushing a wrong key on a calculator) can be found this way. *Double check all calculations*.

7) Some problems closely resemble examples worked out in the chapter. *Try to do the problem first without referring to the example*. If you need to follow the example, you have not yet mastered solving that kind of problem; try a few more.

8) *Never consult a solutions manual to see or check an answer until after you have made a real effort and worked for some time on solving the whole problem. Once you have seen all the steps in the answer to a problem, you learn very little by working on it*.

9) Several textbooks specifically about problem solving in general chemistry are on reserve in the library. Consult the reading list below for some suggestions.

10) If you work hard on a problem set and still have trouble, ***come right away to get some help***. Prof. Chapman's office hours are meant primarily to provide help for you in problem solving. *Don't feel shy or uneasy about coming for help*. Never hesitate to ask because you think question is too elementary: if you have some simple questions, get them answered now! Moreover, seemingly elementary points are frequently more subtle than you may realize. ***You are here to learn chemistry; we want you to learn it, so make good use of office hours.***

SUPPLEMENTARY READINGS

General chemistry textbooks frequently differ in their levels of presentation. Some emphasize descriptive chemistry, others are more quantitative; some authors have a rather terse style, others favor lengthier discussion. It may be helpful to read a more qualitative discussion of a subject before tackling one that is mathematically rigorous. Segal is very clear, careful, and accurate, has many good problems and a complete solutions manual. (Prof. Segal taught this course at Barnard for many years. It is, alas, no longer available for purchase.) Munowitz is an interesting newer book: each chapter has a quite detailed and well-written qualitative section before delving into the more quantitative material.

Your goal is to understand the material well enough to solve all of the assigned problems. ***If you can solve the problems, you know the subject; if you can't, you don't.***

Many of the books listed below are on reserve in the Barnard library. Recent editions are listed, but there is often little substantive difference between editions. Older books may use notation and units that are no longer preferred. If there is a book that you find particularly useful, please tell me.

GENERAL CHEMISTRY TEXTBOOKS

American Chemical Society, *Chemistry in Context* (McGraw-Hill 2006)

P.W. Atkins and J.A. Beran, *General Chemistry*, 2nd Ed. (Scientific American Books, 1992)

P.W. Atkins and L.L. Jones, *Chemistry: Molecules, Matter, and Change*, 3rd Ed. (Freeman, 1997)

G.M. Bodner and H.L. Pardue, *Chemistry, an Experimental Science*, 2nd Ed. (Wiley, 1995)

J.E. Brady, *General Chemistry, Principles and Structure*, 5th Ed. (Wiley, 1990)

T.L. Brown, H.E. LeMay, and B.E. Bursten, *Chemistry, The Central Science* 10th Ed. (Prentice-Hall, 2006)

R. Chang, *Chemistry*, 7th Ed. (McGraw-Hill, 2002)

R.E. Davis, K.D. Gailey, and K.W. Whitten, *Principles of Chemistry* (Saunders, 1984)

D.D. Ebbing, S.D. Gammon, and R.O. Ragsdale, *Essentials of General Chemistry* 2/e (Houghton-Mifflin 2006)

R.J. Gillespie, D.A. Humphreys, N.C. Baird, and E.A. Robinson, *Chemistry*, 2nd Ed. (Allyn and Bacon, 1989)

J.W. Hill and R.H. Petrucci, *General Chemistry: An Integrated Approach 2nd Ed.* (Prentice-Hall, 1999)

Gilbert, TR; Kirss, RV; Davies G, *Chemistry: The Science in Context* (Norton, 2004)

Hill, Petrucci, McCreary, Perry, *General Chemistry*, 4th Ed. (Prentice-Hall 2005)

J.C. Kotz and K.F. Purcell, *Chemistry and Chemical Reactivity*, 2nd Ed. (Saunders, 1991)

W.L. Masterton, E.J. Slowinski, and C.L. Stanitski, *Chemical Principles*, 6th Ed. (Saunders, 1985)

John McMurry and Robert C. Fay, *Chemistry,* 3/e (Prentice-Hall 2001)

D.A. McQuarrie and P.A. Rock, *General Chemistry*, 3rd Ed. (Freeman, 1991)

SUPPLEMENTARY READINGS: GENERAL CHEMISTRY TEXTS (continued)

M. Munowitz, *Principles of Chemistry* (Norton 2000)

J. Olmstead and G.M. Williams, *Chemistry* 3rd Ed. (Wiley, 2002)

D.W. Oxtoby, W.H. Freeman, and T. Black, *Chemistry, Science of Change*, (Harcourt-Brace, 3rd Ed.: 1998, 4th Ed. 2003)

D.W. Oxtoby and N.H. Nachtrieb, *Principles of Modern Chemistry*, 3rd Ed. (Saunders, 1996)

B.G. Segal, *Chemistry: Experiment and Theory*, 2nd Ed. (Wiley, 1989), plus solutions manual.

M. Silverberg, *Chemistry: The Molecular Nature of Matter and Change*, 4th Ed. (McGraw-Hill 2006)

J.M. Spencer, G.M. Bodner, and L.H. Rickard, *Chemistry: Structure and Dynamics* (Wiley, 1999)

K.D. Whitten, K.D. Gailey, and R.E. Davis, *General Chemistry*, 3rd Ed. (Saunders, 1988)

S.S. Zumdahl, *Chemical Principles* 5th Ed. (D. C. Heath, 2005)

STUDY SKILLS, MATH AND PROBLEM SOLVING

R.S. Boikess and C.H. Sorum, *How to Solve General Chemistry Problems*, 7th Ed. (Prentice-Hall, 1987)

R.A. DeLorenzo, *Problem Solving in General Chemistry*, 2nd Ed. (Wm. C. Brown, 1993)

F. Drewes and K.L.D. Milligan, *How to Study Science*, 3rd Ed. (McGraw-Hill, 2000)

G.W. Gibson and G.C. Faber, *Mastering Chemistry Problems*, 2nd Ed. (Prentice-Hall, 1988)

D.E. Goldberg, *How to Solve Word Problems in Chemistry* (McGraw-Hill 2001)

D.M. Goldish, *Basic Mathematics for Beginning Chemistry*, 3rd. Ed. (McMillan, 1983)

A.B. Loebel, *Chemical Problem-Solving by Dimensional Analysis*, 3rd Ed. (Houghton Mifflin, 1987)

E.I. Peters and W.T. Scroggins, *Chemical Skills* (McGraw-Hill 1992)

W.S. Seese and G.W. Daub, *In Preparation for College Chemistry*, 4th Ed., (Prentice-Hall, 1990)

S. Tobias, *Succeed with Math* (The College Board, 1987)