

**CHEM. W237 - PHYSICAL CHEMISTRY LABORATORY
FALL 2005**

Lecture (B121): M 11:40-12:30
Lab (B403): Tu & Th 12:40-3:30

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Office Hours:
Monday 10:00-11:00, Tuesday & Thursday 11:00-12:00.

Instructors:

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Text: The experiments to be performed can be found in “Experimental Physical Chemistry-A Laboratory Textbook,” by Arthur M. Halpern (referred to as H), and “Experiments in Physical Chemistry,” by Shoemaker, Garland and Nibler (referred to as SGN), or supplemental handouts.

Prerequisites: Chem 129, Chem 213, Chem 231 or 232 or both; *A second semester of Physical Chemistry lecture must be taken concurrently if only one of the two semesters has been completed.*

Any student who has a need for accommodation based on the impact of a disability should contact me privately to discuss the specific situation as soon as possible. Contact Disability Resources and Services at 215-204-1280 in 100 Ritter Annex to coordinate reasonable accommodations for students with documented disabilities.

INTRODUCTION

Physical chemistry is the application of physical methods to the study of molecular processes and properties. It has a long and illustrious history founded primarily on experiment, although the advent of quantum mechanics has allowed for the calculation of molecular properties without the input of experiment (though we're not quite there yet). While much of modern physical chemistry is technically quite sophisticated there are many wonderful experiments that can be performed which demonstrate basic physical and chemical properties of matter.

W237 is a writing-intensive course. It is the capstone course for chemistry majors at Temple. You will write formal laboratory reports. Getting the right answer is not enough! Part of your grade will be based on style and clarity. Please set aside enough time to achieve this goal.

STRUCTURE OF THE COURSE

There are seven experiments in the syllabus spanning thermodynamics to quantum mechanics and kinetics. You will do all of the experiments and write individual lab reports on each of them. You will see each experimental setup twice. First, working in small groups and guided by an instructor, you will figure out how to make measurements on the assigned apparatus. During this training period, known as "Round Robins", lectures will be given to cover the theoretical background necessary to understand the what and how of each experiment. The Round Robins will take 3 weeks.

In your second encounter with the apparatus, you will actually perform the experiment in groups of two. On the Monday before the lab, you will be given a quiz that will test your understanding of the experiment *before* you actually perform it. We presume that you can collect the data and analyze it with little input from your instructors. However, there will be a mandatory data analysis period following the completion of each experiment. These sessions, indicated as "CL" in the Experiment Schedule (page 13), will be held in the Computer Lab (BE220) under the guidance of one of the instructors. The point of these sessions is to work up the raw data to the point where we can be sure you are on the right track.

All of these elements are summarized in the Master Schedule on pages 10-11 of this syllabus.

TRAINING: ROUND ROBINS

The purpose of the round robins is to gain a basic familiarity with the equipment used in the course. The Round Robin Schedule is found at the back of this syllabus on page 12. You will be given a number (from 1-20) that corresponds to a particular set of Round Robin sessions. **You are required to participate in the Round Robin as indicated on the schedule and you should take notes about the session directly in your lab notebook.** Your instructors will keep attendance records.

During the Round Robin sessions you are encouraged to explore and test experimental ideas. We hope you will find a sense of fun and exploration rather than fear or tedium. Perhaps the most important thing is to learn when some result you obtain makes sense or not! You will know when you have accomplished this task when you have been able to make a few dummy measurements successfully. In some cases this procedure may take an hour while in other cases it may take all of the available class time.

I have asked the course instructors to participate in the group as if they too were learning about the apparatus for the first time. The idea is that you will have a chance to see how a more experienced scientist approaches and troubleshoots a new experiment.

EXPERIMENTS

After the Round Robin sessions are completed (about 3 weeks) the class will be broken down into groups of two and the experiments will be performed according to the schedule at the end of

this syllabus on page 13. You are welcome to make a written request for a lab partner before the first set of labs start. However, I will put you into a group if no request is made.

Come prepared to take data! The instructors will be examining your notebooks and your grade will be adversely affected if you do not take your preparation seriously. Your preparation should include an introduction and purpose for the experiment, any relevant calculations or constants you need (molecular weight, density, etc.), and prepared tables into which you can write the data as you take it. **If you do not come in prepared as described above you can expect to lose a grade on the lab report.**

<u>EXPERIMENTS TO BE PERFORMED (7 in all)</u>	<u>Abbreviation</u>	<u>duration</u>
Mutual Solubility (H #10)	Sol	2 lab periods
2-Naphthol: Excited State Acidity Constant (H #34)	pKa*	1 lab period
Heat Capacity Ratio (SGN #3 but look at #H2)	CpCv	1 lab period
Conductance of Solutions (SGN #17)	Cond	1 lab period
<i>Cis-trans</i> isomerization of <i>N</i> -acetylproline by NMR (handout)	NMR	1 lab period
Absorption Spectra of a Conjugated Dye (SGN #34)	Abs	1 lab period
Deprotonation and Protonation Rate Constants (H #35)	S-V	1 lab period

All experiments take one lab period with the exception of the Absorption experiment. While the instructors will help you get out of a bind, you are expected to work independently at this point and part of your lab grade will reflect this independence. However we expect things to go wrong so don't hesitate to point out a problem or ask a question that requires an instructor's attention.

While you will work in pairs performing the experiments and collecting data each of you will be required to take your own notes. When you hand in a lab report it will be graded along side that of your partner's to assure that each of you work independently on the report. The format of the report is given below. *Please include a xerox copy or carbon copy of your data as an appendix to the report.*

LAB QUIZZES

An experiment-based quiz will be given during the Monday hour in BE121 once experiments begin (Week 4 and on). The purpose of the quiz is to make sure you have properly prepared for the lab you are about to do and will include questions about experimental details and simple calculations given sample data. *Each person will take this quiz independently.* Do not expect any help from your lab partner. The quizzes are closed notes/closed book. Please bring a calculator.

ERROR ANALYSIS PROBLEM SET

The importance of error analysis in this course cannot be overstated but often the students find the amount of error analysis required can be daunting. You should remember much of this from Chem 129 and Chem 213. To help remind you of this material, please read Chapter 2 of SGN and complete the following problem set:

p. 37: problems 1-2

p. 66: problems 1-3

This problem set is due at the beginning of class, Thursday September 8th and is worth 5% of your grade. If you need help with the problem set don't hesitate to ask any of the instructors!

GRADING

Your grade will be calculated according to the following criteria:

Experiment reports (6) : 75% (12.5% x 6) [65% scientific content/35% writing style]
Quizzes : 20% (3.33% x 6)
Error Analysis Set : 5%

"Scientific content" means the precision and accuracy of your result, and the quality of your error analysis, graphs, and tables. "Writing style" means how well you tell the story, how carefully you match verb to subject, your use of tense, and other aspects of style. Note that the best 6 out of 7 labs and quizzes will count toward your grade. I do not anticipate that a "curve" will be applied.

LABORATORY NOTEBOOKS

You should have a lab notebook which may be of any brand, but should be about 8-1/2 x 11", ***solidly bound (not wire-bound), with at least 100 numbered pages***. All data taken in the lab must be recorded in this notebook, neatly and clearly identified. At the end of each lab period you and the instructor must sign your notebook. A xeroxed copy of the data must be submitted with your laboratory report as an appendix.

Your notebook should be a detailed account of all work you performed in the lab. Unavoidable deviations from the established procedure, problems encountered, mishaps suffered, and other pertinent observations should all be recorded. It should not be written at the end of the day, but must be recorded as you go along. Since your reports can be written only if you have a good record of your work and data, you must keep your notebook up to date and in a sensible and readable manner. For example, numbers must be accompanied by the appropriate units and be labeled as to what quantity was measured.

LABORATORY REPORTS

For each experiment you will prepare a laboratory report using the format described below. The knowledge gained from an experiment is of little value unless it can be communicated. You should write your report in a lucid, easy-to-follow manner, readily comprehensible by anyone with a basic background in physical chemistry. Because this course has been designated a writing-intensive course, a great deal of importance will be attached to the quality of your writing.

Please take note of the following points :

1. ***Your report is to be entirely your own work.*** Although you may gather data with your group, you must do the calculations and write-up yourself. Evidence of unacknowledged collaboration in the preparation of your report will result in a penalty. (Note that your report will be graded alongside your partner's.)
2. ***Reports are due at the beginning of the lab period one week after the day the experiment was completed.*** This is indicated by the symbol "\$\$" in the schedule. This is also true for the Absorption ("Abs") experiment, even though no "\$\$" is evident (this lab is the easiest to perform and write up).
3. All reports must be typewritten double-spaced, including equations, tables, and special symbols. Use a word processor with an equation editor. If you do not know how to install this feature one of the instructors can assist you. **NEATNESS COUNTS TOWARD YOUR GRADE!** Do not hand in reports that are too lightly printed or otherwise hard to read.
4. ***Plagiarism*** - Note that you will take data together but each partner is responsible for his/her own write-up and report. **Duplication of text, graphs, calculations, tables, or formatting used by other students is not acceptable. Copying from websites, textbooks, and other sources is not permissible and your lab report will be given an "F" grade if this is the case.**
5. **The file for your lab report must be submitted electronically via Blackboard to receive a grade.** This must be done by the time you submit your hardcopy report. To submit a file just log in to your TUPORTAL account and go to the Blackboard site for Chem W237. There you will find a menu item labeled "Turnitin Assignment". Click on this link and follow the instructions. The window for file submission will be closed by the time class starts on the day of submission.
6. Your lab report score will be reduced by one full grade for each day that a lab report is late (without a medical excuse).

LAB REPORT REWRITES

Your 1st *two* lab reports will be carefully graded for both style and scientific content and returned for rewriting. This is our feedback on your writing style as well as the format of the lab report. You have the option of doing nothing and accepting your grade. **However, if you take the time to make the changes indicated your grade will improve.**

It is extremely important that you show effort in improving your writing style. A significant part of your lab grade will depend on how well you have incorporated the instructor's comments into your narrative. After the 2nd lab report we will assume you have learned from the comments in your reports and no further rewrites will be accepted. However, you will still be graded on style as well as content.

You will have one (1) week to return the corrected lab report for a re-grade. In no event will the re-grade result in a lower grade (except for plagiarism)!

CALCULATIONS

Calculations should be consistent with the measured data, i.e., do not arbitrarily discard significant figures and, conversely, **do not include long strings of meaningless digits**. If you have trouble with any calculation, you are encouraged to see one of the instructors in the lab. Always bring your notebook with you to help the instructor locate the source of your difficulties.

LAB REPORT FORMAT (REQUIRED)

1. Cover page : The first page should contain the following information and nothing else: (1) your name and student ID number; (2) name of the experiment; (3) the name(s) of partner's, if any; (4) the dates on which you started and finished the experiment; and (5) the date on which you are submitting the report. An example follows:

James Watson (ID #)
The Structure of DNA (SGN #777)
Partner: Francis Crick
Date started: January 1, 1953
Date completed: January 12, 1953
Date submitted: March 31, 1953

2. Abstract : A concise (**300 words or less**) summary of the purpose of the experiment, what was measured, by what technique, and the relevant results and associated errors. A comparison of the results with theoretical models or known literature values is also appropriate.
3. Introduction : A 1-3 page introduction can include background information and the purpose of the the experiment, relevant mathematical expressions, theoretical information, etc. *This should be in the form of a narrative (tell a story!)*.
4. Experimental : This should include
 - a. Materials section : list chemicals used (in a sentence)
 - b. Methods or Techniques section : names of equipment and/or discussion of methods used.
 - c. Procedures section : discussion of procedures (e.g. how solutions were prepared) used for the experiment.
5. Results:
 - a. A clear *description* of your results must be given, together with the established errors and all appropriate units. It is important to write clearly in complete sentences indicating where the results are presented (e.g Table I, Figure 2, Graph 1, Appendix I etc.). *A reminder: you are telling a story! Use a narrative style.* Important intermediate results should also be given (for example, if you use averages of several experimental runs as the starting point of your calculations, or derive your data from chart recordings).
 - b. Make use of graphs and tables whenever possible to show clearly the effect of an independent variable (e.g. temperature, concentration, etc.) on the observable (dependent variable). Use Microsoft Excel or another plotting program. For graphs make sure you label all axes clearly using the appropriate units. When graphing a model calculation (e.g. a linear fit) it is best to plot the data as points

and the fit as a solid line on the same graph. **Make sure you apply a legend to the plot to identify what each line or symbol stands for. In either case be sure to give a title to the graph or table.**

- c. Errors : An error analysis should be included in your results section. The error estimates on the final results may require that you use the propagation of errors technique. Whenever appropriate, perform a suitable statistical analysis of your results. If you question the validity of one or more experimental data points and wish to discard them, you will have to provide a reasonable (quantitative, if possible) justification. The extent of the error analysis required will vary greatly depending on the experiment. In an appendix, a sample error analysis must be included.
 - d. Sample calculations : Describe briefly the operations you performed to reduce your raw data to the final results. In an appendix, show one numerical example of each type of calculation using your own data. For example, if data of the same kind were obtained at three different temperatures, only one sample calculation should be given. On the other hand, if the same set of data was used to obtain two different derived quantities, two sample calculations are expected, one for each different type of quantity. You must write a complete sentence directing the reader to the appendix.
 - e. Model calculations : This will be appropriate only for some experiments and should be skipped entirely for others. State briefly the basic premises and results of the model. Then use the model to obtain a theoretical estimate of only those quantities derived from your experimental data. Show a sample of each different type of theoretical calculation in an appendix.
6. Discussion : This section should include comments on the significance of your results and your confidence in them. It should include, where appropriate, comparisons of your results with those in the literature and with the predictions of a theoretical model. Are the results in reasonable agreement with your expectations? Are they consistent with each other? Why or why not? Keep this section brief and to the point, i.e., directly related to the actual results you obtained. ***Questions which you are asked in the notes, Halpern and/or in SGN should be answered here.*** A clear, concise, and specific discussion should be given of the errors, together with a numerical estimate of their effect on your data and on the derived quantities you calculated. In some cases only very minimal discussion of errors is in order, while others may require considerable effort. Do not exceed two pages .
 7. Appendices : The appendices will include xeroxed copies of your laboratory notebook pages for the experiment in question, sample calculations and error analyses.

Assemble the report with the different sections in the order given above. Begin each section on a new page.

The following suggestions also apply to the reports:

1. Graphs **must** be computer generated with the axes clearly labeled, including **units**. Try to scale graphs so that data or curves occupy a significant fraction of the page, i.e., do not

bunch all of the information in one corner of the page. Label each data point clearly, using different symbols or colors for different sets of data. Each graph should have a brief **title** that describes what kind of information is shown. Whenever appropriate, error bars should be shown for your experimental data points.

2. Tables **must** include titles and numbering.
3. In several reports you will refer to theoretical and/or literature information. Each time you do this you must give a complete reference.
4. Write in third person; do not use “I”, “we”.
5. Do not wait until the last minute to prepare your report. You may run into unexpected trouble – and help may not be available then.

LAB CLEAN-UP

Before you leave at the end of each lab period your group must:

- (1) Empty and clean all glassware, except for the containers (properly labelled with name of chemical and date) storing those materials you will use later that week(s).
- (2) Clean the bench (and balance area, if you have used it) and surrounding areas.
- (3) Store all glassware and equipment the same way you found it.
- (4) Turn off power to all equipment. Your instructor will not sign your lab notebook (see below) until you have cleaned up.

SAFETY: Violation of safety rules outlined below may result in **expulsion from the lab.**

Serious accidents in Physical Chemistry Laboratories, although rare, are not unheard of. Understand how the apparatus works and what you are asked to do with it before you do it. Do not exert force on the equipment or try to do anything to which you encounter resistance – a sure symptom that you are doing something wrong or that there is an equipment malfunction. Equipment malfunctions can have serious safety consequences, especially for those experiments using gases at very high pressures, or experiments where potentially lethal voltages may exist. If you are not sure that you understand a particular operation, or if you think that the apparatus may not be functioning properly, ask your instructor.

You must observe the following safety rules for the protection of yourself and those working near you.

1. **Eye protection** – wear approved safety goggles at all times, as required by state law.
2. **Fire hazards** – study the location of the fire extinguisher(s), shower, and eye wash, which will be shown to you by your instructor. The use of flammable organic solvents required in this lab constitutes an obvious fire hazard. Organics must not be disposed of in the sink drains; organic waste containers are provided.
3. **Electrical hazards** – In addition to the usual hazards found in chemistry labs, some experiments require the use of electrical circuits carrying potentially lethal voltages. Voltage is not in itself a reliable indication of danger because, since the body's resistance

varies so widely, it is not possible to predict in general how much current will exist in response to a given voltage. Prevention is the best medicine for electric shock. That means having a healthy respect for all voltages, and always following safety procedures when working with electrical equipment.

4. High pressure –In some experiments you will use gases stored at very high pressure. Gas cylinders must remain securely tied to the benches at all times; you must never attempt to move a cylinder, or change regulator settings. If you run out of gas, tell your instructor.
5. Broken glass – You should already be aware, from your previous lab work, of the hazards of broken glass. Observe the appropriate precautions; clean up broken glass immediately (Dustpan and brush, not fingers !) and report any broken or sharp edges to your instructor at once. Never use glass apparatus with cracks or chips.
6. Mercury – Handle with care any apparatus containing mercury. Be sure to report any spills, since mercury constitutes a potential health hazard and must be taken care of promptly. Be careful also to keep gold or silver jewelry, watches, etc., out of contact with mercury, which can amalgamate with them.
7. Pipetting – Never pipet any liquid by mouth; rubber bulbs are provided for this purpose.
8. Report every accident, no matter how minor, to your instructor.
9. If chemicals are to be used for more than 1 period, they must be labeled with the name of chemical (not abbreviated), and the date.
10. Dispose of chemicals (glass) in chemical waste (disposable glass) containers provided.
11. **Food and beverages are not allowed** inside the lab.

MASTER SCHEDULE – W237 FALL 2005

Week 1: 8/29-9/1	M	Introduction and Course Structure (Thomas)
	Tu	Lecture Tu-1: A – Measurement and Errors (Stanley) Round Robin Tu-1: BC
	Th	Lecture Th-1: A – NMR and Structure (DeBrosse) Round Robin Th-1: BC
Week 2: 9/5-9/8	M	Labor Day Holiday
	Tu	Lecture Tu-2: A – Absorption of Light (Stanley) Round Robin Tu-2: BC
	Th	Lecture Th-2: A – Emission of Light (Stanley) Round Robin Th-2: BC
		<u>Error Analysis Write-up due!</u>
Week 3: 9/12-9/15	M	Lecture – Stern-Volmer Kinetics (Stanley)
	Tu	Lecture Tu-3: A - Heat Capacity (Thomas) Round Robin Tu-3: BC
	Th	Lecture Th-3: A – Conduction of Ions (Stanley) Round Robin Th-3: BC
Week 4: 9/19-9/22	M	Lecture - Excited State Properties: Acidity (Stanley) Quiz
	Tu	Lab 4A
	Th	Lab 4B
Week 5: 9/26-9/29	M	Report "Do's and Don't's" Quiz
	Tu	Lab 5A
	Th	Lab 5B
Week 6: 10/3-10/6	M	Quiz
	Tu	Lab 6A
	Th	Lab 6B
Week 7: 10/10-10/13	M	Quiz
	Tu	Lab 7A
	Th	Lab 7B

MASTER SCHEDULE – W237 FALL 2005 (continued)

Week 8: 10/17-10/20	M	Quiz
	Tu	Lab 8A
	Th	Lab 8B
Week 9: 10/24-10/28	M	Quiz
	Tu	Lab 9A
	Th	Lab 9B
Week 10: 10/31-11/3	M	Quiz
	Tu	Lab 10A
	Th	Lab 10B
Week 11: 11/7-11/10	M	Quiz
	Tu	Lab 11A
	Th	Lab 11B
Week 12: 11/14-11/17	M	Quiz
	Tu	Lab 12A
	Th	Lab 12B
Week 13: 11/21-11/22	M	Quiz
	Tu	Lab 13A
	Th	Thanksgiving Break
Week 14: 11/28-12/1	M	Quiz
	Tu	Exp. 14A
	Th	Exp. 14B
Week 15: 12/5-12/6	M-W	Finish up lab reports

Notes: Monday lectures are given in BE121.

Tuesday/Thursday lectures are given in BE404

W237 Round Robin Schedule – Fall 2005
(Read the lab assignment before your Round Robin session!)

Student	Tu-1A	Tu-1B	Tu-1C	Th-1A	Th-1B	Th-1C	Tu-2A	Tu-2BC	Th-2A	Th-2BC	Tu-3A	Tu-3BC	Th-3A	Th-3BC
1	Lecture	NMR	UV/Vis	Lecture	CpCv		Lecture	Cond	Lecture	Flu	Lecture	Sol	Lecture	
2	Lecture	NMR	UV/Vis	Lecture	CpCv		Lecture	Cond	Lecture	Flu	Lecture	Sol	Lecture	
3	Lecture	NMR	UV/Vis	Lecture	CpCv		Lecture	Cond	Lecture	Flu	Lecture	Sol	Lecture	
4	Lecture	NMR	UV/Vis	Lecture	CpCv		Lecture	Cond	Lecture	Flu	Lecture	Sol	Lecture	
5	Lecture	NMR	UV/Vis	Lecture	CpCv		Lecture	Cond	Lecture	Flu	Lecture	Sol	Lecture	
6	Lecture	UV/Vis	NMR	Lecture	Sol		Lecture	Flu	Lecture	CpCv	Lecture	Cond	Lecture	
7	Lecture	UV/Vis	NMR	Lecture	Sol		Lecture	Flu	Lecture	CpCv	Lecture	Cond	Lecture	
8	Lecture	UV/Vis	NMR	Lecture	Sol		Lecture	Flu	Lecture	CpCv	Lecture	Cond	Lecture	
9	Lecture	UV/Vis	NMR	Lecture	Sol		Lecture	Flu	Lecture	CpCv	Lecture	Cond	Lecture	
10	Lecture	UV/Vis	NMR	Lecture	Sol		Lecture	Flu	Lecture	CpCv	Lecture	Cond	Lecture	
11	Lecture	CpCv		Lecture	UV/Vis	NMR	Lecture	Sol	Lecture	Cond	Lecture		Lecture	Flu
12	Lecture	CpCv		Lecture	UV/Vis	NMR	Lecture	Sol	Lecture	Cond	Lecture		Lecture	Flu
13	Lecture	CpCv		Lecture	UV/Vis	NMR	Lecture	Sol	Lecture	Cond	Lecture		Lecture	Flu
14	Lecture	CpCv		Lecture	UV/Vis	NMR	Lecture	Sol	Lecture	Cond	Lecture		Lecture	Flu
15	Lecture	CpCv		Lecture	UV/Vis	NMR	Lecture	Sol	Lecture	Cond	Lecture		Lecture	Flu
16	Lecture	Sol		Lecture	NMR	UV/Vis	Lecture	CpCv	Lecture		Lecture	Flu	Lecture	Cond
17	Lecture	Sol		Lecture	NMR	UV/Vis	Lecture	CpCv	Lecture		Lecture	Flu	Lecture	Cond

	e			e			e		e			e		
18	Lecture	Sol		Lecture	NMR	UV/Vis	Lecture	CpCv	Lecture		Lecture	Flu	Lecture	Cond
19	Lecture	Sol		Lecture	NMR	UV/Vis	Lecture	CpCv	Lecture		Lecture	Flu	Lecture	Cond
20	Lecture	Sol		Lecture	NMR	UV/Vis	Lecture	CpCv	Lecture		Lecture	Flu	Lecture	Cond

Notes: We assume you've used an NMR and UV/Vis spectrometer in previous classes

Periods: A: 12:40-1:30; B: 1:30-2:30; C: 2:30-3:30; BC: 1:30-3:30

WEEK

W237 Experiment Schedule - Fall 2005

<u>GROUP</u>	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B	9A	9B
1	pKa*	CL	\$\$		Abs	CL	Sol	Sol	CL	\$\$	S-V	CL
2		S-V	CL	\$\$	Sol	Sol	CL	\$\$	NMR	CL	\$\$	pKa*
3	Abs	CL	pKa*	CL	\$\$	NMR	CL	\$\$	Sol	Sol	CL	\$\$
4		Abs	CL	S-V	CL	\$\$	Sol	Sol	CL	\$\$	Cond	CL
5	Sol	Sol	CL	\$\$	pKa*	CL	\$\$	NMR	CL	\$\$	CpCv	CL
6	Cond	CL	\$\$	Abs	CL	S-V	CL	\$\$	CpCv	CL	\$\$	NMR
7	NMR	CL	\$\$	Cond	CL	\$\$	pKa*	CL	\$\$	Sol	Sol	CL
8	CpCv	CL	\$\$	Sol	Sol	CL	\$\$	S-V	CL	\$\$	NMR	CL
9	Cond	CL	\$\$	NMR	CL	\$\$	Abs	CL	pKa*	CL	\$\$	CpCv
10		CpCv	CL	\$\$	NMR	CL	\$\$	Abs	CL	S-V	CL	\$\$

10B	11A	11B	12A	12B	13A	14A	14B	15A	<u>GROUP</u>
Cond	CL	\$\$	NMR	CL	\$\$	CpCv	CL	\$\$	1
\$\$	CpCv	CL	\$\$	Cond	CL	\$\$	Abs	CL	2
CL	\$\$	CpCv	CL	\$\$	Cond	CL	\$\$		3
pKa*	CL	\$\$	CpCv	CL	\$\$	NMR	CL	\$\$	4
	S-V	CL	\$\$	Abs	CL	Cond	CL	\$\$	5
\$\$		pKa*	CL	\$\$	Sol	Sol	CL	\$\$	6
CpCv	CL	\$\$	S-V	CL	\$\$	Abs	CL		7
Cond	CL	\$\$		pKa*	CL	\$\$	Abs	CL	8
\$\$	Sol	Sol	CL	\$\$	S-V	\$\$	CL		9
Sol	CL	\$\$	Cond	CL	\$\$	pKa*	CL	\$\$	10