Minnesota State University, Mankato  
Curriculum Proposal

Please type or select the requested information. Print completed forms, add appropriate paper attachments, and route through MSU's curricular process for recommendations and decisions.

| College: Science, Engineering and Technology | (Check all that apply): Undergraduate |
| Department: Chemistry and Geology | Graduate |
| Program: | CIP # |
| Type of Change: COURSE PROPOSALS | Proposed: Change in Credits |
| Title Current: Organic Chemistry II | Title Proposed: Organic Chemistry II |
| 24-Char. Abbrev: CHEM 321 | (if applicable) |

Include a course or program description for the Bulletin (30-40 words maximum for courses, 100 for programs):
The chemistry of polyenes and aromatic compounds, and further coverage of reactions of aldehydes and ketones, carboxylic acids and their derivatives, and amines, including the reactions of enolates. This will include the study of the mechanisms of reactions, multi-step synthetic transformations, and an introduction to the spectroscopy of organic compounds.

Rationale or Justification: for change:
Material removed from Chem 320 will be incorporated into this expanded Chem 321. Increase in credit necessary to accommodate added material.

For General Education or Cultural Diversity Courses Only

<table>
<thead>
<tr>
<th>GE Category #</th>
<th>GE Category Name (Maximum of 3 Categories)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

Note: For Writing Intensive Courses, attach a description of the kind and quantity of writing. For Upper Division Courses, include a description of the respects in which it is broad and general rather than narrow and specific, and so suitable as GE.

Attach paper copies of the following:
a. Syllabus or course outline.
b. Course's student learning outcomes associated with each GE competency or CD designation.
c. List of strategies to be used to assess students' achievement of each GE competency or CD designation.

For New Courses

<table>
<thead>
<tr>
<th>Instructional Type: Lecture</th>
<th>Grading Format: X Grade □ P/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course is an elective</td>
<td>Pre- or Co-requisites:</td>
</tr>
<tr>
<td>Course is required for prog</td>
<td>CHEM &amp; Biochem Majors, PreProfessional Programs</td>
</tr>
<tr>
<td>Other courses are being changed or eliminated. (Explain.)</td>
<td></td>
</tr>
</tbody>
</table>

Course will be offered:
□ Fall Semester  □ Spring Semester  □ Summer Session

Course content or title is similar to courses in other departments. (Attach copy of letter of agreement with other program(s) contacted. Indicate the nature of the discussions and/or resolution of differences or potential conflicts.)

Attach paper copies of the following:
a. Syllabus or course outline.
b. Course's student learning outcomes.
c. A list of resources required to offer and support this course.
d. A description of how teaching this course will affect department staffing.
e. If 400/500 level course, an explanation of added expectations of graduate students.
Minnesota State University, Mankato
Curriculum Proposal

***For Program Proposals***

Attach paper copies of the following:

a. Student learning outcomes for the program.

b. Minutes from department and college curriculum meetings in which action was taken on this proposal.

c. Program Assessment Plan. Forms are available on the Academic Affairs Web site:
   [http://www.mnsu.edu/acadaf/words/PRA_SampSLOAssessPlan.doc](http://www.mnsu.edu/acadaf/words/PRA_SampSLOAssessPlan.doc)

d. List of program requirements for New programs, or a list of Current and Proposed program requirements for Redesigned programs.

e. A list of resources required to offer and support this program.

f. A description of how offering this program will affect department staffing.

g. A list of additional library holdings required for this program.

Please include rationale for any proposed changes in number of program credits:


***For Programs Requiring MnSCU Approval***

If any of the following changes are proposed, please fill out and attach MnSCU Program Approval Forms, which are available on the Academic Affairs Web site:

1. Creation of an entirely new program.

2. Redesign of existing programs, which takes any of the following forms:
   - Addition or deletion of a program option. Options are part of program design in which 30-50% of the courses are required as part of a common core for all students, and which offers curriculum alternatives greater than 30% of the total number of credits in the major. Options are appropriate to baccalaureate or masters programs.
   - Addition or deletion of a program emphasis. Emphases are part of program design in which more than 50% of the courses are required as part of a common core for all students, and which offers curriculum alternatives with a minimum of nine credits. Emphases are appropriate to associate and baccalaureate programs.
   - Change in program name.
   - Change in program CIP #.
   - Change in TOTAL program credits.
   - Change in degree award. For example, changing a B.A. to B.S.
   - Creation of a new degree award in a related academic area. Examples include creation of a certificate program from an existing degree program, or a new degree program from an existing degree program (e.g., Art History BA from Art BA.)

3. Relocation of an existing program. This is a proposal to move an existing program from one site to be exclusively offered at another site, and requires closing the program offered at the original site. For example, a program offered both on-campus and through extended campus is to be offered only at the extended campus site.

4. Replication of an existing program. This is a proposal to offer an existing program at a new site, which may be an existing MnSCU-approved site, or another campus of the same institution. Replicated programs are offered at both the original site and the new location.

5. Suspension or reinstatement of a program. This proposal suspends admission of students into an existing program, and is good for three years. Reinstatement proposals request the reopening of student admissions into a given program.

6. Closure of a program. This proposal requests closure of an existing program and its from an institution's official inventory of academic programs. Unless a department seeks to re-open a suspended program, it should be closed within three years of suspension.
<table>
<thead>
<tr>
<th>Section</th>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department</td>
<td>Department Chair</td>
<td>10/04/05</td>
</tr>
<tr>
<td>College Curriculum Committee</td>
<td>Committee Chair</td>
<td>06/27/05</td>
</tr>
<tr>
<td>College Dean</td>
<td>Dean</td>
<td>10/31/05</td>
</tr>
<tr>
<td>General Education Subcommittee</td>
<td>General Education Subcommittee Chair</td>
<td>Date</td>
</tr>
<tr>
<td>Undergraduate Curriculum and Academic Policy Committee</td>
<td>UCPP Faculty Chair</td>
<td>Date</td>
</tr>
<tr>
<td>Faculty Association Graduate Committee</td>
<td>Faculty Association Graduate Chair</td>
<td>Date</td>
</tr>
<tr>
<td>Graduate Dean</td>
<td>Graduate Dean</td>
<td>Date</td>
</tr>
<tr>
<td>Academic Affairs Council</td>
<td>Assistant Vice President</td>
<td>Date</td>
</tr>
<tr>
<td>Senior Vice President and Vice President for Academic Affairs</td>
<td>Sr. Vice President / Vice Pres. Academic Affairs</td>
<td>Date</td>
</tr>
</tbody>
</table>
Organic Chemistry 321 Curriculum Proposal

C. Resources required to offer and support this course (Chem 321).

No additional resources are needed to accommodate this proposed change.

D. A description of how teaching this course (Chem 321) will affect department staffing.

The changes in this course proposal will add a total of one additional contact hour of load to the faculty teaching this course. This additional hour of load, in combination with the load increases (three hours) proposed in the Chem 320 and 331 changes can be accommodated by rearranging laboratory assignments within the department and by hiring student or adjunct help to cover the combined total of four hours between all three course proposals.
Department of Chemistry and Geology
Department Meeting Minutes
October 10, 2005

Present: Clement, Groh, Hadley, Hoppie, Losh, Lusch, Pomije, Pribyl, Quirk-Dorr, Rambo, Rife, Salerno, Swart, Thoemke, Vorlicek

Meeting was called to order at 9:03 a.m.

There were no minutes to approve.

Announcements:

The Dept. of Physics plans to change its two-semester calc. based physics (221&222) to three semesters at 4 credits each. This could impact physical chemistry which would put the chem. major off course to 5 years.

Reminder about the career fair on Tues. Oct. 11

The blueprints for the Trafton addition are in C-126. All are encouraged to make comments in the log book until the end of the month. The architects are aware of the concerns about office windows.

Chem. 407 name change: Vorlicek discussed changing the name of Water Chemistry to Environmental Chemistry. There will be no change in content, but the name change would better reflect the course content.

Hadley discussed the revised advising sheets. Motion to approve the changes passed. Swart discussed putting it on the website in pdf.

Chem. 320 Groh discussed moving some content out of 1st semester, moving some of it to 2nd semester and extending 2nd semester to 3 credits. He also discussed having a 1 hour meeting time for prelab. Motion to draw up the paperwork and get it to Pomije by C-SET deadlines passed.

Chem. 495 Quirk-Dorr requested a change from P-F to grades. Motion to approve passed.

Tenure and promotion policy: there were concerns about the 8-hour turnaround for voting. Changed to a 2-day voting window. Alternate accommodations can be made if a faculty member is unavailable at the time of the voting. Motion to approve the changes passed.

Reminder to encourage students to attend the Ford Lectureship Oct. 24.

Meeting adjourned at 9:47 a.m.

Respectfully submitted
Patricia L. Rambo
Groh, Brian L

From: Marg, Gregg A  
Sent: Tuesday, October 18, 2005 11:43 AM  
To: Groh, Brian L  
Subject: RE: organic course changes

Brian,

I presented the proposed changes in the organic chemistry curriculum at our department meeting on Oct 7. There were no objections raised to the proposal. The general consensus was that the changes were very reasonable and would not have a negative impact on our students. We would like you to advertise the changes aggressively to the students, perhaps with a combination of posters in the hallways and announcements to your classes. We will make similar efforts to inform our students. While there was no formal motion of support made, I would characterize our response as one of general support for a very logical change.

Gregg

gregg.marg@mnsu.edu  
507-389-5731

-----Original Message-----
From: Groh, Brian L  
Sent: Tuesday, October 18, 2005 11:35 AM  
To: Marg, Gregg A  
Subject: organic course changes

Gregg,
Here are the changes proposed to the organic curriculum:

1. Organic I (Chem. 320) will be offered only in the fall. The spring offering of Organic I in 2006 will be the last. We will offer organic chem. I (Chem 320) at two separate times in the fall. One section of lecture at 9 am and the other at 10 am (the same time it has been offered in the past). Annually we will be able to serve at least as many Chem 320 students as we have in the past.

2. Organic I will move some content to spring semester to ensure that the material can be covered during the fall semester. This will include moving the pre-lab meeting to a single time in each 320 lecture section for all students to attend. (There will be a total of two pre-lab meetings, one for each course.) We are looking for a time that will not conflict with any courses that biology students are enrolled. These two sections will meet separately, one at 1 pm on Wednesdays and the other at 1 pm on Thursdays.

3. Organic II (chem. 321) will add one contact hour to the lecture. It will meet M, W, F rather than M, W. This course is only required in the toxicology major.

4. Organic II lab (Chem 331) will also have a separate pre-lab meeting time once a week at a time that will minimize conflicts with any biology courses. A time has not yet been set.

5. Chem 423 will move to spring semester from fall semester. I do not believe this last change impacts any of the biology programs.

These are the course changes we are proposing. Please let me know if these meet with your department’s approval. Thank you for your help.

Brian Groh

************************************************************************
Dr. Brian Groh, Chairperson  
Department of Chemistry and Geology  
Minnesota State University, Mankato

10/18/2005
Chemistry 321 – Organic Chemistry II
Course Proposal

Attached are:

1. A copy of the table of contents of the text, indicating the material to be covered, since existing syllabi are not detailed enough to reflect the changing content of the course.

2. A copy of the existing syllabus.

3. Course student learning outcomes.

4. List of resources required and impact on departmental staffing.

5. Department of Chemistry and Geology Meeting Minutes noting the proposed course changes.

6. Department of Biology email from Greg Marg supporting the proposed changes.
Course Outline

11-5 Alcohols as Nucleophiles and Electrophiles; Formation of Tosylates 469
   Summary: S_N2 Reactions of Tosylate Esters 471

11-6 Reduction of Alcohols 472

11-7 Reactions of Alcohols with Hydrobolic Acids 472

11-8 Reactions of Alcohols with Phosphorus Halides 477

11-9 Reactions of Alcohols with Thionyl Chloride 478

11-10 Dehydration Reactions of Alcohols 480

   Problem-Solving Strategy: Proposing Reaction Mechanisms 484

11-11 Unique Reactions of Diols 488

11-12 Esterification of Alcohols 490

11-13 Esters of Inorganic Acids 491

11-14 Reactions of Alkoxides 494
   Key Mechanism: The Williamson Ether Synthesis 494
   Problem-Solving Strategy: Multistep Synthesis 496
   Summary: Reactions of Alcohols 499
   Chapter 11 Glossary 502
   Study Problems 503

Beginning of Main Chem 321 Material

12 Infrared Spectroscopy and Mass Spectrometry 508

12-1 Introduction 508
12-2 The Electromagnetic Spectrum 509
12-3 The Infrared Region 510
12-4 Molecular Vibrations 511
12-5 IR-Active and IR-Inactive Vibrations 513
12-6 Measurement of the IR Spectrum 514
12-7 Infrared Spectroscopy of Hydrocarbons 517
12-8 Characteristic Absorptions of Alcohols and Amines 522
12-9 Characteristic Absorptions of Carbonyl Compounds 523
12-10 Characteristic Absorptions of C—N Bonds 529
12-11 Simplified Summary of IR Stretching Frequencies 530
12-12 Reading and Interpreting IR Spectra (Solved Problems) 532
12-13 Introduction to Mass Spectrometry 537
12-14 Determination of the Molecular Formula by Mass Spectrometry 541
12-15 Fragmentation Patterns in Mass Spectrometry 544
   Summary: Common Fragmentation Patterns 549
   Chapter 12 Glossary 551
   Study Problems 552

13 Nuclear Magnetic Resonance Spectroscopy 559

13-1 Introduction 559
13-2 Theory of Nuclear Magnetic Resonance 559
13-3 Magnetic Shielding by Electrons 562
13-4 The NMR Spectrometer 564
13-5 The Chemical Shift 565
13-6 The Number of Signals 572
13-7 Areas of the Peaks 573
13-8 Spin-Spin Splitting 576
   Problem-Solving Strategy: Drawing an NMR Spectrum 581
14 Ethers, Epoxides, and Sulfides 623 (covered in the context of other topics)

14-1 Introduction 623
14-2 Physical Properties of Ethers 623
14-3 Nomenclature of Ethers 628
14-4 Spectroscopy of Ethers 631
14-5 The Williamson Ether Synthesis 633
14-6 Synthesis of Ethers by Alkoxymercuration–Demercuration 634
14-7 Industrial Synthesis: Bimolecular Dehydration of Alcohols 635
   Summary: Syntheses of Ethers 636
14-8 Cleavage of Ethers by HBr and HI 636
14-9 Autoxidation of Ethers 639
   Summary: Reactions of Ethers 639
14-10 Sulfides (Thioesters) 640
14-11 Synthesis of Epoxides 642
   Summary: Epoxide Syntheses 645
14-12 Acid-Catalyzed Ring Opening of Epoxides 645
14-13 Base-Catalyzed Ring Opening of Epoxides 649
14-14 Orientation of Epoxide Ring Opening 650
14-15 Reactions of Epoxides with Grignard and Organolithium Reagents 652
14-16 Epoxide Resins: The Advent of Modern Glues 653
   Summary: Reactions of Epoxides 655
Chapter 14 Glossary 656
Study Problems 658

✓15 Conjugated Systems, Orbital Symmetry, and Ultraviolet Spectroscopy 663

✓15-1 Introduction 663
✓15-2 Stabilities of Dienes 663
✓15-3 Molecular Orbital Picture of a Conjugated System 665
✓15-4 Allylic Cations 669
✓15-5 1,2- and 1,4-Addition to Conjugated Dienes 670
✓15-6 Kinetic versus Thermodynamic Control in the Addition of HBr
to 1,3-Butadiene 672
✓15-7 Allylic Radicals 674
✓15-8 Molecular Orbitals of the Allylic System 676
✓15-9 Electronic Configurations of the Allyl Radical, Cation, and Anion 678
✓15-10 S_N2 Displacement Reactions of Allylic Halides and Tosylates 679
15-11 The Diels–Alder Reaction 680
   Key Mechanism: The Diels–Alder Reaction 680
15-12 The Diels–Alder as an Example of a Pericyclic Reaction 689
15-13 Ultraviolet Absorption Spectroscopy 692
   Chapter 15 Glossary 699
   Study Problems 701

16 Aromatic Compounds 705
16-1 Introduction: The Discovery of Benzene 705
16-2 The Structure and Properties of Benzene 705
16-3 The Molecular Orbitals of Benzene 709
16-4 The Molecular Orbital Picture of Cyclobutadiene 712
16-5 Aromatic, Antiaromatic, and Nonaromatic Compounds 714
16-6 Hückel’s Rule 714
16-7 Molecular Orbital Derivation of Hückel’s Rule 716
16-8 Aromatic Ions 717
16-9 Heterocyclic Aromatic Compounds 723
16-10 Polynuclear Aromatic Hydrocarbons 727
16-11 Aromatic Allotropes of Carbon 729
16-12 Fused Heterocyclic Compounds 731
16-13 Nomenclature of Benzene Derivatives 732
16-14 Physical Properties of Benzene and Its Derivatives 734
16-15 Spectroscopy of Aromatic Compounds 735
   Chapter 16 Glossary 738
   Study Problems 740

17 Reactions of Aromatic Compounds 749
17-1 Electrophilic Aromatic Substitution 749
   Key Mechanism: Electrophilic Aromatic Substitution 750
17-2 Halogenation of Benzene 751
17-3 Nitration of Benzene 753
17-4 Sulfonation of Benzene 755
17-5 Nitration of Toluene: The Effect of Alkyl Substitution 757
17-6 Activating, Ortho, Para-Directing Substituents 759
   Summary: Activating, Ortho, Para-Directors 762
17-7 Deactivating, Meta-Directing Substituents 763
   Summary: Deactivating, Meta-Directors 766
17-8 Halogen Substituents: Deactivating, but Ortho, Para-Directing 766
   Summary: Directing Effects of Substituents 768
17-9 Effects of Multiple Substituents on Electrophilic
   Aromatic Substitution 768
17-10 The Friedel–Crafts Alkylation 771
17-11 The Friedel–Crafts Acylation 775
   Summary: Comparison of Friedel–Crafts Alkylation and Acylation 778
17-12 Nucleophilic Aromatic Substitution 780
17-13 Addition Reactions of Benzene Derivatives 785
17-14 Side-Chain Reactions of Benzene Derivatives 787
17-15 Reactions of Phenols 791
18 Ketones and Aldehydes 805

18-1 Carbonyl Compounds 805
18-2 Structure of the Carbonyl Group 806
18-3 Nomenclature of Ketones and Aldehydes 806
18-4 Physical Properties of Ketones and Aldehydes 809
18-5 Spectroscopy of Ketones and Aldehydes 811
18-6 Industrial Importance of Ketones and Aldehydes 818
18-7 Review of Syntheses of Ketones and Aldehydes 818
18-8 Synthesis of Ketones and Aldehydes Using 1,3-Dithianes 822
18-9 Synthesis of Ketones from Carboxylic Acids 823
18-10 Synthesis of Ketones from Nitriles 824
18-11 Synthesis of Aldehydes and Ketones from Acid Chlorides 825
Summary: Syntheses of Ketones and Aldehydes 826
18-12 Reactions of Ketones and Aldehydes: Nucleophilic Addition 829
Key Mechanism: Nucleophilic Additions to Carbonyl Groups 831
18-13 The Wittig Reaction 832
18-14 Hydration of Ketones and Aldehydes 836
18-15 Formation of Cyanohydrins 838
18-16 Formation of Imines 840
Key Mechanism: Formation of Imines 840
18-17 Condensations with Hydroxylamine and Hydrazines 843
Summary: Condensations of Amines with Ketones and Aldehydes 844
18-18 Formation of Acetals 845
Key Mechanism: Formation of Acetals 846
Problem-Solving Strategy: Proposing Reaction Mechanisms 848
18-19 Use of Acetals as Protecting Groups 850
18-20 Oxidation of Aldehydes 852
18-21 Reduction of Ketones and Aldehydes 853
Summary: Reactions of Ketones and Aldehydes 855
Glossary 858
Study Problems 861

19 Amines 870

19-1 Introduction 870
19-2 Nomenclature of Amines 871
19-3 Structure of Amines 873
19-4 Physical Properties of Amines 875
19-5 Basicity of Amines 877
19-6 Effects on Amino Basicity 878
19-7 Salts of Amines 880
19-8 Amines Salts as Phase Transfer Catalysts 882
19-9 Spectroscopy of Amines 884
19-10 Reactions of Amines with Ketones and Aldehydes (Review) 888
19-11 Aromatic Substitution of Arylamines and Pyridine (Review) 888
19-12 Alkylation of Amines by Alkyl Halides 892
7 Structure and Synthesis of Alkenes 279

7-1 Introduction 279
7-2 The Orbital Description of the Alkene Double Bond 280
7-3 Elements of Unsaturation 281
7-4 Nomenclature of Alkenes 283
7-5 Nomenclature of cis-Trans Isomers 285
   Summary: Rules for Naming Alkenes 287
7-6 Commercial Importance of Alkenes 288
7-7 Stability of Alkenes 290
7-8 Physical Properties of Alkenes 296
7-9 Alkene Synthesis by Elimination of Alkyl Halides 298
7-10 Alkene Synthesis by Dehydration of Alcohols 306
   Key Mechanism: Acid-Catalyzed Dehydration of an Alcohol 307
7-11 Alkene Synthesis by High-Temperature Industrial Methods 309
   Problem-Solving Strategy: Proposing Reaction Mechanisms 310
   Summary: Methods for Synthesis of Alkenes 314
   Chapter 7 Glossary 316
   Study Problems 318

8 Reactions of Alkenes 321

8-1 Reactivity of the Carbon–Carbon Double Bond 321
8-2 Electrophilic Addition to Alkenes 322
   Key Mechanism: Electrophilic Addition to Alkenes 322
8-3 Addition of Hydrogen Halides to Alkenes 324
8-4 Addition of Water: Hydration of Alkenes 330
8-5 Hydration by Oxymercuration–Demercuration 333
8-6 Alkoxymercuration–Demercuration 335
8-7 Hydroboration of Alkenes 336
8-8 Addition of Halogens to Alkenes 342
8-9 Formation of Halohydrins 345
8-10 Catalytic Hydrogenation of Alkenes 348
8-11 Addition of Carbenes to Alkenes 350
8-12 Epoxidation of Alkenes 353
8-13 Acid-Catalyzed Opening of Epoxides 355
8-14 Syn Hydroxylation of Alkenes 358
8-15 Oxidative Cleavage of Alkenes 360
8-16 Polymerization of Alkenes 363
   Problem-Solving Strategy: Organic Synthesis 367
20 Carboxylic Acids 935

- 20-1 Introduction 935
- 20-2 Nomenclature of Carboxylic Acids 935
- 20-3 Structure and Physical Properties of Carboxylic Acids 939
- 20-4 Acidity of Carboxylic Acids 940
- 20-5 Salts of Carboxylic Acids 944
- 20-6 Commercial Sources of Carboxylic Acids 947
- 20-7 Spectroscopy of Carboxylic Acids 948
- 20-8 Synthesis of Carboxylic Acids 952
  Summary: Syntheses of Carboxylic Acids and Derivatives; Nucleophilic Acyl Substitution 957
- 20-9 Condensation of Acids with Alcohols: The Fischer Esterification 958
  Key Mechanism: Fischer Esterification 959
- 20-10 Esterification Using Diazomethane 962
- 20-11 Condensation of Acids with Amines: Direct Synthesis of Amides 963
- 20-12 Reduction of Carboxylic Acids 963
- 21-14 Alkylation of Carboxylic Acids to Form Ketones 965
- 21-15 Synthesis and Use of Acid Chlorides 966
  Summary: Reactions of Carboxylic Acids 968
  Chapter 20 Glossary 970
  Study Problems 971

21 Carboxylic Acid Derivatives 978

- 21-1 Introduction 978
- 21-2 Structure and Nomenclature of Acid Derivatives 979
- 21-3 Physical Properties of Carboxylic Acid Derivatives 985
- 21-4 Spectroscopy of Carboxylic Acid Derivatives 988
- 21-5 Interconversions of Acid Derivatives by Nucleophilic Acyl Substitution 994
  Key Mechanism: Addition–Elimination Mechanism of Nucleophilic Acyl Substitution 995
- 21-6 Transesterification 1003
  Problem-Solving Strategy: Proposing Reaction Mechanisms 1004
- 21-7 Hydrolysis of Carboxylic Acid Derivatives 1006
- 21-8 Reduction of Acid Derivatives 1011
22 Condensations and Alpha Substitutions of Carbonyl Compounds 1041

22-1 Introduction 1041
22-2 Enols and Enolate Ions 1042
22-3 Alpha Halogenation of Ketones 1046
22-4 $\alpha$ Bromination of Acids: The HVZ Reaction 1051
22-5 Alkylation of Enolate Ions 1052
22-6 Formation and Alkylation of Enamines 1053
22-7 The Aldol Condensation of Ketones and Aldehydes 1056
   Key Mechanism: Base-Catalyzed Aldol Condensation 1056
22-8 Dehydration of Aldol Products 1060
   Key Mechanism: Base-Catalyzed Dehydration of an Aldol 1060
22-9 Crossed Aldol Condensations 1061
   Problem-Solving Strategy: Proposing Reaction Mechanisms 1062
22-10 Aldol Cyclizations 1064
22-11 Planning Syntheses Using Aldol Condensations 1065
22-12 The Claisen Ester Condensation 1067
   Key Mechanism: The Claisen Ester Condensation 1067
22-13 The Dieckmann Condensation: A Claisen Cyclization 1070
22-14 Crossed Claisen Condensations 1071
22-15 Syntheses Using $\beta$-Dicarbonyl Compounds 1074
22-16 The Malonic Ester Synthesis 1076
22-17 The Acetoacetic Ester Synthesis 1079
22-18 Conjugate Additions: The Michael Reaction 1081
22-19 The Robinson Annulation 1085
   Problem-Solving Strategy: Proposing Reaction Mechanisms 1086
   Summary: Enolate Additions and Condensations 1088
   Chapter 22 Glossary 1090
   Study Problems 1092

23 Carbohydrates and Nucleic Acids 1097

23-1 Introduction 1097
23-2 Classification of Carbohydrates 1098
23-3 Monosaccharides 1099
23-4 Erythro and Threo Diastereomers 1102
23-5 Epimers 1103
23-6 Cyclic Structures of Monosaccharides 1104
23-7 Anomers of Monosaccharides; Mutarotation 1108
23-8 Reactions of Monosaccharides: Side Reactions in Base 1110
23-9 Reduction of Monosaccharides 1112
23-10 Oxidation of Monosaccharides; Reducing Sugars 1113
23-11 Nonreducing Sugars: Formation of Glycosides 1115
23-12 Ether and Ester Formation 1117
23-13 Reactions with Phenylhydrazine: Osazone Formation 1119
23-14 Chain Shortening: The Ruff Degradation 1120
23-15 Chain Lengthening: The Kiliani–Fischer Synthesis 1121
23-16 Summary: Reactions of Sugars 1122
23-17 Fischer’s Proof of the Configuration of Glucose 1124
23-18 Determination of Ring Size; Periodic Acid Cleavage of Sugars 1127
23-19 Disaccharides 1129
23-20 Polysaccharides 1134
23-21 Nucleic Acids: Introduction 1137
23-22 Ribonucleosides and Ribonucleotides 1139
23-23 The Structure of Ribonucleic Acid 1141
23-24 Deoxyribose and the Structure of Deoxyribonucleic Acid 1141
Chapter 23 Glossary 1147
Study Problems 1149

24 Amino Acids, Peptides, and Proteins 1153
24-1 Introduction 1153
24-2 Structure and Stereochemistry of the α-Amino Acids 1154
24-3 Acid–Base Properties of Amino Acids 1158
24-4 Isolelectric Points and Electrophoresis 1160
24-5 Synthesis of Amino Acids 1161
24-6 Resolution of Amino Acids 1167
24-7 Summary: Syntheses of Amino Acids 1166
24-8 Structure and Nomenclature of Peptides and Proteins 1170
24-9 Peptide Structure Determination 1174
24-10 Solid-Phase Peptide Synthesis 1180
24-11 Solid-Phase Peptide Synthesis 1183
24-12 Classification of Proteins 1188
24-13 Levels of Protein Structure 1189
24-14 Protein Denaturation 1191
Chapter 24 Glossary 1193
Study Problems 1196

25 Lipids 1200
25-1 Introduction 1200
25-2 Waxes 1200
25-3 Triglycerides 1201
25-4 Saponification of Fats and Oils; Soaps and Detergents 1204
26 Synthetic Polymers 1222

26-1 Introduction 1222
26-2 Addition Polymers 1223
26-3 Stereochemistry of Polymers 1229
26-4 Stereochemical Control of Polymerization; Ziegler–Natta Catalysts 1230
26-5 Natural and Synthetic Rubbers 1230
26-6 Copolymers of Two or More Monomers 1232
26-7 Condensation Polymers 1232
26-8 Polymer Structure and Properties 1236
Chapter 26 Glossary 1238
Study Problems 1240

Appendices 1243

1A NMR Absorption Positions of Protons in Various Structural Environments 1244
1B Spin-Spin Coupling Constants 1246
1C $^{13}$C Chemical Shifts in Organic Compounds 1247
2A Characteristic Infrared Group Frequencies 1248
2B IR: Characteristic Infrared Absorptions of Functional Groups 1251
3 UV: The Woodward–Fieser Rules for Predicting UV-Visible Spectra 1253
4A Methods and Suggestions for Proposing Mechanisms 1257
4B Suggestions for Developing Multistep Syntheses 1260
5 $pK_a$ Values for Representative Compounds 1261

Mechanism Boxes

CHAPTER 6 Allylic Bromination 222
Inversion of Configuration in the $S_N2$ Reaction 238
Racemization in the $S_N1$ Reaction 245
Hydride Shift in an $S_N1$ Reaction 247
Methyl Shift in an $S_N1$ Reaction 248
Rearrangement in an E1 Reaction 255

CHAPTER 7 Dehydrohalogenation by the E2 Mechanism 298
Stereochemistry of the E2 Reaction 300
E2 Debromination of a Vicinal Dibromide 304

CHAPTER 8 Ionic Addition of HX to an Alkene 325
Free-Radical Addition of HBr to Alkenes 327
CHEM 321 - Organic Chemistry
Spring 2005

Instructor: Dr. Brian Groh
Office: Trafton N 357
Phone: 389-5921
E-mail: brian.groh@mnsu.edu
Web Page: www.intech.mnsu.edu/groh/
Course URL: http://www.intech.mnsu.edu/d2l/login/
Office Hours: M 11-1, T 9-12; W 11-12; Th 1-2 other times by appointment. Office hours are subject to change. Please check my website for up to date information.

Lecture Materials:
Required:

Recommended:
Molecular Models: HGS Molecular Structure Model C Set for Organic Chemistry, or similar model set. (Check with students from previous years for used kits.)

Grading:
Lecture:
Quizzes – in-class (3 @ 25 pts. Each) 75 18%
Alternative or online assessment 65 16%
Exams (3 @ 70 points each) 210 49%
Final Exam (cumulative) 70 17%
Total 410 100%

Grade Guidelines: A - 90% and up; B - 80% and up; C - 70% and up; D - 60% and up. (Percentages will be normalized to the highest score.)

Notes:

- Grading guidelines are listed above. At the discretion of the instructor, these cutoffs may be reduced, but will not be increased.
- There is no provision to make-up missed exams or quizzes. Should you miss a quiz for any reason you will be given the average of your other quizzes less 4 points. Should you miss an exam for any reason you will be given the average of your other exams less 10 points.
- In case of a cancellation of class on an exam or quiz date, the exam or quiz will be given at the next class meeting.
- Exams and quizzes will be returned to students. It is highly recommended that these be saved for subsequent review in preparation for other exams, especially the cumulative final exam.
- If you feel there was an error in grading you must see your instructor within one week of the return date. If an exam is accepted for re-grading, the instructor reserves the right to re-grade any additional portion or the entire exam, not just a single question. Any errors in addition or recording of scores will be corrected without reevaluation of the quiz or exam.
- If at any time during the quarter you have any questions regarding your current score and standing you are encouraged to see your instructor.
- Students are encouraged to work together on assignments and in the laboratory, however each student must submit their own original work.
- Attendance in class is essential. While the text will be followed closely, additional materials and questions by students may supplement the lecture.
- Assignments submitted late will be worth 20% less each day delayed (including weekends).
- Homework problems will be assigned from the text. They are not to be handed in. Rather they are intended to serve as a guide to concepts that need to be learned. Students are strongly encouraged to work enough problems to master the concepts presented. The number of problems required to master the concepts will vary with each student. Some students may wish, or need to work nearly all the problems at the end of the chapter.
- Please check the course website (D2L) and my web pages for handouts, assignments, experimental details, etc. as this as the material becomes available.

Course Description: The principles and chemistry of aromatic compounds, amines, and carbonyl compounds will be introduced. This will include a study of mechanisms, synthetic transformations, and concerted reactions, as well as an introduction to IR, MS and NMR spectroscopies. The prerequisite for this course is CHEM 320.

Dishonesty: Dishonest behavior, such as cheating or plagiarism, will result in a failing grade.

Disabilities: Individuals who have any disability, either permanent or temporary, which might affect their ability to perform in this class, are encouraged to inform their instructor at the start of the semester. Adaptation of methods, materials or testing may be made as required for equitable participation. Alternatively, you may wish to contact the Disability Services Office (AH 117, ph. 2825) or the Learning Center (ML 0132, ph. 1791) so that appropriate arrangements can be made.

Note: While an effort will be made to closely follow this syllabus it is subject to modification at any time.
<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Topic (Chapter) / Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jan 17</td>
<td>No Classes</td>
</tr>
<tr>
<td></td>
<td>Jan 19</td>
<td>Ch 12 – Infrared Spectroscopy and Mass Spectrometry</td>
</tr>
<tr>
<td>2</td>
<td>Jan 24</td>
<td>Lab 2 – Thiamine Catalyzed Benzoin Condensation (complete)</td>
</tr>
<tr>
<td></td>
<td>Jan 26</td>
<td>Ch 12 – Infrared Spectroscopy and Mass Spectrometry</td>
</tr>
<tr>
<td></td>
<td>Jan 31</td>
<td>Lab 3 – Preparation of Benzil from Benzoin: Nitric Acid Oxidation (macroscale); mp of benzil</td>
</tr>
<tr>
<td></td>
<td>Feb 2</td>
<td>Online Quiz 1 (NMR spectroscopy); Ch 13 – Nuclear Magnetic Resonance Spectroscopy</td>
</tr>
<tr>
<td>4</td>
<td>Feb 7</td>
<td>Ch 13 – Nuclear Magnetic Resonance Spectroscopy</td>
</tr>
<tr>
<td></td>
<td>Feb 9</td>
<td>Quiz 1; Ch 15 – Conjugated Systems, Orbital Symmetry and Ultraviolet Spectroscopy</td>
</tr>
<tr>
<td></td>
<td>Feb 14</td>
<td>Lab 5 – Spectroscopy (handout)</td>
</tr>
<tr>
<td></td>
<td>Feb 16</td>
<td>Ch 15 – Conjugated Systems, Orbital Symmetry and Ultraviolet Spectroscopy</td>
</tr>
<tr>
<td></td>
<td>Feb 21</td>
<td>Ch 16 – Aromatic Compounds</td>
</tr>
<tr>
<td></td>
<td>Feb 23</td>
<td>Exam 1</td>
</tr>
<tr>
<td>7</td>
<td>Feb 28</td>
<td>Lab 7 – Aldol (synthesis and recrystallization - handout)</td>
</tr>
<tr>
<td></td>
<td>March 2</td>
<td>Ch 16 – Aromatic Compounds</td>
</tr>
<tr>
<td></td>
<td>Ch 17</td>
<td>Reactions of Aromatic Compounds</td>
</tr>
<tr>
<td>8</td>
<td>March 7</td>
<td>Lab 8 – Nitration of Methyl Benzoate; Ch 40 (microscale)</td>
</tr>
<tr>
<td></td>
<td>March 9</td>
<td>Online Quiz 2 (Benzene chemistry); Ch 17 – Reactions of Aromatic Compounds</td>
</tr>
<tr>
<td></td>
<td>Mar 14-18</td>
<td>Spring Break – review Ch 18 – Aldehydes and Ketones (on your own)</td>
</tr>
<tr>
<td>9</td>
<td>Mar 21</td>
<td>Lab 9 – Identification of Unknowns</td>
</tr>
<tr>
<td></td>
<td>Mar 23</td>
<td>Ch 17 – Reactions of Aromatic Compounds; Ch 19 – Amines</td>
</tr>
<tr>
<td>10</td>
<td>Mar 28</td>
<td>Lab 10 – Identification of Unknowns</td>
</tr>
<tr>
<td></td>
<td>Mar 30</td>
<td>Online Quiz 3 (Amines); Ch 19 – Amines</td>
</tr>
<tr>
<td></td>
<td>April 4</td>
<td>Quiz 2; Ch 21 – Carboxylic Acid Derivatives</td>
</tr>
<tr>
<td>11</td>
<td>April 6</td>
<td>Lab 11 – Identification of Unknowns</td>
</tr>
<tr>
<td></td>
<td>April 11</td>
<td>Ch 21 – Carboxylic Acid Derivatives</td>
</tr>
<tr>
<td></td>
<td>April 13</td>
<td>Ch 21 – Carboxylic Acid Derivatives</td>
</tr>
<tr>
<td>13</td>
<td>April 18</td>
<td>Lab 13 – Identification of Unknowns; Aldol (analysis)</td>
</tr>
<tr>
<td></td>
<td>April 20</td>
<td>Ch 21 – Carboxylic Acid Derivatives</td>
</tr>
<tr>
<td></td>
<td>April 25</td>
<td>Online Quiz 4 (Alpha carbonyl subst; this quiz will be due on Tuesday April 6 by 10 am)</td>
</tr>
<tr>
<td></td>
<td>April 27</td>
<td>Ch 22 – Alpha Substitution and Condensation of Enols and Enolate Ions</td>
</tr>
<tr>
<td>14</td>
<td>April 25</td>
<td>Lab 14 – Identification of Unknowns</td>
</tr>
<tr>
<td></td>
<td>April 27</td>
<td>Online Quiz 5 (Rxn of alpha carbonyls); Ch 22 – Alpha Substitution and Condensation of Enols and Enolate Ions</td>
</tr>
<tr>
<td>15</td>
<td>May 2</td>
<td>Quiz 3; Ch 22 – Alpha Substitution and Condensation Enols and Enolate Ions</td>
</tr>
<tr>
<td></td>
<td>May 4</td>
<td>Lab 15 – Complete unknowns and check-out</td>
</tr>
<tr>
<td>16</td>
<td>May 13</td>
<td>Final Exam – Friday, 10:15-12:15; This is a standardized exam covering the entire year.</td>
</tr>
</tbody>
</table>

Note: Online quizzes are listed when available and will generally be due one week later at 10 am.
CHEM 321 – Organic Chemistry II
Student Learning Outcomes

1. Acquire a knowledge of the preparation, properties, and reactions of aromatic compounds.

2. Acquire a mechanistic understanding of organic reactions.

3. Acquire an introductory knowledge of the spectroscopic methods for the determination of the structure of organic compounds: Infrared (IR) and Nuclear Magnetic Resonance (NMR) Spectroscopy, and Mass Spectrometry (MS).

4. Acquire an enhanced and expanded knowledge of aldehydes and ketones, amines, carboxylic acids and their derivatives.

5. Acquire a knowledge of enolate formation and reactions.