The University Of Western Ontario
Faculty of Engineering

GREEN PROCESS ENGINEERING/DEPARTMENT OF CHEMICAL AND BIOCHEMICAL ENGINEERING

GPE 2214b – Green Chemistry II

Course Outline 2014/2015- Winter term

Description
This course both builds on and expands the basics of green chemistry while learning and developing the ideas of organic chemistry. The course examines the 12 principles of green chemistry, alternative feedstocks, green solvents, atom economy and other green pathway metrics, synthesis pathways, catalysts (heterogeneous and homogeneous), the design of safer chemicals and reducing toxicity. Application of these concepts are applied to the development of green industrial processes and basic approaches to alternative energy for a sustainable future. This course also has a significant laboratory component, providing labs illustrating several basic concepts of green chemistry. The students are exposed to various analytical instruments and how they operate for use in a green bio-refinery. In addition, a short group project is presented on current topics of interest in green chemistry.

Prerequisites
GPE 2213A/B-Open only to students registered in the Green Process Engineering Program.

Corequisites
None

Contact Hours
3 lecture hours, 3 laboratory (0.5 course)

Instructor
Dr. P. Charpentier (CMLP 3333) Tel: 519-661-2111 ext: 83466 email: pcharpen@uwo.ca

Teaching Assistant(s)
TBD

Lab Technician
Brian Dennis (SEB1083) Telephone: 519-661-2111 ext: 80536 email: bdennis4@uwo.ca

Undergraduate Assistant
Ingrid Timusk (TEB 477) Telephone: 519-661-2111 ext: 82131 email: ingrid.timusk@uwo.ca

**Required Texts**

**Course Notes**
Course notes will be available for download from the course website.

**Laboratory Notes**
Lab notes will be available for download from the course website.

**Laboratory**
The laboratory section of this course consists of 4 experiments. Bench-scale experimentation will start in mid-January. Students will form small groups (e.g. 2-3 students) to do the experiments although lab reports will be written up individually. Consult the lab schedule on Sakai to determine the dates of the labs and whether they will be submitted individually or in groups. During the laboratory sessions students will get acquainted with laboratory equipment and instrumentation (GC, IR and UV spectrophotometer), basic laboratory techniques such as distillation, extraction, re-crystallization and column chromatography and with green alternatives to common organic chemical reactions.

You must also have, for this course, laboratory safety goggles and a laboratory coat. Students are expected to abide to the safety rules and procedures described in the lab manual. Students without safety goggles will not be allowed into the laboratory and will receive a mark of zero for that particular lab. More serious safety violations may result in your failure of this course.

**Review Basics of Green Chemistry**
The course will review the basics of green chemistry taught in Green Chemistry 1. It reminds students of basic concepts including alternative feedstocks, green solvents, atom economy and other green pathway metrics, synthesis pathways, catalysts (heterogeneous and homogeneous), the design of safer chemicals, and reducing toxicity. The students are reminded on applying these basics to reaction pathways taught in organic chemistry and to the development of green industrial processes.

**Module 1-Basics of Alcohols, Carbohydrates and Polysacharides**
At the end of this module, students should be able to:
- name alcohols using IUPAC nomenclature based on structure,
- draw chemical structures based from both common and IUPAC names,
be able to recognize and draw carbohydrate structures,
understand the basic reactions of alcohols (oxidation, reduction, dehydration, esterification, alkoxides).
- use green metrics to evaluate designing molecules from renewable sugar based molecules
Module 2-Basics of Carboxylic Acids, Fats and Transesterification

At the end of this module, students should be able to:
- name carboxylic acids using IUPAC nomenclature based on structure,
- draw chemical structures based from both common and IUPAC names,
- understand the basic reactions of acids and fatty acids (esterification, transesterification).
- understand basic biodiesel chemistry and saponification
- understand the basic reaction processes used for biodiesel production
- use green metrics to evaluate designing molecules from renewable sugar based molecules

Module 3: Polymers & Biopolymers

At the end of this module, students should be able to:
- Define polymers natural (carbohydrates, proteins)
- know basic naming and structures of synthetic polymers (addition and step-growth polymers)
- know basic stereochemistry of polymers,
- understand the chemistry of industrial processes to make green polymers from renewable starting materials (e.g. polylactic acid, polyesters, polyurethanes).

Module 4: Aromatic Compounds, Reactions, Lignin

- draw the Structure and Properties of Benzene, heterocyclic aromatic compounds, allotropes of carbon (diamond, graphite, carbon nanotubes, graphene)
- define Aromaticity, Heterocyclic Aromatic Compounds, Polynuclear Aromatic Hydrocarbons
Understand the reactions of Aromatics (electrophilic aromatic substitution, activation, deactivation, Friedel-crafts Alkylation/acylation)
- Understand basic lignin chemistry and uses of lignin

Module 5: Functional Groups,

- know basic functional groups and chemistry of Ethers, Epoxides, Ketones/Aldehydes, Amines:
- be able to name and the synthesis of functional groups
- understand various green chemistry such as Epoxy Resins from Lignin
Specific Learning Objectives for the Course:
At the end of this course students should be able to:

- comprehend and recall basic functional groups and reactions of organic chemistry.
- recite and demonstrate competence in organic chemistry and utilize green chemistry metrics for analyzing reactions
- be able to design chemicals that are environmentally responsible
- be able to understand and analyze the impact of organic reactions and processes on the environment and safety.
- be able to carry out basic laboratory experiments in green organic chemistry and comprehend their significance.
- be able to analyze and interpreting the data from these experiments.
- appreciate current mega-challenges requiring green processing.

Course Evaluation
Evaluations will focus on testing the understanding of fundamental concepts of green organic chemistry and on applying this knowledge to solving problems. The laboratory component includes basic skill building as well. Students must be prepared in advance for both the lectures and the laboratory. Some notes will be updated on the web site, but students should make their own notes during class. Laboratory reports are due one week after the completion of the lab. Late submission carries a penalty of 10% per day for 7 days, after which the particular lab will be marked zero. All labs must be submitted.

The final course mark will be determined as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Laboratory</td>
<td>20 %</td>
</tr>
<tr>
<td>Quizzes (best 4 out of 5)</td>
<td>20 %</td>
</tr>
<tr>
<td>Assignments</td>
<td>10 %</td>
</tr>
<tr>
<td>Project</td>
<td>10 %</td>
</tr>
<tr>
<td>Final Examination</td>
<td>40 %</td>
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</tbody>
</table>

No calculators of any kind will be permitted during examinations.

Note
1) Students must pass the final examination to pass this course. Students who fail the final examination will be assigned 48% if the aggregate mark is higher than 50% or the aggregate mark.
2) Students must attend all labs, turn in all laboratory reports, and achieve a passing grade in the laboratory component to pass this course. If you miss a lab for medical or compassionate reasons, you must notify the instructor immediately to make arrangements to make up the lab and provide adequate documentation for your absence. Failure to provide the adequate documentation will result in a mark of 0 and possibly automatic failure of the course.
3) Assignments are to be handed in to the GPE 2214 locker in TEB (#C463) on the specified due date provided by the Instructor.
4) There will be no make-up tests. If you are unable to write a test for medical or compassionate reasons, you must provide the appropriate documentation and the weighting of the mid-year (for fall semester tests) or final (for spring semester tests) exam will be adjusted accordingly. Failure to provide the adequate documentation will result in a mark of 0.

**Use of English**
In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for the improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

**Attendance**
Any student who, in the opinion of the instructor, is absent too frequently from class or laboratory periods in any course, will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Dean, the student will be debarred from taking the regular examination in the course.

**Cheating**
University policy states that cheating is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning (see Scholastic Offence Policy in the Western Academic Calendar).

**Plagiarism**
Students must write their essays and assignments in their own words. Whenever students take an idea, or a passage of text from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence (see Scholastic Offence Policy in the Western Academic Calendar).

The University of Western Ontario has software for plagiarism checking. Students may be required to submit their work in electronic form for plagiarism checking.

**Conduct**
Students are expected to arrive at lectures on time, and to conduct themselves during class in a professional and respectful manner that is not disruptive to others.

**Sickness and Other Problems**
Students should immediately consult with the instructor or Department Chair if they have any
problems that could affect their performance in the course. Where appropriate, the problems should be documented (see attached). The student should seek advice from the Instructor or Department Chair regarding how best to deal with the problem. Failure to notify the Instructor or Department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal. Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.

**Notices**
Students are responsible for regularly checking their email and notices posted on the webct course site and Instructors' doors.

**Consultation**
Students are encouraged to discuss problems with their teaching assistant and/or instructor. Office hours will be arranged for the students to see the instructor and teaching assistants. Other individual consultation can be arranged by appointment with the appropriate instructor.

**ATTRIBUTES introduced, taught and evaluated**

In this course the evaluation is carried out both in the form of a test after each module, a small group presentation and a final exam as well 4 laboratory reports.

The table below identifies the attributes that are introduced, taught and evaluated. GPE 2214 is considered an intermediate course continuing to develop the basics of science and knowledge of molecular green engineering required in more advanced courses. Students are judged as: **below expectations, meet expectations and exceed expectations**.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Classification</th>
<th>Level</th>
<th>Rubrics for Evaluated attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge Base</td>
<td>Taught</td>
<td>Intermediate</td>
<td>N/A</td>
</tr>
<tr>
<td>Investigation</td>
<td>Taught and Evaluated</td>
<td>Intermediate</td>
<td>Below Expectation</td>
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<td>Meets Expectation</td>
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<td>Exceeds Expectation</td>
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<tr>
<td>Impact of engineering on society and the environment</td>
<td>Taught and Evaluated</td>
<td>Intermediate</td>
<td>Below Expectation</td>
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<td>Exceeds Expectation</td>
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**Evaluation Methodology for Investigation**
The student must achieve a level of competence to be able to investigate a specific laboratory synthesis experiment and examine ways to enhance its production using course concepts.
• The student will examine appropriate laboratory techniques to synthesize a desired chemical, e.g. biodiesel production
• Various green metrics will be considered to identify best synthesis routes
• The student will carry out appropriate experiments and analyze experimental data discussing the results within the context of previous procedures and green metrics.

ASSESSMENT

Students form small groups of 2-3 students and are provided with a chemical compound of interest to be synthesized, e.g. azo dye, biodiesel, polymer, biochar. Students meet with the instructor and lab technician to discuss their project and potential approaches. Students provide a detailed 1-2 page proposal to examine in the laboratory in 3-4 X 3 hour lab periods examining the effect of green solvents, one-pot procedures or use of a catalyst. After the laboratory investigation, students write up a detailed laboratory report and are marked as below.

Marking Scheme for Each Student

1. Project proposal............................................................................................ /10
2. Abstract ...................................................................................................... /5
3. Introduction.................................................................................................. /5
4. Experimental Approach using course concepts......................................... /10
5. Discussion of results describing green metrics (e.g. atom economy, reaction steps) ... /10
6. Recommendations and Conclusions.......................................................... /10

2) Impact of Engineering on Society and the Environment

The student must achieve a level of competence to be able to recognize and describe the relevance and the impact to society of a current problem based on green chemistry and to effectively communicate the chemistry and possible solutions to a diverse technical audience.

The student must be able to examine the origins of the problem, critically compare feasible alternatives and suggest the associated benefits and challenges based on green chemistry metrics and concepts taught in the course towards sustainability and impacts on the society and environment.
ASSESSMENT

Students form small groups of 2-3 students and identify a current problem of interest, e.g. biodiesel production using local renewable feedstocks. Students meet with the instructor with each student having a clear role for the presentation and is evaluated individually.

Specific indicators are assessed by both the instructor and 2 graduate students (at both MESc/PhD and PDF levels) through (a) a meeting prior to presentation to discuss their project and potential solution and during a 20 minute presentation to the class. The Evaluation scheme utilized by the examiners is as follows:

**Marking Scheme for Each Student**
- Background of current challenge.................................................................................................. /10
- Clarity of project/problem objectives ......................................................................................... /10

Use of Course Concepts in showing Green

Chemistry........................................................................................................................................ /10
- Feasible recommendations using green metrics (e.g. atom economy) ................................ /10

- Quality of overall team presentation (content, voice, diction and answering questions from audience)................................................................. /10
INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS
OR EXAMINATIONS OR SUBMIT ASSIGNMENTS AS SCHEDULED

IF, ON MEDICAL OR COMPASSIONATE GROUNDS, YOU ARE UNABLE TO WRITE TERM TESTS OR FINAL EXAMINATIONS OR COMPLETE COURSE WORK BY THE DUE DATE, YOU SHOULD FOLLOW THE INSTRUCTIONS LISTED BELOW. YOU SHOULD UNDERSTAND THAT ACADEMIC ACCOMMODATION WILL NOT BE GRANTED AUTOMATICALLY ON REQUEST. YOU MUST DEMONSTRATE TO YOUR DEPARTMENT (OR THE UNDERGRADUATE SERVICES OFFICE IF YOU ARE IN FIRST YEAR) THAT THERE ARE COMPELLING MEDICAL OR COMPASSIONATE GROUNDS THAT CAN BE DOCUMENTED BEFORE ACADEMIC ACCOMMODATION WILL BE CONSIDERED. DIFFERENT REGULATIONS APPLY TO TERM TESTS, FINAL EXAMINATIONS AND LATE ASSIGNMENTS. READ THE INSTRUCTIONS CAREFULLY. (SEE THE 2014 UWO ACADEMIC CALENDAR).

A. GENERAL REGULATIONS & PROCEDURES

1. Check the course outline to see if the instructor has a policy for missed tests, examinations, late assignments or attendance.

2. Bring your request for academic accommodation to the attention of the chair of your (or the Undergraduate Services office if you are in first year) PRIOR to the scheduled time of the test or final examination or due date of the assignment. If you are unable to contact the relevant person, leave a message with the appropriate department (or with the Undergraduate Services Office if you are in first year). The address, telephone and fax numbers are given at the end of these instructions. Documentation must be provided as soon as possible.

3. If you decide to write a test or an examination you should be prepared to accept the mark you earn. Rewriting tests or examinations or having the value of a test or examination reweighted on a retroactive basis is not permitted.

B. TERM TESTS

1. If you are unable to write a term test, inform your instructor and the Chair of your Department (or the Undergraduate Services Office if you are in first year) PRIOR to the scheduled date of the test. If the instructor is not available, leave a message for him/her at the department office and inform the Chair of the Department (or the Undergraduate Services Office if you are in first year).

2. Be prepared to provide supporting documentation to the Chair and the Undergraduate Services Office (see next page for information on documentation).

3. Discuss with the instructor if and when the test can be rescheduled. N.B. The approval of the Chair (or the Undergraduate Services Office if you are in first year) is required when rescheduling term tests.

C. FINAL EXAMINATIONS

1. If you are unable to write a final examination, contact the Undergraduate Services Office PRIOR TO THE SCHEDULED EXAMINATION TIME to request permission to write a Special Final Examination. If no one is available in the Undergraduate Services Office, leave a message clearly stating your name & student number (please spell your full name).

2. Be prepared to provide the Undergraduate Services Office with supporting documentation (see next page for information on documentation) the next day, or as soon as possible (in cases where students are hospitalized). The following circumstances are not considered grounds for missing a final examination or requesting special examinations: common cold, sleeping in, misreading timetable and travel arrangements.

3. In order to receive permission to write a special examination, you must obtain the approval of the Chair of the Department and the Associate Dean and in order to apply you must sign a “Recommendation for a Special Examination Form” available in the Undergraduate Services Office. The Undergraduate Services Office will then notify the course instructor(s) and reschedule the examination on your behalf.

N.B. It is the student’s responsibility to check the date, time and location of the special examination.

D. LATE ASSIGNMENTS

1. Advise the instructor if you are having problems completing the assignment on time (prior to the due date of the assignment).

2. Be prepared to provide documentation if requested by the instructor (see reverse side for information on documentation).

3. If you are granted an extension, establish a due date. The approval of the Chair of your Department (or the Associate Dean if you are in first year) is not required if assignments will be completed prior to the last day of classes.

4. i) Extensions beyond the end of classes must have the consent of the instructor, the department Chair and the Associate Dean. Documentation is mandatory.

ii) A Recommendation of Incomplete Form must be filled out indicating the work to be completed and the date by which it is due. This form must be signed by the student, the instructor, the department Chair and the Associate Dean.
E. **SHORT ABSENCES**

If you miss a class due to a minor illness or other problems, check your course outlines for information regarding attendance requirements and make sure you are not missing a test or assignment. Cover any readings and arrange to borrow notes from a classmate.

F. **EXTENDED ABSENCES**

If you are absent more than one week or if you get too far behind to catch up, you should consider reducing your workload by dropping one or more courses. (Note drop deadlines listed below). You may want to seek advice from the academic counsellor in your Department or Ms Karen Murray in the Undergraduate Services Office if you are in first year.

G. **DOCUMENTATION**

If you consulted an off-campus doctor or Student Health Services regarding your illness or personal problem, **you must provide the doctor with a Student Medical Certificate** to complete at the time of your visit and then bring it to the Department (or the Undergraduate Services Office if you are in first year). **This note must contain the following information: severity of illness, effect on academic studies and duration of absence.**

**In Case of Serious Illness of a Family Member:** Provide a Student Medical Certificate to your family member's physician to complete and bring it to the Department (or the Undergraduate Services Office if you are in first year).

**In Case of a Death:** Obtain a copy of the death certificate or the notice provided by the funeral director's office. You must include your relationship to the deceased and bring it to the Department (or the Undergraduate Services Office if you are in first year).

**For Other Extenuating Circumstances:** If you are not sure what documentation to provide, ask the Departmental Office (or the Undergraduate Services Office if you are in first year) for direction.

**Note:** Forged notes and certificates will be dealt with severely. **To submit a forged document is a scholastic offence** (see below).

H. **ACADEMIC CONCERNS**

You need to know if your instructors have a policy on late penalties, missed tests, etc. This information may be included on the course outlines. If not, ask your instructor(s).

You should also be aware of attendance requirements in some courses. You can be debarred from writing the final examination if your attendance is not satisfactory.

If you are in academic difficulty, check out the minimum requirements for progression in the calendar. If in doubt, see your academic counsellor.

**Calendar References:** Check these regulations in your 2014 Western Academic Calendar available at [www.westerncalendar.uwo.ca](http://www.westerncalendar.uwo.ca).

Absences Due to Illness: [http://www.westerncalendar.uwo.ca/2014/pg117.html#](http://www.westerncalendar.uwo.ca/2014/pg117.html#)

Academic Accommodations for Students with Disabilities: [http://www.westerncalendar.uwo.ca/2014/pg118.html](http://www.westerncalendar.uwo.ca/2014/pg118.html)

Academic Accommodations for Religious or Holy Days: [http://www.westerncalendar.uwo.ca/2014/pg119.html](http://www.westerncalendar.uwo.ca/2014/pg119.html)


Examinations: [http://www.westerncalendar.uwo.ca/2014/pg129.html](http://www.westerncalendar.uwo.ca/2014/pg129.html)

Scheduling of Term Assignments: [http://www.westerncalendar.uwo.ca/2014/pg113.html](http://www.westerncalendar.uwo.ca/2014/pg113.html)

Scholastic Offences: [http://www.westerncalendar.uwo.ca/2014/pg97.html](http://www.westerncalendar.uwo.ca/2014/pg97.html)

Student Medical Certificate: [http://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf)

Engineering Academic Regulations: [http://www.westerncalendar.uwo.ca/2014/pg1442.html](http://www.westerncalendar.uwo.ca/2014/pg1442.html)

**Note:** These instructions apply to all students registered in the Faculty of Engineering regardless of whether the courses are offered by the Faculty of Engineering or other faculties in the University.

**Drop Deadlines:**

- First term half course (i.e. “A” or “F”): November 5, 2014
- Full courses and full-year half courses (i.e. “E”, “Y” or no suffix): November 30, 2014
- Second term half or second term full course (i.e. “B” or “G”): March 7, 2015

Undergraduate Services Office: SEB 2097 telephone: (519) 661-2130 fax: (519) 661-3757

Dept. of Chemical and Biochemical Engineering & Green Process Engineering TEB 477 telephone: (519) 661-2131 fax: (519) 661-3498

Dept. of Civil and Environmental Engineering: SEB 3005 telephone: (519) 661-2139 fax: (519) 661-3779

Dept. of Electrical and Computer Engineering, Software Engineering, Mechatronics Engineering TEB 279 telephone: (519) 661-3758 fax: (519) 850-2436

Dept. of Mechanical and Materials Engineering: SEB 3002 telephone: (519) 661-4412 fax: (519) 661-3020

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