University College Dublin – School of Chemistry

Organic Chemistry for UC Students (*OChem 1 + 2*)

June 24th – August 16th 2019

Instructor: Dr Marcus Baumann, Dr Mike Casey

Aims: The principal aim of this summer course is to provide each student with a firm understanding of the key concepts prevalent in organic chemistry and the resulting properties of organic molecules. These will be presented based on standard U.S. text books and will be complemented by specific examples of compounds present in important drug molecules and natural products. As such the course initially introduces key concepts such as molecular structure, chemical bonding and orbital interactions. The resulting properties of molecules are then introduced on key compound classes such as alkanes, alkenes and alkynes that later will be complemented by aromatic rings and functional groups such as alcohols, carbonyls and amines. Furthermore, the crucial properties that explain the reactivity of organic molecules and enable a detailed understanding through distinct reaction mechanisms will be highlighted throughout the course. Finally, these concepts will be applied towards the planned synthesis of target molecules in combination with suitable structure determination methods.

Duration: This summer course will take place over 2 consecutive 4-week periods.

Objectives and Learning Outcomes: By the end of this course each student will have acquired an understanding of the following concepts and principles that determine the importance of organic chemistry in modern society.

- Describe the nature of chemical bonding present in organic molecules.
- Explain the reasons for acidic or basic properties of molecules.
- Analyse the structure of alkanes and cycloalkanes and rationally name these compounds.
- Explain the reactivity of organic molecules based on orbital considerations.
- Describe organic reaction pathways through curved arrow mechanisms.
- Account for the properties of alkenes and alkynes based on their structure.
- Describe and account for substitution and elimination reactions of organohalides.
- Understand and apply key structure determination methods for organic compounds.
- Understand the importance of aromatic compounds based on benzene.
- Understand the effect of key functional groups on the properties of organic molecules.

Reading list:

- McMurry, *Organic Chemistry*, 8th Edition;
- McMurry, *Study Guide and Solutions Manual for McMurry's Organic Chemistry*, 8th Edition;
- Any molecular model kit.

Tentative Lecture Schedule:

Week	Date	Lecturer	Topics	McMurry chapters 8th
1	24/06-28/06	MC	**Structure and Bonding; Polarity, Acids & Bases**	1, 2, 6
2	01/07-05/07	MC	**Alkanes and Cycloalkanes, Amines, Mechanisms**	3, 4, 24a
3	08/07-12/07	DG	**Alcohols, Ethers, Epoxides, Halides (substitution and elimination reactions), Stereochemistry**	17a, 18a, 10, 11, 5
4	15/07-19/07	PE	**Alkenes, Alkynes, Polymers (radical reactions)**	7, 8, 9, 31
5	22/07-26/07	MB	**Structure Determination: NMR, IR, MS, UV**	12, 13, 14
6	29/07-02/08	MR	**Benzene and aromatic compounds (S_EAr), phenols**	15, 16, 17
7	05/08-09/08	MB	**Carbonyl chemistry, alpha-substitution, acylation reactions, aldol reactions**	19, 20, 21, 22, 23
8	12/08-16/08	EMC	**Drugs and Natural Product Classes, Heterocyclic examples**	24b, 25, 26, 27, 28

Teaching Methods:

Regarding teaching and learning methods, a combination of lecture-based teaching, continuous assessment, laboratory-based practical experimentation and self-study will be used. Key concepts and tools will be presented in lectures, while regular practical laboratories and tutorial sessions, as well as informal self-study sessions, will enable the students to apply this knowledge to solve problems relevant to chemistry. In detail:

1. Lectures
   There are 8 lectures per week scheduled for 1 hour each.
2. Homework / Problem Solving
   One set of problems will be handed out each week, which must be submitted for marking.
3. Workshops
   There is a 2-hour workshop each week devoted to problem solving and questions on the past exam paper.
4. Laboratories
   There are three 3-hour laboratory afternoons scheduled each week in which new experiments will be performed. The students will typically work individually. In the final week of module 2, a mini-research project is scheduled in which the students work in teams to design their own experiments on the topic of 'O-alkylation of acetaminophen with different electrophiles'. This 'scientific inquiry' approach allows the students to define their own research questions and plan their experiments accordingly. Several meetings prior to the labs are taking place where a staff member will discuss the student's ideas and guide them.
5. Independent Study
   In addition, each of the 2 modules (weeks 1-4 and 5-8) will require a minimum of 40 hours independent study.

2019 weekly schedule:

time	Monday	Tuesday	Wednesday	Thursday	Friday
09:00	Lecture	Lecture	Lecture	Lecture	Independent study
10:00	Lecture	Lecture	Lecture	Lecture	Staff tutorial/Exam
11:00	Independent study	Workshop	Independent study	Independent study	Weekly test/exam
12:00	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH
13:00	Independent study	Independent study	Independent study	Independent study	*Excursion*
14:00	Lab	Lab	Lab	Tutorial	
15:00	Lab	Lab	Lab	Tutorial	
16:00	Lab	Lab	Lab		
17:00	Independent study	Independent study	Independent study	Independent study	
18:00	Spare time	Spare time	Spare time	Spare time	

Assessment:

The assessment of this course will be aided by means of problem sets/tutorials/workshops, laboratory reports, problem sets as well as a Friday tests and a final exam as outlined below:

Type	Due Date	Weighting
Problem set/tutorials/workshops	weekly	5%
Laboratory (reports)	weekly	30%
3 Friday tests	weekly	25%
Final exam	in week 4	40%

On the first, second and third Friday of each module a one-hour test exam will be held on the topics covered in that week's lectures. On the fourth Friday a two-hour exam covering all topics of that module will be held. Questions are typically in 'short answer' format rather than MCQ.

List of experiments in 2019:

Lab 1: Separation of a mixture (benzoic acid, dimethoxybenzene) by acid-base extraction.

Lab 2: Separation of a mixture (salicylic acid, 4-aminophenol) by acid-base extraction.

Lab 3: Separation of a mixture (pentane, heptane) by distillation.

Lab 4: Synthesis and isolation of isoamyl acetate.

Lab 5: Synthesis of tert. butyl chloride from tert. butanol.

Lab 6: Synthesis of trimetozine via amide formation.

Lab 7: Bromination of stilbene.

Lab 8: Synthesis of aspirin.

Lab 9: Wittig reaction of 4-carboxybenzyltriphenylphosphonium bromide with HCHO.

Lab 10: Synthesis of dibenzylidene acetone by aldol condensation.

Lab 11: Reduction of benzophenone (tlc, IR).

Lab 12: Isolation of lycopene (UV, tlc).

Lab 13: Synthesis of a dipeptide (Boc-Ala-Gly; NMR, MS).

Lab 14: Addition of PhMgBr to ethyl benzoate (IR, NMR).

Lab 15: Methanolysis of dichloronitrobenzene (MS, NMR).

Lab 16: Spectroscopic determination of an unknown compound.

Lab 17: Synthesis of protected monosaccharide.

Lab 18: Iodination of salicylamide.

Lab 19+20: Mini research project.