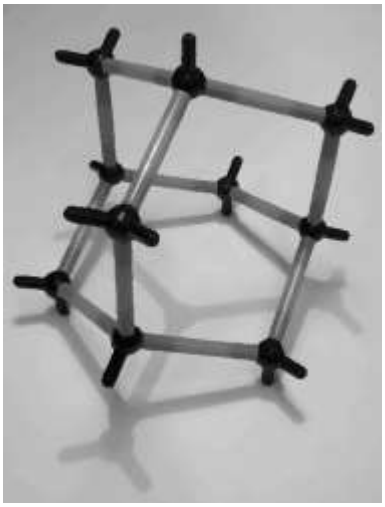
Course Guide

2016/17

CHARLES UNIVERSITY IN PRAGUE

Department of Organic Chemistry



Organic Chemistry II

A Guide to the Course

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ORGANIC CHEMISTRY II FOR ERASMUS STUDENTS

A Guide to the Course

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Outline of the Course

This course is divided into two sections. The first deals with flat compounds as reagents and products, and with chemistry in three dimensions. Reactions of aromatic compounds and of enols and enolates are the key reactions in the first part. We consider the "handedness" or chirality of molecules and how that affects their structure and reactivity. Molecules can be right- or left-handed: the creation and manipulation of this chirality are the key reactions in this part. Each reaction can be used in chemistry and in biology often with strikingly different results.
The second part introduces you to the chemistry of basic biomolecules such as saccharides, amino acids, peptides, proteins and lipids. The approach throughout the course will be based on structure and mechanism.

Recommended books

Organic Chemistry, McMurry, Cornell University, 2011.
Organic Chemistry, Clayden, Greeves, Warren and Wothers, OUP, 2001.

Key Organic Reactions (week 1 – 7)

Week 1

Aldehydes and ketones.

- Synthesis of aldehydes and ketones (*e.g.* Friedel-Crafts reactions).
- Oxidation of aldehydes and ketones (*e.g.* Jones oxidation).
- Nucleophilic additions to aldehydes and ketones: relative reactivity, hydration, addition of HCN, addition of Grignard and organometallic reagents, additions of amines and hydrazines, *etc.*

Literature:
Clayden, Greeves, Warren; chapters 10, 21, 23

McMurry; chapter 19

Homework:
Clayden, Greeves, Warren; chapter 10

Week 2

Aldehydes and ketones

- Kishner-Wolff reaction, Clemmensen reduction, Kursanov-Parnes reduction, Mozingo reduction, formation of acetals and ketals, Wittig reaction, Peterson olefination, Tebbe reaction, Canizzaro reaction. Conjugated addition to alpha,beta-unsaturated aldehydes and ketones. (Synthetic examples: synthesis of Duloxetine, asymmetric synthesis of steroids.) (CGW; #10; #23)

Literature:

Clayden, Greeves, Warren; chapters 10, 21, 23, 24, 25

McMurry; chapter 20

Homework:

Clayden, Greeves, Warren; chapters 23, 24, 25

Week 3

Carboxylic acids and nitriles

- Physical properties of carboxylic acids, dissociation, effect of substitution on pKa, effect of substitution on pKa of benzoic acids. Synthesis of carboxylic acids (oxidation of alcohols and aldehydes, oxidative cleavage of the double bonds, oxidation of alkyl aromatic compounds, hydrolysis of nitriles, carboxylation of Grignard and organolithium compouns, Kolbe-Schmidt process, Willgerodt reaction, haloform reaction, Arndt-Eistert reaction, Perkin reaction, malonester synthesis, Favorskii rearrangement, Chemistry of nitriles. synthesis of nitriles (SN2 substitution, Sandmeyer reaction, dehydration of amides). Reactions of nitriles (reduction, addition of water, and organometallic reagents, addition of water, organometallic reagents).(Synthetic examples: synthesis of ibuprofen a fenclovac). (CGW; #10; #23)

Literature:

Clayden, Greeves, Warren; chapters 15, 21, 25, 36, 38, 39

McMurry; chapter 21

Homework:

Clayden, Greeves, Warren; chapters 21, 22, 25, 39

Week 4

Functional derivatives of carboxylic acids

- Nucleophilic acyl substitution. Acyl halides (synthesis, reaction: *e.g.* Friedel-Crafts acylation), anhydrides of carboxylic acids (preparation, reactions), carboxylic acid esters (preparation, reactions), carboxylic acid amides (preparation, reactions). Thioesters and acyl phosphonates (natural derivatives of carboxylic acids). Polyamides and polyesters.

Literature:

Clayden, Greeves, Warren; chapters 21, 22, 23, 24, 25

McMurry; chapter 21

Homework:

Clayden, Greeves, Warren; chapters 23, 24, 25

Week 5

Keto-enol tautomerisation (acid and base catalysed rearrangement).

- Reactivity of enols and mechanism of alpha-alkylation. Alpha-halogenation of aldehydes, ketones (Favorskii rearrangement) and carboxylic acids (Hell-Volhard-Zelinsky reaction). Acidity of hydrogens in the alpha position to the carbonyl group. Reactivity of enolates: halogenation (haloform reaction), alkylation (malonester synthesis, acetoacetic synthesis). Direct alkylation of carbonyl compounds. Selenylation (formation of the double bonds).

Literature:

Clayden, Greeves, Warren; chapters 35, 36, 38

McMurry; chapter 22

Homework:

Clayden, Greeves, Warren; chapters 35, 36, 38

Week 6

Condensation reactions of carbonyl compounds

- Condensation of aldehydes and ketones (formation of enones) and their application in organic synthesis. Cross aldol condensation (Mukaiyama aldol reaction). Intramolecular aldol condensation. Claisen condensation and its cross variant. Other condensation reactions: Knoevenagel reaction, Perkin reaction. Michael reaction. Robinson annulation.

Literature:

Clayden, Greeves, Warren; chapters 26, 22, 32

McMurry; chapter 23

Homework:

Clayden, Greeves, Warren; chapters 26

Week 7

Amines

- Bonding in amines. Physical properties of amines. Basicity of amines: alkylamines, arylamines, heterocyclic amines, carboxylic acid amides. Synthesis of amines (reduction of nitriles, reduction of nitro compounds, SN reactions of amines and arylamines. Sandmeyer reaction. Substitution reactions: azide synthesis, Gabriel synthesis, reductive amination). Curtius rearrangement. Hofmanna elimination. Electrophilic aromatic substitution of arylamines. Diazonium salts (Sandmeyer reaction).

Literature:

Clayden, Greeves, Warren; chapters 22, 26, 15, 28, 38

McMurry; chapter 24

Homework:

Clayden, Greeves, Warren; chapters 22, 26

Introduction to Biomolecules (week 8 – 11)

Week 8

Saccharides

- Classification of saccharides. Stereochemistry of saccharides (Fischer projection) and their configuration. Cyclic structure, anomers (mutarotation). Reaction of monosaccharides: esterification, etherification (Williamson reaction, glycosides, digitoxin, Koenigs-Knorr reaction and its mechanism, methylarbatin, salicyn), reduction (alditols), oxidace (aldonic acids), chain growth (Kiliani-Fischer synthesis) a chain degradation (Wohl degradation). Disaccharides (maltose, cellobiose, laktose, sacharose) polysaccharides (starch, amylose, amylopectin, cellulose, chitin). Deoxysaccharides, aminosaccharides, ascorbic acid). Sweetness and sweeteners (saccharin, aspartame, etc.)

Literature:

Clayden, Greeves, Warren; chapters 42,15, 30

McMurry; chapter 25

Homework:

Clayden, Greeves, Warren; chapters 42, (29, 30)

Week 9

Amino acids, peptides and proteins

- Structure of amino acids. Fischer projection. Isoelectric point. Synthesis of Amino acids. Peptides and proteins. Covalent bonding in peptides. Structure of peptides and its determination (Edmann and Sanger degradation). Synthesis of peptides.

Literature:

Clayden, Greeves, Warren; chapters 14, 42

McMurry; chapter 26

Homework:

Clayden, Greeves, Warren; chapters 14, 42

Week 10

Biomolecules and lipids

- Soaps. Phospholipids, prostaglandins. Terpenoids (isoprenoids). Steroids and their structure. Heterocyclic compounds. 5- a 6-membered heterocycles: pyrrole, furan, thiophene, pyridine. Their electrophilic and nucleophilic substitution. Nucleosides, nucleotides and nucleic acids.

Literature:

Clayden, Greeves, Warren; chapters 42, 29, 30

McMurry; chapter 27

Homework:

Clayden, Greeves, Warren; chapters 42, 29, 30

Week 11

Pericyclic reactions

- Molecular orbitals of conjugated systems and their relation to pericyclic reactions. Thermal and photochemical electrocyclic reactions: cyclization of hexatrienes, cyclization of dienes and ring-opening of cyclobutenes. Cycloaddition reactions: Diels-Alder reaction 2+2-cycloaddition. Sigmatropic rearrangements: 1,5- rearrangement, Cope and Claisen rearrangement.

Literature:

Clayden, Greeves, Warren; chapters 32, 33, 34, (35)

McMurry; chapter 28

Homework:

Clayden, Greeves, Warren; chapters 32, 33, 34, (35)

Supervision and Homework

Each lecture course is accompanied by a problems sheet from which your supervisor will ask you to complete a number of questions. You may also be set additional questions, perhaps from past examination papers. For each supervision you should expect to prepare some written work, to hand it in for marking in advance of the supervision and to receive it back, marked and with written comments from your supervisor, within a reasonable time (usually by the end of the week).

Examination

The examination consists of a one three-hour written paper that contains (up to) seven questions; candidates must answer five questions, which will carry equal weight.

You will be provided with a Data Book which contains a simple Periodic Table, values of physical constants, certain mathematical formulae and selected character tables. You will be provided with a copy of the Data Book when you appear for the examination. You are permitted to bring unassembled molecular models into the examination. No other reference material is permitted during the examination.

There are three possible dates for the examination on offer, which are as follows:

09.01.2017 (Mon),
11.01.2017 (Wed),
13.01.2017 (Fri) from 09:00 - 12:10.

Students may choose to abstain from one examination up to 24 h before the set date, and only on account of a certified medical emergency or other grievous circumstances. If all three dates are missed the course is considered as failed without further ado.

The following class boundaries will be used for all the examination:

- candidates who achieve a percentage mark of 80.0-100.0 are awarded a 1st class
- candidates who achieve a percentage mark of 60.0-79.9 are awarded a 2nd class
- candidates who achieve a percentage mark of 50.0-59.9 are awarded a 3rd class
- candidates who achieve a percentage mark of 0.0-49.9 fail the exam.

Organic Chemistry II - Teaching schedule 2016

All lectures will be held at 12:00 in seminar room 138, Department of Organic Chemistry

Winter Term			
1	10-Oct	Mo	
	11-Oct	Tu	
	12-Oct	We	
	13-Oct	Th	
	14-Oct	Fr	KOR
	15-Oct	Sa	
	16-Oct	Su	
2	17-Oct	Mo	KOR
	18-Oct	Tu	
	19-Oct	We	
	20-Oct	Th	
	21-Oct	Fr	
	22-Oct	Sa	
	23-Oct	Su	
3	24-Oct	Mo	KOR
	25-Oct	Tu	
	26-Oct	We	
	27-Oct	Th	
	28-Oct	Fr	
	29-Oct	Sa	
	30-Oct	Su	
4	31-Oct	Mo	KOR
	01-Nov	Tu	
	02-Nov	We	
	03-Nov	Th	
	04-Nov	Fr	
	05-Nov	Sa	
	06-Nov	Su	
5	07-Nov	Mo	KOR
	08-Nov	Tu	
	09-Nov	We	
	10-Nov	Th	
	11-Nov	Fr	
	12-Nov	Sa	
	13-Nov	Su	
6	14-Nov	Mo	KOR
	15-Nov	Tu	
	16-Nov	We	
	17-Nov	Th	
	18-Nov	Fr	
	19-Nov	Sa	
	20-Nov	Su	

Winter Term			
7	21-Nov	Mo	KOR
	22-Nov	Tu	
	23-Nov	We	
	24-Nov	Th	
	25-Nov	Fr	
	26-Nov	Sa	
	27-Nov	Su	
8	28-Nov	Mo	IBM
	29-Nov	Tu	
	30-Nov	We	
	01-Dec	Th	
	02-Dec	Fr	
	03-Dec	Sa	
	04-Dec	Su	
9	05-Dec	Mo	IBM
	06-Dec	Tu	
	07-Dec	We	
	08-Dec	Th	
	09-Dec	Fr	
	10-Dec	Sa	
	11-Dec	Su	
10	12-Dec	Mo	IBM
	13-Dec	Tu	
	14-Dec	We	
	15-Dec	Th	
	16-Dec	Fr	
	17-Dec	Sa	
	18-Dec	Su	
11	19-Dec	Mo	IBM
	20-Dec	Tu	
	21-Dec	We	
	22-Dec	Th	
	23-Dec	Fr	
	24-Dec	Sa	
	25-Dec	Su	
	26-Dec	Mo	
	27-Dec	Tu	
	28-Dec	We	
	29-Dec	Th	
	30-Dec	Fr	
	31-Dec	Sa	
	01-Jan	Su	

Winter Term			
12	02-Jan	Mo	
	03-Jan	Tu	
	04-Jan	We	
	05-Jan	Th	
	06-Jan	Fr	
	07-Jan	Sa	
	08-Jan	Su	
13	09-Jan	Mo	**Exam 1/3**
	10-Jan	Tu	
	11-Jan	We	**Exam 2/3**
	12-Jan	Th	
	13-Jan	Fr	**Exam 3/3**
	14-Jan	Sa	
	15-Jan	Su	

Note:
There **are three possible dates** for the examination on offer towards the end of the term. Students may chose to **abstain from any one examination up to 24 h before the set date**, and only on account of a certified medical emergency or other grievous circumstances. **If all three dates are missed the course is considered as failed without further ado.**