2021-2022

UNIVERSITY OF SCIENCE AND TECHNILOGY OF HANOI

ANNEX 2
COURSE SYLLABUS

BACHELOR CHEMISTRY PROGRAM

Table of Contents

PROGRAM OVERVIEW

No.	Code	Course title	ECTS	Total hours	Lecture hours	Practical hours	Tutorial hours	Lecturer
SECOND YEAR PROGRAM								
1	CHEM2.01	Analytical Chemistry (General Concepts)	3	36	28	8	0	Bùi Văn Hợi
2	CHEM2.02	Analytical Chemistry Lab	2	32	00	32	0	Bùi Văn Hợi
3	CHEM2.03	Inorganic Chemistry I (General Concepts and Chemistry of Elements)	2	24	16	4	4	Phạm Hồng Ngọc & Trần Bữu Đăng
4	CHEM2.04	Inorganic Chemistry II (Coordination Chemistry)	3	36	24	6	6	Trần Đình Phong & Trần Bữu Đăng
5	CHEM2.05	Instrumental Analysis I (Spectroscopic Methods)	3	36	24	6	6	Tô Hải Tùng & Lê Văn Hoàng
6	CHEM2.06	Organic Chemistry II (Chemistry of Functional Groups)	3	36	24	6	6	Nguyễn Đức Anh
7	CHEM2.07	Physical Chemistry I	3	36	24	6	6	Nguyễn Thị Tuyết Mai & Trần Bữu Đăng
8	CHEM2.08	Physical Chemistry II	3	36	24	6	6	Nguyễn Thị Tuyết Mai & Trần Bữu Đăng
9	CHEM2.09	Project-based course I: Introduction to research methods, reference collection and analysis	3	36	16	20	0	Lê Thị Lý & Lê Văn Hoàng
10	CHEM2.11	Food Chemistry and Technology	3	36	30	6	0	Phạm Hồng Ngọc
11	CHEM2.12	Instrumental Analysis II (Spectroscopic methods cont. and microscopics)	3	36	24		12	Lê Thị Lý
12	CHEM2.13	Organic Chemistry Lab	2	32	4	28		Tô Hải Tùng
13	CHEM2.14	Organic Synthesis	3	36	30		6	Tô Hải Tùng
14	CHEM2.15	Physico -Chemistry of Surfaces and Interfaces	3	30	30		0	Vũ Thị Thu
15	CHEM2.16	Polymer Chemistry	3	36	24	12		Nguyễn Đức Anh
16	CHEM2.17	Project-based course II: Actualy sampling, design experiments, data analysis	3	36	16	20		Vũ Cẩm Tú
17	CHEM2.18	Solid State Chemistry	2	24	20		4	Lê Thị Lý
18	CHEM3.6	Structure Determination	3	36	24		12	Tô Hải Tùng
THIRD YEAR PROGRAM								
19	CHEM3.01	Chemistry of Nanomaterials	3	36	24	6	6	Trần Đình Phong & Nguyễn Ngọc Đức

20	CHEM3.02	Electrochemistry	3	38	24	10	4	Nguyễn Văn Quỳnh
21	CHEM3.03	Biochemistry and Bioinorganic Chemistry	3	36	30	6		Phạm Hồng Ngọc
22	CHEM3.04	Chemistry of Natural and Biodegradable Polymers	3	36	24	12		Nguyễn Đức Anh
23	CHEM3.05	Chemistry of Natural products: Bioactive Compounds	3	36	24	12		Tô Hải Tùng
24	CHEM2.10	Catalysis	3	36	24	6	6	Trần Đình Phong & Nguyễn Ngọc Đức
25	CHEM3.07	Chemistry of Materials in Energy Conversion and Storage I	3	36	30		6	Lê Thị Lý
26	CHEM3.08	Chemistry of Materials in Energy Conversion and Storage II	3	36	24	6	6	Trần Đình Phong & Nguyễn Ngọc Đức
27	CHEM3.09	Chemistry of Heterocyclic Compounds	2	24	24	0	0	Tô Hải Tùng
28	CHEM3.10	Chemistry of Surfactants and Formulation of Life Products	3	36	24	12	0	Nguyễn Đức Anh
29	CHEM3.11	Project-based course III:	2	24	8	16	0	Lê Thị Lý & Lê Văn Hoàng
30	I3.1	Internship	20					

<u>CHEM2.01</u>: ANALYTICAL CHEMISTRY

I. Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	28		8	**36**

3.Prerequisites: General Chemistry, Inorganic chemistry

4.Recommended background knowledge:

5.Subject description:

This course will give to students in the first part the basic knowledge of analytical chemistry, the basic tool used in analytical chemistry field. In the second part, the students will learned the basic of sample preparation with different kinds of samples (gas, liquid, solid). 4 main equilibrium in the solution will be taught in the third part. This part will provide student the understanding of existing form in the solution. The fourth part will give to students the basic analysis by titration and gravimetric method applying 4 equilibrium above.

6.Objectives & Outcome:

After this course, the successful student will:

- be able to evaluate if a measurement is statistically significant and, if it is, report the value of the measurement to the correct precision
- be aware of the capabilities of many measurement techniques and be able to select an appropriate technique for measuring the composition of a sample
- recognize when measurement science can contribute to the solution of a problem, and also recognize aspects of a problem that cannot be dealt with by measurement
- know how to make a buffer and understand why buffers are important
- know how to make a working curve, a working curve using internal standards, a determination using standard additions, and know when to use each approach
- understand the importance of reagent blanks and instrumental background
- be able to compute speciation in a complex mixture at equilibrium
- understand and can apply common analytical methods: titration, gravimetric analysis.
- learn the basic principle of instrumental analysis used for analysing both inorganic and organic substances.

7.Assessment/ Evaluation

Component	Attendance	Practical	Assignments	Reports	Midterm	Final
Percentage %	10-20%	10-25%	0	0	20-30%	40-50%

8.Prescribed Textbook(s)

1. . Daniel C. Harris. Quantitative Chemical Analysis. Eighth Edition. W. H. Freeman and Company, 2010.
2. David Harvey. Modern Analytical Chemistry. McGraw-Hill, 2000
3. Gary D. Christian. Fundamentals of Analytical Chemistry. Sixth Edition. John Wiley & Sons, Ins, 2004.
4. D. Kealey & P.J. Haines. Analytical chemistry. Instant notes. BIOS Scientific Publishers Ltd., 2002

II. Course content & schedule:

1. Introduction of analytical chemistry

General Steps in a chemical analysis

2. Basic Tool of analytical chemistry

-Significant number in analytical chemistry
- Unit for Expressing concentration
- Basic equipment and instrumentation
- Preparing solutions
- Titration Calculations
- Volumetric and Gravimetric equipment
- The laboratory notebook
- Statistics in analytical chemistry
  + Experimental error
  + Propagation of uncertainty
  + Significant Test

3. Calibrations, standardizations and blank corrections

- Methods of least squares
- Calibration curves

4. Sample preparation

- Statistics of sampling
- Dissolving Samples for Analysis
- Sample preparation Techniques

5. Chemical Equilibrium

- The Equilibrium Constant
- Acid- base Equilibria, pH, Buffer
- Complex Formation
- Solubility Product ; The effect of Ionic strength on solubility of Salts
- Redox Reactions

6. Volumetric analysis / Titration

- Acid- base Titrations
- EDTA titrations
- Titrations based on precipitation reactions
- Redox Titration

7. Gravimetric Methods of analysis

- Precipitation
- Combustion Analysis

8. Introduction to instrumental analysis

Fundamentals and Applications of Spectrophotometry, Atomic spectroscopy

Chromatography and other separation techniques

9. Application

- Determination of acidity, alkalinity, total hardness
- Determination of Fe percentage in Mohr salt
- Determination of major components in cement
- Determination of Fe, Cu, Al, Zn in the alloy of aluminium

10. Practicals

Determination of Fe percentage in Mohr salt by gravimetric method and by using UV-Vis (NANO specialty)

Calibration glassware and determination of Fe species in Mohr salt by using UV-Vis (CHEM specialty)

III. Reference Literature:

<u>CHEM2.02</u>: ANALYTICAL CHEMISTRY LAB

I. Course description:

1.Credit points: 2 ECTS

2.Time commitment:

Items	Lecture	Lab-work	Tutorial	**Total**
No. of hours		32		**32**

3.Prerequisites: General Chemistry, Analytical chemistry

4.Recommended background knowledge: No

5.Subject description:

This course will provide to students:

- the basic skills in the laboratory
- the use of lab-wares
- the basic steps for analysing a sample
- the application of equilibrium in analysing sample

6.Objectives & Outcome:

After this course, the successful student will:

- be able to prepare solutions in laboratory.
- be aware of the capabilities of many measurement techniques and be able to select an appropriate technique for measuring the composition of a sample
- be able to analyse the quantity of a substance in real samples at % level

7.Assessment/ Evaluation:

Component	Attendance	Practical report	Assignments	Midterm	Final
Percentage %	30	40	0	0	30

8.Prescribed Textbook(s):

- Daniel C. Harris. Quantitative Chemical Analysis. Eighth Edition. W. H. Freeman and Company, 2010.

- David Harvey. Modern Analytical Chemistry. McGraw-Hill, 2000

- Vogel's. Text book of Quantitative Chemical Analysis. 5th edition. John Wiley and Sons, 1989.

II. Course content & schedule:

- Determination of acidity
- Determination of alkalinity
- Determination of total hardness
- Determination of Fe percentage in $(NH4)_2FeSO_4.12H_2O$
- Determination of Al_2O_3, Fe_2O_3, CaO, MgO in cement
- Determination of Fe, Cu, Al, Zn in the alloy of aluminium

III. Reference Literature: N/A.

CHEM2.03: INORGANIC CHEMISTRY I

I. Course description:

1.Credit points: 2 ECTS

2.Time commitment:

Items	Lecture	Practical	Tutorial	**Total**
No. of hours	16	4	4	**24**

3.Prerequisites: General chemistry I, General chemistry II

4.Recommended background knowledge: A basic understanding on atomic structure, chemical bond and chemical reactions

5.Subject description:

This course aims to strengthen understanding of students on several general concepts that have been described in General Chemistry I, II such as chemical bonding in molecules, chemical bonding in condensed structures, impacts of chemical bonding on physio-chemical properties. These concepts are subsequently used to understand the chemistry of Hydrogen, the group 1 elements and the group 14 elements. The chemistry of these elements plays a critical role in their current application in energy conversion and storage (fuel cells, battery, solar cell)

6.Objectives & Outcome:

After this course, student should be able to:
+ Describe the electronic structure of atom, especially that of d-elements.
+ Describe different type of chemical bonding within molecules and in condensed systems.
+ Get familiar with impacts of chemical bonds on physio-chemical properties.
+ Get familiar with acid-base, redox properties.
+ Describe key chemical properties of Hydrogen, group 1 and group 14 elements

7.Assessment/ Evaluation:

Component	Attendance	Exercises	Assignments	Practice	Midterm	Final
Percentage %		0	20	0	30	50

8.Prescribed Textbook(s):

Inorganic Chemistry by Atkins, Overton, Rourke, Weller, Amstrong. Fifth edition, 2010. Oxford University Press

II. Course content & schedule:

Chapter	Contents	Hours			Ref./Resources	Assignment(s)
		Lect.	Exr.	Prc.		
1	**Atomic structure, the periodic trends**	1.5				
2	**Molecular structure and bonding** (Recall of Valence bond theory, Molecular orbital theory, Structure and bond properties)	1.5	1			
3	**Structure of simple solids** (structure of metals, alloys, ionic solids; defects	3.0	1			

	and non-stoichiometry)					
4	**Acid-bases** (Bronsted and Lewis concepts on acidity)	**1**	**1**			
5	**Oxidation-Reduction** (Redox potential, redox stability, diagrammatic presentation of potential data)	**3**	**1**	**2**		Redox chemistry of water and CO_2
	Midterm examination					
6	**The group I elements** (The elements, hydrides, oxides, chalcogenides, solubility and hydration)	**3**				Chemistry in Li battery
7	**The group 14 elements** (The elements, extended Si-O compounds, carbon-based materials, the use of Si in energy devices)	**3**		**2**		The chemistry of carbon-based materials
	Final examination					
	Total	**16**	**4**	**4**		

III. Reference Literature: N/A.

- Chemical functionalization of carbon nanomaterials : chemistry and applications by Vijay Kumar Thakur, Manju Kumari Thakur; CRC press, 2018
- Physics and chemistry of carbon-based materials, edited by Kubozono, Springer 2019

CHEM 2.04: INORGANIC CHEMISTRY II

I.Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	24	6	6	**36**

3.Prerequisites: General chemistry I, II and Inorganic Chemistry I

4.Recommended background knowledge: Electronic structure of atom, Molecular orbital, Fundamentals of chemical reactions.

5.Subject description:

This course is a continuation of the Inorganic Chemistry I. It describes the physio-chemical aspects of coordination compounds of d-block elements: ranging from chemical bonding, geometry, electronic spectra, thermodynamics of its formation, its preparation to its reactivity as well as some of its potential application.

6.Objectives & Outcome:

After this course, students are able to:

+ Describe the formation of complexes of d-block elements: bonding & geometry. Distinguish bonding within these complexes with that of covalent compounds.

+ Understand the impacts of constitution and structure of complexes onto its physical and chemical properties (chemical reactivity).

+ Propose appropriate strategy to synthesize a targeted complex as well as describe its expected physio-chemical properties.

+ Understand the biological role as well as potential applications of coordination complexes.

7.Assessment/ Evaluation

Component	Attendance	Exercises	Assignments	Reports	Midterm	Final
Percentage %	0	0	20	20	30	30

8.Prescribed Textbook(s)

[1]. Inorganic Chemistry by Atkins, Overton, Rourke, Weller, Amstrong. Fifth edition, 2010. Oxford University Press.

II. Course content & schedule:

Chapter	**Contents**	**Hours** Lect.	Exr.	Prc.	**Remarks**
1	**Lecture 1: General concepts in coordination chemistry** (ligands, nomenclature, constitution and geometry, thermodynamics of complex formation)	**2**			
	Lecture 2: d-metal organometallic chemistry: Chemical bonding	**2**	**1**		

	(18 e rule, coordination number, electron counting, oxidation state)				
	Lectures 3,4: d-metal complexes: electronic structure and properties (Crystal field theory, ligand field theory)	**4**	**2**		
	Lectures 5,6: d-metal complexes: electronic structure and properties (Electronic spectra, charge-transfer band, selection rule)	**4**	**1**	**3**	**Lab work 1**: Preparation and UV-vis spectra of $[Co(H_2O)_6]^{2+}$, $[Co(NH_3)_6]^{2+}$ and $[CoCl_4]^{2-}$ complexes
	Lecture 7: Preparation of some selected complexes (with typical ligands like CO, PR_3, hydride, alkyl, alkene, diene, carbenes)	**2**			
	Lectures 8-10: Reactions of coordination compounds (ligand substitution, redox reaction, photochemical reaction)	**6**	**2**	3	**Lab work 2**: Preparation of cobaloxime, its oxidation by O_2, its reduction by $NaBH_4$
	Lecture 11: Application of physical methods in coordination chemistry (Isolation, NMR, EPR, IR, Raman, Crystallography)	**2**			
	Lecture 12: Biological inorganic chemistry (electron transfer, oxygen transport and storage, catalytic processes, nitrogen cycle, the chemistry of elements in medicine)	**2**			
	Total	**24**	**6**	**6**	

III. Reference Literature:

The organometallic chemistry of transition metals, by Crabtree, Fourth edition, Wiley Interscience, 2005

CHEM2.05: INSTRUMENTAL ANALYSIS I

I.Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	24	6	6	**36**

3.Prerequisites:

4.Recommended background knowledge: General chemistry, Analytical Chemistry

5.Subject description:

The course will provide principles of spectroscopic methods which have been applied in characterization of diverse samples. The students will be able to understand the basics of spectroscopic methods and practical experiences in the usage of modern 21^{st} century analytical instruments. Several examples of characterization of pharmaceutical, environmental, biological samples by spectroscopic methods will also be provided to participants.

6.Objectives & Outcome:

After this course, the students will understand about theories and practical applications of wide range of optical instrumentations including Ultraviolet–visible spectroscopy, Fluorescence, Phosphorescence, Chemiluminescence, Atomic absorption spectroscopy, Emission spectroscopy, Near-Infrared Absorption spectroscopy, Infrared Absorption spectroscopy and Raman spectroscopy. X-ray based spectroscopy methods and their applications in surface characterization will be briefly discussed

7.Assessment/ Evaluation

Component	Attendance	Labwork	Assignments	Reports	Midterm	Final
Percentage %	10	10	0	0	30	50

8.Prescribed Textbook(s)

Principles of Instrumental Analysis – Douglas A. Skoog, James J. Leary

II. Course content & schedule:

Class	**Contents**	**Hours**			**Ref./Resources**	**Assignment(s)**
		Lect.	**Exr.**	**Prc.**		
1	Introduction - Classification of Analytical methods - Types of Instrumental methods - Instrumental Analysis Properties of Electromagnetic Radiation - An overview - Electromagnetic Radiation - Properties of Electromagnetic Radiation - Examples of Electromagnetic Radiation	3				
2	Optical Spectroscopy - Optical instruments components	3	1			

	- Radiation sources - Wavelength selectors - Radiation detectors - Signal processors - Fiber optics - Examples of samples and instrument designs Exercises					
3	Ultraviolet–visible spectroscopy - Principles of Absorption spectroscopy - Molar absorptivity and absorbing species - Quantitative analysis of Absorption measurements - Qualitative analysis of Absorption measurements - Examples of Absorption measurement instruments Exercises	3	1	3		
4	Molecular Fluorescence, Phosphorescence and Chemiluminescence - Theory of Fluorescence and Phosphorescence - Applications of Fluorescence and Phosphorescence methods - Examples of Fluorescence and Phosphorescence instruments - Chemiluminescence Exercises	3	1			
5	Mid-term exam	2				
5	Atomic spectroscopy - Sample atomization - Types and Sources of Atomic spectra - Flame and electro-thermal atomization - Atomic Absorption spectroscopy - Flame emission spectroscopy - Examples of Atomic spectroscopy Instruments Emission spectroscopy - Emission spectroscopy based on plasma sources - Emission spectroscopy based on Arc and Spark sources - Examples of Emission spectroscopy instruments Exercises	2	1			
6	Infrared Absorption Spectroscopy - Theory of Infrared Absorption - Infrared sources and detectors - Infrared instruments - Quantitative analysis of Infrared Absorption measurements - Qualitative analysis of Infrared	2	1	3		

	Absorption measurements - Near-infrared spectroscopy - Examples of Infrared Absorption Spectroscopy instruments Exercises					
7	Raman spectroscopy - Theory of Raman spectroscopy - Instrumental design of Raman spectroscopy - Quantitative analysis of Raman spectroscopy - Applications of Raman spectroscopy - Examples of Raman Spectroscopy instruments Exercises	2	1			
8	X-Ray based spectroscopy - Fundamental principles - Instrumental components - X-Ray Fluorescence methods - X-Ray Absorption methods - X-Ray Diffraction methods - Examples of X-Ray based spectroscopy instruments Exercises	2	1			
9	Separation method - An Introduction to Chromatographic Separations. - Gas Chromatography - High-Performance Liquid Chromatography	2				

III. Reference Literature:

[1] Principles of Instrumental Analysis – Douglas A. Skoog, James J. Leary

[2] Analytical chemistry and quantitative analysis – Hage Carr

CHEM2.06: ORGANIC CHEMISTRY II

I. Course description:

1. **Credit points:** 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	24	6	6	**36**

3.Prerequisites: General Chemistry; Organic Chemistry I.

4.Recommended background knowledge: Chemistry, Maths.

5.Subject description:

The course Organic Chemistry II is to continue providing students the main classes of organic functionalities and main organic reactions mechanisms. In the course, the student will study: (1) Stereochemistry; (2) Radical and radical reactions; (3) Nucleophilic substitution reactions; (4) Elimination reactions; (5) Addition reaction to multiple bonds (C-C; C-O); (6) Electrophilic substitution to aromatic compounds; (7) Reduction and Oxidation reactions; (8) Pericyclic reactions.

6.Objectives & Outcome:

After the course, students will be able to:

- Understand the reactions of organic functionalities.
- Provide the reactions mechanisms
- Understand and analyze the effects of surrounding conditions to organic reactions
- Propose a reactions plan for organic synthesis
- Ability to work as a team to solve a given problem (team project).
- Ability to present the solution of their team to the whole class.

7.Assessment/ Evaluation

Component	Attendance	Exercises	Practice	Reports	Midterm	Final
Percentage %	0	10	10	0	20	60

8.Prescribed Textbook(s)

[1]. T.W. Graham Solomon, Craig B. Fryhle, Scott A. Snyder, **Organic Chemistry 11th Edition**, Wiley, 2013

[2] Francis A. Carey, Richard J. Sundberg; **Advanced Organic Chemistry - Part A and B, 5th Edition,** Springer, 2007

II. Course content & schedule:

Chapter 1: Stereochemistry

1.1. Configuration

1.2. Conformation

1.3. Stereoselective and Stereospecific Reactions

Chapter 2: Radical and Radical reactions

2.1. Radicals

2.2. Radical substitution of alkanes

2.3. Radical addition and polymerization of alkenes

Chapter 3: Nucleophilic substitution reactions

3.1. Mechanisms for Nucleophilic Substitution

3.2. Structural and Solvation Effects on Reactivity

3.3. Structure and Reactions of Carbocation Intermediates

Chapter 4: Elimination reactions

4.1. Mechanisms for Elimination
4.2. Regiochemistry and stereochemistry of Elimination reactions

Chapter 5: Addition reactions to multiple bonds

5.1. Addition reaction to carbon-carbon multiple bonds
5.2. Addition reaction to carbon – oxygen double bonds

Chapter 6: Carbonyl compounds

6.1. The α-carbon substitution of carbonyl groups
6.2. Acyl substitution reactions of carboxylic acid and its derivatives.

Chapter 7: Aromatic compounds

7.1. Aromaticity
7.2. Aromatic reactions

Chapter 7: Reduction and Oxidation reaction

8.1. Reduction reactions
8.2. Oxidation reactions

Chapter 8: Pericyclic reactions

9.1. The Diels – Alder reactions
9.2. 1,3-dipolar cycloaddition reactions
9.3. [2+2] cycloaddition reactions

Chapter 9: Chemistry of amines

10.1. Basicity of amines
10.2. Diazonium salts
10.3. Click Azide – Alkynes reactions

CHEM2.07: PHYSICAL CHEMISTRY I

I. Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	24	6	6	**36**

3.Prerequisites: General chemistry.

4.Recommended background knowledge: General chemistry.

5.Subject description:

The course provides the learners basic and modern knowledge on theorical and experimental basics of chemical thermodynamics such as heat and energy, chemical equilibrium, phase equilibrium, optimal conditions of a reaction in labs, industrial sectors or nature. The applications of theses knowledge in industry.

Besides, the course provides the learners an environment to develop the personal skills such as finding and resolving the problem, the ability of life-long studying, and other professional skills for working in the future.

6.Objectives & Outcome:

On successful completion of the course students will be able to:

- Explain and apply concepts of physical chemistry;
- Explain the broad role of the chemist and chemical engineer in physical chemical measurements and processes;
- Solve problems in physical chemistry by using appropriate methodologies;
- Demonstrate procedures and instrumental methods applied in analytical and practical tasks of physical chemistry;
- Apply the scientific process in the design, conduct, evaluation and reporting of experimental investigations;
- Assess and mitigate risks when working with chemicals and hazardous substances

7.Assessment/ Evaluation

Component	Attendance	Exercises	Practical	Reports	Midterm	Final
Percentage %	5	10	20	0	30	35

8.Prescribed Textbook(s):

[1] Physical Chemistry, P. W. Atkins, Sixth edition, Oxford University Press

II. Course content & schedule:

Class	Contents	Hours: Lect.	Hours: Exr.	Hours: Prc.	Ref./Resources	Assignment(s)
1	**Chapter 1. Revisited Thermodynamic basic** The first Law The second Law Gibbs Free Energy Chemical potential	2	0	0		
2	**Chapter 2. Chemical Equilibrium** *I. Chemical Equilibrium and Equilibrium constant*	2				

	II. The response of equilibria to the conditions II.1. The response of equilibria to temperature – Van't Hoff equation					
3	II.2. How equilibria respond to pressure II.3. How equilibria respond to inert addition II.4. The response of equilibria to concentration II.5. Le Chatelier principle	2	0	0		
4	*III. Chemical equilibrium of heterogenous systems* *IV. Methods to determine the equilibrium constant*	1	1			
5	**Chapter 3. Phase rules** *I. Phase, components and degree of freedom* *II. The Gibbs's phase rule*	2	0	0		
6	*III. Phase transition and phase equilibrium* *IV. The phase diagrams rule*	2				
7	**Chapter 4. Phase equilibrium of pure substances** *I. The response of transition temperature to pressure - Clapeyron equation* *II. The response of vapour pressure to temperature - Clausius Clapeyron equation*	2	0	0		
8	*III. Phase diagrams of of pure substance*	1	1			
9	***Practical 1: Vapour pressure - Clausius Clapeyron equation***	0	0	3		
10	**Chapter 5: The properties of mixtures** *I. Homogenous mixtures (Solutions)* Ideal solutions -Raoult's law Ideal–dilute solutions Real solutions – Henry's Law	2	0	0		
11	*II. Colligative properties of ideal–dilute solutions* II.1. Lowering the vapour pressure II.2. Elevation of boiling point II.3. Depression of freezing point II.4. Osmotic pressure	2				
12	*III. Phase diagrams of mixtures* III.1. Vapour-liquid phase diagrams III.2. Liquid-liquid phase diagrams a. Completely miscible liquids Ideal solutions Raoult and Dalton law Konovalop-1 law	2	0	0		
13	Real solutions Konovalop-2 law Distillation of solutions b. Immiscible liquids Liquid – vapour equilibrium The boiling point Steam distillation Liquid – liquid equilibrium c. Partially miscible liquids	2	0	0		
14	III.3. Liquid-solid phase diagrams	2	0	0		

	Solubility – Shreder's equation					
15	***Practical 2: Mixtures of 2 partially miscible liquids***	0	0	3		
16	Exercises	0	2	0		
17	Exercises and Conclusion	0	2	0		

III. Reference Literature:

CHEM2.08: PHYSICAL CHEMISTRY II

I.Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	24	6	6	**36**

3.Prerequisites: General Chemistry

4.Recommended background knowledge: General Chemistry

5.Subject description:

This Part 1: Kinetics including reaction mechanism, chain reactions, photochemistry reactions and collision theory.

Part 2: Dispersion systems including interfaces, surface tension, wetting, surfactants, disperse systems and properties.

6.Objectives & Outcome:

After this course, students can be able to get fundamental and modern knowledge of:

- Kinetic rules, mechanism, optimal conditions of a chemical reaction in nature, in lab, and in industries as well as in life.
- Dispersion systems and surficial phenomena relating to chemical technology.

7.Assessment/ Evaluation

Component	Attendance	Exercises	Practical	Reports	Midterm	Final
Percentage %	5	10	15		30	40

8.Prescribed Textbook(s):

[1] Physical Chemistry, P. W. Atkins, nine edition, Oxford University Press

II. Course content & schedule:

Class	Contents	Hours: Lect.	Hours: Exr.	Hours: Prc.	Ref./Resources	Assignment(s)
1-4	**PART 1: KINETIC** **Chapter 1.1:** Chemical kinetic I.1. The rates of chemical reactions I.2. Reaction dynamic I.4. Collision theory and Transition-state theory	6	0	0		
5-7	**Chapter 1.2:** Kinetic of photochemistry reactions and Chain reactions	6	0	0		
8	*Exercises*	0	2	0		
9	***Practical 1**: Study of first order reaction kinetics*	0	0	3		
10	**PART 2: DISPERSE SYSTEMS** **Chapter 2.1.** Introduction to Interfacial Phenomena I.1. Surface tension I.2. Surfactant	4	0	0		
11	**Chapter 2.2.** Introduction of disperse systems 1. Some definitions 2. Classification	2	0	0		
12-14	**Chapter 2.3.** Properties of colloids	6				

	1. Molecular kinetic properties 2. Optical properties 3. Electric properties 4. Structure 5. Fabrication of colloids 6. Purification of colloids 7. Stability and aggregation of colloids					
15-16	*Exercises*	0	4	0		
17	***Practical 2**: Preparation and aggregation of colloids*	0	0	3		

III. Reference Literature:

CHEM2.09: PROJECT BASED I

Synthesis Silver Nanostructure

I.Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	16	0	20	**36**

3.Prerequisites: None

4.Recommended background knowledge: Inorganic chemistry

5.Subject description:

The reason: Silver nanoparticles are presented as a magical material/ solution for many application for example: to kill bacteria even virus, catalyst, sensor, ... Therefore, it could be a good time to get students discover this material and learn about it physico-chemical or/and biological properties.

Student learns through a given topics. The assigned topics simulates an actual issue/ challenge being confronted by our society. Students are expected to gain both literature knowledge and experimental skills under the guidance of lecturers.

6.Objectives & Outcome:

Literature understanding:

+ Overview of silver nanostructure: shape, size, method and application

+ Preparation methods for different Ag nanostructures (e.g. nanosphere, nanowires, etc).

+ Methods to stabilize these Ag nanostructures in solution, gel, solid matrix.

+ Physical, Chemical and Biological properties of these Ag nanostructures (e.g. plasmonic absorption)

Experimental proofs

+ Each student should submit 01 sample of Ag nanostructure stabilized (either in solution, gel or solid).

+ Technical details about the material submitted: morphology (scanning electron microscopy - SEM, absorption spectrum (UV-Vis),

7.Assessment/ Evaluation

Component	Attendance	Literature review	Practical	Reports	Midterm	Final report
Percentage %	0	30	30	0	0	40

8.Prescribed Textbook(s)

Scientific papers

II. Course content & schedule:

Part I: 8 section of 2h each

+ In each section (2 section/ week), each student is asked to make a short presentation (about 15 min) about his/ her literature work to fulfill the literature understanding requirement (see the section 3(i) this above).

After each presentation, instructors will comment/ suggest so the students could further improve their understanding. She/ he will then present their improved version in the subsequent section.

+ When completing 8 sections, each student need to submit an experimental plan to prepare his/ her silver nanostructure. The experimental plan should be as details as possible. The instructors will then ask for revision or approve the experimental plan.

Part II: 01 month of experimentation

+ Upon approval of the experimental plan, Department will offer chemicals and materials to students. They should keep these stuffs inside the Chemistry practical lab (Room 705, USTH).
+ Department will assign an instructor to guide the student during his/ her experimentation: teach the experimental skills.
+ Each student need to arrange with his/ her instructor for suitable time to conduct his/ her experiment.
+ When the sample is ready (upon the approval of the Lab instructor), student can request for characterizations: FTIR (USTH), UV-vis (USTH) and SEM (IMS).
+ When the above characterizations are available, the students should submit to get approval of the instructors.
+ Subsequently, the instructors will recommend students with samples for catalytic activity measurement (at USTH).

Part III. Report preparation

+ When the samples and characterization results are available, student should submit and discuss with his/ her instructor to get approval.
+ Student will then prepare a final report (the template will be provided).
+ Final report will be then submitted to the instructor to approve for the final result

CHEM2.11: FOOD CHEMISTRY AND TECHNOLOGY

I. Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	30		6	**36**

3.Prerequisites: Organic Chemistry, General biology

4.Recommended background knowledge: English reading and comprehension

5.Subject description:

The course covers the following:

- Introduction to major classes of Biochemistry in Foods
- Structure and functions of important proteins in Foods
- Introduction, structure, functions and affecting factors of enzymes in Foods
- Properties, synthesis and functions of lipids in Foods
- Introduction, structure and properties of Carbohydrates in Foods
- Aromatic compounds, vitamins in Foods
- Important food additives
- Sources and properties of food contamination
- Introduction to Some products in Food industry

6.Objectives & Outcome:

Upon completion of the course, the student should achieve an understanding of the following:

- The structure, characteristics, functions of 4 main biological compounds in Foods
- The structure, characteristics, functions of important proteins in Foods
- Characteristic and functions of Aromatic compounds and vitamins in Foods
- Food additives and Food contamination
- Basic food products

7.Assessment/ Evaluation:

Component	Attendance	Report	Assignments	Lab-work	Midterm	Final
Percentage %	10	20	0	0	20	50

8.Prescribed Textbook(s):

[1] Belitz, H.-D., Grosch, W. & Schieberle, P. *Food Chemistry*. (Springer Berlin Heidelberg, 2009). doi:10.1007/978-3-540-69934-7

II. Course content & schedule:

Class	Contents	Hours			Ref./Resources	Assignment(s)
		Lect.	Tut.	Lab.		
1	Amino acids, Peptides, Proteins	2				
2	Enzymes	2				
3	Lipids	2				

4	Carbohydrates	2				
5	Aroma compounds	2				
6	Vitamins	2				
7	Minerals	2				
8	Food additives	2				
9	Food contamination	2				
10	Some food products	2				
11	Practice 1			3		
12	Practice 2			3		

III. Reference Literature:

CHEM2.12: INSTRUMENTAL ANALYSIS II

I.Course description:

1. Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	24	12	0	**36**

3.Prerequisites: Experimental Section of Project based course

4.Recommended background knowledge: General chemistry, general physics, analytical chemistry and physics

5.Subject description:

The course will provide principles of x-ray diffraction (XRD) method which is a technique used in materials science for determining atomic and molecular structure; Scanning-Electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons; Transmission electron microscope (TEM) is a microscopy technique in which a beam of electrons is transmitted through a specimen to form an image with an ultrathin section less than 100 nm thick or a suspension on a grid; High-resolution transmission electron microscopy (HRTEM) is an imaging of specialized TEM that allows for direct imaging of the atomic structure of the sample; and X-ray photoelectron spectroscopy (XPS) is a surface-sensitive quantitative spectroscopic technique that measures the elemental composition at the parts per thousand range, empirical formula, chemical state and electronic state of the elements.

6. Objectives & Outcome:

After this course, the students will understand about the methodologies to analysis structure phase, microstructure phase and elemental composition of samples. The course will provide the technique of treatment the measurement results.

7.Assessment/ Evaluation

Component	Attendance	Exercises	Practical	Reports	Midterm	Final report
Percentage %	10	30	0	0	20	40

8.Prescribed Textbook(s)

II. Course content & schedule:

Part I: X-ray Diffraction (XRD) (10 hours)

- Chapter 1: X-ray and Diffraction
- Chapter 2: Lattices and Crystal Structures
- Chapter 3: Practical Aspects of X-ray diffraction
- Chapter 4: XRD patterns and software

Part II: X-ray photoelectron Spectroscope (XPS) (6 hours)

- Chapter 1: Introduction, XPS instrumentation
- Chapter 2: Data collection and Quantification
- Chapter 3: Casa XPS

Part III: Scanning Electron Microscope (SEM) (8 hours)

- Chapter 1: Instrumentation, Methodology
- Chapter 2: SEM for Materials Science
- Chapter 3: Shape and Size by using ImageJ software

Part IV: Transmission Electron Microscope (TEM) (6 hours)

- Chapter 1: Instrumentation and methodology of TEM
- Chapter 2: Analysis TEM images

Part V: High-Resolution Transmission Electron Microscope (HRTEM) (6 hours)

- Chapter 1: HRTEM measurement
- Chapter 2: Analysis HRTEM images

III. References Literature:

[1]. X-Ray Diffraction A Practical Approach by C. Suryanarayana, M. Grant Norton

[2]. X-ray photoelectron spectroscopy an introduction to principles and practices by Paul Van der Heide

[3]. Scanning Electron Microscopy by V. Kazmiruk

[4]. Transmission electron microscopy a textbook for materials science by David B. Williams, C. Barry Carter

[5]. High-Resolution Electron Microscopy by John C. H. Spence

CHEM2.13: ORGANIC CHEMISTRY LAB

I.Course description:

1.Credit points: 2 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	4		28	**32**

3.Prerequisites: Organic Chemistry, General Chemistry

4.Recommended background knowledge:

5.Subject description:

The aim of this course is to present (1) the basic techniques in organic chemistry (extraction, distillation and purification), (2) the basic reaction design and operation.

6.Objectives & Outcome:

After the course, students will be able to:

- Read NFPA, HMIS labels and understand the hazard of chemicals used.
- Use of laboratory equipment: Balance, hot plate and heating mantles, micropipette, vacuum pump, rotavapor.
- Separate mixture of liquid-liquid, liquid-solid, gas – liquid. Separate mixtures of substances by chromatographic techniques.
- Assemble glassware and perform the following techniques as a part of synthetic procedures: simple distillation, fractional distillation, steam distillation, reflux, trapping gases.
- Observe and interpret chemical reactions: color change, temperature change, precipitate formation, and gas evolution.
- Extract information and write experimental procedures from laboratory texts and supplemental material.
- Prepare a detailed laboratory notebook as a record of experimental procedure and outcomes.

7.Assessment/ Evaluation

Component	Attendance	Exercises	Practice	Reports	Midterm	Final
Percentage %	0	0	40	0	0	60

8.Prescribed Textbook(s)

[1] Williamson, Kenneth L., **Macroscale and Microscale Organic Experiments, 5th edition,** Houghton Mifflin Company, 2007

II. Course content & schedule:

Chapter 1. Glass tools and safety regulation in organic lab

1.1. Glass tools

1.2. Safety regulation in laboratory

Chapter 2. Basic techniques in organic laboratory

2.1. Extraction

+ Extraction of caffeine from tea leaves

2.2. Crystallization and sublimation

+ Purification of caffeine crystal

+ Melting point measurement

2.3. Distillation

+ Simple distillation
+ Fractional distillation

Chapter 3. Simple reactions set up

3.1. Fisher esterification
3.2. Reduction of vanillin using sodium boron hydride
3.3. Synthesis of methyl orange as Azo dyes
3.4. The Claisen condensation reactions

III. Reference Literature:

[1] J. R. Mohrig, D. Alberg, **Laboratory Techniques in Organic Chemistry**, **4th edition**, W. H. Freeman, 2014

[2] Anne Padias, **Making the Connections 3: A How-To Guide for Organic Chemistry Lab Techniques**, Hayden-McNeil, 2015

CHEM2.14: ORGANIC SYNTHESIS

I.Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	30	6		**36**

3.Prerequisites: Organic chemistry I and II

4.Recommended background knowledge: Chemistry (General Chemistry, Organic chemistry)

5.Subject description:

This is the advanced organic chemistry course with specific directions. The aim of this course is to present the background of general synthetic methods in organic chemistry: the formation of bonds (C-C bond; C-O bond; C-N bond; C-Hal bond …); application of reactions in organic synthesis (oxidation, reduction, cyclization…); the protecting groups in organic synthesis.

6.Objectives & Outcome:

Upon completion of this course, a student should involve knowledge of:

- The basic knowledge of organic synthesis (bond formation, types of reaction, protection …)
- The mechanisms of synthetic methods
- Synthetic strategies
- Experiments of organic synthesis: protocol, purification and determination of products

7. **Assessment/ Evaluation**

Component	Attendance	Exercises	Assignments	Reports	Midterm	Final
Percentage %	10	10	0	0	30	50

8.Prescribed Textbook(s)

[1]. Organic Synthesis, 4th edition, Michael B. Smith, 2016, Elsevier.

II. Course content & schedule:

1. Chapter 1: Introduction

1.1. Definition
1.2. Useful preparations
1.3. Isolation and purification
1.4. Determination of products
1.5. Notice in organic synthesis experiments

2. Chapter 2: Formation of C-C bond

2.1. General strategies
2.2. Methods
2.3. Examples

3. Chapter 3: Formation of C-O bond

3.1. General strategies
3.2. Methods
3.3. Examples

4. **Chapter 4: Formation of C-N bond**

4.1. General strategies

4.2. Methods

4.3. Examples

5. **Chapter 5: Formation of C-Hal bond**

5.1. General strategies

5.2. Methods

5.3. Examples

6. **Chapter 6: Synthesis based on reactions**

6.1. Cyclization reactions

6.2. Reduction reactions

6.3. Oxidation reactions

7. **Chapter 7: Protecting group in organic synthesis**

7.1. General strategies

7.2. Protection of Hydroxyl groups

7.3. Protection of Carbonyl groups

7.4. Protection of Amine groups

III. Reference Literature:

[1]**.** Organic Synthesis (4th edition), Michael B. Smith, Elsevier, 2016

[2]. Principles of Organic Synthesis (3rd edition), Richard O.C. Norman, James M. Coxon, CRC press, 1993

[3]. Modern Organic Synthesis in the Laboratory, Jie Jack Li, Chris Limberakis, Derek A. Pflum, Oxford University Press, 2007.

[4]. Protective Groups in Organic Synthesis (4th edition), Peter G. M. Wuts, Theodora W. Greene, Wiley, 2006.

CHEM2.15: PHYSICO-CHEMISTRY OF SURFACES AND INTERFACES

I. Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	30	4		**34**

3.Prerequisites: General chemistry, General Physics, solid-state-physics

4.Recommended background knowledge: Materials Characterization Technique

5.Subject description:

The aim of this course is to present fundamental, elaboration and characterization techniques of surfaces and interfaces of materials.

6.Objectives & Outcome:

Upon completion of this course, a student should be able to:

- Understand fundamental phenomena at surfaces & interfaces of materials
- Know basic techniques to elaborate solid/solid, solid/liquid, liquid/liquid interfaces
- Know basic techniques to characterize interfaces

7.Assessment/ Evaluation

Component	Attendance	Exercises	Assignments	Reports	Midterm	Final
Percentage %	10	0	0	20		70

8.Prescribed Textbook(s):

[1] Physics and Chemistry of Interfaces – Hans-Jürgen Butt, Karlheinz Graf, Michael Kappl, Wiley Publisher, 2003 (the most recommended)

[2] Jacob N Israelachvili, Intermolecular and Surfaces forces.

[3] Adamson, Physical chemistry of surfaces.

[4] J Lyklema, Fundamentals of Interface and Colloid Science.

[5] HS Nalwa, Handbook of Surfaces and Interfaces of Materials

II. Course content & schedule:

Class	Contents	Hours: Lect.	Exr.	Prc.	Ref./Resources	Assignment(s)
1	**1. Introduction**	0	0	0		
2	**2. Liquid surfaces** 2.1. Surface tension ● Macroscopic and microscopic definitions ● Dynamic and thermodynamic calculations 2.2. Young – Laplace equation ● Curvature of the surface ● Laplace pressure ● Relationship between surface curvature and Laplace pressure (Young-Laplace equation) ● Derivation of Young-Laplace equation (both dynamic and thermodynamic approaches)	4	1	0	Chapter 2, textbook	

	● Case 1: Liquid drop in air ● Case 2: Air bubble in liquid ● Case 3: Soap bubble 2.3. Kelvin equation ● Vapour pressure ● Relationship between vapour pressure and surface curvature (Kelvin equation) ● Derivation of Kelvin equation (both dynamic and thermodynamic approaches) ● Case 1: Liquid drop in vapour – Ostward ripening in unstable fogs ● Case 2: Vapor bubble in liquid – Water boiling ● Case 3: Capillary condensation – Adhesion between two nanoparticles; Adsorption of water into porous materials					
3	**3. Electric double layer (EDL) and effects at charged surfaces** 3.1. Charging mechanism at solid surfaces ● Mercury ● Metals ● Silver iodide ● Oxides ● Mica ● Semiconductors ● Cell membranes 3.2. Helmholtz and Gouy Chapman models 3.3. Poisson-Boltzmann theory of the diffuse double layer ● Poisson-Boltzmann equation ● Solution for planar surfaces at low potentials ● General solution for planar surfaces ● Grahame equation ● Capacity of the diffuse EDL 3.4. Stern model ● Limitations of Poisson-Boltzmann theory ● General description of Stern model ● Case of metal surfaces in electrolytes 3.5. Effects at charged interfaces ● Zeta potential and hydrodynamic radius. ● Navier-Stokes equation ● Electro-Osmosis and streaming potential ● Electrophoresis and sedimentation potential	6	2	0	Chapter 4+5, textbook	
4	**4.Surface forces** 4.1. DLVO theory 4.1.1. Van der Waals interactions ● Keesom, Debye and London interactions ● Lifshitz theory ● Surface energy and Hanmaker constant	4	0	0	Chapter 6, textbook	

	● Case of spherical quartz particle hangs on a planar quartz surface ● Case of two spheres 4.1.2. Electrostatic interactions 4.1.3. Case 1: Stability of colloidal systems 4.2. Non-DLVO interactions ● Solvation forces ● Hydration forces ● Hydrophobic interaction ● Steric interactions ● Friction ● Lubrication 4.3. Description of surface forces ● Derjaguin approximation ● Disjoining pressure					
5	**5. Contact angle phenomena and wetting** 5.1. Young s equation ● Three-phase contact line ● Contact angle ● Relationship between contact angles and surface tensions (Young equation) ● Line tension ● Complete wetting 5.2. Important wetting geometries ● Capillary rise ● Particles at liquid-gas interface ● Network of fibres 5.3. Measurement of water contact angle ● Sessile drop method ● Sessile bubble method ● Wilhelmy plate method ● Capillary rise method ● Hysteresis in contact angle measurements 5.4. Dynamics of wetting and dewetting 5.5. Applications ● Flotation ● Detergency ● Microfluidics ● Adjustable wetting	4	1	0	Chapter 7, textbook	
	Mid-term examination					Presentation (Themes to be updated)
6	**6. Solid surfaces** 6.1. Description of crystalline surfaces ● 2D Bravais lattices ● Low-index cutting crytalline surfaces ● Surface relaxation and reconstruction	8	0	0	Chapter 8, 10, textbook	

	• Surface steps and defects 6.2. Surface energy • Surface energy • Wulff theorem – Crystal shape 6.3. Electronic structures • Work function • p-n junction • M-S junction 6.4 Surface modification • Physisorption • Self-assembled monolayers (SAMs) • Polymerization on surfaces • Chemical vapor deposition (CVD) • Etching 6.5. Characterization of solid surfaces • Morphological behaviors • Structural behaviors • Other behaviors					
7	**7. Adsorption** 7.1. Fundamental concepts • Adsorbate, adsorbent, and adsorpt • Physisorption and Chemisorption • Adsorption time and accommodation coefficient • Description of adsorbate structures: Wood notations 7.2. Classification of Adsorption isotherms 7.3. Adsorption models 7.4. Adsorption from the gas phase • Measurement of adsorption isotherms • Measurement of specific surface area • Adsorption on porous solids – hysteresis 7.5. Adsorption from solution	2	0	0	Chapter 9, textbook	
8	**8. Surfactants, micelles, emulsions and foams** 8.1. Surfactants 8.2. Spherical micelles, cylinders, and bilayers 8.3. Macroemulsions 8.4. Microemulsions 8.5. Foams	2	0	0	Chapter 12, textbook	
9	**Final examination**	0	0	0		Paper test

III. Reference Literature:

CHEM2.16: POLYMER CHEMISTRY

I.Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	24		12	**36**

3.Prerequisites: Polymer Chemistry, Organic Chemistry

4.Recommended background knowledge:

5.Subject description:

The aim of this course is to present the background of polymer science. In the course, students will study: (1) The polymer structure and morphologies, (2) Parameter of polymers, (3) The conventional and modern polymerization methods, (4) The polymerization processes, (5) Modification of polymers

6.Objectives & Outcome:

After the course, students will be able to:

- Describe the different type of polymers
- Understand mechanisms of conventional and controlled polymerization methods
- Understand structures and morphologies of polymers and their related properties.
- Determination the parameters of polymers (repeating unit, molecular weight, degree of polymerization…)
- Present applications of polymers and polymer composites.
- Ability to work as a team to solve a given problem.
- Ability to present the solution of their team to the whole class.

7.Assessment/ Evaluation

Component	Attendance	Exercises	Practice	Reports	Midterm	Final
Percentage %	0	0	10	0	30	60

8.Prescribed Textbook(s)

[1] C. E. Carraher, Jr, ***Carraher's Polymer Chemistry – Ninth Edition,*** CRC Press, 2014

II. Course content & schedule:

Chapter 1. Introduction of polymers

Chapter 2. Polymer Parameters

2.1. Degree of polymerization

2.2. Molar mass of polymers

2.3. Polymer Dispersity index

Chapter 3. Polymer Structures and properties

3.1. Polymer chain model

3.2. Structures and conformation of polymers

3.3. Polymer morphologies

Chapter 4. Polymerization Techniques

4.1. Conventional polymerization techniques

4.2. Modern polymerization techniques

Chapter 5. Step-growth polymerization

5.1. Concept of step-growth polymerization

5.2. Step-growth polymers

Chapter 6. Conventional chain-growth polymerization

6.1. Concept of chain-growth polymerization

6.2. Free radical polymerization

6.3. Ionic polymerization

6.4. Stereoregular polymerization

Chapter 7. Controlled radical polymerization

7.1. Reversible termination polymerization

7.2. Reversible chain transfer polymerization

7.3. Ring-opening polymerization

7.4. Metathesis ring-opening polymerization

Chapter 8. Reactions of polymers – Polymer modification

8.1. Crosslinking

8.2. Polymer Degradation

Chapter 9. Advanced polymers

9.1. Copolymers - Design of well-defined copolymer

9.2. Conducting polymers

9.3. Stimuli-responsed polymers

III. Reference Literature:

[1] G. Odian, **Principles of Polymerization,** Wiley, 2004

[1]. [2] Wei-Fang Xu, **Principles of Polymer Design and Synthesis, The Lecture Note in Chemistry,** Springer, 2013

CHEM2.17: PROJECT BASED II

I. Course description:

1. Credit points: 3 ECTS

2. Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	16	0	20	**36**

3. Prerequisites: None

4. Recommended background knowledge: Environmental chemistry

5. Subject description:

The reason: Glyphosate has become the most widely used broad-spectrum herbicide in the world and in Vietnam. The use, fate and persistence of herbicide in agricultural field and in urban areas are extremely important to farming and environmental health. Manufacturers report that the half-life of glyphosate in the environment in a few days, but this depends on the type of samples, the microbial community in the environment, and the temperature. Proper quantification of glyphosate persistence, accumulation, and potential residues is increasingly important. Therefore the quantification of glyphosate in different environment such as surface water or sediment could be investigated in undergraduate course.

The student will know how to synthetic the research topic from the literature review, then application for designing the research experiments in the laboratory. Besides, they will learn more techniques in collecting, analyzing the samples and data under the direction of supervisors or lecturers.

6. Objectives & Outcome:

Literature understanding:

+ Literature review for synthesize the method for herbicide glyphosate analysis in water and sediment environments by using UV-Vis or fluorescence spectrometry

+ Method for collecting and analysis of water or sediment samples

+ Physical and chemical characteristic of glyphosate and monitoring parameters of water and sediment samples.

Experimental proofs

+ Each student will collect 01 sample (surface water or sediments from the real fields of the water environment (river, lake, canal, etc.,) to analysis.

+ Analysis tools: materials, chemicals and consumable analysis

+ Analysis equipment: UV-Vis and fluorescence spectrometer

7. Assessment/ Evaluation

Component	Attendance	Literature review	Practical	Reports	Midterm	Final defense
Percentage %	0	20	30	20	0	30

8. Prescribed Textbook(s)

Scientific papers

II. Course content & schedule:

<u>Part I: 8 section of 2h each</u>

+ In each section (2 section/ week), each student is asked to make a short presentation (about 15 min) about his/ her literature work to fulfill the literature understanding requirement (see the section 3(i) this above).

After each presentation, instructors will comment/ suggest so the students could further improve their understanding. She/ he will then present their improved version in the subsequent section.

+ When completing 4 sections, each student need to submit an experimental plan to prepare his/ her laboratory experiment. The experimental plan should be as details as possible. The instructors will then ask for revision or approve the experimental plan.

Part II: 01 month of experimentation

+ Upon approval of the experimental plan, Department will offer chemicals and materials to students. They should keep these stuffs inside the Chemistry practical lab (Room 705, USTH).

+ Department will assign an instructor to guide the student during his/ her experimentation: teach the experimental skills.

+ Each student need to arrange with his/ her instructor for suitable time to conduct his/ her experiment.

+ When the sample is ready (upon the approval of the Lab instructor), student can request for characterizations or analysis on UV-Vis or 3D-Fluor devices.

Part III. Report preparation

+ When the samples and characterization results are available, student should submit and discuss with his/ her instructor to get approval.

+ Student will then prepare a final report (the template will be provided).

+ Students will present their final report in front of a Department committee.

+ Final report will be then submitted to the instructor to approve for the final result.

III. Reference

CHEM2.18: SOLID STATE CHEMISTRY

I. Course description:

1.Credit points: 2 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	20	4		**24**

3.Prerequisites: General chemistry, Inorganic chemistry

4.Recommended background knowledge: Chemical bonding theory, molecular orbital, molecular geometry, thermodynamics of chemical reactions.

5.Subject description:

This course describes (i) the chemical bonding and structure of solid materials, emphasizing its formation and the natural presence of defects; (ii) the interaction of solid material with its environment translating to several important physico-chemical properties like optical absorption, light emission, thermal/ photoconductivity, magnetics, chemical activity and catalysis. Few examples of emerging solid materials like MOFs, 2D transition metal chalcogenides are also discussed in details.

6.Objectives & Outcome:

After this course, students are expected to:

- Have strong knowledge on structure and chemical bonding within solid materials, the nature of defects and the potential strategies to limit or increase these defects.
- Have knowledge on available methods for preparing solid materials as well as characterized their structure.
- Have knowledge on the interaction of solid material with its environment, its physico-chemical properties like thermal/ photoconductivity, light emission, adsorption capability, chemical reactivity and catalytic activity.
- Aware about then contribute to deal with the current challenges in preparation of emerging materials like MOF, perovskite, MoS_2, etc in a well-controlled manner.

7.Assessment/ Evaluation

Component	Attendance	Exercises	Assignments	Reports	Midterm	Final
Percentage %	0	10	0	0	40	50

8.Prescribed Textbook(s)

[1]. Solid State Chemistry: An Introduction (Fourth Edition) by Smart and Moore (2012)

II. Course content & schedule:

Lecture	**Contents**	**Hours**			**Remarks**
		Lect.	**Exr.**	**Prc.**	
1	Chapter 1: An introduction to Crystal structures	**2**	**2**		
2	Chapter 2: Physical methods for characterizing solids	**2**	**2**		
3	Chapter 3: Synthesis method	**2**			

4	Chapter 4: Solids: Their Bonding and Electronic properties	**2**			
5	Chapter 5: Defects and Nonstoichiometry	**2**			
6	Chapter 6: Microporous and Mesoporous solids	**2**			
7	Chapter 7: Optical properties of solids	**2**			
8	Chapter 8: Magnetic and Electrical properties	**2**			
9	Chapter 9: Superconductivity	**2**			
10	Chapter 10: Nanostructures and solids with low-dimensional properties	**2**			
	Total	**20**	**4**		

III. Reference Literature: N/A

CHEM3.6: STRUCTURE DETERMINATION

I.Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	24	12		**36**

3.Prerequisites: Organic chemistry I and II

4.Recommended background knowledge: Chemistry (General Chemistry, Organic chemistry)

5.Subject description:

In this course, student will study physical methods applied in organic chemistry to determine the structure of compounds. These are four main techniques: UV-Vis (Ultraviolet-Visible), IR (Infrared), NMR (Nuclear Magnetic Resonance) and MS (Mass Spectroscopy). The aim of this course is to present operating principle and how to use data of spectra (UV-Vis, IR, NMR and MS) to characterize structure of one organic compounds.

6.Objectives & Outcome:

Upon completion of this course, a student should involve knowledge of:

- The main principle to operate four physical methods
- Data from the methods
- Based on the obtained spectral data, students can determine the structure of non-complex organic compounds

7.Assessment/ Evaluation

Component	Attendance	Exercises	Assignments	Reports	Midterm	Final
Percentage %	10	10	0	0	30	50

8.Prescribed Textbook(s)

[1]. Spectrometric Identification of Organic Compounds, 8th Edition, Robert M. Silverstein, Francis X. Webster, David J. Kiemle, David L. Bryce, Wiley, 2014

II. Course content & schedule:

8. Chapter 1: Introduction

1.1. Physical methods used to determine structure

1.2. Examples

9. Chapter 2: Spectroscopy methods: IR and UV-Vis

2.1. General principle

2.2. UV-Vis applied in structure determination

2.3. IR applied in structure determination

2.4. Examples and exercises

10. Chapter 3: Nuclear Magnetic Resonance

3.1. General principle

3.2. ^{1}H-NMR and ^{13}C-NMR

3.3. General introduction of 2D-NMR

3.4. Examples and exercises

11. Chapter 4: Mass Spectroscopy

4.1. General principle

4.2. Fragmentation in MS

4.3. Examples and exercises

III. Reference Literature:

[1]. Spectrometric Identification of Organic Compounds, 8th Edition, Robert M. Silverstein, Francis X. Webster, David J. Kiemle, David L. Bryce, Wiley, 2014.

[2]. Introduction to Spectroscopy, 5th Edition, Donald L. Pavia, Gary M. Lampman, George S. Kriz, James A. Vyvyan, Cengage Learning, 2014

THIRD YEAR PROGRAM

CHEM3.01: CHEMISTRY OF NANOMATERIALS

I.Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	24	6	6	**36**

3.Prerequisites: General chemistry, Inorganic Chemistry, Organic Chemistry, Electrochemistry

4.Recommended background knowledge: General knowledge of chemistry, inorganic chemistry, organic chemistry and electrochemistry are required. Knowledge in chemical bonding, structure of molecules and condensed materials, principles of chemical reactions (thermodynamic and kinetic aspects) are demanded.

5.Subject description:

This course discusses on (i) chemical methods for preparation of nanomaterials with desired structure and function and (ii) chemistry of materials at nanoscale with special emphasized in catalysis. The first part deals with different chemical approaches/ chemical processes for preparing a functional nanomaterial: e.g. via top-down or bottom up approaches using an acid-based or redox chemical process with or without support of a soft/ hard template for directing the structure. Chemical strategies for post-functioning a nanomaterial in order to achieve a desired structure and operation will be also discussed in parallel with magical one-pot preparation. The second part deals with the description of chemical properties of materials in nanoscale with emphasized in catalysis. A comparison in chemistry at nanoscale to that achieved for a molecule or a bulk material in the milimetric scale will be discussed.

6.Objectives & Outcome:

After this course, the students will be able to:

- Understand the reason behind a choice made in the literature for preparing a nanostructured and functional nanomaterials with a special application perspective.
- Be able to analyze the demand and propose an appropriate chemical process/ strategy for designing and preparing a functional nanomaterial with desired structure and function.
- Understand the differences in chemical properties (reactivity, catalytic activity, etc) of a material in nano size in comparison with an equivalence in molecular or bulk (milimetric) scale.
- Be able to propose a nanostructure to respond an application perspective.

7.Assessment/ Evaluation

Component	Attendance	Exercises	Assignments	Reports	Midterm	Final
Percentage %	10	0	20	20	20	30

8.Prescribed Textbook(s)

[1] NanoChemistry : A chemical approach to nanomaterials by Geoffrey A. Ozin and Andre C. Arsenault, RSC Publishing 2005

Note : A hard copy of this text book is available at USTH Library.

II. Course content & schedule:

Class N	Contents	No. of Hours			Ref./ Resources	Remarks
		Lect.	Exr.	Prc.		

o .						
1	**Class 1: Introduction Nanochemistry basics** (Why nano, general concepts of nanomaterials, nanostructure, nanophysics and nanochemistry)	2h			*Text book, chapter I*	
Part I: Chemistry for preparing nanomaterials						
2	**Class 2: General concepts** (Acid-base reaction, redox reaction, bottom up and top down process to achieve nanosized materials)	3h			*Lecture materials will be provided*	
3	**Class 3: Principles of nanomaterials growing in solution** (Surface tension, size dependences, elemental steps, stabilization of nanomaterials, thermodynamic versus kinetics, some detailed examples)	2h			*Lecture materials will be provided*	
4	**Class 4: Principles of nanomaterials growing in solution (cont.)** (Effect of temperature, surfactant, introducing of surface charges, effect of solvents *etc*)	2h			*Lecture materials will be provided*	
5	**Class 5: Synthesis of nanoparticles in homogeneous solution** From metal salts as precursors, Turkevic method for Au NPs; From Organometallic precursors	2h			*Lecture materials will be provided*	
6	**Class 6: Preparation of nanostructured materials** Nanostructures: nanosphere, nanorods, nanowires, nanopillars, nanotubes Methods: Chemical etching, exfoliation, synthesis with soft and hard templates, Vapor-Liquid-Solid Synthesis of Nanowires, Self-assemblage (SAMS, Layer-by-layer assembled materials)	4h			*Text book, Chapters 2-6*	***Note:*** *Self-learning on:* Physical vapor deposition; chemical vapor deposition; atomic layer deposition.
7	**Exercises on preparation methods for nanomaterials with targeted structure and property**		3h		*Lecture materials will be provided*	
8	**Lab work 1: Preparation of MoS_2 nanoparticles and nanosheets** *Via* a bottom up approach: Chemical oxidation or reduction of $[MoS_4]^{2-}$ precursor			3h	*Detail experimental procedure will be provided*	Work in Lab with teaching assistants and lab assistants

9	**Lab work 2: Preparation of MoS_2 nanoparticles and nanosheets** Via a top down approach: Ultrason-assisted exfoliation of bulk MoS_2			3h	*Detail experimental procedure will be provided*	Work in Lab with teaching assistants and lab assistants
Part II: Chemistry of Nanomaterials						
10	**Class 7: A general description of Chemical reactions (*a recall*)** Thermodynamics (Free Gibbs energy, thermodynamic descriptors for a chemical reaction; Chemical equilibrium); Kinetics (Elemental steps, Chemical reaction rate, Catalysis)	2h			*Lecture materials will be provided*	This class is conducted in the case AMSN students take the course
11	**Class 8: Chemical reactivity in dependence of size, morphology, structure and chemical composition of nanomaterials** Some selected examples are discussed	3h			*Lecture materials will be provided*	
12	**Class 9: Catalytic performance in dependence of size, morphology, structure and chemical composition of nanomaterials** Some selected examples are discussed (*e.g.* nanocatalysts for the hydrogen desulfurization reaction, CO oxidation, organic synthesis)	2h			*Lecture materials will be provided*	
13	**Class 10: Catalytic performance in dependence of size, morphology, structure and chemical composition of nanomaterials (Continued)** Some selected examples are discussed (*e.g.* nanocatalysts for the hydrogen evolution reaction, water oxidation reaction, oxygen reduction reaction)	2h			*Lecture materials will be provided*	
14	**Exercises on special/ unique property of nanostructured materials (in comparison with bulk materials)**		2h		*Lecture materials will be provided*	
15	**Biomimetics: from biological structure to main-made nanostructure**					If the class 7 is not needed

III. Reference Literature: N/A

Nanobiotechnology : Concept, Applications and Perspectives, Edited by C.M. Niemeyer and C. A. Mirkin, Wiley-VCH 2004 (Recommended for an extended reading to those who are interested in the interface between Nanosciences and Biotechnology).

CHEM3.02: ELECTROCHEMISTRY

I. Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	24	4	10	**38**

3.Prerequisites: Students should have knowledge on fundamental physical chemistry

4.Recommended background knowledge: Fundamental knowledge on electrochemistry is needed

5.Subject description:

The course provides basic knowledge on electrochemistry, including fundamental, apparatus and essential electrochemical technique for certain potential applications.

6.Objectives & Outcome:

Understanding the chemistry of some electrochemical objects.

7.Assessment/ Evaluation:

Component	Attendance	Exercise	Practical	Midterm	Final
Percentage %	10	10	20	0	60

8.Prescribed Textbook(s): [1] Allen J. Bard Larry R. Faulkner, Electrochemical Methods: Fundamentals and Applications, John Wiley & Sons, Inc., 2001

II. Course content & schedule:

Class	Contents	Hours: Lect.	Hours: Exr.	Hours: Prc.	Ref./Resources	Assignment(s)
1	**1. General introduction to Electrochemistry** a. Electrochemical Reactors b. Basic electrochemical thermodynamics c. Haft-reaction and reduction potentials d. Nernst equation e. Introduction of interfacial potential differences *i. The Physics of Phase Potentials* *ii. Interactions Between Conducting Phases* *iii. Measurement of Potential*	5	1	0		

	Differences iv. *Electrochemical Potentials* v. *Fermi Level and Absolute Potential*					
2	***2.*** **Mass transfer by migration and diffusion** **a.** Derivation of general mass transfer equation **b.** Migration **c.** Mixed migration and diffusion near an active electrode ***i.*** *Balance Sheets for Mass Transfer During Electrolysis* ***ii.*** *Effect of Adding Excess Electrolyte* **d.** Diffusion ***i.*** *Fick's Laws of Diffusion* **ii.** *Boundary Conditions in Electrochemical Problems*	3	1	0		
3	**3. Kinetics of electrode reactions** a. Butler – Volmermodel of electrode kinetics i. *Dynamic Equilibrium* ii. *The Arrhenius Equation and Potential Energy Surfaces* iii. *Effects of Potential on Energy Barriers* iv. *The Standard Rate*		2	0		

	Constant v. *The Transfer Coefficient* b. Implications of the Butler – Volmer model for the one-step, one-electron process i. *Equilibrium Conditions. The Exchange Current* ii. *The Current-Overpotential Equation* iii. *Approximate Forms of the i-η Equation*					
4	**4. Apparatus and Essential electrochemical technique** a. Conventional electrochemical system b. Potentiometry c. Amperometry d. Voltammetry i. *Potentiostatic* ii. *Potentiodynamic, CV* iii. *Galvanostatic* iv. *Galvanodynamic* v. *Ohmic drop* e. Electrochemical Methods of Analysis	3	0	5		
5	**5. Electrochemical modification and characterization of electrode surface (Application)** a. Using CVS for the modification of electrode surface by reduction of diazonium salts. b. Chemical modification of	6	0	2		

	electrode surface with conducting polymer. c. Electrochemical deposition of metal nanoparticles for application in active plasmon devices. d. Electrochemical Energy Conversion e. Photoelectrochemistry and photogalvanic cells i. *Semiconductor Electrodes* *ii. Current-Potential Curves at Semiconductor Electrodes* *iii. Photo effects at Semiconductor Electrodes* *iv. Surface Photocatalytic Processes at Semiconductor Particles* *v. Electrochemistry of Photolytic Products* *vi. Photogalvanic Cells*					

III. Reference Literature:

[2].[1]. Christopher M.A. Brett and Ana Maria Olivia Brett, Electrochemistry: Principles, Methods and Applications, Oxford University Press, 1993.

[3].[2]. V. S. Bagotsky, Fundamentals of Electrochemistry, Second Edition, John Wiley & Sons, Inc., Publication, 2005

[4].[3]. R.G.Compton, C.E. Banks, Understanding Voltammetry, Second Edition, Imperial College Press, 201

CHEM3.03: BIOCHEMISTRY AND BIOINORGANIC CHEMISTRY

I.Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	30		6	**36**

3.Prerequisites: Organic Chemistry, General biology

4.Recommended background knowledge: English reading and comprehension

5.Subject description:

The course covers the following:

- Composition, structures, characteristics and biological roles of proteins, carbohydrates, lipids, and nucleic acids (DNA and RNA).
- The digestion of carbohydrates, fats, proteins in the body.
- Enzymes and ribozymes: catalysis mechanism, kinetics of enzyme catalysis, activation and inhibition of enzymatic activities, enzyme nomenclature and classification.
- Principles of bioenergetics, metabolism and energy formation, including substrate level phosphorylation and oxidative phosphorylation associated with electron transfer chain.
- General information about structural and molecular biology for chemist
- Concepts of biological ligands for metal ions
- Common methods to study metals in Biological Systems
- Enzymes-Metal structure, interaction and functions for: Sodium & Potassium, Magnesium, Calcium, Zinc, Iron, Copper, Nickel & Cobalt, Manganese and Non-metal.

6.Objectives & Outcome:

Upon completion of the course, the student should achieve an understanding of the following:

- the composition, structure, characteristics, localization, functions of 4 main biological compounds and their degradation and biosynthesis in the living cells and organisms.
- the main metabolic pathways with energy change of the living cells and organisms
- some living phenomena on in the light of biochemistry
- general structure and molecular biology of metal-related enzymes
- common techniques to investigate metals in Biological systems
- Main concept in structures and functions of metal-related protein (relating to Sodium & Potassium, Magnesium, Calcium, Zinc, Iron, Copper, Nickel & Cobalt, Manganese and Non-metal).

7.Assessment/ Evaluation

Component	Attendance	Assay	Assignments	Reports	Midterm	Final
Percentage %	10	20	0	0	20	50

8.Prescribed Textbook(s)

[1] John L. Tymoczko, Jeremy M. Berg, Lubert Stryer, Biochemistry: A Short Course (2nd Edition), 2013

[2] Crichton, R. R. (2012). Biological Inorganic Chemistry: A New Introduction to Molecular Structure and Function (2nd ed.) (2nd ed.). Elsevir. Retrieved from https://www.elsevier.com/books/biological-inorganic-chemistry/crichton/978-0-444-53782-9

[3] Joseph J. Stephanos, A. W. A. (2014). Chemistry of Metalloproteins: Problems and Solutions in Bioinorganic Chemistry. Wiley. Retrieved from https://www.wiley.com/en-us/Chemistry+of+Metalloproteins%3A+Problems+and+Solutions+in+Bioinorganic+Chemistry-p-9781118470442

II. Course content & schedule:

Class	Contents	Hours			Ref./Resources	Assignment(s)
		Lect.	Tut.	Lab.		
1	Introduction. Nucleic acids	3				
2	Protein composition and structure. Enzymes.	3				
3	C-H, Lipids. Cell membranes	1.5				
4	Metabolism. Digestion.	1.5				
5	C-H metabolism.	3				
6	Metabolism of Lipids & N-containing molecules	3				
7	Introduction to basic Coordination Chemistry and Structure of Proteins	2				
8	Intermediary Metabolism and Methods to study metals in Biological systems	2				
9	Sodium and Potassium - Channels and Pumps	2				
10	Magnesium - Phosphate Metabolism and Photoreceptors & Calcium - Cellular Signaling	2				
11	Zinc - Lewis Acid and Gene Regulator	2				
12	Iron: Essential for Almost All Life	2				
13	Copper - Coping with Dioxygen	2				
14	Metals in Medicine and Metals as Drugs	1				
15	Practice: DNA			3		
16	Practice: Proteins			3		

III. Reference Literature:

CHEM3.04: CHEMISTRY OF NATURAL AND BIODEGRADABLE POLYMERS

I.Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	24	0	12	**36**

3.Prerequisites: Polymer Chemistry, Organic Chemistry

4.Recommended background knowledge:

5.Subject description:

This course is an introduction to natural and biodegradable polymers for third-year students. In this course, students will study: (1) factors affected to degradation of polymers; (2) the natural polymers (3) the synthetic biodegradable polymers and (4) polymers processing.

6.Objectives & Outcome:

After the course, students will be able to:

- Understand the different factors affected to degradation mechanism of polymers.
- Understand the methods for stabilization of polymer products
- Propose the use of additive for prevention of degradations
- Understand the structure and chemistry of natural and synthetic biodegradable polymers
- Selection of appropriate methods for production of polymers
- Ability to work as a team to solve a given problem.
- Ability to present the solution of their team to the whole class.

7.Assessment/ Evaluation

Component	Attendance	Exercises	Practice	Reports	Midterm	Final
Percentage %	0	0	20	0	20	60

8.Prescribed Textbook(s)

[1] Michael Niaounakis – **Biopolymers-Reuse, Recycling, and Disposal**, William Andrew Publisher, 2013

[2] Williams P.A. - **Renewable Resources for Functional Polymers and Biomaterials,** RSC, 2011

II. Course content & schedule:

Chapter 1: Polymer degradation

1.1. Thermal degradation in inert media. Polymer burning; Flame retardation

1.2. Thermal-oxidative; photo-oxidative degradations. Antioxidants; Light stablizers Mechanisms

1.3. Biodegradation and chemical degradation.

1.4. Stalibization – Reuse – recycling of polymers

Chapter 2: Natural polymers

2.1. Polysaccharides

2.2. Polyphenols / lignin

2.3. Proteins fibers

2.4. Rubbers

2.5. Biomass Conversion

Chapter 3: Synthetic biopolymers (5 x 1.5h)

3.1. Types of biodegradable polyesters

3.2. Biodegradable plastics compositions

Chapter 4: Polymer processing

III. Reference Literature:

[1] Vladimir Strezov; Tim J Evans, **Biomass processing technologies,** CRC Press, 2014

[2] Ranjit S. Dhillon, **Biomass Conversion_ The Interface of Biotechnology, Chemistry and Materials Science,** Springer**,** 2012

CHEM3.05: CHEMISTRY OF NATURAL PRODUCTS: BIOACTIVE COMPOUNDS

I.Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	24		12	**36**

3.Prerequisites: Organic chemistry I and II

4.Recommended background knowledge: Chemistry (General Chemistry, Organic chemistry)

5.Subject description:

This course is a general introduction of common natural products classes. In this course, students will study main secondary metabolites in nature: carbon-skeleton structure of natural products, classification, isolation from the natural material and production in industry, biosynthesis pathway of compounds.

In addition, application and role of natural compounds will be introduced by the lecture and by the presentation of students

6.Objectives & Outcome:

Upon completion of this course, a student should involve knowledge of:

- Basic knowledge of main secondary metabolites in nature: terpenoids, steroids, flavonoids and alkaloids
- The general biosynthesis pathway of natural compounds
- The application of natural products

7.Assessment/ Evaluation

Component	Attendance	Exercises	Assignments	Reports	Midterm	Final
Percentage %	10	0	10	10	20	50

8.Prescribed Textbook(s)

[1]. Introduction to Natural Products Chemistry, 1st Edition, Rensheng Xu, Yang Ye, Weimin Zhao, CRC Press, 2010

II. Course content & schedule:

Chapter 1: Introduction

1.1. Definition

1.2. Secondary metabolites

1.3. General biosynthesis pathways

1.4. Application of Chemistry of Natural products

Chapter 2: Terpenoid

2.1. Introduction

2.2. Classification

2.3. Structure of Terpenoids

2.4. Biosynthesis

2.5. Role and application

Chapter 3: Steroids

3.1. Introduction

3.2. Classification

3.3. Structure of Steroids

3.4. Biosynthesis

3.5. Role and application

Chapter 4: Flavonoids

4.1. Introduction

4.2. Classification

4.3. Structure of Flavonoids

4.4. Biosynthesis

4.5. Role and application

Chapter 5: Alkaloids

5.1. Introduction

5.2. Classification

5.3. Structure of Alkaloids

5.4. Biosynthesis

5.5. Role and application

III. Reference Literature:

[1]. Introduction to Natural Products Chemistry, 1st Edition, Rensheng Xu, Yang Ye, Weimin Zhao, CRC Press, 2010.

[2]. Natural Products Chemistry: Sources, Separations and Structures, 1st Edition, Raymond Cooper, George Nicola, CRC Press, 2014**:**

CHEM2.10: CATALYSIS

I.Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	24	6	6	**36**

3.Prerequisites: Physical Chemistry, Inorganic Chemistry, Instrumental Analysis

4.Recommended background knowledge: Thermodynamics and kinetics of chemical reactions, coordination chemistry, analytical methods

5.Subject description:

The course introduces key principles of heterogeneous & homogeneous catalysis. Key concepts of catalysis, elementary reactions, reaction pathway, chain reactions and catalytic sequences are discussed. Relevant phenomenon & features such as surface chemistry, porosity, adsorption, desorption, *etc* are also described. The role of catalysis in organic synthesis, chemical industry, energy conversion and environmental treatment processes is emphasized.

This course represents a CORE course for the track: chemistry for energy conversion & storage which will be specialized in the B3 program.

6.Objectives & Outcome:

After this course, the students should be able to:

+ Describe key concepts, terminology of catalysis.
+ Describe and apply the popular kinetics models.
+ Identify important industrial catalytic processes and the most common catalyst materials.
+ Identify reaction sequences and suggest reaction mechanisms for chemical reactions.
+ Have a good knowledge about synthesis methods for preparing catalysts and catalyst characterization methods.

7.Assessment/ Evaluation

Component	Attendance	Exercises	Assignments	Reports	Midterm	Final
Percentage %	0	0	0	20	40	40

8.Prescribed Textbook(s)

I. Chorkendorff and J. W. Niemantsverdriet: Concepts of Modern Catalysis and Kinetics, 3rd edition

II. Course content & schedule:

Chapter	Contents	Hours			Ref./Resources	Assignment(s)/Notes
		Lect.	Exr.	Prc.		
1	Introduction to catalysis	1.5			Chapter 1	
2	Kinetics (the rate equation and power rate law, reaction and thermodynamic equilibrium, integrated rate equations, couple reaction in batch reactor, adsorption isotherms, etc)	3.0	1		Chapter 2	
3	Reaction rate theory (Boltzmann distribution and partition function, collision theory, activation of	3.0	1		Chapter 3	

	reacting molecules by collision, transition state theory, surface reaction)					
4	Catalysis characterization (a recall of XRD, XPS, EXAFS, electron microscopy, AMF; emphasize on, temperature-programmed reduction/ oxidation/ sulfidation, in-situ FTIR, in-situ Raman, etc)	1.5			Chapter 4	Recall on technics being discussed in Instrumental analysis I, II. Emphasize on advanced in-situ technics
5	Homogeneous catalyst	1.5	1		Ref. 1	
6	Organometallic catalysts in organic synthesis	3.0	1	2	Ref. 1	
7	Heterogeneous catalyst (adsorbate sites/ active sites, surface area, catalyst support, catalyst preparation)	1.5	1	2	Chapter 5	
8	Surface reactivity (physisorption, chemical bonding, chemisorption, important trends in surface reactivity)	1.5			Chapter 6	
9	Kinetics of reactions on surfaces (elementary surface reactions, kinetic parameters from fitting Langmuir-Hinshelwood models)	1.5	1		Chapter 7	
10	Heterogeneous catalysis in practice: Hydrogen (Steam reforming process, reactions of synthesis gas, water gas shift reaction, synthesis of NH_3, promoter and inhibitor)	2.0		2	Chapter 8	
11	Oil refining and petro-chemistry (hydrotreating, gasoline production, reaction of small olefins)	2.0			Chapter 9	
12	Environmental catalysis (automotive exhaust catalysis, air pollution by large stationary source)	2.0			Chapter 10	

III. Reference Literature:

[1]. M. Bochmann, Organometallics and Catalysis : An Introduction, 2014, Oxford University Press

CHEM3.07: CHEMISTRY OF MATERIALS IN ENERGY CONVERSION AND STORAGE I

I. Course description:

1. Credit points: 3 ECTS

2. Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	30	6		**36**

3. Prerequisites: General chemistry, Inorganic Chemistry, Inorganic Materials, Semiconductor, Electrochemistry

4. Recommended background knowledge:

General knowledge of chemistry and physics of semiconductors (light absorption and harvesting, charge generation and mobility, redox reactions *etc*).

General knowledge of electrochemistry, chemistry of nanomaterialsMaths, Physics and C language

5. Subject description:

This course discusses about roles of advanced materials in Energy conversion and storage applications. It starts with a description about energy conversion and storage concepts as well as the keys parameters describing performance of devices. Different generation of solar cell technology will be then discussed. Special attention will be focused on the materials and engineering aspects that decide the operation and performance of solar cell

6. Objectives & Outcome:

The students will be able to describe:

- Design concepts and operation of different solar cells.
- Performance of solar cells and parameters that influence their performance
- Engineering challenge in Si solar cell
- Challenges in development of advanced materials for emerging solar cells

7. Assessment/ Evaluation

Component	Attendance	Lab Reports and Tutorial performance	Reports	Midterm	Final
Percentage %	10	30	0		60

8. Prescribed Textbook(s)

II. Course content & schedule:

Class No.	**Contents**	**No. of Hours**			**Ref./ Resources**	**Remarks**
		Lect.	**Exr.**	**Prc.**		
1	**Concepts and Fundamental definitions of energy conversion and storage** (Energy as a contemporary challenge,	3h			Materials will be provided	

	different types of energies and sources of energy, energy conversion, energy storage, energy conversion yield, energy storage capacity *etc*)					
2	**Silicon solar cell (Single crystal)** (Design concepts, physics of operation process, fundamental parameters: energy conversion efficiency, quantum yield, fill factor *etc*, Device engineering and materials aspects)	6h	3h		Materials will be provided	
3	**Silicon solar cell (polycrystalline and amorphous)** (Design concepts, physics of operation process, fundamental parameters: energy conversion efficiency, quantum yield, fill factor *etc*, Device engineering and materials aspects)	3h	3h		Materials will be provided	
6	**Thin film solar cell** (Device engineering and materials aspects; comparison versus Si solar cells)	3h			Materials will be provided	
7	**Organic photovoltaics** (Design concepts, physics of operation process, fundamental parameters: energy conversion efficiency, quantum yield, fill factor *etc*, Device engineering and materials aspects)	3h			Materials will be provided	
8	**Dye-sensitized solar cell** (Design concepts, physics of operation process, fundamental parameters: energy conversion efficiency, quantum yield, fill factor *etc*, Device engineering and materials aspects)	3h			Materials will be provided	
9	**Emerging perovskite solar cells** (Design concepts, physics of operation process, fundamental parameters: energy conversion efficiency, quantum yield, fill factor *etc*, Device engineering and materials aspects)	3h			Materials will be provided	
10	**The primary Batteries** (Design concepts, physics of operation process, fundamental parameters: Energy conversion efficiency, Device engineering and material aspects)	3h				

11	**Rechargeable Batteries** (Design concepts, physics of operation process, fundamental parameters: Energy conversion efficiency, Device engineering and material aspects)	3h				

III. Reference Literature:

[1]. Energy conversion, Edited by D. Yogi Goswami, Frank Kreith, Boca Raton: CRC Press, Taylor & Francis Group, 2008.
[2]. Materials in energy conversion, harvesting, and storage**,** Kathy Lu, Hoboken, New Jersey : Wiley, 2014

<u>CHEM3.08</u>: CHEMISTRY OF MATERIALS IN ENERGY CONVERSION AND STORAGE II

I.Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	24	6	6	**36**

3.Prerequisites: Chemistry of Nanomaterials, Electrochemistry, Kinetics & Catalysis

4.Recommended background knowledge: Thermodynamics and kinetics of chemical reactions; design and preparation of functional nanomaterials;

5.Subject description:

This course discusses about potential technological solutions for harvesting and converting solar energy into chemical energy (solar water splitting, solar CO_2 reduction) as well as solution for its efficient storage (Li-ion battery).

6.Objectives & Outcome:

After this course, the students should be able to:

+ Describe key concepts, terminology of energy conversion & storage.

+ Describe being-developed designs for solar water splitting, solar CO_2 reduction and Li-ion battery.

+ Analyze advantages and disadvantage of H_2 technology in compared to Li-ion battery and solar cell (already discussed in the Materials for energy conversion & storage I).

+ Understand the current challenges being confronted (both chemical issue and material issue) to meet the design requirements.

+ Propose solution for design/ develop novel catalysts/ materials, *etc*

7.Assessment/ Evaluation

Component	Attendance	Exercises	Assignments	Reports	Midterm	Final
Percentage %	0	0	10	0	40	50

8.Prescribed Textbook(s)

Lithium ion batteries: fundamentals and performance, edited by Wakihara and Yamamoto, 1998.

II. Course content & schedule:

Chapter	Contents	Hours			Ref./Resources	Assignment(s)/Notes
		Lect.	Exr.	Prc.		
	Part I: Solar Fuels (Solar water splitting)	**16**	6			
1	Introduction (Solar energy, Concepts of energy harvesting and storage, hydrogen economy, hydrogen from natural gas, etc)	2				
2	Thermodynamics & Kinetics of water electrolysis;	4	2	2		

	CO_2 reduction reactions					
3	Experimental tools (for probing water electrolysis, CO_2 reduction reactions including electrochemical analysis, spectroscopic analyses)	2		2		
4	Light harvesting materials (Fundamental operation of light harvesting materials, physico-chemical requirements for efficient light harvesting materials, materials for anode/ cathode construction; issues being confronted to extend materials robustness)	4	2	2		
5	Device engineering (different strategies to assemble light harvester/ catalyst, photoelectrodes assemblage, probing the operation of devices)	4	2			
	Part II: Li-ion battery	**8**				
7	Design concepts (design considerations, fundamental operation, device performance: in compared with Lead acid battery)	2				
8	Anode materials: Chemistry, materials and practical issues (take few materials for detail discussion like carbon-based materials, nitrides)	2				
9	Cathode materials: Chemistry, materials and practical issues (take few materials for detail discussion like TiS_2, VSe_2, MnO_2, etc)	2				
10	Electrolyte (fundamental requirements, organic electrolyte, glassy electrolyte)	2				
	Part III: Other technologies (proton exchange membrane fuel cell, capacitor, etc)	2				
	Total	**24 (+2)**	**6**	**6**		

III. Reference Literature:

Photoelectrochemical Water Splitting: Materials, Processes and Architectures, edited by Hans-Joachim Lewerenz, Laurie Peter, 2014, RSC publishing.

CHEM3.09: CHEMISTRY OF HETEROCYCLIC COMPOUNDS

I.Course description:

1.Credit points: 2 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	24	0	0	**24**

3.Prerequisites: Organic chemistry I and II

4.Recommended background knowledge: Chemistry (General Chemistry, Organic chemistry)

5.Subject description:

This course is an introduction to important heterocycles in organic chemistry. These compounds are the huge group in organic chemistry and play a main role in many fields. In this course, students will study and discuss heterocyclic compounds: (1) Structure and physical properties; (2) Chemical properties and specific reactions; (3) Preparation of compounds (in the laboratory and in industry).

In addition, application of heterocyclic compounds will be introduced by the lecture and by the presentation of students

6.Objectives & Outcome:

Upon completion of this course, a student should involve knowledge of:

- Basic knowledge of introduced heterocycles: structure; chemical properties and preparation.
- The mechanism of reactions and preparation methods
- The application and role of heterocycles in fields: organic chemistry; medicinal chemistry; chemical biology; material science …

7.Assessment/ Evaluation

Component	Attendance	Exercises	Assignments	Reports	Midterm	Final
Percentage %	10	0	0	0	40	50

8.Prescribed Textbook(s)

[1]. Heterocyclic Chemistry, 5th Edition, Joule and Mills, 2010, Wiley

II. Course content & schedule:

Chapter 1: Introduction

1.1. Definition
1.2. Classification
1.3. Nomenclature

Chapter 2: Five-membered heterocycles containing one heteroatom: Pyrrole, Thiophene and Furan

2.1. Introduction and general properties
2.2. Preparation (in laboratory and in industry)
2.3. Chemical properties
2.4. Application

Chapter 3: Indole, Pyrazole and Imidazole

3.1. Introduction and general properties
3.2. Preparation (in laboratory and in industry)
3.3. Chemical properties
3.4. Application

Chapter 4: Six-membered heterocycles containing one heteroatom: Pyridine

4.1. Introduction and general properties
4.2. Preparation (in laboratory and in industry)
4.3. Chemical properties
4.4. Application

Chapter 5: Quinoline and Isoquinoline

5.1. Introduction and general properties
5.2. Preparation (in laboratory and in industry)
5.3. Chemical properties
5.4. Application

III. Reference Literature:

[1]. Heterocyclic Chemistry, 5th Edition, J. Joule and K. Mills, 2010, Wiley

[2]. Handbook of Heterocyclic Chemistry, 3rd Edition, Alan Katritzky Christopher Ramsden John Joule and Viktor Zhdankin, 2010, Elsevier

CHEM3.10: CHEMISTRY OF SURFACTANTS ANF FORMULATION OF LIFE PRODUCTS

I.Course description:

1.Credit points: 3 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	24		12	**36**

3.Prerequisites: Organic Chemistry, Physicochemistry of surfaces and interfaces.

4.Recommended background knowledge:

5.Subject description:

The aim of this course is to present (1) the background, chemistry and applications of surfactants, (2) The formulation and ingredients of daily life products (detergents and cosmetics), (3) The designing and manufacturing of daily life products.

6.Objectives & Outcome:

After the course, students will be able to:

- Describe the surfactants structures and types of surfactants
- Understand the phenomena of surfactants solution
- Determine critical micellar concentration of surfactants
- Understand the theoretical properties of surfactants
- Understand the mechanism of house hold products activity
- Propose the ingredients, formulating composition and production of daily life products

7.Assessment/ Evaluation

Component	Attendance	Exercises	Practice	Reports	Midterm	Final
Percentage %	0	0	10	0	30	60

8.Prescribed Textbook(s)

[1] Milton J. Rosen, Joy T. Kunjappu - **Surfactants and Interfacial Phenomena, Fourth Edition,** Wiley, 2012

[2] Louis Ho Tan Tai - **Formulating Detergents and Personal Care Products_ A Guide to Product Development**, AOCS Press, 2000

II. Course content & schedule:

Chapter 1. Introduction of surfactants

1.1. Surfactants

1.2. Types of surfactants

Chapter 2. Phenomena of surfactants solution

2.1. Adsorption and Aggregation of surfactants

2.2. Micelles formation of surfactants

2.3. CMC and HLB

Chapter 3. Properties and application relating to surfactants

3.1. Reduction of surface tension

3.2. Wetting and wettability

3.3. Emulsion and microemulsion

3.4. Solubility enhancement of insoluble particles

3.5. Dispersion and Aggregation of particles

3.6. Foaming and defoaming processes

3.7. Surfactants in Nanotechnology and chemistry synthesis

Chapter 4. Household products formulations

4.1. Detergency and detergent formulation

4.2. Cosmetics and personal care products

4.3. Fragrances

Chapter 5. Toxicology and Legistrations

III.Reference Literature:

[1] Richard J. Farn, **Chemistry and Technology of surfactants,** Blackwell Publishing, 2006

[3] Hiroshi Iwata, Kunio Shimada, **Formulas, Ingredients and production of Cosmetics**, Springer 2013

CHEM3.11: PROJECT BASED III

I.Course description:

1.Credit points: 2 ECTS

2.Time commitment:

Items	Lecture	Tutorial	Practical	**Total**
No. of hours	8	0	16	**24**

3.Prerequisites: None

4.Recommended background knowledge: Inorganic chemistry

5.Subject description:

The reason: Cuprous oxide (Cu_2O) nanoparticles are presented as a p-type semiconductor for many application fields e.g. solar cell, catalyst, photocatalyst for water splitting and CO_2 reduction, sensor, etc. In controlling the activity and selectivity of electrocatalysis, it is important to understand how they are affected by the crystal facets. Cu_2O nanoparticles can be expected for different crystal facets which presents the different of morphologies. Therefore, it could be a good time to get students discover this material and learn about its physic-chemical properties and its applications.

Student learns through a given topics. The assigned topics simulates an actual issue/ challenge being confronted by our society. Students are expected to gain both literature knowledge and experimental skills under the guidance of lecturers.

6.Objectives & Outcome:

Literature understanding:

+ Preparation methods for different Cu_2O nanostructures (e.g. nanocube with {100} facets, octahedral with {111} facets, nanosphere, nanowires, etc).

+ Methods to stabilize these cuprous oxides in solution, gel and

+ Physical, Chemical properties of these Cu_2O nanostructures (e.g. plasmonic absorption) with emphasize on <u>its toxicology</u>.

Experimental proofs

+ Each student should submit 01 sample of Cu_2O nanostructure stabilized (either in solution, gel or solid).

+ Technical details about the material submitted: morphology, crystal structure and catalytic activities

7.Assessment/ Evaluation

Component	Attendance	Literature review	Practical	Reports	Midterm	Final defense
Percentage %	0	20	30	20	0	30

8.Prescribed Textbook(s)

Scientific papers

II. Course content & schedule:

<u>Part I: 4 section of 2h each</u>

+ In each section (2 section/ week), each student is asked to make a short presentation (about 15 min) about his/ her literature work to fulfill the literature understanding requirement (see the section 3(i) this above).

After each presentation, instructors will comment/ suggest so the students could further improve their understanding. She/ he will then present their improved version in the subsequent section.

+ When completing 4 sections, each student need to submit an experimental plan to prepare his/ her silver nanostructure. The experimental plan should be as details as possible. The instructors will then ask for revision or approve the experimental plan.

Part II: 01 month of experimentation

+ Upon approval of the experimental plan, Department will offer chemicals and materials to students. They should keep these stuffs inside the Chemistry practical lab (Room 705, USTH).

+ Department will assign an instructor to guide the student during his/ her experimentation: teach the experimental skills.

+ Each student need to arrange with his/ her instructor for suitable time to conduct his/ her experiment.

+ When the sample is ready (upon the approval of the Lab instructor), student can request for characterizations: XRD, SEM (IMS).

+ When the above characterizations are available, the students will prepare electrode for electrochemical measurements (Room 703, USTH).

+ Subsequently, the instructors will recommend students with samples for gas chromatography measurement (218 IMS).

Part III. Report preparation

+ When the samples and characterization results are available, student should submit and discuss with his/ her instructor to get approval.

+ Student will then prepare a final report (the template will be provided).

+ Students will present their final report in front of a Department committee.

+ Final report will be then submitted to the instructor to approve for the final result