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## **“FOREST” Project Handbook: The “FOREST” best practices in the Vietnamese Universities**

**Vietnam National University of Forestry (VNUF)**

**Thai Nguyen University of Sciences (TNUS)**

**Ho Chi Minh University of Technology and Education (HCMUTE)**

**Hue University of Sciences (HUSC)**

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# “FOREST” Project Handbook: The Master’s Program in Vietnamese Universities

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## Introduction

Welcome to the Future-Oriented Chemistry Handbook, an integral component of our ambitious project dedicated to pioneering solutions in the field of chemistry tailored towards addressing the urgent challenges of climate change. As the global community grapples with the pressing need for sustainable development and environmental stewardship, the significance of harnessing the power of chemistry to mitigate climate change has never been more paramount.

The Future-Oriented Chemistry project endeavors to lay the foundation for a groundbreaking Master's program, designed to equip aspiring chemists with the knowledge, skills, and innovative mindset necessary to confront climate change head-on. At the heart of this endeavor lies the integration of green chemistry principles into every facet of our academic curriculum and research pursuits.

Through this handbook, we aim to provide a comprehensive overview of the Future-Oriented Chemistry project, outlining its objectives, methodologies, and the envisioned outcomes. We invite you to embark on this journey with us as we explore the transformative potential of chemistry in shaping a more sustainable and resilient future for generations to come.

## Project Overview

The Future-Oriented Chemistry project represents a pioneering initiative aimed at revolutionizing the landscape of chemical education and research in response to the escalating challenges posed by climate change. With a steadfast commitment to sustainability and innovation, this project seeks to establish a comprehensive Master's program in chemistry that is intricately linked to the urgent imperatives of climate action and in line with Bologna provisions, an European standard.

At its core, this project recognizes the critical role that chemistry plays in both contributing to and mitigating the impacts of climate change. By harnessing the principles of green chemistry, emphasizing the design, synthesis, and application of environmentally benign substances and processes, we aspire to cultivate a new generation of chemists who are adept at leveraging their expertise to address the multifaceted dimensions of the climate crisis.

The Future-Oriented Chemistry project is characterized by its interdisciplinary approach, drawing upon insights from fields such as environmental science, materials science, renewable energy, and policy studies. Through collaborative partnerships with industry stakeholders, government agencies, and academic institutions, we aim to foster a dynamic learning environment that fosters innovation, creativity, and real-world impact.

- **Work Package 1: Preparation:** On March 1-2, 2021, the first kick-off meeting with partners was held online due to the Covid19 pandemic. During this meeting, the presentation of the project partners– all work packages, all other outcomes, and a tentative schedule over three years were introduced. The Partnership Agreement, including its content, important paragraphs, what to be done locally, information to be included and deadlines, was discussed, and the following policies were developed: communication strategy, distribution strategy, operation plan and sustainability plan. The purchasing of FOREST equipment, Visibility and disseminations issues, Quality control and Managemental issues were discussed.

- **Work package 2: Development Master's programm comprising:**

An online workshop was organized to train how to create the questionnaire and survey for the FOREST Master program.

Before the development of the Master program, a survey was conducted among local teachers, colleagues from partner universities, local managers. Their views were taken into account in terms of the strengthening the content of the FOREST master program. According to this direction, a new FOREST Master program was constructed according to the Bologna provisions. In 26. March 2021, an online training webinar on compiling and conducting questionnaires was hold by the University of Catania (UNICT).

- A coordinating meeting was organized in VNUF in August 2023 to start a new phase of the project after 18 months suspended due to the Ukraine war since Feb.2022. In this meeting, two new Vietnamese universities, including HCMUTE and HUSC, were introduced as the new partners
- A summer school was organized by the four Vietnamese Universities and European partners at VNUF from 28th.August to 1st.September. 2023 to advertise the new FOREST master program to the potential students.
- The offline conference on “Curriculum development“ was organized at HCMUTE with the two new Vietnamese partners with the presence of lecturers come from LiU and MUL, on November 21-22, 2023.
- The hybrid workshop on “T&L&A training” was organized at the Institute Polytechnique of Tomar (IPT), Tomar, Portugal from 3-5. January 2024.
- **Work Package 3: Development New structural units**, including; work on a planning package for the launch of the “Centers of Excellence”. Work on the package begins according to plan from June 2021. The “Centers of Excellence” was set up at TNUS and VNUF with equipment funded by European project Erasmus+.
- **Work Package 4: Quality Plan:** Discussions were held on the quality plan, work was carried out on its implementation. Surveys were conducted among students and teachers for the quality of the content of the project activities. IPT and HUSC are responsible for this work package with the cooperation of other partners.
- **Work package 5: Distribution and exploitation.** TNUS and HCMUTE are responsible for the implementation of the package on the socialist Republic of Vietnam, the development of a plan for dissemination and sustainable development with the cooperation of other partners.

Vietnamese National University of Forestry (VNUF) and HCMUTE are responsible for the project website within the framework of the project (link). For filling the site on the Vietnam is responsible by Vietnamese and in English languages – done by VNUF and HCMUET.

In addition, the website of each university contains a news and general page on the Erasmus + programs host by Linkoping University.

- **Work Package 6: Project management and coordination.** It begins with the first online coordination meeting host by Linköping University. Works in close cooperation with all partners. Operational management of project activities is carried out by the Project Coordinator (LiU) and VNUF. At the institutional level, coordination and management of project activities is carried out by contact persons-coordinators of

projects at the university. The final conference of the FOREST project was organized on 12. January 2024 at TNUS, Vietnam with the presence of Linkoping, Catania, Polytechnique Institute of Tomar, and four Vietnamese Universities including VNUF, TNUS, HCMUET and HUSC.

Through this handbook, we endeavor to provide a comprehensive roadmap for the development and implementation of the Future-Oriented Chemistry Master's program. From curriculum design and pedagogical strategies to research priorities and student engagement initiatives, this project seeks to set new standards for excellence in education and research at the intersection of chemistry and climate change.

Join us as we embark on this transformative journey towards a future where chemistry serves as a catalyst for positive change, leading the way towards a more sustainable and resilient world for all.

# Chapter 1: The FOREST Master's program in Vietnam: Best practices in Vietnam National University of FORESTRY (VNUF)

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The FOREST project experienced 2 unexpected problems with the Covid-19 pandemic led to social distancing and no mobility was done, then Ukraine war led to the exclusion of Russian partners in the FOREST consortium and the 2 new Vietnamese HEIs participation in mid-2023. VNUF joined the FOREST project from the beginning and has to overcome these obstacles to complete the project as its deadline is January 14, 2024. Although no overseas exchange activity for VNUF's teachers and students was designed to help us strengthen our capacity, some online activities such as online training with IPT (Portugal) in January 2024 and MUL (Austria) have helped us a lot to communicate with experienced teachers from Europe and exchanged with them the best practices to develop a European standard high-quality MSc program based on the Bologna process standards, but also new and updated T&L&A techniques for teachers and curriculum design with MUL colleagues at the offline training in HCMUTE, Vietnam in November 2023.

As the leading training and research centre in the fields of forestry, natural resources, environment, disaster mitigation and prevention in Vietnam, thereby contributing to the sustainable development of the economy, society and environment, we, VNUF, integrate into our existing MSc program on Forest products engineering with the chemical solutions that may help to increase the income value of the local people via sustainable livelihood such as medicinal plants, forest products food, biomass energy including wood pellets and charcoal, wood composites as high-quality wood-based materials. Additionally, the aspects of LCA and sustainability sciences will be taught to raise awareness of furniture producers about the importance of reducing waste and energy to lower the impact on the environment for the manufacturing sector both in the processing, during using the product and after the life cycle.

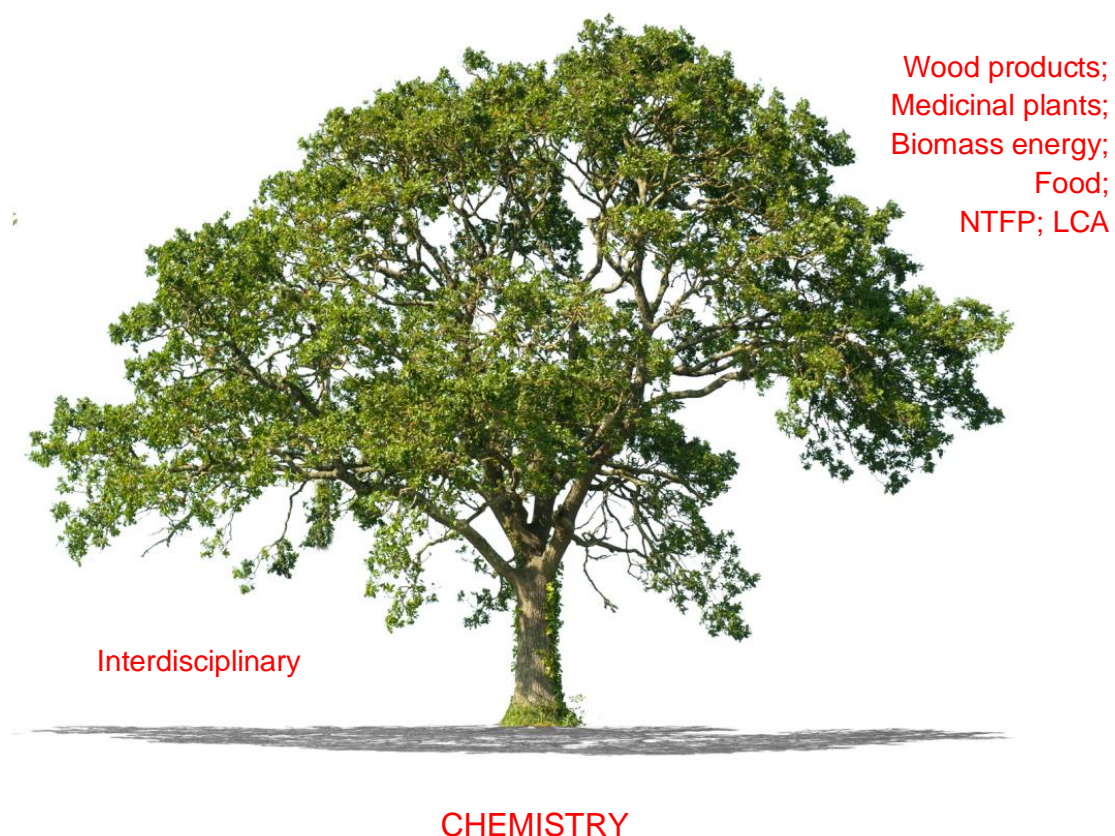
## **I. The FOREST Master program at VNUF:**

A TNA (Training Need Assessment) has been carried out to identify the knowledge, skills and competencies that labour market demand in the next 5 years when the students complete the Master programme via asking the employers, research institutes, companies, universities/ colleges, NGO, young students who will be future Master students. A gap identified helps our university to fill in the current training program to develop a new FOREST master program with "future-oriented chemistry".



VNUF has developed a competency-based curriculum in line with Bologna provisions. We have learnt EU best practices in university-business partnerships aimed at providing students with real cases. The Forest and Climate change module has raised awareness of climate change impact and consequences for the future among business structures and communities, especially Vietnam is one of the world's top five most vulnerable countries to climate change. Typhoons, floods, droughts, and landslides frequently threaten a high proportion of the country's 100+ million people and economic assets concentrated along its long, densely populated, coast. Forest is considered a nature-based solution for climate change (@FAO). Forestry practices include planting new forests, allowing forests to regrow naturally where they have been cut down, and improving forest management.

The new FOREST Master program at the Vietnam National University of Forestry fits well with the mission and vision of our university and our non-stop efforts to work towards a Greener Vietnam with resilient forests, landscapes, and communities.



**Figure 1. The concept of the new FOREST MSc program at VNUF**

- 1. Master's Program: Forest products Engineering  
Code: 8.54.90.01**
- 2. Objectives:**

- This master training program provide in-depth theoretical knowledge, high practical skills, the ability to do independent research, guide scientific and professional research, work creatively and have the ability to discover, solve new problems in the field of science and technology of forest product processing

### 3. Learning Outcomes:

<b>Symbols</b>	<b>Program Learning Outcomes (PLOs)</b>
<b>I.</b>	<b>Knowledge</b>
PLO1	Basic understanding of Philosophy
PLO2	Have basic knowledge of English according to regulations of the Ministry of Education and Training
PLO3	Have basic knowledge of Scientific Research Methods, Applied Wood Science, Cutting Tools in Woodworking, Wood Chemistry, Glues and Coatings, Electronics and Automatic Control, Forests and Climate Change,....
PLO4	Have knowledge of modern woodworking equipment.
PLO5	Have knowledge of wood processing technology, drying technology, wood quality improvement technology, surface finishing technology of wood materials, composite materials, automation of production processes, forest product chemistry, and use non-timber forest products such as medicinal plants, food, and biomass energy.
PLO6	Have knowledge about quality management of wooden furniture production, organization of wood processing production, selection and use of wood processing machines, product life cycle assessment, sustainable science.
<b>II.</b>	<b>Skills</b>
PLO7	Inspect and assess the quality of wood, wood materials and wood products.
PLO8	Use effectively and improve wood processing machines, equipment and automation lines in wood and non-wood forest product processing factories.
PLO9	Proficient in drying technology, wood processing technology and wood materials, wood material surface decoration technology, exploitation and post-harvest preservation technology of non-wood forest products.
PLO10	Organize, direct and manage production activities at wood processing factories, supervise and construct wood projects, organize research and technology transfer activities on wood and forest product processing.
PLO11	Able to communicate and work in English.
PLO12	Proficient in using information technology tools in professional and social activities.
PLO13	Have social communication and teamwork skills.
<b>III.</b>	<b>Attitudes</b>
PLO14	Have good moral qualities and a healthy lifestyle.
PLO15	Love your job, be honest and have a high sense of discipline at work.
PLO16	Strictly comply with country laws and regulations of organizations.
PLO17	Have a sense of self-awareness and responsibility towards work, the team, yourself and the community.
PLO18	Have an industrial style and serious working attitude.

<b>Symbols</b>	<b>Program Learning Outcomes (PLOs)</b>
PLO19	Have a spirit of community service, integration and international cooperation.
PLO20	Be conscious of self-study, practice and update knowledge.
PLO21	Have a sense of creative thinking.
PLO22	Graduates from the Master's program in Forest Products Engineering will meet the English proficiency according to regulations of the Ministry of Education and Training.
PLO23	Graduates from the Master's program in Forest Products Engineering will meet the basic information technology application level according to Circular No. 03/2014/TT-BTTTT dated March 11, 2014 of the Ministry of Information and Communications.

#### 4. List of subjects:

<b>Subject code</b>		<b>Subjects</b>	<b>ECTS</b>
<b>Text</b>	<b>Number</b>		
<b>I. General knowledge</b>			<b>12</b>
FUTH	501	Philosophy	6
FUTA	502	English	6
<b>II. Basic knowledge</b>			<b>28</b>
<b>Compulsory</b>			<b>12</b>
CNNC	503	Research methodology	4
CBKG	504	Applied wood science	4
CBCG	505	Wood cutting tools	4
<b>Electives (select 16 ECTS)</b>			<b>16/32</b>
CBTU	506	Modeling and optimization of technological processes	4
CBDL	507	Measurement fundamentals	4
CBKD	508	Wood adhesives and coatings	4
<b>CBHG</b>	<b>509</b>	<b>Wood chemistry</b>	<b>4</b>
CBDT	510	Electronics and automatic control	4
CBCH	511	Technological process and chemical equipment	4
<b>BĐKH</b>	<b>512</b>	<b>Forest and Climate change</b>	<b>4</b>
<b>ĐGVĐ</b>	<b>513</b>	<b>Life cycle assessment</b>	<b>4</b>
<b>III. Professional knowledge</b>			<b>50</b>
<b>Compulsory</b>			<b>30</b>
CBTB	514	Modern woodworking equipment	6
CBXG	515	Modern wood processing technology	4
CBSG	516	Forest product drying technology	4
CBVL	517	Technology to improve wood quality	6
<b>CBBT</b>	<b>518</b>	<b>Wood composites</b>	<b>6</b>
CBTS	519	Technology for finishing the surface of wood materials	4
<b>Electives (select 20 ECTSs)</b>			<b>20/52</b>
CBĐG	520	Organization of wood production and processing	4
CBHH	521	Wood chemical processing technology	4
CBTĐ	522	Automation in forest product processing	4
CBWW	523	Select and use woodworking machines	4
CBQL	524	Quality management of wooden furniture production	4
CBCT	525	Bamboo processing technology	4

Subject code		Subjects	ECTS
Text	Number		
CBWN	526	Wood-nonwood composite	4
CBSM	527	Seminar	4
NLSK	528	Biomass energy	4
HHDL	529	Medicinal plant chemistry	4
GTDD	530	Nutrition values of forest products food	4
KHBV	531	Sustainability science	4
HHLS	532	Forest products chemistry	4
<b>IV. Graduation thesis</b>			<b>30</b>
<b>Total</b>			<b>120</b>

Note: The subjects in red are newly developed subjects within the FOREST project.

## 5. Matrix of knowledge and skills according to learning outcomes

Subject code	Subject	Credits	Knowledge				Skills/ Competences									Attitudes						IT, English			
							Professional skills				Soft skills														
			LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8	LO9	LO10	LO11	LO12	LO13	LO14	LO15	LO16	LO17	LO18	LO19	LO20	LO21	LO22	LO23
<b>A. General knowledge</b>			<b>12</b>																						
FUTH 501	Philosophy	6	X									X		X	X	X	X	X	X	X	X				
FUTA 502	English	6		X								X	X	X	X	X	X	X	X	X	X	X			
<b>B - Basic knowledge</b>			<b>28</b>																						
<b>B1 - Compulsory</b>			<b>12</b>																						
CNNC 503	Research methodology	4			X					X		X	X	X	X	X	X	X	X	X	X	X	X		
CBKG 504	Applied wood science	4			X		X		X	X	X		X	X	X	X	X	X	X	X	X	X	X		
CBTN 505	Wood cutting tools	4			X	X	X		X	X	X		X	X	X	X	X	X	X	X	X	X			
<b>B2- Elective (16/32)</b>			<b>16</b>																						
CBTU 506	Modeling and optimization of technological processes:	4			X	X	X			X	X	X		X	X	X	X	X	X	X	X	X	X		
CBDL 507	Measurement fundamentals	4			X	X	X			X	X	X		X	X	X	X	X	X	X	X	X	X		
CBKD 508	Wood adhesives and coatings	4			X		X				X	X		X	X	X	X	X	X	X	X	X			
CBHG 509	Wood chemistry	4		X	X		X				X	X		X	X	X	X	X	X	X	X	X			
CBDT 510	Electronics and automatic control	4			X	X	X	X			X	X	X		X	X	X	X	X	X	X	X	X		
CBCH 511	Technological process and chemical equipment	4			X	X	X				X	X	X		X	X	X	X	X	X	X	X	X		
BDKH 512	Forest and Climate change	4		X	X									X	X	X	X	X	X				X		
DGVD 513	Life cycle assessment	4		X				X						X	X	X	X	X	X				X		

Subject code	Subject	Credits	Knowledge						Skills/ Competences						Attitudes						IT, English			
									Professional skills				Soft skills											
			LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8	LO9	LO10	LO11	LO12	LO13	LO14	LO15	LO16	LO17	LO18	LO19	LO20	LO21	LO22
<b>C - Professional knowledge</b>		<b>50</b>																						
<i>C1 - Compulsory</i>		<i>30</i>																						
CBTB 514	Modern woodworking equipment	6			X	X	X	X			X	X	X		X	X	X	X	X	X	X	X	X	X
CBXG 515	Modern wood processing technology	4			X		X	X			X	X	X		X	X	X	X	X	X	X	X	X	X
CBSG 516	Forest product drying technology	4			X		X				X	X	X		X	X	X	X	X	X	X	X	X	X
CBVL 517	Technology to improve wood quality	6			X	X	X				X	X	X		X	X	X	X	X	X	X	X	X	X
CBBT 518	Wood composites	6		X	X	X	X				X	X		X	X	X	X	X	X	X	X	X	X	X
CBTS 519	Technology for finishing the surface of wood materials	4			X	X	X				X	X	X		X	X	X	X	X	X	X	X	X	X
<i>C2 -Elective (20/52)</i>		<i>20</i>																						
CBDG 520	Organization of wood production and processing	4			X		X	X			X	X		X	X	X	X	X	X	X	X	X	X	X
CBHH 521	Wood chemical processing technology	4			X		X				X	X		X	X	X	X	X	X	X	X	X	X	X
CBTD 522	Automation in forest product processing	4			X	X	X	X			X	X	X		X	X	X	X	X	X	X	X	X	X
CBWW 523	Select and use woodworking machines	4			X	X	X	X			X	X		X	X	X	X	X	X	X	X	X	X	
CBQL 524	Quality management of wooden furniture production	4			X	X	X	X	X		X	X		X	X	X	X	X	X	X	X	X	X	X

Subject code	Subject	Credits	Knowledge						Skills/ Competences						Attitudes										IT, English	
									Professional skills				Soft skills													
			LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8	LO9	LO10	LO11	LO12	LO13	LO14	LO15	LO16	LO17	LO18	LO19	LO20	LO21	LO22	LO23	
CBCT 525	Bamboo processing technology	4			X		X				X	X		X	X	X	X	X	X	X	X	X	X			
CBWN 526	Wood-nonwood composite	4			X		X				X	X		X	X	X	X	X	X	X	X	X	X			
CBSM 527	Seminar	4		X	X		X		X	X	X	X		X	X	X	X	X	X	X	X	X	X			
NLSK 528	Biomass energy	4		X			X			X	X	X				X	X	X	X	X	X			X	X	
HHDL 529	Medicinal plant chemistry	4		X			X			X	X	X				X	X	X	X	X	X			X	X	
GTDD 530	Nutrition values of forest products food	4		X			X			X	X	X				X	X	X	X	X	X			X	X	
KHBV 531	Sustainability science	4		X				X							X	X	X	X	X	X				X	X	
HHLS 532	Forest products chemistry	4		X			X			X	X	X				X	X	X	X	X	X			X	X	
<b>D – Graduation thesis</b>		<b>30</b>	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
<b>Total</b>		<b>120</b>																								

## **6. Description of subject**

### **6.1. General knowledge**

#### **Philosophy (Code: FUTH501; Credits: 6):**

According to the regulations of the Ministry of Education and Training.

#### **English (Code: FUTA502; Credits: 6):**

The English program is designed towards the domestic TOEFL exam with a total score of TOEFL ITP 450, iBT 45 or equivalent...

### **6.2. Basic knowledge**

#### **Research methodology (Code: CNNC503; Credits 4)**

The Research Methodology module provides students with basic knowledge of scientific research methodology; Scientific research issues in the field of forestry; Methods of developing scientific research topic outlines; Methods of writing scientific reports; Empirical modeling theory; experimental optimization methods; Apply some specialized software for experimental research.

#### **Applied wood science (Code: CBKG504; Credits 4)**

The Applied Wood Science module is the professional basis of the industry and includes a number of main contents: anatomical structure of coniferous and broadleaf wood; The relationship between structure, processing and use of wood; the relationship between wood and water; deformation and plasticity of wood; wood quality; Classification and use of wood.

#### **Wood cutting tools (Code: CBCG505; Credits 4)**

The module introduces knowledge about cutting knives, the nature and methods of analyzing the dynamics of the wood cutting process, the quality of the cutting process, methods of finding and solving research problems in cutting.

#### **Modeling and optimization of technological processes (Code: CBTU506; Credits 4)**

The module includes the following main contents: Theoretical basis of modeling; Modeling technological processes in wood processing; Solve optimization problems on models; Research direction to develop modeling and optimization of wood processing technology processes.

#### **Measurement fundamentals (Code: CBDL507; Credits 2)**

The Measurement Fundamentals module presents the following basic issues:

- General concepts, quantities and units.
- Types of measurement errors and measurement uncertainties
- Methods and procedures when measuring
- Some main measuring tools.

#### **Wood adhesives and coatings (Code: CBKD508; Credits 2)**

The module presents the following issues: 1- Overview, 2- Theory of bond formation, 3- Use of glues, coatings, and coatings in forest product processing, 4-



Modification of glue, coating, 5- Determine some properties of jewelry adhesives and films.

#### **Wood chemistry (Code: CBHG509; Credits 4)**

The module includes knowledge about the structure and basic properties of chemical components in wood and fibrous plants: Lignin, Cellulose, carbohydrates, extractive substances and other components. The influence of wood chemical components in the processing of wood materials.

#### **Electronics and automatic control (Code: CBĐT510; Credits 4)**

The Electronics and Automatic Control module will equip students with the most necessary knowledge and skills to search and update information. The content of the course focuses on three main parts: the first part presents basic semiconductor elements, algorithmic circuits and common microprocessors in control problems; Part two is the applications of specialized PLC programmable controllers; The final content is the method of analyzing a general data collection, control and processing system, and the choice of optimal solutions for some practical applications.

#### **Technological process and chemical equipment (Code: CBCH511; Credits 4)**

The module includes knowledge about the principles of processes, separation of heterogeneous systems, mass transfer (distillation, absorption, adsorption, extraction, concentration). Structure and operating principles of basic equipment in chemical processing and influencing factors.

#### **Forest and Climate change (Code: BĐKH512; Credits 4)**

This module provides basic concepts/knowledge about forests, climate change and the role of forests, a nature-based solution to adapt and minimize the impact of climate change, especially in the Vietnamese context, one of the countries most affected by climate change in the world. The richer the forest, the more carbon it stores, and the higher its biodiversity, the greater its role in minimizing the negative impacts of climate change. Sustainable forest development contributes positively to the Prime Minister's goal of net zero emissions by 2050 at COP26.

#### **Life cycle assessment (Code: ĐGVĐ513; Credits 4)**

This module provides basic knowledge and skills about the life cycle of wood products, as well as assessing the environmental impact during product production, use and disposal after the end of the life cycle. Students have the skills to evaluate the life cycle of a typical wood product.

### **6.3. Professional knowledge**

#### **Modern woodworking equipment (Code: CBTB514; Credits 6)**

The module introduces theoretical knowledge about structure, working principles, processes and operating techniques of modern machines in wood processing while also building proficient skills in disassembly, maintenance and programming. and operate modern woodworking machines.

#### **Modern wood processing technology (Code: CBXG515; Credits 4)**

The module introduces theoretical knowledge about modern wood processing technologies (modern processes and techniques used in wood processing), and at the same time builds proficient practical skills in operating machines and tools. Modern wood processing line.

### **Forest product drying technology (Code: CBSG516; Credits 4)**

The module provides in-depth knowledge about lumber drying technology, some special drying methods, veneer drying technology, wood chip drying technology, energy and drying costs.

### **Technology to improve wood quality (Code: CBVL517; Credits 6)**

The module provides knowledge about the concept of wood quality, factors affecting wood quality; Overview of improving wood quality; Wood modification technology includes the following types of technology: chemical modification of wood; thermal modification of wood; modified wood impregnation; Wood treatment technology: wood discoloration treatment technology; plasticization treatment; treatment to improve biological durability.

### **Wood composites (Code: CBBT518; Credits 6)**

The module provides students with knowledge about: concepts, characteristics, applications and development history of some types of wood composite materials; production technologies of Glulam, structural composite lumber (SCL); At the same time, providing skills in calculating technological parameters to produce wood composite materials; Check the quality of raw materials and wood composite products.

### **Technology for finishing the surface of wood materials (Code: CBTS519; Credits 4)**

This subject provides knowledge on finishing technology for wooden furniture surfaces with liquid coatings: pneumatic method, electrostatic method, high pressure method, contact method; Finishing technology for panels: gluing wood veneer, gluing impregnated paper, gluing synthetic veneer, gluing decorative laminates; Methods of testing and evaluating the quality of finishing layer.

### **Organization of wood production and processing (Code: CBĐG520; Credits 4)**

Production process and structure of wood processing factory, modern wood processing production management systems, methods of testing and evaluating the quality of wood and wood products; quality control in some types of wood processing technology; Inventory and handle products with technical defects and remedial measures.

### **Wood chemical processing technology (Code: CBHH521; Credits 4)**

This subject provides knowledge on raw materials, technological process for producing semi-finished fiber products, advanced pulp production technology, Cellulose chemistry, wood hydrolysis technology. Chemical modification of wood.

### **Automation in forest product processing (Code: CBTĐ522; Credits 4)**

This subject includes the main contents: General problems of production process automation; Basic elements and equipment in automatic systems; Conventional and advanced automatic adjustment and control systems; Automating technological processes of forest product processing. Research and development direction of production process automation.

### **Select and use woodworking machines (Code: CBWW523; Credits 4)**

This subject includes the main contents: Machine technical level, machine quality indicators and assessment methods, procedures for evaluating machine

technical level; Use machines and standards for effective use of machines and equipment; Research direction on effective use of machines in modern production.

**Quality management of wooden furniture production (Code: CBQL524; Credits 4)**

This subject provides students with basic knowledge of quality management, introducing quality management systems according to standards (ISO 9000, TQM, Q-Base), and methods. Manage Six Sigma and provide inspection methods, tools, quality control and assessment techniques commonly used in wooden furniture manufacturing.

**Bamboo processing technology (Code: CBCT525; Credits 4)**

This subject includes the following basic contents: Characteristics and properties of bamboo, processing technology for common bamboo products, technology for producing artificial bamboo boards, technology for processing bamboo products. Special products from bamboo.

**Wood-nonwood composite (Code: CBWN526; Credits 4)**

The subject includes the following 3 main contents: (1) Overview of wood-nonwood composite materials; (2) Technology for producing inorganic binding materials; (3) Technology for producing wood-plastic composite materials.

**Seminar (Code: CBSM527; Credits 4)**

This subject provides students with practical knowledge about the fields of wood processing in production and trade: raw materials, products, production technology, market and production management.

**Biomass energy (Code: NLSK528; Credits 4)**

This module provides knowledge and skills about biomass energy, typical forms of biomass raw materials (pellets and charcoal; activated carbon), production technology and product quality criteria and its quality control.

**Medicinal plant chemistry (Code: HHDL529; Credits 4)**

This module provides knowledge and skills to recognize and evaluate the quality of medicinal herbs under typical forest canopy with high economic and commercial value, understand the medicinal properties of selected medicinal herbs and introduce post-harvest processing/preservation technologies to ensure quality of raw materials for subsequent deep processing stages to produce medicine.

**Nutrition values of forest products food (Code: GTDD530; Credits 4)**

This module provides knowledge and skills to recognize and evaluate the quality and nutrition values of typical forest foods with high economic and commercial value, and introduce post-harvest processing/preservation technologies to ensure the quality of raw materials for the next stages of food processing.

**Sustainability science (Code: KHBV531; Credits 4)**

This module provides basic knowledge and skills in sustainability science, sustainable development goals (SDGs) and Economic, Environmental and Social aspects. Benefits of green growth; Sustainability in the chemical industry; 12 principles of Green Chemistry; Supports the integration of environmental and social regulations into core business activities.

## **Forest products chemistry (Code: HHLS532; Credits 4)**

This module concentrates on the chemical uses of non-wood forest products. It outlines the traditional products such as rosin, turpentine, tannin extracts, cinnamomum bark, essential oils and shellac, as well as pharmaceutical and health products.

The details of the Master's program can be viewed on the homepage: <https://forest.on.liu.se>

## **II. The Center of Excellence:**

VNUF develop innovative LLL modules in terms of content focusing on the chemical processing of forest products and T&L resources and delivers them in short training/ seminar format, and through policy workshops. A new structural unit is introduced to enhance the consulting, education and research capacity of VNUF: centres of excellence in future-oriented chemistry. The centre is embedded into the university structure (within the wood chemistry lab, Wood industry and Interior design college (WIID), VNUF); they will provide expertise on chemical uses of medicinal plants and forest products foods as climate change mitigation techniques and solutions for Vietnam thus contributing to science-based decisions in the environmental and sustainability sphere.

The center was established in 2023 and has been home for WIID students to do experiments and research on wood and forest products chemistry since then.

## **III. The summer schools**

The 2023 summer school was organized in hybrid mode to promote the new MSc programs developed by 4 Vietnamese HEIs to 68+ undergraduate students both online and offline in late August and the beginning of September. The lectures from both European HEIs professors and Vietnamese HEIs professors create a unique one-week training for students in Vietnam. The students' positive feedbacks encourage us to continue our work to improve the training program and inspire them with new programs and offer them the competencies that the job market requires. This also creates a "common language" between students and teachers to better understand young students' desires and the soft skills gap. Furthermore, a social network between students from 4 HEIs located in the North (TNUS and VNUF), Central (HUSC) and South (HCMUTE) of Vietnam is created to strengthen their capacity via this networking and social and academic exchange activities later on.

# Chapter 2: The FOREST master's program in Vietnam: Best practices in Thai Nguyen University of Sciences (TNUS)

*Vuong Truong Xuan, Nguyen Thi Phuong Mai, Nguyen Thi Dong, Nguyen Thi Thu Thuy, Nguyen Thi Hong Hoa, Thai Nguyen University of Sciences, Vietnam*

The Erasmus + project "Integrated approach to the training of a chemistry Master's program" at Thai Nguyen University of Sciences (TNUS) began its work in 2021.

## **I. THE FOREST PROJECT**

**The main objective of the project:** To enhance the quality of chemistry education and employability of the chemistry graduates of VN universities through introducing state-of-the-art Master's programs in line with Bologna provisions and to mitigate the impact of climate change in VN by introducing community capacity building.

### **Objectives of the project:**

1. To develop a new interdisciplinary high-quality multi-track Master's program in Future-oriented Chemistry in line with the Bologna provisions while adapting the EU best practice.
2. To upgrade the teaching staff skills in T&L&A.
3. To set up "Center of Excellence" in future-oriented chemistry.
4. To raise awareness of local communities of climate change impact and chemical solutions for its mitigation.

### **Impact at the institutional level:**

Within the framework of the project, the TNUS developed a Master's program in the direction of Chemistry related to climate change and in the 2023-2024 academic year, there was an admission to this Master's program.

The master students are being trained at the expense of state grants through the Ministry of Education and Training of the Social Republic of Vietnam, which in our opinion indicates the further stability of the FOREST master program.

The TNUS has established a "Center of Excellence" equipped with laboratory apparatus and computer facilities to facilitate the execution of training sessions, seminars, and workshops on a limited scale within the chemistry faculty.

During the implementation of the project, interaction with other Vietnamese partner universities and European partners has been strengthened. Also, before the development of the Master's program, a survey was conducted among teachers, experts, students and managers of schools and institutes in the city and local regions.

### **Impact at the international level**

A consortium comprising universities collaborating with project stakeholders has been established to facilitate the exchange of expertise and optimal methodologies in designing a Master's program focused on "Future-Oriented Chemistry in the Context of Climate Change" education in the Socialist Republic of Vietnam. This initiative is being undertaken with the support of European partners universities.

TNUS participated in webinars organized by project coordinators, where discussions centered on the execution of planned activities and the admission process for the Master's program. A focal point of these discussions was the construction of a Master's program in Chemistry, along with the formulation of modules covering subjects pertinent to green chemistry and climate change, aiming to foster sustainable development in the future.

Through the online collaboration involving partner universities utilizing Google Documents and Zoom, a framework for a Master's program was developed, incorporating considerations for students, teachers and staff mobility within the structure.

The development of a master's degree based on international educational standards contributes to the development of the education system of the Socialist Republic of Vietnam and brings it to the international level.

To develop the FOREST master program for the training of teachers in the FOREST direction, all partner universities of the project, including four Vietnamese and four European universities were involved.

## **II. THE MASTER PROGRAM**

The FOREST Master' program "Analytical Chemistry" was developed based on the original Master's program called 'Analytical Chemistry" by TNUS with the addition of new modules and subjects related to environment and climate change. There are 120 ECTS, of which updated disciplines taking into account the practice and were classified as common knowledge block, Basic and majoring knowledge block and Graduation thesis

#### **4. Title of the Master's Program: Analytical Chemistry**

**Code: 8.44.01.18**

#### **5. The objectives of the Master Program:**

##### **2.1. Common objectives**

Training highly-qualified scientists in the field of orientation for analytical chemistry application with abilities of independent and creative research in order to discover and solve new scientific and practical problems in the field of analytical chemistry with good moral, and political qualities for serving the people, aiming for meeting the country's socio-economic and scientific-technological development requirements.

Training for work skills in the laboratory to perform analytical procedures that use analytical equipment according to strictly scientific methods and standards.

Providing highly-qualified and specialized human resources in Analytical Chemistry who are experts in the field of orientation for Analytical Chemistry and climate change to serve training facilities with the ability to work at factories, industrial parks, pharmaceutical and cosmetic testing centers, environmental monitoring centers, research institutes, industrial parks, departments of science and technology, etc.

### **2.2. Specific objectives**

Objective 1: Equipping postgraduate students with basic scientific knowledge of Chemistry, Analytical Chemistry and climate change and adaptation solutions for sustainable development.

Objective 2: Training for high skills in the field of Analytical Chemistry and climate change to research, discover and solve practical problems.

Objective 3: Equipping for abilities to work independently, creatively, and willing to coordinate at work.

### **6. The Learning Outcomes of the programme:**

<b>Symbols</b>	<b>Program Learning Outcomes (PLOs)</b>
	<b>Knowledge</b>
PLO1	Apply general knowledge and foundation knowledge of Analytical Chemistry in professional work.
PLO2	Apply basic disciplinary and interdisciplinary knowledge related to Analytical Chemistry, climate change and adaptation solutions for sustainable development.
	<b>Regarding skills</b>
PLO3	Have skills in analyzing, synthesizing, and evaluating data and information to come up with scientific solutions to problems.
PLO4	Have skills in representing research knowledge, and discussing professional and scientific issues with researcher-mates and others.
PLO5	Have skills in organizing, administering and managing advanced professional activities.
PLO6	Have skills in research, development, and creative use of technologies in the field of analytical chemistry and profession
PLO7	Have proficiency in using English at work
	<b>Regarding autonomy and responsibility</b>
PLO8	Ability to research and come up with important ideas. Adaptable, self-directed, and guides others. Provide expert conclusions in the field of analytical chemistry. Manage, evaluate and improve professional activities

PLO9	Ability to set tasks for experts in related professions to participate in solving sustainable development issues in the context of climate change.
PLO10	Have ethical qualities and professional attitudes in the analytical chemistry working environment

### 7. The Structure of the Master program ( Modules/subjects/ECTS):

The orientation for the analytical chemistry application master's degree training program at the University of Sciences is designed to include: common knowledge block, basic knowledge block, majoring knowledge block (including analytical chemistry, climate change and environment) and the master thesis. The common structure of the specific program framework is as follows:

**Table 4.1: The general structure of the analytical chemistry master's program**

Knowledge block		Quantity of ECTS		Proportion (%)	
Common knowledge block	Philosophy	06	<b>18</b>	15	
	English	12			
Basic and majoring knowledge block	Basic block (42 ECTS)	Compulsory	30	<b>42</b>	
		Elective	12		
	Majoring knowledge block (30 ECTS)	Compulsory	18	<b>30</b>	25
		Elective	12		
Graduation thesis		<b>30</b>	25		
<b>Total</b>		<b>120</b>	<b>100</b>		

**Table 4.2. List of modules/subjects of the master program**

No.	Code	Name of subject	ECTS
<b>I. General knowledge block (2 subjects)</b>			<b>18</b>
1	MLN5501	Philosophy	6
2	ENG152	English	12
<b>II. BASIC MAJORING KNOWLEDGE AND MAJORING BLOCK</b>			
<b>2.1 Basic majoring knowledge block</b>			
<b>2.1.1. Compulsory basic subject (5 subjects)</b>			<b>30</b>
3	AIC213	Advanced Inorganic Chemistry	6
4	AOC213	Advanced Organic Chemistry	6
5	ASC212	Advanced Structural Chemistry	6



No.	Code	Name of subject	ECTS
6	MPC213	Modern Physico-chemical Methods of Analysis	6
7	ASM212	Application of spectro methods in structural analysis	6
<b>2.1.2. Optional basis majoring subject (2/7 subjects)</b>			<b>12</b>
8	ACC212	Advanced chemistry of complex substances	6
9	FPA212	Foods, Functional foods and Pharmaceuticals Analysis	6
10	SAC 213	Statistics in Analytical Chemistry	6
11	MAM 212	Material Analytical Methods	6
12	MRE 212	Methods of Refining and Extracting	6
13	SEA213	Spectro and electro analytical methods	6
14	AAC313	Advanced Analytical Chemistry	6
<b>2.2. Majoring knowledge block (5 subjects)</b>			<b>30</b>
<b>2.2.1. Compulsory majoring subject (3 subjects)</b>			<b>18</b>
15	AMC 313	Analytical Methods for Chromatography	6
16	CCA213	Climate Change and Adaptation	6
17	ENA 313	Environmental Analysis	6
<b>2.2.2. Optional majoring subject (2/9 subject)</b>			<b>12</b>
18	SPT 313	Sample Preparation Techniques in Analytical Chemistry	6
19	MAE 313	Modern Analytical Methods of Electrochemistry	6
20	CEM212	Capillary electrophoretic analytical methods)	6
21	CSE313	Chemical Speciation of Elements	6
22	SCA313	Spectro-chemical Analysis	6
23	BAC 212	biological analysis	6
24	TMQL5019	Natural resources and environment management	6
25	TMNL504	Management forest for sustainable development	6
26	TMCT 510	Management of Solid Waste and Hazardous Waste	6
<b>3. Graduation Thesis</b>			
27	MTH491	Master thesis	30

No.	Code	Name of subject	ECTS
<b>Total:</b>			<b>120</b>

Note: Red color indicates the new subjects of the master program related to climate change

### 8. Correlation matrix between modules and the program learning outcomes

Subject code	Subject	ECTS	Knowledge		Skills					Regarding autonomy and responsibility		
			PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO10
<b>I. General knowledge</b>		<b>18</b>										
MLN5501	Philosophy	6	X							X	X	X
ENG152	English	12							X			
<b>II. Basic majoring knowledge and majoring block</b>												
<b>II.1 Basic majoring knowledge</b>		<b>42</b>										
<b>II.1.1 - Compulsory</b>		<b>30</b>										
AIC213	Advanced Inorganic Chemistry	6	X				X			X	X	
AOC213	Advanced Organic Chemistry	6	X		X		X			X	X	
ASC212	Advanced Structural Chemistry	6	X		X		X			X	X	
MPC213	Modern Physico-chemical Methods of Analysis	6	X		X		X			X	X	X
ASM212	Application of spectro methods in structural analysis	6	X	X	X		X			X	X	X
<b>II.1.2. Elective (12 ECTS)</b>		<b>12</b>										
ACC212	Advanced chemistry of complex substances	6	X	X	X		X			X		
FPA212	Foods, Functional foods and Pharmaceuticals Analysis	6		X	X	X	X	X		X	X	
SAC 213	Statistics in Analytical Chemistry	6		X	X					X		

MAM 212	Material Analytical Methods	6	X	X	X		X	X		X	X	X
MRE 212	Methods of Refining and Extracting	6	X	X	X		X			X	X	X
SEA213	Spectro and electro analytical methods	6	X	X	X	X	X	X		X	X	X
AAC313	Advanced Analytical Chemistry	6	X	X	X		X			X	X	X
<b>II.2 Majoring knowledge block (5 subjects)</b>		<b>30</b>										
<b>II.2.1. Compulsory majoring subject (3 subjects)</b>		<b>18</b>										
AMC 313	Analytical Methods for Chromatography	6	X	X	X		X	X		X	X	X
CCA213	Climate Change and Adaptation	6		X	X		X				X	
ENA 313	Environmental Analysis	6	X	X	X		X				X	X
<b>II.2.2. Optional majoring subject (2/9 subject)</b>		<b>12</b>										
SPT 313	Sample Preparation Techniques in Analytical Chemistry	6	X	X	X			X		X	X	X
MAE 313	Modern Analytical Methods of Electrochemistry	6		X	X		X	X		X	X	X
CEM212	Capillary electrophoretic analytical methods)	6		X			X	X			X	X
CSE313	Chemical Speciation of Elements	6		X	X	X	X	X		X	X	X
SCA313	Spectro-chemical Analysis	6		X			X	X		X		
BAC 212	biological analysis	6		X			X			X		
TMQL50 19	Natural resources and environment management	6		X			X				X	
TMNL50 4	Management forest for sustainable development	6		X			X				X	
TMCT 510	Management of Solid Waste and	6		X			X				X	

	Hazardous Waste											
<b>IV. MASTER THESIS</b>	<b>30</b>	X	X	X	X	X	X	X	X	X	X	X
<b>Total</b>	<b>120</b>											

The details of the Master's program can be viewed on the homepage: <https://forest.on.liu.se>

## II. THE CENTER OF EXCELLENCE

The Thai Nguyen University of Sciences (TNUS) has pioneered the development of cutting-edge Low-Latency Learning (LLL) modules with a focus on content pertaining to chemistry, climate change, and pedagogical resources. These modules are disseminated through concise training sessions and seminars, as well as policy workshops. To augment its consulting, educational, and research capabilities, TNUS has inaugurated a novel structural entity: the Center of Excellence in Future-Oriented Chemistry. Situated within the Analytical Chemistry Laboratory at TNUS, this center is dedicated to furnishing expertise on the utilization of chemicals, green chemistry practices, and climate change mitigation strategies tailored for Vietnam, thereby fostering evidence-based decision-making in environmental and sustainability domains. Founded in 2022, the center has served as a primary venue for chemistry students to conduct experiments and undertake research endeavors in both general and analytical chemistry domains. Additionally, it serves as an academic hub for lecturers and scientists to organize seminars and workshops addressing themes related to chemistry and climate change

# Chapter 3: FOREST master's program in Vietnam: Best practices in Ho Chi Minh University of Technology and Education (HCMUTE)

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The introduction of Master programme of Chemical Engineering in Ho Chi Minh City University of Technology and Education began with the realisation of the Erasmus + program project “Future Oriented Chemistry – FOREST” from August 2023.

**The main goal of the project is** to improve the quality of Master programme towards green and sustainable development at partner universities.

## **Specific objectives of the project:**

- Development of master's programs of Chemical Engineering based on Future Oriented Chemistry;
- Improve capacity to develop Master's training programs according to European standards.
- Develop transferable courses between member universities;
- Develop online courses;
- Teaching teachers new skills;
- Impact and change the thinking of stakeholders about future oriented chemistry.
- Creation of Excellence Center;

**Needs for FOREST master program.** The project team of HCMUTE together with Faculty of Chemical and Food Technology (FCT) has conducted a workshop with stakeholders including HCMUTE lecturers, lecturers from other universities, alumni, and enterprises to collect contributions and develop the Expected Learning Outcomes.

**Outputs of the workshop.** The results of the survey show that it is necessary to develop a Master's programs of Chemical Engineering oriented towards green technology and sustainable development at HCMUTE. The Master's program being developed at FCT needs to change the Learning Outcomes and courses to meet the new requirements of modern education. The training program must focus on three elements: knowledge, skills and attitudes. In particular, there must be courses on engineering technology related to sustainable development.

## **The analytical data of the survey were used for developing learning outcomes of master program**

**Development of master program.** The program has been developed within the framework of the **European project Erasmus+ “Master programme of Chemical Engineering”** with the participation of Linköping University (Sweden), University of Leoben (Austria), Polytechnic Institute of Tomar (Portugal), Thai Nguyen University of Sciences (TNUS), Hue University of Sciences (HUS) and Vietnam National University of Forestry (VNUF).

The educational program has been developed under the state mandatory standard of postgraduate education of the Republic of Kazakhstan. Learning outcomes are formulated based on the European Credit Transfer and Accumulation System (ECTS) guidelines.

**Name of the programme:** “Master programme of Chemical Engineering”

**Code:** 8.52.03.01

**Number of ECTS credits for the programme:** 120

**Aim/purpose with the programme:**

- The Master's program in Applied Chemical Engineering aims to train high-quality human resources in the field of engineering technology to meet societal needs.
- It provides comprehensive knowledge and necessary skills to evaluate, analyze, and synthesize relevant factors to solve practical problems in chemical engineering.
- The program keeps students updated on new knowledge and technological trends in chemical engineering.
- Graduates are equipped with the knowledge and skills necessary for significant roles in organizations, companies, universities, and research institutes in the field of Chemical Engineering. They are also prepared to continue their education for further advancement.
- Proficiency in English specialized in Chemical engineering technology and English communication in a multinational working environment.

**Learning outcomes for the programme.**

Learning outcomes of the program are described in Table 1.

**Table 1. Programme Learning Outcomes**

<b>Symbols</b>	<b>Program Learning Outcomes (PLOs)</b>
<b>I.</b>	<b>Knowledge</b>
PLO1	Evaluate basic and advanced knowledge to decide on solutions in production in the field of Chemical engineering.

PLO2	Analyze technological processes and decide on key issues to improve technological processes in the field of chemical engineering.
<b>II.</b>	<b>Skills</b>
PLO3	Ability to build an effective teamwork and demonstrate leadership.
PLO4	Ability to analyze data and present scientific and technical results.
PLO5	Proficiency in English specialized in Chemical engineering technology and communication in a multinational working environment.
<b>III.</b>	<b>Attitudes</b>
PLO6	Awareness and appreciation of the importance of self-learning and the necessity of lifelong learning.
PLO7	Recognition of the role of research and development.
PLO8	Creative, responsible, and honest approach when carrying out research tasks.

### Content of the programme

The curriculum content of the Master's degree is divided into five modules, which is done so according to the main focus of the program. The program's courses are presented in Table 2.

**Table 2. Content of the programme.**

Subject code		Subjects/ Môn học	ECTS
Text	Number		
<b>I. General knowledge</b>			<b>12</b>
PHIL	530219	Philosophy	6
RMTS	530126	Research Methodology and Theory of Science	6
<b>II. Basic knowledge</b>			<b>24</b>
AOCH	533307	Advanced Organic Chemistry	6
APHY	534207	Applied Physical Chemistry	6
PROM	535907	Project management	6
<b>TOXC</b>	<b>535607</b>	<b>Toxicology *</b>	<b>6</b>
<b>III. Professional knowledge</b>			<b>42</b>
<b>Compulsory</b>			<b>18</b>
<b>ESMD</b>	<b>533907</b>	<b>Energy storage materials and devices *</b>	<b>6</b>
<b>BIRE</b>	<b>534007</b>	<b>Biofuels and renewable energy *</b>	<b>6</b>
<b>AWRP</b>	<b>535007</b>	<b>Anti-degradation and improved weather resistance of polymer materials *</b>	<b>6</b>
<b>Electives (select 24 ECTSs)</b>			<b>24/114</b>
SOLC	533207	Solid-state Chemistry	6
MFHR	536007	Management of facilities and human resources	6
FHCP	535107	Fundamental of scale up in chemical processes	6
<b>MSEL</b>	<b>533707</b>	<b>Material Selection *</b>	<b>6</b>
FINE	535707	Fine chemical engineering	6
<b>CENA</b>	<b>533807</b>	<b>Catalytic Engineering and nanocatalysts *</b>	<b>6</b>

Subject code		Subjects/ Môn học	ECTS
Text	Number		
SPOL	533407	Structure and physio-chemical properties of polymers	6
MACE	534307	Modern analytical methods in chemical engineering	6
ASOC	533507	Advanced Statistical and Optimization in Chemical Engineering	6
APCH	533607	Advanced Polymer Chemistry	6
<b>HERT</b>	<b>535407</b>	<b>Heterogeneous reaction technique *</b>	<b>6</b>
<b>NANT</b>	<b>534908</b>	<b>Nanomaterial technology *</b>	<b>6</b>
CSSP	535307	Calculation and simulation of chemical structures and processes	6
<b>CTNC</b>	<b>534507</b>	<b>Chemical technology of natural compounds *</b>	<b>6</b>
FCTE	534607	Fragrance and cosmetic technology	6
FIBT	534707	Fiber technology	6
ELPT	534807	Electrolysis and plating technology	6
DRUD	535207	Chemistry of drug delivery systems	6
CCHE	535507	Colorant chemistry	6
<b>IV. Internship</b>			<b>12</b>
INTE	534407	<i>Internship 1</i>	6
INTE	536107	<i>Internship 2</i>	6
<b>IV. Graduation thesis</b>			<b>30</b>
<b>Total</b>			<b>120</b>

Note: \*The courses are designed according to green technology and sustainable development orientation.

#### **Module 1 (12 ECTS): General knowledge**

It aims to provide a holistic overview of the history and philosophy of scientific development of science, issues related to the skills of conducting a scientific research.

#### **Module 2 (24 ECTS): Basic knowledge**

Basic knowledge module provides basic knowledge in Chemical engineering. This module provides basic knowledge in chemical engineering such as organic chemistry, physical chemistry, toxicology, as well as management skills.

#### **Module 3 (18 Compulsory ECTS + 24 Elective ECTS) : Professional knowledge**

Professional knowledge module provides specialized knowledge in the field of Chemical Engineering. In particular, students study 18 compulsory ECTS related to the field of green chemical technology and sustainable development. Students can then choose 24 out of a total of 114 ECTS according to their individual orientation.

#### **Module 4 (12 ECTS): Internship**

The module provides students with knowledge and skills to work in a corporate environment. Students can relate the theoretical knowledge they have learned in the training program with practical business knowledge. Students have the opportunity to



consolidate specialized knowledge and develop necessary professional skills through group work activities and production activities at the enterprise. In addition, through the internship, students will demonstrate the role of an expert in controlling and handling chemical engineering problems.

### Module 5 (50 ECTS): Master Thesis

The module provides students with the ability to solve a scientific and technical duty including: determining the scope of a topic, developing research methods, conducting research, collecting, analyzing and synthesize data to find a scientific and technical rule in the field of Chemical engineering. Finally, students are asked to explain research results in writing and speaking in a clear and logical methods.

### Mapping of PLOs and CLOs at the Master programme

The course curriculum determined the specific and measurable PLOs of the programme as shown in Table 3.

**Table 3. Mapping of ELOs and CLOs at the CET programme**

No.	Course Code		Course Name	Program Learning Outcomes (PLOs)							
	Text	Number		1	2	3	4	5	6	7	8
<b>I. General knowledge</b>											
1	PHIL	530219	Philosophy	x	x						x
2	RMTS	530126	Research Methodology and Theory of Science	x	x						x
<b>ii. basic knowledge</b>											
3	AOCH	533307	Advanced Organic Chemistry	x				x	x		
4	APHY	534207	Applied Physical Chemistry	x		x		x			
5	PROM	535907	Project management	x		x			x		
6	TOXC	535607	Toxicology	x				x	x		
<b>iii. professional knowledge</b>											
<b>compulsory</b>											
7	ESMD	533907	Energy storage materials and devices	x				x	x		
8	BIRE	534007	Biofuels and renewable energy	x					x	x	
9	AWRP	535007	Anti-degradation and improved weather resistance of polymer materials	x							
<b>electives</b>											
10	SOLC	533207	Solid-state Chemistry	x		x		x			
11	MFHR	536007	Management of facilities and human resources	x		x			x		
12	FHCP	535107	Fundamental of scale up in chemical processes	x	x					x	
13	MSEL	533707	Material Selection	x					x	x	
14	FINE	535707	Fine chemical engineering	x				x	x		
15	CENA	533807	Catalytic Engineering and nanocatalysts	x		x					x

16	SPOL	533407	Structure and physio-chemical properties of polymers	x						x	x	
17	MACE	534307	Modern analytical methods in chemical engineering	x		x						x
18	ASOC	533507	Advanced Statistical and Optimization in Chemical Engineering		x			x				x
19	APCH	533607	Advanced Polymer Chemistry	x		x		x				
20	HERT	535407	Heterogeneous reaction technique	x	x						x	
21	NANT	534908	Nanomaterial technology	x		x				x		
22	CSSP	535307	Calculation and simulation of chemical structures and processes	x					x			x
23	CTNC	534507	Chemical technology of natural compounds	x		x					x	
24	FCTE	534607	Fragrance and cosmetic technology	x		x					x	
25	FIBT	534707	Fiber technology	x				x				x
26	ELPT	534807	Electrolysis and plating technology	x					x			x
27	DRUD	535207	Chemistry of drug delivery systems	x	x						x	
28	CCHE	535507	Colorant chemistry	x	x						x	
<b>iv. internship</b>												
29	INTE	534407	<i>Internship 1</i>			x	x			x		x
30	INTE	536107	<i>Internship 2</i>			x	x			x		x
<b>IV. Graduation thesis</b>				x	x			x			x	x

## Online Courses

To facilitate student exchange between member universities when the Forest master program operates, the coordinators have directed HCMUTE to develop two online courses. The Department of Chemical Technology, Faculty of Chemical and Food Technology has developed two online courses including Applied Physical Chemistry and Advanced Organic Chemistry.

### Online Course 1: Applied Physical Chemistry (6 ECTS, Compulsory)

**Course Description:** The course "Applied Physical chemistry" is designed to provide students with fundamental physical chemistry knowledge and its applications in multidisciplinary areas including phase diagram, smart polymers, and heat and electrochemical energy conversion and storage. Through this subject, students are able to read and understand phase diagrams, analyze and evaluate materials and technological processes. At the same time, students are also trained to develop critical thinking and the ability to use specialized English

**Course objectives:** The students are provided fundamental and applied physical chemistry knowledge in phase diagram, smart polymers and its applications, heat and electrochemical energy conversion and storage devices

### **Course Learning Outcomes (CLOs)**

**CLO1.** Acquire, evaluate, and integrate knowledge of physical chemistry in different practical applications as phase diagram analysis, phase change materials in thermal energy storage and conversion, smart polymers and their applications, and the fundamentals of electrochemistry and electrochemical energy storage devices.

**CLO2.** Able to use specialized English in reading scientific documents and presentations.

**CLO3.** Recognize and appreciate the importance of self-study and the need for life-long learning.

### **Content of Course:**

- Chapter 1: phase diagrams and their applications
- Chapter 2: thermal energy conversion and storage using phase change materials
- Chapter 3: smart polymers and their applications
- Chapter 4. Fundamentals on electrochemistry and electrochemical energy storage devices
- Final seminar presentations.

### **Online Course 2: Advanced Organic Chemistry.**

**Course Description:** This course is designed to provide students with knowledge about the reaction mechanism of organic synthesis reactions through experiments; techniques in organic synthesis; strategies and tactics in organic synthesis; IR, NMR, MS spectroscopy methods are used to determine the structure of organic compounds.

**Course Objectives:** The students are provides knowledge about the reaction mechanism of functional groups, C-C coupling reactions, and the mechanism of synthesis reactions of some intermediate functional groups in total synthesis; techniques in organic synthesis and organic synthesis process design, elucidate the structure of organic compounds using IR, NMR and MS spectroscopy methods.

### **Course Learning Outcomes (CLOs)**

**CLO1.** Present, explain, and analyze organic reaction mechanisms; and elucidate the chemical structure of organic compounds.

**CLO2.** Fluently use English terms in organic synthesis and structure elucidation using spectroscopic methods.

**CLO3.** Recognize and evaluate the important role of each step in the organic synthesis process, techniques and methods in organic synthesis, structure determination, thereby realize the importance and applications of organic synthesis.

### **Content of Course:**

- Chapter 1: functional group modifications
- Chapter 2: Skeletal Modifications
- Chapter 3: The Techniques of Organic Synthesis
- Chapter 4: Spectrometric Identification of Organic Compounds

# Chapter 4: The FOREST master's program in Vietnam: Best practices in Hue University of Sciences (HUSC)

*Tran Thi Ai My, Tran Anh Tuan, Nguyen Thi Ai Nhung, Hue University of Sciences, Vietnam*

The introduction of the Master program of Chemistry at Hue University of Sciences began with the realisation of the Erasmus + program project “Future-Oriented Chemistry – FOREST” in August 2023.

**The main goal of the project is** to improve the quality of the Master's program towards green and sustainable development at partner universities.

**Specific objectives of the project:**

- Development of the Master's program of Chemistry based on Future-Oriented Chemistry;
- Improve capacity to develop a Master's program in Chemistry according to European standards.
- Develop transferable courses between member universities;
- Develop online courses;
- Teaching new skills for teachers;
- Impact and change the thinking of stakeholders about future-oriented chemistry.

**Needs for FOREST master program.** HUSC's project team together with the Science and Training Council of the Department of Chemistry met to agree on adding new subjects to increase awareness of climate change and prevention solutions, aiming to train human resources based on the future-oriented Chemistry.

**The analytical data of the survey were used for developing learning outcomes of the master's program**

**Development of master program.** The program has been developed within the framework of the **European project Erasmus+ “Master’s program of Chemistry”** with the participation of Linkoping University (Sweden), University of Leoben (Austria), Polytechnic Institute of Tomar (Portugal), University of Catania (Italy), Thai Nguyen University of Sciences (TNUS), Ho Chi Minh City University of Technology and Education (HCMUTE) and Vietnam National University of Forestry (VNUF).

Learning outcomes are formulated based on the European Credit Transfer and Accumulation System (ECTS) guidelines.

**Name of the program: “Master’s degree of Chemistry”**

Major : **Chemistry**  
Code : **8440112**  
Education level : **Master Degree**  
Training Orientation : **Applied**

**1. Objectives**

The goal of a Master's degree training program in Chemistry is to provide students with advanced and specialized knowledge in the field of chemistry, equipping them with the skills and expertise necessary for successful careers in academia, research, or industry. This program typically focuses on deepening understanding in core areas of chemistry such as organic, inorganic, physical, and analytical chemistry, while also fostering critical thinking, problem-solving abilities, and laboratory techniques. Through coursework, research projects, and hands-on experiences, students are challenged to explore the frontiers of chemical science and contribute to the advancement of knowledge in their chosen area of specialization. Additionally, a Master's degree in Chemistry aims to cultivate effective communication skills, ethical practices, and a commitment to lifelong learning, preparing graduates to make meaningful contributions to scientific research, innovation, and education.

**1.1. General objectives:**

- The general objective of a Master's degree training program in Chemistry is to provide students with an advanced and comprehensive education in the various branches of chemistry.
- This includes a deepening of theoretical knowledge, development of practical laboratory skills, and exposure to cutting-edge research methodologies.

**1.2. Specific objectives**

- **Advanced Knowledge:** Provide students with advanced and specialized knowledge in key areas of chemistry, including organic, inorganic, physical, and analytical chemistry.
- **Research Skills:** Develop strong research skills, including the ability to design and conduct experiments, analyze data, and draw meaningful conclusions. Encourage students to contribute original research to the field.
- **Specialization:** Allow students to specialize in a particular sub-discipline of chemistry, such as biochemistry, environmental chemistry, materials chemistry, or medicinal chemistry, enabling them to become experts in a specific area.
- **Critical Thinking:** Foster critical thinking and problem-solving skills, challenging students to approach scientific challenges with creativity and analytical rigor.
- **Laboratory Techniques:** Provide hands-on experience in advanced laboratory techniques, instrumentation, and methods relevant to contemporary research in chemistry.
- **Communication Skills:** Cultivate effective communication skills, both written and oral, to enable students to convey their research findings, ideas, and scientific concepts to diverse audiences.

- Ethical Practices: Emphasize the importance of ethical practices in scientific research and instill a strong sense of integrity in the conduct of experiments and reporting of results.
- Collaboration and Interdisciplinary Skills: Encourage collaboration and interdisciplinary approaches by providing opportunities for students to work with researchers from other fields, fostering a holistic understanding of complex scientific problems.
- Preparation for Ph.D. or Industry Careers: Prepare students for further academic pursuits, such as pursuing a Ph.D., or for careers in industry, where they can apply their knowledge to solve real-world problems.
- Professional Development: Equip students with the tools and skills needed for professional development, including networking, grant writing, and staying current with advancements in the field.

## 2. Learning Outcomes:

Symbols	Program Learning Outcomes (PLOs)
<b>I.</b>	<b>Knowledge</b>
PLO1	Basic understanding of Philosophy
PLO2	Have basic knowledge of English according to regulations of the Ministry of Education and Training
PLO3	Have basic knowledge of Scientific Research Methods, Advanced Inorganic Chemistry, Advanced Organic Chemistry, Advanced Theoretical Chemistry, Advanced Analytical Chemistry, Nanochemistry and Application, Study Methods for Bioactive Natural Compounds, Green Chemistry - Bioactive Natural Products, Ecological and Human Health Risk Assessments, Management of hazardous solid waste, Analysis of Toxic Chemicals in the Environment, Chemical solutions to adapt and mitigate climate change...
PLO4	Know a deep and advanced understanding of key principles and theories in chemistry and specialized knowledge in their chosen area of concentration.
PLO5	Knowledge and the ability to design, conduct, and analyze original research contribute to the body of knowledge in the field.
PLO6	Know specialized expertise in a particular sub-discipline of chemistry, positioning them as experts in their chosen area.
<b>II.</b>	<b>Skills</b>
PLO7	Critical Thinking Skills: Graduates should have honed their critical thinking and analytical skills, enabling them to assess and solve complex problems within the realm of chemistry.
PLO8	Laboratory Proficiency: Graduates should be proficient in advanced laboratory techniques and instrumentation relevant to their field of study.
PLO9	Ability to analyze data and present scientific and technical results.
PLO10	Effective Communication: Successful completion of the program implies proficiency in communicating scientific ideas and research findings through well-written reports, publications, and effective oral presentations.

PLO11	Professional Development Skills: Acquisition of skills related to professional development, including networking, grant writing, and staying informed about advancements in the field.
PLO12	Preparation for Further Study or Employment: Graduates should be well-prepared for either pursuing further academic studies, such as a Ph.D. program, or entering the workforce in industry or research.
PLO13	Leadership and Initiative: Graduates may exhibit leadership qualities and the ability to take initiative in research projects, collaborations, or other professional activities.
<b>III.</b>	<b>Attitudes</b>
PLO14	Have good moral qualities and a healthy lifestyle.
PLO15	Love your job, be honest and have a high sense of discipline at work.
PLO16	Strictly comply with country laws and regulations of organizations.
PLO17	Have a sense of self-awareness and responsibility towards work, the team, yourself and the community.
PLO18	Have an industrial style and serious working attitude.
PLO19	Have a spirit of community service, integration and international cooperation.
PLO20	Be conscious of self-study, practice and update knowledge.
PLO21	Have a sense of creative thinking.
PLO22	Graduates from the Master's program in Chemistry will meet the English proficiency according to regulations of the Ministry of Education and Training.
PLO23	Graduates from the Master's program in Chemistry will meet the basic information technology application level according to Circular No. 03/2014/TT-BTTTT dated March 11, 2014 of the Ministry of Information and Communications.

### 3. Total knowledge volume of the program:

Total credits for the entire program : 120 ECTS

Breakdown:

- General knowledge : 6 ECTS
- Specialized knowledge : 84 ECTS, where
  - Compulsory subjects : 42 ECTS
  - Elective subjects : 42 ECTS
- Practice : 12 ECTS, where
  - Compulsory subjects : 6 ECTS
  - Elective subjects: : 6 ECTS
- Graduation Thesis : 18 ECTS

### 4. List of subjects:

No.	Code	Name of subject	ECTS
<b>I. GENERAL KNOWLEDGE</b>			<b>6</b>
1	07.043	Philosophy (Triết học)	6



<b>II. SPECIALIZED KNOWLEDGE</b>			<b>84</b>
<b>A. Compulsory subjects</b>			<b>42</b>
1	HH.04.037	Advanced Inorganic Chemistry	6
2	HH 04.038	Advanced Organic Chemistry	6
3	HH 04.040	Advanced Theoretical Chemistry	6
4	HH 04.034	Advanced Analytical Chemistry	6
5	HH 04.025	Coordination Chemistry	6
6	HH 04.036	Nanochemistry and Application	6
7	HH 04.087	Physical Chemistry Measurement For Sold Materials	6
8	HH 04.086	Study Methods for Bioactive Natural Compounds	6
<b>B. Elective subjects</b>			<b>42 (42/108)</b>
1	HH 04.044	Crystal Chemistry	6
2	HH.04.007	Some Selected Topics in Inorganic Chemistry	6
3	HH.04.006	Some Selected Topics in Organic Chemistry	6
4	HH.04.041	Advanced Environmental Chemistry	6
5	HH.04.094	Applied Statistics in Chemistry	6
6	HH 04.028	Chemistry of rare elements	6
7	HH 04.111	Inorganic materials	6
8	HH 04.108	Silicate materials	6
9	HH 04.101	Application of Computational Chemistry in Organic Chemistry	6
10	HH 04.115	Catalysis in organic synthesis	6
11	HH 04.081	Food analysis techniques	6
12	HH 04.010	Application of Color Substitutes In Life	6
13	HH 04.051	Separation and Enrichment Techniques	6
14	HH 04.128	Green Chemistry - Bioactive Natural Products	6
15	HH 04.129	Ecological and Human Health Risk Assessments	6
16	HH 04.130	Management of hazardous solid waste	6
17	HH 04.131	Analysis of Toxic Chemicals in the Environment	6
18	HH 04.132	Chemical solutions to adapt and mitigate climate change	6
<b>III. PRACTICE</b>			<b>12</b>
<b>A. Compulsory subjects</b>			<b>6</b>
1	HH 04.078	Practice 1: Modern Spectrophotometric Analysis	6
<b>B. Elective subjects</b>			<b>6 (6/12)</b>
1	HH 04.066	Practice 2: Modern Electrochemical Analysis	6
2	HH 04.079	Practice 3: Modern Chromatographic Analysis	6
<b>IV. MASTER'S THESIS</b>			<b>18</b>
<b>TOTAL ECTS</b>			<b>120</b>

Note: The subjects in red are newly developed subjects within the FOREST project

### 5. Matrix of knowledge and skills according to learning outcomes

Subject code	Subject	Credits	Knowledge						Skills/ Competences						Attitudes							IT, English		
									Professional skills				Soft skills											
			LO 1	LO 2	LO 3	LO 4	LO 5	LO 6	LO 7	LO 8	LO 9	LO 10	LO 11	LO 12	LO 13	LO 14	LO 15	LO 16	LO 17	LO 18	LO 19	LO 20	LO 21	LO 22
<b>I. General knowledge</b>																								
07.043	Philosophy	6	X										X		X	X	X	X	X	X	X	X		
<b>II. Specialized knowledge</b>																								
<b>A - Compulsory</b>																								
HH.04.037	Advanced Inorganic Chemistry	6			X						X		X	X	X	X	X	X	X	X	X	X		
HH 04.038	Advanced Organic Chemistry	6			X		X		X		X	X		X	X	X	X	X	X	X	X	X		
HH 04.040	Advanced Theoretical Chemistry	6			X		X		X		X	X		X	X	X	X	X	X	X	X	X		
HH 04.034	Advanced Analytical Chemistry)	6			X		X		X		X	X		X	X	X	X	X	X	X	X	X		
HH 04.025	Coordination Chemistry	6			X		X		X		X	X		X	X	X	X	X	X	X	X	X		
HH 04.036	Nanochemistry and Application	6			X		X		X		X	X		X	X	X	X	X	X	X	X	X		
HH 04.087	Physical Chemistry Measurement For Sold Materials	6			X		X		X		X	X		X	X	X	X	X	X	X	X	X		
<b>B- Elective (42/108)</b>																								
HH 04.044	Crystal Chemistry	6			X	X	X				X	X	X		X	X	X	X	X	X	X	X		
HH.04.007	Some Selected Topics in Inorganic Chemistry	6			X	X	X				X	X	X		X	X	X	X	X	X	X	X		

Subject code	Subject	Credits	Knowledge						Skills/ Competences						Attitudes						IT, English			
									Professional skills			Soft skills												
			LO 1	LO 2	LO 3	LO 4	LO 5	LO 6	LO 7	LO 8	LO 9	LO 10	LO 11	LO 12	LO 13	LO 14	LO 15	LO 16	LO 17	LO 18	LO 19	LO 20	LO 21	LO 22
HH.04.006	Some Selected Topics in Organic Chemistry	6			X		X				X	X		X	X	X	X	X	X	X	X			
HH.04.041	Advanced Environmental Chemistry	6		X	X		X				X	X		X	X	X	X	X	X	X	X			
HH.04.094	Applied Statistics in Chemistry	6			X	X	X	X			X	X	X		X	X	X	X	X	X	X	X		
HH 04.028	Chemistry of rare elements	6			X	X	X				X	X	X		X	X	X	X	X	X	X			
HH 04.111	Inorganic materials	6		X	X									X	X	X	X	X	X	X				
HH 04.108	Silicate materials	6			X	X	X				X	X	X		X	X	X	X	X	X	X			
HH 04.101	Application of Computational Chemistry in Organic Chemistry	6			X	X	X				X	X	X		X	X	X	X	X	X	X		X	
HH 04.115	Catalysis in organic synthesis	6			X		X				X	X			X	X	X	X	X	X	X			
HH 04.081	Food analysis techniques	6		X	X		X				X	X			X	X	X	X	X	X	X			
HH 04.010	Application of Color Substitutes In Life	6			X	X	X	X			X	X	X		X	X	X	X	X	X	X			
HH 04.051	Separation and Enrichment Techniques	6			X	X	X				X	X	X		X	X	X	X	X	X	X			
HH 04.128	Green Chemistry - Bioactive Natural Products	6		X	X	X	X	X			X	X	X		X	X	X	X	X	X	X			

Subject code	Subject	Credits	Knowledge						Skills/ Competences						Attitudes						IT, English			
									Professional skills			Soft skills												
			LO 1	LO 2	LO 3	LO 4	LO 5	LO 6	LO 7	LO 8	LO 9	LO 10	LO 11	LO 12	LO 13	LO 14	LO 15	LO 16	LO 17	LO 18	LO 19	LO 20	LO 21	LO 22
HH 04.129	Ecological and Human Health Risk Assessments	6		X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	X	X	X	
HH 04.130	Management of hazardous solid waste	6		X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	X	X	X	
HH 04.131	Analysis of Toxic Chemicals in the Environment	6		X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	X	X	X	
HH 04.132	Chemical solutions to adapt and mitigate climate change	6		X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	X	X	X	
<b>III. PRACTICE</b>		<b>12</b>																						
<b>A - Compulsory</b>		<b>6</b>																						
HH 04.078	Practice 1: Modern Spectrophotometric Analysis	6			X	X	X			X	X	X		X	X	X	X	X	X	X	X	X	X	
<b>B -Elective (6/12)</b>		<b>6</b>																						
HH 04.066	Practice 2: Modern Electrochemical Analysis	6			X		X	X			X	X		X	X	X	X	X	X	X	X	X	X	
HH 04.079	Practice 3: Modern Chromatographic Analysis	6			X		X				X	X		X	X	X	X	X	X	X	X	X	X	
<b>IV. MASTER THESIS</b>		<b>18</b>	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
<b>Total</b>		<b>120</b>																						

## **6. Brief description and workload of the subjects**

### **6.1 Philosophy (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* The subject consists of four topics: Chapter 1 covers characteristics of Western philosophy, Eastern philosophy (including Vietnamese philosophical thought at a basic level), and Marxist philosophy. Chapter 2 explores advanced topics related to Marxist-Leninist philosophy in the current stage and its worldview, methodology, and global role. Chapter 3 delves into the interrelation between philosophy and various sciences, emphasizing the role of worldview and methodology in the development of science and in the perception, teaching, and research of subjects in the natural sciences and technology field. Chapter 4 analyzes issues regarding the role of sciences in societal life.

### **6.2. Advanced Inorganic Chemistry (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* The module provides students with advanced knowledge of inorganic chemistry theory to solve several problems related to the chemistry of inorganic substances and inorganic reactions including heat. Kinetics in inorganic chemistry, redox reactions, acid and base reactions.

### **6.3. Advanced Organic Chemistry (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* The content includes the following main basic knowledge: The nature of bonds in organic compounds; Spatial structure of organic compounds; Relationship between properties and structures of organic compounds; Organic reactions: types of reactions, reactants and reaction mechanisms.

### **6.4. Advanced Theoretical Chemistry (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* This module includes advanced knowledge about applying the principles of thermodynamics to chemical equilibrium research and phase equilibrium research. Chemical kinetics research methods and experimental data processing. Theory of elementary processes. Research on electrochemical kinetics. Research on statistical thermodynamics and thermodynamics of non-equilibrium processes.

### **6.5. Advanced Analytical Chemistry (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* This module introduces advanced knowledge about calculating ion balance in solutions, quantifying substances using volumetric analysis, and basic knowledge about ensuring analytical quality. Additionally, students develop scientific reasoning skills and proficiency in using specialized English.

#### **6.6. Coordination Chemistry (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* The module provides students with knowledge about coordination compounds (complexes) including basic concepts of complexes, the role of complexes in life and industry, nomenclature and isomerism of complexes, methods of synthesizing complexes, methods of determining the composition of complexes and methods of analyzing the structure of complexes.

#### **6.7. Nanochemistry and Application (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* Introduction to physicochemical properties of solid surfaces, nanostructures and zero-dimensional, one-dimensional, and two-dimensional nanomaterials. Technologies for manufacturing nanomaterials such as physical vapor phase deposition, chemical atomic layer deposition, electrochemical deposition, self-joining, etc. Structural characterization methods such as XRD, SAXS, SEM, TEM, SPM, BET, chemical characteristics such as optical, electronic, ion spectra, etc. Applications of nanomaterials.

#### **6.8. Physical Chemistry Measurement For Solid Materials (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* *Introducing methods of analyzing the structure of inorganic materials: electron absorption spectrum, nuclear magnetic resonance, mass, infrared, X-ray diffraction, thermal analysis, electron microscopy; Apply these methods in studying material structure.*

#### **6.9. Study Methods for Bioactive Natural Compounds (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* *The module equips students with basic knowledge about natural compounds: origin, methods of isolation, purification, structure determination and biological activity; Basic theory on chemical structure, biological activity and applications of some groups of natural compounds being used as medicines, functional foods, and agricultural products: flavonoids, compounds containing nitrogen, terpenoids, steroids and some other groups of natural compounds.*

#### **6.10. Crystal Chemistry (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* This module offers foundational knowledge on crystallography, the structure of solids in crystalline and amorphous states, phase transitions in solids, fundamental characteristics of solid-state reactions (thermodynamics, kinetics mechanisms, and dynamic models), and various methods for synthesizing solids (materials) and their applications in the production of inorganic compounds and materials. Additionally, the course provides insights into structural analysis methods and the relationship between structure and certain properties (optical, electrical, magnetic, etc.) of solids.

### **6.11. Some Selected Topics in Inorganic Chemistry (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* Introducing methods of analyzing the structure of inorganic materials: electron absorption spectrum, nuclear magnetic resonance, mass, infrared, X-ray diffraction, thermal analysis, electron microscopy; Apply these methods in studying material structure.

### **6.12. Some Selected Topics in Organic Chemistry (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* This module includes: Nomenclature and spatial structure of organic compounds; Stereochemistry, chemical selectivity: agents, reactions; and Pericyclic reactions.

### **6.13. Advanced Environmental Chemistry (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* This module covers the following contents: Global environmental issues: acid rain, greenhouse effect and climate change, ozone layer depletion and the ozone hole, persistent organic pollutants (POPs) in the environment: causes, impacts, and control solutions. Method for rapid assessment of water, air, and soil environmental pollution sources: determine the pollution load from wastewater sources, exhaust gases, and solid waste emitted into the environment. Water quality assessment method based on the Water Quality Index (WQI): approach to building and using WQI, WQI model of the Sanitation Foundation of the US, Canada, and India...

### **6.14. Applied Statistics in Chemistry (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* This module introduces the application of quantities and statistical tools to process, check, and evaluate experimental results; consider correlation and regression; and Experimental planning (variance analysis, modeling, and optimization

of experiments) in chemical research. Students are also introduced to applying statistical software (stratigraphic 7.0, Minitab, or SPSS) to solve related research problems.

**6.15. Chemistry of rare elements (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* The module provides students with advanced knowledge of the chemistry of rare earth elements and ore processing methods; refined; extraction; cup; division and acquisition of rare earth elements. Application of rare elements in the fields of science, technology and life.

**6.16. Inorganic materials (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* The module provides students with some advanced knowledge about the production process of some common inorganic materials.

**6.17. Silicate materials (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* The module "Silicate materials" introduces basic raw materials to produce Portland cement (limestone, clay, iron ore); Portland cement production techniques (calculation of mixing ratio, clinker smelting process, clinker grinding); additives for cement; Curing process of Portland cement; Concrete corrosion and concrete protection measures. Introduction to basic raw materials for ceramic production (kaolin, clay, feldspar, quartz sand); ceramic production techniques (calculating material proportions, processing materials, shaping products, drying, firing, glazing); pigments for ceramics and some types of pigments commonly used in ceramic production.

**6.18. Application of Computational Chemistry in Organic Chemistry (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* This module uses software Gaussian 09, Spartan, AIM2000, NBO6, VASP... to calculate thermodynamic quantities of organic compounds: Bond strength, Electron affinity, Calculate and simulate spectra applied in Organic chemistry: IR spectrum, NMR, Raman... Research the reaction mechanism, study the kinetics of the reaction and influencing factors, study the antioxidant activity of organic compounds, and study the simulation of biological activity using appropriate simulation methods. synthesis and orientation of organic synthesis using simulation methods.

**6.19. Catalysis in organic synthesis (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None



*Previous subject:* None

*Summary:* This module includes: Theory of catalysis, physical and chemical bases of catalysis including Catalytic research methods and Catalysis in the oil processing industry.

#### **6.20. Food analysis techniques (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* This module provides knowledge about the chemical composition of food: glucose, protein, lipid, vitamins; Ingredients related to food safety: products formed due to metabolism during food preservation, ingredients related to raw material sources: heavy metals, residues of plant protection chemicals... food processing process.

#### **6.21. Application of Color Substitutes in Life (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* This module includes the theory of color compounds: concepts of colorants, dyes, and pigments; Some important families of color compounds and dyes; Analyzing and evaluating dyes and color compounds; and Colorants in classical photography and electronic photography, in ink and printing, in cosmetics and pharmaceuticals, in analysis and the environment...

#### **6.22. Separation and Enrichment Techniques (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* This module introduces several separation and enrichment methods such as Liquid-liquid extraction, solid phase extraction, precipitation, and distillation... commonly used in substance analysis. Each method presents principles, content, influencing factors, etc., as well as calculation exercises related to the method.

#### **6.23. Green Chemistry - Bioactive Natural Products (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* The module provides students with the concept and classification of biologically active natural compounds: terpenoids, steroids, phenolic compounds and flavonoids, alkaloids, carbohydrates, etc. At the same time, it helps students gain knowledge about density functional theory, molecular docking simulation, and application of algorithms and calculation methods to solve the nature of bonds, structure, and properties. properties, relationships between structure - properties, structure - activity of natural compounds. Provide knowledge about using computational software to predict the physical and chemical properties of natural compounds. Apply knowledge to solve problems in scientific research and practice.

#### **6.24. Ecological and Human Health Risk Assessments (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* The module provides students with basic knowledge about the pollution of toxic chemicals such as POPs, trace elements and microplastics in different environmental objects. And provide tools and methods to assess risks to ecosystems and human health.

#### **6.25. Management of hazardous solid waste (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* The module provides students with an overview of the characteristics of hazardous waste, processes and principles for storing, transporting, treating and safely disposing of hazardous waste. Topics/concepts including programs, regulations, hazards and methods related to hazardous waste management in household, business, agriculture and industry are also introduced to help students identify, describe and compare them in developing and developed countries.

#### **6.26. Analysis of Toxic Chemicals in the Environment (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* The module provides students with basic knowledge about toxic chemicals (POPs, trace elements and microplastics) in the environment, the causes and modern analytical methods to analyze them.

#### **6.27. Chemical solutions to adapt and mitigate climate change (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* The module provides students with basic knowledge about climate and climate change, the causes and solutions to adapt to climate change and mitigate the impact of climate change. climate change to humans and nature and reduce greenhouse gas emissions.

#### **6.28. Practice 1: Modern Spectrophotometric Analysis (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* Principles of spectrum generation, principle diagram of spectrometer structure, correlation between molecular structure atoms and spectra. Analyzing the spectra and determining the structural formula of the organic compound. Application of spectroscopic methods in the fields of organic compound research.

#### **6.29. Practice 2: Modern Electrochemical Analysis (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* This module introduces modern electrochemical analysis methods: theory and practice: Potential measurement method using ion selective electrodes and applications in practical analysis; Modern polar spectroscopy methods (differential pulse spectroscopy, square wave spectroscopy) and their applications in inorganic and organic analysis; Anodic Stripping Voltammetry and Adsorptive Stripping Voltammetry and application in trace analysis; Cyclic Voltammetry method.

**6.30. Practice 3: Modern Chromatographic Analysis (6 ECTS):**

*Learning time allocation:* 6 (1/1/4)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* Principles and practicing of analysis up to the determination of the structure of a substance. Some sample analysis methods are applied on actual samples, how to choose analysis methods and process analysis results for some unknown compounds and unknown compounds.

**6.31. Master Thesis (30 ECTS):**

*Learning time allocation:* 30 (0/10/20)

*Subject prerequisite:* None

*Previous subject:* None

*Summary:* In this master thesis, students are tasked with addressing a scientific and technical by using various methods. This involves defining the scope of a topic, developing a research methodology, conducting the research, collecting data, and analyzing and synthesizing the data to discover a scientific and technical pattern in the field of Chemistry. Ultimately, students are required to interpret the research results clearly and logically through both written and verbal communication.



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**Hue University of Sciences (HUSC)**

**2024**