



Teacher(s)	De Wilde Juray ;
Language :	English
Place of the course	Louvain-la-Neuve
Main themes	The production of basic chemicals is addressed. In the first part of the course, an overview of the chemical industry is given. A second part of the course addresses the various unit operations typically encountered in a chemical process. Basic models for the design of chemical reactors are described in the third part of the course. Finally, some key processes are covered in detail, including flow-sheets and aspects of reaction kinetics/catalysis, reactor design, separation and purification of reactants and products, energy needs and environmental impact and safety.
Learning outcomes	<p>At the end of this learning unit, the student is able to :</p> <p>Contribution of the course to the program objectives Referring to the LOs of the KIMA diploma, the following LOs are aimed at:</p> <ul style="list-style-type: none"> • Axe 1: 1.1, 1.2; • Axe 2: 2.2, 2.3, 2.4, 2.5; • Axe 3: 3.1, 3.2, 3.3; • Axe 4: 4.1, 4.2, 4.4; • Axe 5: 5.3, 5.5, 5.6; • Axe 6: 6.1, 6.2, 6.3. <p>Specific learning outcomes of the course</p> <p>Disciplinary learning outcomes At the end of this course the student will be able to:</p> <ul style="list-style-type: none"> - Give an overview of the (petro)chemical industry, the most important processes and their interactions. - Give the typical refining schemes and the processes involved. - Provide an overview of the various unit operations used in the chemical processes: <ul style="list-style-type: none"> • Types of unit operation (reaction, separation, heat exchange, ...) • Technology (ies) used for the different unit operations - Make or interpret a flow-sheet incorporating different unit operations. - Calculate mass/species balances and energy balances for chemical processes taking into account the different unit operations - Model and design chemical reactors¹ <ul style="list-style-type: none"> • Well-mixed, in batch or continuous operation • Plug flow - Take a variety of measures to increase the energy efficiency and to reduce the environmental impact of a chemical process. - For the following production processes: <ul style="list-style-type: none"> • Steam cracking : ethylene, propylene, butadiene • Steam reforming : syngas and hydrogen, ammonia, methanol • Catalytic reforming : benzene, toluene, xylene, gasoline • Catalytic cracking: gasoline • Sulfuric acid • Nitric acid • Maleic anhydride - Describe in detail: <ul style="list-style-type: none"> • the process flow sheet (species and heat) and the interaction with other processes, • the process safety, • the feedstock and product requirements, • the process conditions, • the chemistry and reaction thermodynamics and kinetics, • the catalyst if used, • the reactor types used and their design, i.e. the appropriate reactor model(s), • the measures taken to increase the energy efficiency and to reduce the environmental impact

	<p>Transverse learning outcomes</p> <p>At the end of this course the student will be able to:</p> <ul style="list-style-type: none"> • Study independently the different aspects of a chemical process. • Present and explain the different aspects of a chemical process to a professional audience, in writing and orally. • Look up and use scientific and technical information from various sources, including reference text books and the web. • To use a corpus of scientific and technical knowledge, allowing to solve given problems in the discipline studied. • To analyze, organize and develop an engineering approach for process development responding to specific needs or a given problem, the analysis of a given physical phenomenon or a system. • To contribute, as a team member, to the realization of a project with a given discipline or multiple disciplines according to a well described approach. • To efficiently communicate by writing and presentation, in English or French, the results of a well-defined project. • To show a rigorous behavior and critical thinking in carrying out scientific or technical tasks with respect for ethical issues.
<p>Evaluation methods</p>	<p>The students will be individually graded based on the objectives indicated above. The theoretical exam is with a written preparation and oral defense/discussion. It counts for 70% of the mark. An exercise is part of the exam.</p> <p><u>Evaluation of the mini-projects</u></p> <p>One/two mini-projects (defined in the section on Learning methods) are evaluated. They count for 15/30% of the mark.</p>
<p>Teaching methods</p>	<p>This course combines ex-cathedra teaching, exercise sessions and projects with tutoring.</p> <p>The theoretical courses are ex-cathedra. The students are encouraged to ask questions. In the context of the course, a number of scientific papers have to be read and analyzed.</p> <p>The exercises focus on performing mass/species balances and energy balances for different processes, the safety analysis of a process, the modeling and simulation of well-mixed reactors (batch and continuous) and plug flow. Apart from exercise sessions, two mini-projects are planned to train students in the study and understanding of different aspects of a chemical process independently.</p> <p><u>Example mini-project 1</u> : "Simulation of a commercial reactor for steam cracking of ethane" allows students to apply reactor modeling concepts in particular for plug flow reactors, reaction kinetics and numerical methods to a practical case of great industrial importance. With the developed simulation code of simulation, a sensitivity study is performed. The coupling reactor - furnace must be considered in the analysis of the results.</p> <p><u>Example mini-project 2</u> : "Sulfuric acid production: design of the global process and thermodynamic study of the oxidation of SO₂ to SO₃" allows students to study the mass and energy balances of an industrial process and to identify thermodynamic constraints of conversion.</p> <p>In addition to developing students' technical skills, the mini-projects also aim to teach students how to report a technical study scientifically and concisely, both writing and orally, in front of an audience.</p>
<p>Content</p>	<p>Main themes:</p> <p>The production of basic chemicals is addressed. In the first part of the course, an overview of the chemical industry is given. A second part of the course addresses the various unit operations typically encountered in a chemical process. Basic models for the design of chemical reactors are described in the third part of the course. Finally, some key processes are covered in detail, including flow-sheets and aspects of reaction kinetics/catalysis, reactor design, separation and purification of reactants and products, energy needs and environmental impact and safety.</p> <p>Content:</p> <ul style="list-style-type: none"> • Refining and (petro) chemical industry • Unit operations • Material and energy balances • Analysis and design of chemical reactors : <ul style="list-style-type: none"> • Batch Reactors • Plug flow reactors • Well-mixed Reactors • Introduction to heterogeneous catalytic reactors (fixed bed and fluidized bed) • Safety of chemical processes • Environmental aspects and energy efficiency • Key Processes I: <ul style="list-style-type: none"> • Steam cracking: ethylene, propylene, butadiene & • Steam reforming hydrogen, ammonia & methanol • Catalytic reforming: benzene, toluene & xylene, high-octane gasolines • Catalytic cracking: petrol / C₃-C₄ olefins & isobutane • Maleic anhydride • Key Processes II: <ul style="list-style-type: none"> • Sulfuric acid • Nitric acid

Inline resources	https://moodleucl.uclouvain.be/course/view.php?id=10005
Bibliography	Les notes de cours (en français et en anglais) sont fournies aux étudiants et disponible sur Moodle. Text book: Chemical Reactor Analysis and Design, 3th edition, Gilbert F. Froment, Kenneth B. Bischoff, Juray De Wilde, Wiley, 2010.
Other infos	<p>This course requires basic knowledge in chemistry and chemical engineering (thermodynamics, kinetics and transport phenomena).</p> <p>Learning outcomes:</p> <p>Contribution of the course to the program objectives</p> <p>Referring to the LOs of the KIMA diploma, the following LOs are aimed at:</p> <ul style="list-style-type: none"> • Axe 1: 1.1, 1.2; • Axe 2: 2.2, 2.3, 2.4, 2.5; • Axe 3: 3.1, 3.2, 3.3; • Axe 4: 4.1, 4.2, 4.4; • Axe 5: 5.3, 5.5, 5.6; • Axe 6: 6.1, 6.2, 6.3. <p>Specific learning outcomes of the course</p> <p>Disciplinary learning outcomes</p> <p>At the end of this course the student will be able to:</p> <ul style="list-style-type: none"> • Give an overview of the (petro)chemical industry, the most important processes and their interactions. • Give the typical refining schemes and the processes involved. • Provide an overview of the various unit operations used in the chemical processes: <ul style="list-style-type: none"> • Types of unit operation (reaction, separation, heat exchange, ...) • Technology (ies) used for the different unit operations • Make or interpret a flow-sheet incorporating different unit operations. • Calculate mass/species balances and energy balances for chemical processes taking into account the different unit operations • Model and design chemical reactors <ul style="list-style-type: none"> • Well-mixed, in batch or continuous operation • Plug flow • Take a variety of measures to increase the energy efficiency and to reduce the environmental impact of a chemical process. • For the following production processes: <ul style="list-style-type: none"> • Steam cracking : ethylene, propylene, butadiene • Steam reforming : syngas and hydrogen, ammonia, methanol • Catalytic reforming : benzene, toluene, xylene, gasoline • Catalytic cracking: gasoline • Sulfuric acid • Nitric acid • Maleic anhydride • Describe in detail: <ul style="list-style-type: none"> • the process flow sheet (species and heat) and the interaction with other processes, • the process safety, • the feedstock and product requirements, • the process conditions, • the chemistry and reaction thermodynamics and kinetics, • the catalyst if used, • the reactor types used and their design, i.e. the appropriate reactor model(s), • the measures taken to increase the energy efficiency and to reduce the environmental impact <p>Transverse learning outcomes</p> <p>At the end of this course the student will be able to:</p> <ul style="list-style-type: none"> • Study independently the different aspects of a chemical process. • Present and explain the different aspects of a chemical process to a professional audience, in writing and orally. • Look up and use scientific and technical information from various sources, including reference text books and the web. • To use a corpus of scientific and technical knowledge, allowing to solve given problems in the discipline studied. • To analyze, organize and develop an engineering approach for process development responding to specific needs or a given problem, the analysis of a given physical phenomenon or a system. • To contribute, as a team member, to the realization of a project with a given discipline or multiple disciplines according to a well described approach. • To efficiently communicate by writing and presentation, in English or French, the results of a well-defined project. • To show a rigorous behavior and critical thinking in carrying out scientific or technical tasks with respect for ethical issues.

Faculty or entity in charge	FYKI
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Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Chemical and Materials Engineering	KIMA2M	5		
Master [120] in Biomedical Engineering	GBIO2M	5		
Master [120] in Chemistry and Bioindustries	BIRC2M	5		