



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

	<p><b>Transverse learning outcomes</b></p> <p>At the end of this course the student will be able to:</p> <ul style="list-style-type: none"> <li>• Study independently the different aspects of a chemical process.</li> <li>• Present and explain the different aspects of a chemical process to a professional audience, in writing and orally.</li> <li>• Look up and use scientific and technical information from various sources, including reference text books and the web.</li> <li>• To use a corpus of scientific and technical knowledge, allowing to solve given problems in the discipline studied.</li> <li>• 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.</li> <li>• 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.</li> <li>• To efficiently communicate by writing and presentation, in English or French, the results of a well-defined project.</li> <li>• To show a rigorous behavior and critical thinking in carrying out scientific or technical tasks with respect for ethical issues.</li> </ul>
Evaluation methods	<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>
Teaching methods	<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 SO<sub>2</sub> to SO<sub>3</sub>" 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>
Content	<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"> <li>• Refining and (petro) chemical industry</li> <li>• Unit operations</li> <li>• Material and energy balances</li> <li>• Analysis and design of chemical reactors :</li> <li>• Batch Reactors</li> <li>• Plug flow reactors</li> <li>• Well-mixed Reactors</li> <li>• Introduction to heterogeneous catalytic reactors (fixed bed and fluidized bed)</li> <li>• Safety of chemical processes</li> <li>• Environmental aspects and energy efficiency</li> <li>• Key Processes I:</li> <li>• Steam cracking: ethylene, propylene, butadiene &amp;</li> <li>• Steam reforming hydrogen, ammonia &amp; methanol</li> <li>• Catalytic reforming: benzene, toluene &amp; xylene, high-octane gasolines</li> <li>• Catalytic cracking: petrol / C<sub>3</sub>-C<sub>4</sub> olefins &amp; isobutane</li> <li>• Maleic anhydride</li> <li>• Key Processes II:</li> <li>• Sulfuric acid</li> <li>• Nitric acid</li> </ul>

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

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		