**SYLLABUS**

**Fall semester 2022-2023 academic years**

**on the educational program «*Modern Chemical Breakthrough*»**

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| **Discipline’s code** | **Discipline’s title** | **Independent work of students (IWS)** | **No. of hours per week** | | | | **Number of credits** | **Independent work of student with teacher (IWST)** |
| **Lectures (L)** | **Practical training (PT)** | | **Laboratory (Lab)** |
| PNH7302 | Modern Chemical Breakthrough | 98 | 15 | 30 | | - | 7,5 | 7 |
| **Academic course information** | | | | | | | | |
| **Form of education** | **Type of course** | **Types of lectures** | | | **Types of practical training** | | **Form of final control** | |
| Full-time | Descriptive, Analytical | Problematic, analytical, educational | | | Problem solving, | |
| **Lecturer** | PhD Malchik Fyodor | | | | | | Exam  (project) | |
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| **Telephone number** | +77072442236 | | | | | |

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| **Aim of the course** | **Expected Learning Outcomes (LO)**  As a result of studying the discipline the postgraduate will be able to: | **Indicators of LO achievement (ID)**  (for each LO at least 2 indicators) |
| **Aim of the course:** to form the ability of thinking and designing products/processes/software within the framework described by the new paradigms of chemical and physical-chemical engineering. | 1) Describe and explain the main features of the multi-layered view of chemistry. | 1.1 Describes the three main layers of the multi-layered view of chemical and biochemical engineering and explains the interaction among them. |
| 1.2 Identifies various branches of chemical industry as part of these layers. |
| 2) Understand, explain and recognize the circular economy approach in chemistry. | 2.1 Explains the sustainable resource management concept. |
| 2.2 Finds and explains examples of “cradle to cradle” chemical processes. |
| 3) Understand and explain the concept of chemical “product design and engineering” as opposed to chemical “process design and engineering”. The 3rd paradigm of chemical engineering. | 3.1 Describes and explains the differences between product and process design/engineering. |
| 3.2 Recognizes and explains the steps of a chemical product design. |
| 3.3 Applies some steps of product design in a case study. |
| 4) Understand and explain the concept of green chemical engineering. | 4.1 Explains the main features and ways of achieving green chemistry. |
| 4.2 Explains the main features and ways of achieving green engineering. |
| 4.3 Explains the interdependencies between green chemistry and engineering. |
| 4.4 Finds and explains an example of a process respecting the principles of green chemical engineering. |
| 5) Understand and explain the sustainable resource management as applied to chemical engineering (with respect to global grand challenges) | 5.1 Finds and explains examples of renewable energy sources and sustainable energy management in chemical engineering. |
| 5.2 Finds and explains examples of industrial and social waste as resource. |
| 5.3 Finds and explains examples of sustainable water use (and purification). |
| 5.4. Explains and identifies strategies of carbon capture and storage. |
| 6) Understand the perspectives of computer sciences in chemical engineering. | 6.1 Explains the role of modeling and simulation in chemical engineering, with regard to sustainable development and process control |
| 6.2 Explains the lay-out and function of a virtual laboratory. |
| 7) Understand new trends in analytical equipment development, for the support and assistance of chemical engineering | 7.1. Explains the novel approaches in analytical techniques that support and assist chemical production and engineering. |
| 7.2. Finds and gives examples of improved analytical techniques. |
| **Prerequisites** | Undergraduate studies in Chemistry or Chemical Engineering are of benefit | |
| **Post requisites** | Execution of the final thesis. | |
| **Information resources** | **References**   1. Gani, R, *et al*., “*A multi-layered view of chemical and biochemical engineering*”, *Chemical Engineering Research and Design*, **2020**, 155, A133-A145. 2. Garcia-Serna, J, *et al*., “*New trends for design towards sustainability in chemical engineering: Green engineering*”, *Chemical Engineering Journal*, **2007**, 133, 7-30. 3. Charpentier, J.C, McKenna, T.F, “*Managing complex systems: some trends for the future of chemical and process engineering*”, *Chemical Engineering Science*, **2004**, 59, 1617-1640. 4. Favre, E, *et al.,* “*Trends in chemical engineering education: Process, product and sustainable chemical engineering challenges*”, *Education for Chemical Engineers*, **2008**, 3, e22-e27. 5. Charpentier, J.C, “*Among the trends for a modern chemical engineering, thethird paradigm: The time and length multiscale approachas an efficient tool for process intensification and productdesign and engineering*”, *Chemical Engineering Research and Design*, **2010**, 88, 248-254. 6. Costa, “*Chemical product Design and Engineering*”, in *Kirk-Othmer Encyclopedia of Chemical Technology*, John Wiley & Sons, **2014**. 7. Uhlemann, J, *et al.,* “*Product design and engineering - past, present, future trends in teaching, research and practices: academic and industry points of view*”, *Current Opinion in Chemical Engineering*, **2020**, 27, 10-21. 8. Zhang, L., *et al.,* “*Chemical product design – recent advances and perspectives*”, *Current Opinion in Chemical Engineering*, **2019**, 27, 22-34. 9. Kim, YH, *et al.,* “*Recent Research Trends of Chemical absorption in CCS (Carbon dioxide Capture and Storage) and the role of Process Systems Engineering*”, *Korean Chemical Engineering Research,* **2009**, 47, 531-537. 10. Agrawal, R., “*Chemical engineering for a solar economy (2017 P. v. Danckwerts Lecture*)”, *Chemical Engineering Science*, **2019**, 210, 115215. 11. Cheng, F, “*Functional Materials for Rechargeable Batteries*”, *Advanced Materials*, **2011**, 23, 1695-1715. 12. Binnemans, K., *et al.,* “*Recycling of rare earths: a critical review*”, *Journal of Cleaner Production*, **2013**, 51, 1-22.   **Internet resources:**   1. <https://www.equator-network.org/> 2. <https://www.dnv.com/> 3. <http://chemistry-chemists.com/Uchebniki/Chemistry-books-UnChem.html>   Other/further resources will be provided by the teacher during the semester. | |

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| **Academic policy of the course in the context of university moral and ethical values** | **Academic Behavior Rules:**  All students have to register at the MOOC. The deadlines for completing the modules of the online course must be strictly observed in accordance with the discipline study schedule.  ATTENTION! Non-compliance with deadlines leads to loss of points! The deadline of each task is indicated in the calendar (schedule) of implementation of the content of the curriculum, as well as in the MOOC.  **Academic values:**  - Practical trainings/laboratories, IWS should be independent, creative.  - Plagiarism, forgery, cheating at all stages of control are unacceptable.  - Students with disabilities can receive counseling *via* e-mail |
| **Evaluation and attestation policy** | **Criteria-based evaluation:** assessment of learning outcomes in relation to descriptors (verification of the formation of competencies in midterm control and exams).  **Summative evaluation:** assessment of work activity (project) in an audience (at a webinar); assessment of the completed task. |

**CALENDAR (SCHEDULE) THE IMPLEMENTATION OF THE COURSE CONTENT:**

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| week | Topic name | Number of hours | Max.  score\*\*\* |
| **Module 1**  **New chemical engineering and green chemistry** | | | |
| 1 | **Lec 1.** Introduction: Chemical Engineering - Past, Present, Future. The multi-layered view of chemical and biochemical engineering - Description | 1 | 3 |
| 1 | **Sem 1.** Discussion: Chemistry in the past | 1 | 4 |
| 1 | **Sem 2.** Discussion: Chemistry in future | 1 | 4 |
| 2 | **Lec 2.** How to track science and scientists? | 1 | 3 |
| 2 | **Sem 3.** Creation of scientific profile: Google scholar, Science Direct | 1 | 4 |
| 2 | **Sem 4.** Creation of scientific profile: Scopus, ORCID | 1 | 4 |
| 2 | **IWST 1. Consultation on the implementation of IWS1 on the topic: Difference in ScienceDirect and Scopus databases.** | 1 | 5 |
| 3 | **Lec 3.** The multi-layered view of chemical and biochemical engineering – Recap. The circular economy concept. The 3rd paradigm of chemical engineering – introduction. | 1 | 3 |
| 3 | **Sem 5.** The circular economy concept – Examples. | 1 | 4 |
| 3 | **Sem 6.** The 3rd paradigm of chemical engineering – introductory explanations and examples. | 1 | 4 |
| 3 | **SIW 1. Difference in ScienceDirect and Scopus databases.** |  | 9 |
| 4 | **Lec 4.** Chemical product design and engineering. Steps of chemical product design. | 1 | 3 |
| 4 | **Sem 7.** Chemical product design and engineering. Steps of chemical product design. Examples, interaction and overlaps among steps. | 1 | 4 |
| 4 | **Sem 8.** Identification of steps for various cases, including chemical software products. | 1 | 4 |
|  | **IWST 2. Colloquium (CV writing.).** | 1 | 5 |
| 5 | **Lec 5.** The concept of Green chemical engineering – description, key elements. Green chemistry. | 1 | 3 |
| 5 | **Sem 9.** Green chemistry – presentation, discussion of various approaches. | 1 | 4 |
| 5 | **Sem 10.** Real application of green chemistry. | 1 | 4 |
| 6 | **Lec 6.** Green engineering. Interaction with green chemistry. | 1 | 4 |
| 6 | **Sem 11.** Rounding up into green chemical engineering. | 1 | 4 |
| 6 | **Sem 12.** Real examples of green engineering in the world | 1 | 4 |
| 7 | **Lec 7.** Sustainable resource management as applied to chemical engineering - renewable energy sources and sustainable energy management in chemical engineering. | 1 | 3 |
| 7 | **Sem 14.** Overestimation of the role of Renewable energy | 1 | 4 |
| 7 | **Sem 15.** Renewable energy sources as related to chemical engineering – Examples. | 1 | 4 |
| 7 | **IWST 3. Consultation on the implementation of the IWS 2.** | 1 | 3 |
|  | **LEVEL CONTROL 1** |  | **100** |
|  | **Module 2**  **Chemical resources and modeling and simulation in chemistry** |  |  |
| 8 | **Lec 8.** Sustainable resource management as applied to chemical engineering - industrial and social waste as resource. Part 1 – Social waste. | 1 | 3 |
| 8 | **Sem 16.** Industrial waste as resource in chemical engineering – Examples. | 1 | 3 |
| 8 | **Sem 17.** Industrial waste as global problem | 1 | 4 |
| 8 | **IWS 2. Renewable energy – scheme of one example. Project.** |  | 5 |
| 9 | **Lec 9.** Sustainable resource management as applied to chemical engineering - industrial and social waste as resource. Part 2 – Industrial waste | 1 | 3 |
| 9 | **Sem 9.** Social waste as resource in chemical engineering – Examples. | 1 | 3 |
| 9 | **Sem 19.** Social waste as global problem | 1 | 3 |
| 10 | **Lec 10** Sustainable resource management as applied to chemical engineering - sustainable water use; its purification. | 1 | 3 |
| 10 | **Sem 20.** Sustainable water use in chemical industry | 1 | 3 |
| 10 | **Sem 21.** Water purification. | 1 | 3 |
| 10 | **IWST 4. Colloquium (Essay). Letter to professor** | 1 | **7** |
| 11 | **Lec 11** Sustainable resource management as applied to chemical engineering - strategies of (chemical) carbon capture and (chemical) storage. | 1 | 3 |
| 11 | **Sem 22.** (Chemical) carbon capture and (chemical) storage – Examples. | 1 | 3 |
| 11 | **Sem 23.** Comparative discussion of figures in terms of yields *vs* costs. | 1 | 3 |
| 12 | **Lec 12.** Perspectives of computer sciences in chemical engineering – Modeling and simulation. | 1 | 3 |
| 12 | **Sem 24.** Programs for modelling and simulation. | 1 | 3 |
| 12 | **Sem 25.** Novel aspects and emerging trends of modeling and simulation in chemical engineering – Examples. | 1 | 3 |
| 12 | **IWST 5. Consultation on the implementation of the IWS 3.** | 1 | 4 |
| 13 | **Lec 13** Perspectives of computer sciences in chemical engineering – Process control. | 1 | 3 |
| 13 | **Sem 26.** Novel aspects and emerging trends of process control in chemical engineering – Examples. | 1 | 3 |
| 13 | **Sem 27.** Process control programs | 1 | 3 |
| 13 | **IWS 3. Simulation of chemical process using COMSOL MULTIPHISICS. Project.** | 1 | 4 |
| 14 | **Lec 14** Perspectives of computer sciences in chemical engineering – virtual laboratories. | 1 | 3 |
| 14 | **Sem 28.** Reliability of virtual laboratories. | 1 | 3 |
| 14 | **Sem 29.** Virtual laboratories – examples. | 1 | 3 |
|  | **IWST 6. Colloquium (Presentation). Computer science – History view** | 1 | 5 |
| 15 | **Lec 15** Novel approaches in analytical techniques that support and assist chemical production and engineering. | 1 | 3 |
| 15 | **Sem 30.** Novel approaches in analytical techniques that support and assist chemical production and engineering – Examples. | 1 | 4 |
| 15 | **Sem 31.** Novel analytical equipment. | 1 | 4 |
| 15 | **IWST 7. Consultation on examination issues** | 1 | 0 |
|  | **LEVEL CONTROL 2** |  | **100** |

[Abbreviations: QS - questions for self-examination; TT - typical tasks; IT - individual tasks; MT - midterm.

Comments:

- Form of L and PT: webinar in MS Teams / Zoom (presentation of video materials for 10-15 minutes, then its discussion / consolidation in the form of a discussion / problem solving / ...)

- Form of carrying out the CW: webinar (at the end of the course, the students pass screenshots of the work to the monitor, he/she sends them to the teacher) / test in the Moodle DLS.

- All course materials (L, QS, TK, IT, etc.) see here (see Literature and Resources, p. 6).

- Tasks for the next week open after each deadline.

- CW assignments are given by the teacher at the beginning of the webinar.]

**Dean A.K. Galeyeva**

**Chairman of the Faculty Methodical Bureau R.A. Mangazbayeva**

**Head of the Department A. M. Argimbayeva**

**Lecturer** **F.I. Malchik**