AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name:	Thermodynamics of irreversible processes and nonequilibrium phenomena				
Academic year:	2019/2020	Code:	ZSDA-3-0071-s	ECTS credits:	3
Faculty of:	Szkoła Doktorska AGH				
Field of study:	Szkoła Doktorska AGH	Specialty:	—		
Study level:	Third-cycle studies	Form and type of study:	Full-time studies		
Lecture language:	English	Profile of education:	Academic (A)	Semester:	0
Course homepage:	—				
Responsible teacher:	dr hab. inż. Tkacz-Śmiech Katarzyna (smiech@agh.edu.pl)				

Module summary

The course allows a doctoral candidate gaining knowledge within modern thermodynamics of irreversible processes and non-equilibrium phenomena. Theoretical fundamentals are integrated with solving the problems in practical applications. Linear (chemical reactions, multi-component diffusion, heat transport, multi-component fluid) and nonlinear irreversible systems (oscillatory structures, non-Newtonian fluid) are discussed.

Description of learning outcomes for module

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Connections with FLO	Method of learning outcomes verification (form of completion)
Social competence: is able to			
M_K001	Is aware of the importance of basic research in every discipline, including technology.	SDA3A_K01	Case study
Skills: he can			
M_U001	Is able to use knowledge in the field of thermodynamics of irreversible processes in the description of physicochemical phenomena and technological processes.	SDA3A_U01	Case study
M_U002	Actively participates in the discussion regarding the fundamental laws of nature.	SDA3A_U04	Activity during classes
Knowledge: he knows and understands			
M_W001	Understands the essence of irreversible processes and their relationship with time.	SDA3A_W05	Activity during classes

M_W002	Knows the basis of modern thermodynamics of nonequilibrium phenomena.	SDA3A_W01	Presentation

Number of hours for each form of classes

	Form of classes										
Suma	Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Prace kontrolne i przejściowe	Lektorat
40	20	0	0	0	0	20	0	0	0	0	0

FLO matrix in relation to forms of classes

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Form of classes										
		Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Prace kontrolne i przejściowe	Lektorat
Social competence: is able to												
M_K001	Is aware of the importance of basic research in every discipline, including technology.	+	-	-	-	-	+	-	-	-	-	-
Skills: he can												
M_U001	Is able to use knowledge in the field of thermodynamics of irreversible processes in the description of physicochemical phenomena and technological processes.	-	-	-	-	-	+	-	-	-	-	-
M_U002	Actively participates in the discussion regarding the fundamental laws of nature.	+	-	-	-	-	+	-	-	-	-	-
Knowledge: he knows and understands												
M_W001	Understands the essence of irreversible processes and their relationship with time.	+	-	-	-	-	+	-	-	-	-	-
M_W002	Knows the basis of modern thermodynamics of nonequilibrium phenomena.	+	-	-	-	-	-	-	-	-	-	-

Student workload (ECTS credits balance)

Student activity form	Student workload
Udział w zajęciach dydaktycznych/praktyka	40 h
Preparation for classes	5 h
przygotowanie projektu, prezentacji, pracy pisemnej, sprawozdania	3 h
Realization of independently performed tasks	2 h
Contact hours	1 h
Summary student workload	51 h
Module ECTS credits	3 ECTS

Additional information

Module content

Lectures

Topics covered in this course
1)The formalism of modern thermodynamics
-Thermodynamic systems: equilibrium and nonequilibrium, open, biological
-Legandre transforms of thermodynamic potentials
-The second law of thermodynamics, entropy
-Extremum principles
-Thermodynamic quantities for liquids and solids
2)Nonequilibrium systems
-Local equilibrium, local entropy production
-Nonequilibrium Maxwell relations
-Nonequilibrium effects
3)Linear irreversible thermodynamics
-Linear phenomenological laws and Onsager reciprocal relations
-Examples: diffusion, heat conduction, electrical conduction, chemical reactions, thermoelectric phenomena
4)Nonlinear irreversible thermodynamics
-Symmetry breaking transitions and dissipative structures
-Oscillatory structures and phenomena
5)The nonequilibrium nature of life

Seminar classes

Solving problems
Presentations covering the topics selected individually

Teaching methods and techniques:

Lectures: The lecture is presented in the form of a multimedia presentation combined with a classical blackboard lecture.
Seminar classes: In seminar classes, the basis is a multimedia and oral presentation by students. Discussion and problem solving are another important element of education.

Warunki i sposób zaliczenia poszczególnych form zajęć, w tym zasady zaliczeń poprawkowych, a także warunki dopuszczenia do egzaminu:

To pass the course, a student has to present at least one presentation, show activity during the seminars (discussion and solving the problems) and attend at least 6 from 10 lectures.

Zasady udziału w poszczególnych zajęciach, ze wskazaniem, czy obecność studenta na zajęciach jest obowiązkowa:

Lectures:
– Attendance is mandatory: No
– Participation rules in classes: Lectures present the content in accordance with the syllabus. Some time at the end of the lecture is reserved for questions and discussion. Students receive multimedia materials in advance. In the case of frequent absences from the lecture, the student has to pass a test exam.
Seminar classes:
– Attendance is mandatory: Yes
– Participation rules in classes: Presentations covering additional topics selected individually for students according to their research interest.
Solving typical problems of irreversible thermodynamics.
Presentation of the application of irreversible thermodynamics in technology and materials science.

Method of calculating the final grade

A final grade is provided a grade for the seminar, calculated in proportion to the number of points scored.
A student can get points for:
- the presentation – max. 20 points
- activity – max 20 points

Sposób i tryb wyrównywania zaległości powstałych wskutek nieobecności studenta na zajęciach:

A student can present his/her presentation in another convenient time. He/she can take an additional test of the lectures' content during consultation hours.

Prerequisites and additional requirements

The elementary basis of inorganic chemistry and physical chemistry.

Recommended literature and teaching resources

1. D. Kondepudi, I. Prigogine: MODERN THERMODYNAMICS, From Heat Engines to Dissipative Structures, Wiley 2002.
2. D. Kondepudi: Introduction to modern thermodynamics, Wiley 2007.
3. Tkacz-Śmiech K.: Termodynamika dla ceramików, Kraków 2012.
4. Katarzyna Tkacz-Śmiech: Multicomponent Diffusion, Kraków 2018.
5. Y. Demirel, V. Gerbaud: Nonequilibrium Thermodynamics: Transport and Rate Processes in Physical, Chemical and Biological Systems, Elsevier 2018.

Scientific publications of module course instructors related to the topic of the module

1. Tkacz-Śmiech K.: Termodynamika dla ceramików, Kraków 2012.
2. Katarzyna Tkacz-Śmiech: Multicomponent Diffusion, Kraków 2018.
3. B, Bożek, M, Danielewski, K, Tkacz-Śmiech, M, Zajusz: Interdiffusion: compatibility of Darken and Onsager formalisms, Materials Science and Technology 31 (2015) 1633.
4. M. Danielewski, M. Zajusz, B. Bożek, K. Tkacz-Śmiech: On the consistency of the Darken method with the Onsager representation for diffusion in multicomponent systems, Defect and Diffusion Forum 369 (2016) 53.

Additional information

None