Univerza v Mariboru

Fakulteta za naravoslovje in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Statistična termodinamika
Course title:	Statistical thermodynamics

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Fizika 2. st.		1	1
Physics 2nd degree		1	1

Vrsta predmeta / Course type: obvezni/compulsory

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
30		45			165	8

Nosilec predmeta / Lecturer: Milan Ambrožič

Jeziki / Languages:		
	Predavanja / Lectures:	slovenski/Slovenian
	Vaje / Tutorial:	slovenski/Slovenian

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Pogojev ni. Priporočljiva znanja so: formalno oziroma neformalno osvojeno znanje iz vsebin predmetov Mehanika, Termodinamika, Elektromagnetizem, Nihanje in valovanje, Moderna fizika.	None. Recommended knowledge: formal or informal knowledge from subjects Mechanics, Thermodynamics, Electromagnetism, Vibrational and Wave motion, Modern Physics.

Vsebina:	**Content (Syllabus outline):**

1. Termodinamika. Makroskopska stanja in termodinamične spremenljivke. Enačbe stanja. Zakoni termodinamike. Termodinamični potenciali. Fazne spremembe. Osnove neravnovesne termodinamike. 2. Osnovni pojmi teorije verjetnosti. Diskretne in zvezne porazdelitve verjetnosti. 3. Statistična mehanika. Mikroskopska stanja in princip maksimalne entropije. Teorija ansamblov: mikrokanoničen, kanoničen in velekanoničen ansambelter porazdelitvene funkcije. Boltzmannova statistika. Primeri: idealni plin, idealna raztopina, kristal; toplotna kapaciteta idealnega plina in trdne snovi, paramagnetizem, enačba stanja realnega plina, kemijske reakcije. 4. Osnove kvantne statistične mehanike. Idealni Bosejevi in Fermijevi sistemi. Primeri: harmonski oscilator, idealni plin, sevanje črnega telesa, elektroni v kovini. 5. Kinetična teorija transportnih procesov. Difuzija snovi, prevajanje toplote, viskoznost. 6. Izbrani primeri iz biologije in kemije. Struktura vode in voda kot topilo. Ionske in polimerne raztopine. Elektrokemijski potencial, osmozni tlak, prekomembranski potencial, transport vode in ionov preko celične membrane. Električno nabite površine v ionski raztopini. Adsorpcija. Kooperativna vezava ligandov. Encimske reakcije. Kinetika kemijskih reakcij.	ariables. Equations of state. The laws of thermodynamics. Thermodynamic potentials. Phase transitions. Introduction to non-equilibrium thermodynamics. 2. Principles of probability. Probability distribution functions. 3. Statistical mechanics. Microstates and the principle of maximum entropy. The ensemble theory: microcanonical, canonical and grand canonical ensemble and partition functions. Boltzmann statistics. Examples and applications: ideal gas and ideal solution, solids; heat capacity; paramagnetism, equation of state of real gases, chemical reactions. 4. Introduction to quantum statistics. Ideal Bose and Fermi systems. Examples and applications: ideal gas, harmonic oscillator, black-body radiation, the electron gas in metals. 5. Kinetic theory of transport processes. Diffusion, heat conduction, viscosity. 6. Selected examples from biology and chemistry. Structure of water and water as a solvent. Ionic and polymer solutions. Electrochemical potential, transmembrane potential, osmotic pressure, transmembrane transport of water and ions. Charged surfaces in ionic solutions. Adsorption. Cooperative ligand binding. Enzymatic reactions. Chemical kinetics.

Temeljni literatura in viri / Readings:

1. W. Greiner, L. Neise, H. Stöcker: Thermodynamics and Statistical Mechanics, Springer, New York 1997.
2. S. J. Blundell, K. M. Blundell: Concepts in Thermal Physics, Oxford University Press, Oxford 2006.
3. I. Kuščer, S. Žumer: Toplota (Termodinamika, statistična mehanika, transportni pojavi), DMFA, Ljubljana 2017.
4. K.A. Dill, S. Bromberg: Molecular Driving Forces, Statistical Thermodynamics in Chemistry and Biology, Garland Science, New York 2003.

Cilji in kompetence: / **Objectives and competences:**

Podati metode in koncepte fizikalnega opisa sistemov na mikroskopski in makroskopski ravni s poudarkom na njuni medsebojni povezanosti.	Students gain methods and concepts of description of systems on the micro and macroscopic scales with the interrelationship between the two levels emphasized.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Razumevanje procesov v naravi (primeri iz fizike, kemije in biologije) na makroskopski in mikroskopski ravni. Pri tem študentje osvojijo kvantitativne matematično fizikalne pristope in metode opisa teh pojavov. Študent razume povezavo med makroskopsko obravnavo termodinamike in statistično termodinamiko. Študent zna uporabiti analogije, tako da matematični model na nekem fizikalnem področju kritično prenese na nova področja (elektronski plin itd.). Študent razume, analizira in sintetizira tista področja iz fizike in kemije, ki jih povezuje statistična termodinamika. **Prenesljive/ključne spretnosti in drugi atributi:** Celosten pristop k reševanju problemov in izdelavi matematičnih modelov. Osvojiti znanja uporabne matematike. Sposobnost prepoznati problem in ga teoretično obravnavati v okviru koceptov in metod statistične termodinamike.	**Knowledge and understanding:** Understanding of processes in nature (examples from physics, chemistry and biology) on the macroscopic as well as microscopic scales. The students acquire to use quantitative mathematical and physical methods in comprehensive description of these phenomena. The student understands the relation between the macroscopic treatment of thermodynamics and statistical thermodynamics. The students is able to use analogies to translate the mathematical model for specific physical area critically to new areas (electronic gas etc.). The student understands, analyses and synthesises those areas in physics and chemistry that are connected with statistical thermodynamics. **Transferable/Key Skills and other attributes:** An integral approach to solving problems and elaborating the corresponding mathematical models. To gain advanced mathematical tools. Ability to identify problems and describe them theoretically within the scope of methods of statistical thermodynamics.

Metode poučevanja in učenja:	**Learning and teaching methods:**
- Predavanja - Seminar - Računske vaje	- Lectures - Seminar - Tutorials

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
Način (pisni izpit, ustno izpraševanje, naloge, projekt): pisni in ustni izpit seminarska naloga	 70 30	Type (examination, oral, coursework, project): written and oral exam course work

Reference nosilca / Lecturer's references:

Milan Ambrožič:

RANJKESH SIAHKAL, Amid, AMBROŽIČ, Milan, KRALJ, Samo, SLUCKIN, Tim J.. *Computational studies of history dependence in nematic liquid crystals in random environments*. Physical Review E, 2014, vol. 89, str. 022504-1-022504-14, doi: 10.1103/PhysRevE.89.022504.

HARKAI, Saša, AMBROŽIČ, Milan, KRALJ, Samo. *Impact of diffusion limited aggregates of impurities on nematic ordering*. Physica A, 2017, vol. 467, str. 249-256, doi: 10.1016/j.physa.2016.10.001.

AMBROŽIČ, Milan, KRALJ, Samo. *Field-percolation switching in soft ternary anisotropic system*. Physica A, 2019, vol. 520, str. 11-25, doi: 10.1016/j.physa.2018.12.044.