UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	ELEKTROKEMIJA RAZTOPIN
Course Title:	ELECTROCHEMISTRY OF SOLUTIONS

Študijski program in stopnja Study Programme and Level	Študijska smer Study Field	Letnik Academic Year	Semester Semester
MAG Kemija, 2. stopnja	/	2.	3.
USP Chemistry, 2nd Cycle	/	2nd	3rd

Vrsta predmeta / Course Type: izbirni strokovni / Elective Professional

Univerzitetna koda predmeta / University Course Code: K2I19

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Work	Druge oblike študija	Samost. delo Individual Work	ECTS
45	15	15 LV	/	/	75	5

Nosilec predmeta / Lecturer: doc. dr. Janez Cerar / Dr. Janez Cerar, Associate Professor

Jeziki / Languages:

Predavanja / Lectures:	**slovenski / Slovenian**
Vaje / Tutorial:	**slovenski / Slovenian**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Študent oz. kandidat mora imeti predmet opredeljen kot študijsko obveznost.	The course has to be assigned to the student.

Vsebina:	**Content (Syllabus outline):**
Osnovni pojmi Voda kot najpomembnejše topilo. Vodikova vez. Sile v raztopinah. Solvatacija ionov. Mešana topila. Hidrofobni efekt. Hoffmeistrova vrsta. Enostavni elektroliti. Polielektroliti. **Termodinamične lastnosti raztopin elektrolitov** McMillan-Mayerjeva teorija. Preprosti model raztopine elektrolita. Poisson-Boltzmannova enačba. Srednji elektrostatski potencial. Prostorske porazdelitvene funkcije. Termodinamične količine: notranja energija, osmozni tlak, koeficient aktivnosti, eksperimentalno določanje termodinamičnih količin. Pitzerjeva teorija. Mešanice	**Basic conceptions** Role of water as a solvent. Hydrogen bond. Forces in solutions. Solvatation of ions. Mixed solvents. Hydrophobic effect. Hoffmeister series. Simple electrolytes. Polyelectrolytes. **Thermodynamic properties of electrolyte solutions** McMillan-Mayer theory. Simple model of electrolyte solution. Poisson-Boltzmann equation. Mean electrostatic potential. Spatial distribution functions. Termodynamic quantities: internal energy, osmotic pressure, activity coefficient, experimental determination of thermodynamic quantities. Pitzer theory. Solutions of mixed electrolytes. Ion association.

elektrolitov. Asociacija ionov. Bjerrumova teorija. Moderne teorije raztopin elektrolitov. **Transportne lastnosti raztopin elektrolitov** Prevodnost. Viskoznost. Difuzija elektrolitov. **Splošne teorije polielektrolitov** Manningov model nabite premice. Valjasti (celični) model. Sferični (celični) model. Raztopina polielektrolita z dodatkom enostavnega elektrolita. Metode statistične mehanike: integralske enačbe, računalniške simulacije. **Termodinamične lastnosti raztopin polielektrolitov** Koeficienti aktivnosti. Osmozni koeficient. Razredčilne toplote. Raztopine polielektrolita ter mešanice protiionov različnih valenc. Membransko ravnotežje. Topnost polielektrolitov. **Transportne lastnosti raztopin polielektrolitov** Prevodnost. Transportno število. Elektroforeza. Viskoznost. Sedimentacija in difuzija. **Elektrodika** Električna dvojna plast ob elektrodi. Elektrokapilarnost. Kinetika elektrodnih procesov. Polarizacija elektrod. Prenapetost. Butler-Volmerjeva enačba. Gorivne celice. Korozija.	Bjerrum theory. Modern theories of electrolyte solutions. **Transport properties of electrolyte solutions** Conductivity. Viscosity. Diffusion of electrolytes. **General theories of polyelectrolyte solutions** Manning model. Cell model: cylindrical and spherical symmetry. Polyelectrolytes solution with the added simple salt. Methods of statistical mechanics: Integral equations, computer simulations. **Thermodynamic properties of polyelectrolyte solutions** Activity coefficient. Osmotic coefficient. Enthalpies of dilution. Polyelectrolyte solutions with the mixture of counterions differing in charge. Membrane equilibrium. Solubility of polyelectrolytes. **Transport properties of polyelectrolyte solutions** Conductivity. Transport number. Electrophoresis. Viscosity. Sedimentation and diffusion. **Electrodics** Electric double layer around electrode interface. Electrocapilarity. Kinetics of electrode processes. Polarization of electrodes. Overpotential. Butler-Volmer equation. Fuel cells. Corrosion.

Temeljna literatura in viri / Readings:

- R. A. Robinson in R. H. Stokes *Electrolyte solutions* (2. popravljena izdaja) New York : Dover Publications, 2002, 571 str. (25 %)
- M. Mandel *Physical Properties of Polyelectrolyte Solutions*, Pisa: Pacini Editore, 1999, 190 strani, (40 %).

Dopolnilna literatura:

- J. O'M. Bockris in A.K.N. Reddy *Modern Electrochemistry: ionics* (2. izdaja), New York: Plenum Press, 1998, 769 str.
- J.M.G. Barthel, H. Krienke in W. Kunz *Physical Chemistry of Electrolyte Solutions: Modern Aspects*. New York: Springer, 1998, 401 str.
- V. Vlachy *Raztopine elektrolitov* (interna skripta).
- *Polyelectrolytes* uredili E. Sélégny, M. Mandel in U.P. Strauss, Dordrecht: D. Reidel Publishing Company, 1974.
- S. Forster in M. Schmidt, *Physical Properties of Polymers: Polyelectrolytes in Solution*, Advances in Polymer Science, Berlin: Springer-Verlag, 1995.

Cilji in kompetence:	**Objectives and Competences:**
Cilji: Spoznavanje teorijskih pristopov pri obravnavi termodinamičnih in transportnih lastnosti raztopin elektrolitov in polielektrolitov. *Kompetence:* Razumevanju pojavov tako pri tehnoloških kot pri bioloških procesih. Vsebina predmeta je prilagojena študentom z različnim osnovnim predznanjem fizikalne kemije.	*Objectives:* To get insight into basic theoretical approaches used in studies of thermodynamic and transport properties of both electrolyte and polyelectrolyte solutions. *Competences:* Understanding of physical phenomena occurring in electrolyte and polyelectrolyte solutions. Application of this knowledge for comprehension of technological and biological processes. The content of the course is adapted to students with various basic background of physical chemistry.
Predvideni študijski rezultati:	**Intended Learning Outcomes:**
Znanje in razumevanje Predmet Elektrokemija raztopin poglobi in razširi osnovno znanje o raztopinah elektrolitov. Študent spozna osnovne razlike med enostavnimi elektroliti ter polielektroliti. Pouči se o različnih teorijskih pristopih kot tudi fenomenoloških enačbah pri obravnavi termodinamičnih in transportnih lastnosti raztopin tako enostavnih elektrolitov kot polielektrolitov. Razume prednosti in omejitve obravnavanih teorijskih pristopov.	Knowledge and Comprehension The course *Electrochemistry of solutions* deepens and widens student's basic knowledge about electrolyte solutions. Student becomes familiar with the difference between simple electrolytes and polyelectrolytes. Various theoretical approaches as well as phenomenological equations are presented to student for describing thermodynamic and transport properties of electrolyte and polyelectrolyte solutions. The student is aware of advantages and limitations of given theoretical approaches.
Uporaba Pridobljeno znanje omogoča študentu da zna oceniti red velikosti posameznih termodinamskih in transportnih količin v raztopinah elektrolitov in polielektrolitov, v bolj preprostih primerih pa je sposoben te količine napovedati na polkvantitativnem oziroma celo kvantitativnem nivoju. Ta znanja pripomorejo k boljšemu razumevanju v biologiji, medicini, oceanografiji, geologiji ter drugih področjih znanosti, kakor tudi v biotehnoloških in tehnoloških procesih.	Application The acquired knowledge enables students to estimate order of magnitude of given thermodynamic and transport properties in electrolyte and polyelectrolyte solutions; students are able to predict some physico-chemical quantities on semi-quantitative or even quantitative level. With the help of this knowledge students can better understand phenomena met in biology, medicine, oceanography, geology and other branches of science as well as in biotechnological and technological processes.
Refleksija Skozi primerjanje rezultatov modelnih računov z merskimi podatki študent pride do lastnega razumevanja skladnosti med teorijo in eksperimentom. Pridobi izkušnje, na podlagi katerih začne kritično presojati tako teoretične	Analysis Through the comparison of model calculations with (their own) experimental data student gets his own experience of concordance between theory and experiment. Student acquires skills that help him critically judge both theoretical

rezultate kot eksperimentalno dobljene vrednosti.	results as well as experimentally obtained data.
Prenosljive spretnosti Študent se pri študiju navaja na rabo domače in tuje strokovne literature ter iskanje virov preko IKT. Uči se teorijskih pristopov, ki jih je moč prenesti tudi na druge veje naravoslovja in tehnike. Primoran je zbirati podatke, identificirati in reševati probleme, interpretirati dobljene rezultate ter jih kritično analizirati. O predelani literaturi, predvsem pa o rezultatih seminarskega dela, poroča pisno v poročilu, ki sledi obliki znanstvenega članka. S poglavitnimi ugotovitvami svojega seminarskega seznani svoje kolege ustno.	Skill-transference Ability Through the study student becomes familiar with the use of national and foreign professional literature as well as with the use of informational technology in searching of data sources. He/she learns theoretical approaches that can be transferred to other fields of natural sciences and technology. Student is forced to gather data, to identify and to solve problems, to interpret obtained results, and to analyse them critically. He/she recounts about the studied literature and primarily about the results of his own research work in the written report that follows the form of scientific article. He/she rehearses about the most important findings (seminar task) to his/her study colleagues.

Metode poučevanja in učenja:	**Learning and Teaching Methods:**
Predavanja, seminarji, individualne naloge.	Lectures, seminars, individual tasks.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
- Seminarska naloga vključujoča zahtevnejšo računsko nalogo - Ustni izpit Ocene: od 6-10 (pozitivno) oz. 1-5 (negativno).	**50 %** **50 %**	

Reference nosilca / Lecturer's references:

- Janez Cerar, Jože Škerjanc: Electric transport and ion binding in solutions of fullerenehexamalonic acid T_h-C_{66} $(COOH)_{12}$ and its alkali and calcium salts. *J. Phys. Chem. B,* 2008, vol. 112, str. 892-895.
- Janez Cerar, Jože Škerjanc: Water-soluble fullerenes. 3. Alkali salts of fullerenehexamalonic acid T_h-C_{66} $(COOH)_{12}$. *J. Phys. Chem. B,* 2003, vol. 107, str. 8255-8259.

Janez Cerar, Jože Škerjanc: Water-soluble fullerenes. 2. Sodium fullerenexamalonate T_h-C_{66} $(COONa)_{12}$, a highly asymmetric electrolyte. *J. Phys. Chem. B,* 2000, vol. 104, str. 727-730.