Univerza v Mariboru
Medicinska fakulteta

Univerza v Mariboru
Fakulteta za kemijo in kemijsko tehnologijo

2026/2027

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	**Farmacevtska kemija I.**
Course title:	**Pharmaceutic Chemistry I.**

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Farmacija, 2. stopnja		**2.**	**3. in 4.**
Pharmacy, 2. level		**2.**	**3. in 4.**

Vrsta predmeta / Course type obvezni/obligatory

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Clinical training	Druge oblike študija Other forms of study	Samost. delo Individual work	ECTS
75	**15**	**30**			**150**	**9**

Nosilec predmeta / Lecturer: prof. dr. Zdenko Časar

Jeziki / Languages:		
	Predavanja / Lectures:	**slovenski/slovene**
	Vaje / Tutorial:	**slovenski/slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
/	/

Vsebina:	**Content (Syllabus outline):**
PRVI DEL: Uvod v farmacevtsko kemijo, opredelitev osnovnih pojmov (agens, materia medica...), spoznavanje monografij v Ph. Eur., Formulariumu Slovenicumu. Voda – fizikalno-kemične lastnosti, pomembne v farmaciji. Kemijski vidik pridobivanja pitne in farmacevtskih voda. Sistematična obravnava materije medike po periodnem sistemu. Pri prehodnih elementih je poudarek na koordinativnih spojinah in njihovem delovanju v živem organizmu. Osnove bioanorganske kemije, radionuklidi, radikali. Obravnava anorganske materije medice je podprta s strokovnimi besedili iz aktualne Evropske farmakopeje, Slovenskega dodatka farmakopeji in drugih virov. Samostojno delo s strokovno literaturo. DRUGI DEL: Razvrstitev učinkovin v skupine na osnovi prisotnih funkcionalnih skupin, fizikalno-kemične lastnosti posameznih predstavnikov v povezavi z biološkim delovanjem: - anorganske učinkovine	FIRST PART: Introduction to pharmaceutical chemistry, definition of basic concepts (agens, materia medica ...), introduction of monographs in Ph. Eur., Formularium Slovenicum. Water - physico-chemical properties important in pharmacy. Chemical aspect of drinking and pharmaceutical water production. Systematic treatment of the median state by periodic system. For transitional elements, emphasis is placed on coordination compounds and their functioning in a living organism. The basics of bioinorganic chemistry, radionuclides, radicals. The treatment of inorganic matter of the mead is supported by expert texts from the current European Pharmacopoeia, the Slovenian Pharmacopoeia supplement and other sources. Independent work with professional literature. SECOND PART: Classification of active substances into groups based on functional groups present, physicochemical properties of individual representatives in relation to biological activity: - inorganic active comopunds

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- ogljikovodiki (alkani, alkeni, alkini, cikloalifati, steroli, aromati ter kondenzirani sistemi); - alkoholi, polioli, etri in polimerni etri, ciklitoli in derivati; - alifatske kisline s karboksilno, sulfonsko, fosfonsko skupino, kisline z drugimi funkcionalnimi skupinami; alifatske kisline kot predhodnice avtakoidov. - derivati karboksilnih kislin (estri, lipidi...) - aldehidi in ketoni; semiacetali, sladkorji, polisaharidi, acetali in ketali; - mono in polimerne spojine; - aromati: mono, di in poli substituirani aromati; - amini, alkilamini, arilamini, diarilamini, amidi, poliamidi, proteini, sladila, barvila korigensi; - osnovni in kondenzirani heterociklični sistemi. Fizikalne in kemijske značilnosti ter odnos med strukturo in delovanjem pri določenih skupinah zdravilnih učinkovin: adrenergični agonisti, kalcijevi antagonisti, učinkovine za zniževanje lipidov, ACE inhibitorji, inhibitorji protonske črpalke, anestetiki, lokalni anestetiki, analgetiki, antihistaminiki, antidepresivi, antidiabetiki, hormoni, učinkovine za zdravljenje raka, antibiotiki, tuberkulostatiki, protivirusne učinkovine, antimikotiki, antiparazitiki, vitamini,	- hydrocarbons (alkanes, alkenes, alkynes, cycloaliphates, sterols, aromatics and condensed systems); - alcohols, polyols, ethers and polymer ethers, cyclitols and derivatives; - aliphatic acids with a carboxylic, sulfonic, phosphonic group, acids with other functional groups; aliphatic acids as predecessors of autocoids. - derivatives of carboxylic acids (esters, lipids ...) - aldehydes and ketones; semiacetals, sugars, polysaccharides, acetals and ketals; - mono and polymeric compounds; - aromates: mono, di and poly substituted aromatics; - amines, alkylamines, arylamines, diarylamines, amides, polyamides, proteins, sweeteners, colouring agents; - basic and condensed heterocyclic systems. Physical and chemical characteristics and relationship between structure and action in certain groups of active substances: adrenergic agonists, calcium antagonists, lipid-lowering agents, ACE inhibitors, proton pump inhibitors, anesthetics, local anesthetics, analgesics, antihistamines, antidepressants, antidiabetics, hormones, agents for cancer treatment, antibiotics, tuberculostatics, antiviral agents, antifungals, antiparasitics, vitamins.

Temeljni literatura in viri / Readings:

TEMELJNA LITERATURA:

1. European Pharmacopoeia; Ph. Eur.; 10th Edition (ali novejša; 11th Edition), Strassburg, 2022.
2. Šmid-Korbar, J. in sod., Formularium Slovenicum [Elektronski vir] : slovenski dodatek k Evropski farmakopeji, 4. izdaja (ali najnovejša, vključno z dopolnitvami), Ljubljana : Javna agencija Republike Slovenije za zdravila in medicinske pripomočke, 2018.
3. Obreza, A. in sod., Farmacevtski terminološki slovar, 2. izdaja (ali novejša, vključno z dopolnitvami), Ljubljana : Založba ZRC, 2019.
4. Auterhoff, H., in sod. Lehrbuch der Pharmazeutischen Chemie, 14. izd. 1999, 827 str. (A - Molekulare Wirkungsmechanismen von Arzneistoffen str. 3-14, C - Anorganisch-chemischer Teil str. 117-187, D - Organisch-chemischer Teil str. 191-297).
5. Ali, M. Textbook of Pharmaceutical Chemistry (Inorganic), BS Publishers And Distributors Pvt Ltd, izd. 2018, 314 str. (str. 54-83).
6. Strohfeldt, K. A. Essentials of Inorganic Chemistry: For Students of Pharmacy, Pharmaceutical Sciences and Medicinal Chemistry, John Wiley & Sons Ltd, izd. 2015, 270 str. (str. 19-44 ter str. 132-146).
7. Wermuth, C. G., in sod. The Practice of Medicinal Chemistry, 4th Edition, Academic Press, izd. 2015, 902 str. (str. 302-318).
8. Patrick G. L., An Introduction to Medicinal Chemistry, 5th Edition (ali novejša), Oxford University Press, izd. 2013, 789 str. (str. 1-84 ter str. 413-688).
9. Watson, D. G. Pharmaceutical Chemistry, 1st Edition, Churchill Livingston, Elsevier, izd. 2011, 641 str. (str. 1-552).
10. Časar, Z. Synthesis of Heterocycles in Contemporary Medicinal Chemistry, Springer Cham, izd. 2016, 431 str. (str. 1-27).
11. Časar, Z. Process for the synthesis of HMG-CoA reductase inhibitors : Patent No.: EP2341054 (B1) : date of patent: 25.06.2014. München: European Patent Office, 2014, 31 str.

12. Časar, Z., Košmrlj, J. Key intermediates for the synthesis of rosuvastatin or pharmaceutically acceptable salts thereof : Patent No.: US9376397 (B2) : date of patent: 28.06.2016. United States Patent Office, 2016, 21 str.

DODATNA LITERATURA:

1. The Complete Drug Reference (Martindale) 39th Ed., The Pharmaceutical Press, London, izd. 2017 (izbrana poglavja kot primer).
2. Farrell, N. P. Uses of Inorganic Chemistry in Medicine, The Royal Society of Chemistry, izd. 1999, str. 208 str. (str. 11-25 ter str. 109-123).
3. Roche, V. F., Lemke L. T., in sod. Essentials of Foye's Principles of Medicinal Chemistry, 1st Edition, Lippincott Williams & Wilkins, Baltimore 2016, 608 str.
4. Lazarini, F., Brenčič, J. Splošna in anorganska kemija, izd. 2017.
5. Hagers Handbuch der Drogen und Arzneistoffe. CD-ROM, Springer-Verlag GmbH & Co. Heidelberg, izd. 2008.
6. AHFS Drug information 2009, American society of health-system pharmacists, ZDA, izd. 2009.
7. Centralna baza zdravil 2.

Cilji in kompetence:

Cilji:

PRVI DEL:

Pri predmetu študent pridobi znanja o uporabi anorganskih zdravilnih učinkovin (ZU) in pomožnih snovi, ki jih uvrščamo v anorgansko *materio medico*. Študent spozna tudi njihove fizikalno-kemijske lastnosti, ki so relevantne za njihovo uporabo v farmaciji. Pri predmetu je predstavljeno delovanje določenih atomov, ionov, ali molekul, ki spadajo v anorgansko materijo mediko, ali pa so pomembni, ker smo v neposrednem stiku z njimi. Predstavljen je mehanizem delovanja koordinacijskih spojin, zlasti tistih, kjer je kot centralni ion prisoten ion prehodnega elementa. Študenti se tudi srečajo s strokovnimi besedili v enem izmed tujih jezikov (angleščina in/ali nemščina).

DRUG DEL:

Na predavanjih študent prične s spoznavanjem organskih zdravilnih učinkovin in farmacevtskih pomožnih snovi po veljavni Evropski farmakopeji in po razredih organskih spojin. Študent na primerih enostavnih organskih molekul spozna principe delovanja spojin s posameznimi funkcionalnimi skupinami in povezavo med fizikalno-kemičnimi lastnostmi in obnašanjem teh spojin kot zdravilnih učinkovin v organizmu ter potrditev na osnovi reaktivnosti.

V drugem delu spozna določene skupine zdravilnih učinkovin po veljavni ATC klasifikaciji, kar se nadaljuje pri predmetu Farmacevtska kemija II.

Pri *seminarjih* študenti individualno obdelajo posamezne tematike iz segmenta anorganskih/organskih učinkovin ter z uporabo modernih pedagoških pristopov kot je izvedba inverznih predavanj ter uporaba IKT podpore poglobljeno umestijo tematike v širši kontekst.

Objectives and competences:

Objectives:

FIRST PART:

The course provides the student with knowledge on the use of inorganic active substances (API) and excipients classified as inorganic materia medica. The student also learns about their physicochemical properties relevant for their use in pharmacy. The action of certain atoms, ions, or molecules that belong to inorganic matter is mediated by the object, or they are important because we are in direct contact with them. A mechanism for the action of coordination compounds, especially those where the transition element ion is present as a central ion, is presented. Students also meet professional texts in one of the foreign languages (English and/or German).

DRUGI DEL:

In the scope of the lectures, the student begins to learn about organic active substances and pharmaceutical excipients according to the valid European pharmacopoeia and classes of organic compounds. The student learns the principles of the action of compounds with individual functional groups and the connection between physicochemical properties and the behaviour of these compounds as active substances in the organism and confirmation based on reactivity on simple organic molecule cases.

The second part introduces specific groups of active substances according to the current ATC classification, which continues with the subject of Pharmaceutical Chemistry II.

In *seminars* the students individually examine a chosen topic from inorganic/organic active compounds sections and with the help of modern pedagogic approaches such as inverse lecturing and IKT technologies set the specific topic in a broader context.

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Pri vajah študent spozna sistematično, mednarodna nelastniška in farmakopejska nomenklatura kot osnova istovetnosti učinkovin in se nauči risanja struktur zdravilnih učinkovin na osnovi različnih imen. Spozna kemijske reakcije 1. in 2. stopnje metabolizma in na osnovi strukturne formule zdravilne učinkovine predvidi možne kemijske spremembe zdravilne učinkovine v organizmu. Pri laboratorijskih vajah se seznani s farmakopejsko predpisanimi postopki istovetenja in preizkušanja stopnje čistote zdravilnih učinkovin in jih izvede v praksi. Specifične kompetence, ki jih študent pridobi so: PRVI DEL: • poznavanje pomena elementov in ionov v živem organizmu. • sposobnost vrednotenja pomena in delovanja anorganskih zdravilnih učinkovin in pomožnih snovi na osnovi njihovih fizikalno-kemičnih lastnosti. • usposobljenost za prevajanje in razumevanje strokovnih tekstov s področja farmacevtske kemije, kar je ključno za uveljavljanje slovenske terminologije na širšem področju farmacevtskih znanosti na eni strani, po drugi pa temelji na poznavanju kompleksnejše zgradbe posameznih tipov zdravil. • sposobnost razumevanja pomena in delovanja koordinacijskih spojin v živem organizmu DRUGI DEL: - sposobnost vrednotenja pomena in delovanja organskih zdravilnih učinkovin in pomožnih snovi na osnovi njihovih fizikalno-kemijskih lastnosti. - sposobnost razvrščanja zdravilnih učinkovin v večje skupine na osnovi kemijske strukture oziroma po veljavni ATC klasifikaciji. - usposobljenost za predvidevanje delovanja enostavnih organskih molekul na osnovi njihove strukture. - usposobljenost za risanje struktur zdravilnih učinkovin na osnovi racionalnega kemijskega imena - sposobnost predvidevanja kemizma metaboličnih reakcij na osnovi njihove strukture.	*During the exercises*, the student learns the systematic, international non-pharmaceutical and pharmacopoeial nomenclature as the basis for the identity of the active substances and learns the drawing of the structures of the active substance based on different names. The student learns about the chemical reactions of stages 1 and 2 of the metabolism and on the basis of the structural formula of the active substance, predict possible chemical changes in the active substance in the organism. In laboratory exercises he acquainted himself with the pharmacopoeial prescribed procedures of identifying and testing the degree of purity of the active substances and performing them in practice. The specific competencies students acquire are: FIRST PART: • knowledge of the meaning of elements and ions in a living organism. • ability to evaluate the importance and function of inorganic active substances and excipients based on their physico-chemical properties. • the ability to translate and understand professional texts in the field of pharmaceutical chemistry, which is crucial for the promotion of Slovenian terminology in the wider field of pharmaceutical sciences on the one hand; on the other, it is based on the knowledge of a more complex structure of individual types of medicines. • ability to understand the meaning and functioning of coordination compounds in a living organism SECOND PART: - the ability to evaluate the meaning and functioning of organic active substances and excipients based on their physico-chemical properties. - the ability to classify active substances into larger groups based on the chemical structure or according to the valid ATC classification. - the ability to predict the action of simple organic molecules based on their structure. - the ability to draw up the structure of active substances on the basis of a rational chemical name - the ability to predict the chemistry of metabolic reactions based on their structure.
Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: študent • zna našteti pojme s področja farmacevtske kemije, anorganskih učinkovin in njihovega kemizma.	Knowledge and Understanding: The student • is able to list basic concepts in the field of pharmaceutical chemistry, inorganic active compounds and chemistry of active compounds.

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• zna razložiti interakcije, značilne za zdravilne učinkovine in njihov pomen v delovanju organizma oz. terapiji raznih obolenj. • pojasni terminologijo in obvlada miselne vzorce, ki omogočajo sistematično razvrščanje učinkovin glede na njihovo kemijsko strukturo. • razume pojem kemijske reaktivnosti v kontekstu interakcije učinkovin v živem organizmu Vse koncepte študent tudi ustno in pisno reproducira. <u>Prenosljive spretnosti – niso vezane le na en predmet:</u> Študent zna povezati dosedanje znanje pri razumevanju delovanja anorganskih/organskih ZU in razložiti povsem nove primere. Študent se seznani s prvo povezavo fizikalno-kemijskih lastnosti učinkovin z delovanjem v živih organizmih. Tukaj-osvojeni koncepti se pojavljajo preko celotnega programa in so osnova za razumevanje delovanja drugih (npr. bioloških) zdravilnih učinkovin in naprednih konceptov načrtovanja učinkovin.	• understands the basic interactions typical of the active substances and their importance in the functioning of the organism along with therapy of various diseases. • understands terminology and controls thought patterns that allow systematic grading of drugs based on their chemical structure. • understands the concept of chemical reactivity in the context of active compound interactions with a living organism All concepts are also reproduced by the student in verbal and written manner. <u>Transferable skills - not related to only one subject:</u> The student is able to integrate previous knowledge in understanding how inorganic/organic active compounds work and extrapolate to completely new examples. The student learns for the first time how the physico-chemical properties of active substances are related to their action in living organisms. The concepts here-appropriated are encountered throughout the programme and are the basis for understanding other active compounds (e.g. biologicals) and advanced concepts of novel drug design.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja Seminar (individualne naloge v obliki seminarjev) Vaje (laboratorijske vaje: individualne, problemsko zastavljene z individualnim preverjanjem praktičnega in teoretičnega dela)	Lectures Seminars (individual tasks in the form of seminars) Tutorial (laboratory exercises: individual, problem-oriented with individual verification of practical and theoretical work)

Načini ocenjevanja:	**Delež (v %) / Weight (in %)**	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt) • laboratorijsko delo • seminarska naloga • pisni izpit ŠTUDIJSKE OBVEZNOSTI ŠTUDENTOV • 80% prisotnost na vajah in seminarjih • Seminarska naloga	**30%** **20%** **50%**	Type (examination, oral, coursework, project): • laboratory work • seminar paper • written exam STUDY OBLIGATIONS OF STUDENTS • 80% attendance at seminars and experimental exercises • Seminar paper

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POGOJ ZA PRISTOP K IZPITU • Opravljene vaje so pogoj za pristop h kolokviju ob koncu laboratorijskih vaj (laboratorijsko delo). • Opravljena seminarska naloga. • Opravljeno laboratorijsko delo. Vse delne ocene morajo biti pozitivne za pridobitev končne ocene.		CONDITION FOR ACCESS TO THE EXAM • Passed tutorial for attendance at written colloquium (at the end of laboratory work). • Prepared coursework. • Passed laboratory work. All partial grades must be positive in order to obtain the final mark.

Reference nosilca / Lecturer's references:

ZDENKO ČASAR:

1. TRAMPUŽ, Marko, ŽNIDARIČ, Mateja, GALLOU, Fabrice, ČASAR, Zdenko. Does the red shift in UV–Vis spectra really provide a sensing option for detection of N-nitrosamines using metalloporphyrins?. ACS omega. 2023, vol. 8, iss. 1, str. 1154-1167
2. GRAHEK, Rok, DREV, Miha, ZUPANČIČ, Borut, HREN, Jure, OŠLAJ, Matej, BASTARDA, Andrej, KOCIJAN, Andrej, ČASAR, Zdenko. Stability and degradation pathways of N-nitroso-hydrochlorothiazide and the corresponding aryl diazonium ion. Organic process research & development. 2023, vol. 27, iss. 10, str. 1792–1811
3. ŠTERMAN, Andrej, SOSIČ, Izidor, ČASAR, Zdenko. Primary trifluoroborate-iminiums enable facile access to chiral α-aminoboronic acids via Ru-catalyzed asymmetric hydrogenation and simple hydrolysis of trifluoroborate moiety. Chemical Science. 2022, vol. 13, issue. 10, str. 2946-2953.