RESOLUTION No. 11
of the Teaching Council of the Faculty of Chemistry

dated 12 April 2023

on detailed rules and regulations of graduation
in the field of study of Chemistry
organized by the Faculty of Chemistry at the University of Warsaw

Pursuant to the provisions of § 68, section 2 of the Statute of the University of Warsaw (UW Monitor of 2019, item 190, and Resolution No. 4 of the University Council for Teaching and Learning (if abbreviated, hereinafter referred to as the URK (an abbreviation in Polish)). on the process of graduation at the University of Warsaw, the Teaching Council of the Faculty of Chemistry resolves as follows:

§ 1

1. Detailed rules and regulations of graduation for the field of study of Chemistry organized by the Faculty of Chemistry at the University of Warsaw are hereby adopted.
2. The rules and regulations defined in section 1 hereof are attached to the Resolution.

§ 2

1. The following documents adopted by the Teaching Council of the Faculty of Chemistry shall become ineffective:
   1) Resolution No. 11 of the Teaching Council of the Faculty of Chemistry of 7 April 2020 on the detailed rules and regulations of graduation for the field of study of Chemistry organized by the Faculty of Chemistry at the University of Warsaw;
   2) Resolution No. 43 of the Teaching Council of the Faculty of Chemistry of 30 June 2021 on the amendment of Resolution No. 11 of the Teaching Council of the Faculty of Chemistry of 7 April 2020 on the detailed rules and regulations of graduation for the field of study of Chemistry organized by the Faculty of Chemistry at the University of Warsaw;

§ 3

The Resolution shall enter into force on the day it is signed.

Chairperson of the Teaching Council
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Prof. Beata Krasnodębska-Ostręga, PhD

Attachment No. 1
to Resolution No. 11 of the Teaching Council of the Faculty of Chemistry of 12 April 2023 on the detailed rules and regulations of graduation at the Faculty of Chemistry of the University of Warsaw;

DETAILED RULES AND REGULATIONS OF GRADUATION IN THE FIELD OF STUDY OF CHEMISTRY ORGANIZED BY THE FACULTY OF CHEMISTRY AT THE UNIVERSITY OF WARSAW

§ 1

1. The Teaching Council of the Faculty of Chemistry shall, by means of a resolution, lay down detailed rules and regulations on the graduation process for the field of study of Chemistry consisting of:

1). Detailed rules for the preparation and evaluation of diploma dissertations.
2). Detailed rules for supervising diploma dissertations - general provisions
3). Detailed rules for supervising diploma dissertations at the second-cycle studies.
4). Detailed rules of monitoring the graduation process.

§ 2

1. Detailed rules for the preparation and assessment of diploma dissertations.

1). A diploma dissertation shall be submitted in a printed version in three copies.
2). A diploma dissertation shall consist of the following elements:
- an abstract,
- a description of the current state of knowledge on the subject and an explanation of the rationale for undertaking the research in question,
- the research hypothesis or purpose of the dissertation,
- research methodology or experimental part,
- presentation of the results obtained and their discussion,
- conclusions;
- list of cited literature.

3). The diploma thesis must be written in English. The dissertation in English and in Polish shall include the following: a dissertation abstract, statements by the student and the dissertation supervisor.
4). A diploma dissertation shall be assessed in compliance with the UW Rules and Regulations of Studies (§ 46, sections 1 and 13) and with the guidelines for the graduation process at the University of Warsaw (URK Resolution No. 4, § 2, section 2, points 1 and 2) respectively for the diploma dissertation at the second-cycle studies the topic of the dissertation is defined the dissertation supervisor, so that the student achieves the ability to carry out scientific research, therefore the research should have

the characteristics of novelty. In such a case, the methodology of conducted research, the results and the conclusions shall be described.

5). The diploma dissertation review shall include the following elements: author's name and surname, title, dissertation supervisor's or reviewer's name and surname, the place where the dissertation prepared, an assessment of the compatibility of the content of the dissertation with the topic stated in the title, a formal assessment of the dissertation (layout of the dissertation, correctness of language, mastery of the dissertation writing technique), evaluation of the content of the dissertation, how the work is used (publication, source material, etc.), other comments, as well as the dissertation assessment in accordance with the grading scale set out in § 34, section 2 of the Rules and Regulations of Studies in force at the UW. The exact review form is available in the APD system. The diploma dissertation review shall be approved and made available to the student at least three days before the date of the diploma examination.

6) Pursuant to the Rules and Regulations of Studies in force at the UW (§ 46, section 6) joint preparation of the diploma dissertation by students is allowed after obtaining a positive opinion of the Teaching Council of the Faculty of Chemistry on the application filed by the dissertation supervisor.

§3

1. Detailed rules for conduction a diploma examination at the second-cycle studies include the following:

1). The diploma examination at the second-cycle studies conducted at the Faculty of Chemistry is an oral examination. The examination is conducted in English. During the examination, the student:

- briefly presents the results and content of the dissertation,
- answers at least three questions on the content of the diploma dissertation posed by the members of the examination committee,
- answers a question drawn from a specific pool of questions.

2). The question drawn at random by the examinee during the master's examination comes from one of the four branches of chemistry:

- inorganic and analytical chemistry,
- organic chemistry, chemical technology and biochemistry,
- physical chemistry and spectroscopy,
- theoretical chemistry and crystallography.

3). Assigning a thesis topic, the dissertation supervisor is required to indicate the section from which the master's student will draw the question. The section does not have to be in line with the subject of the specialisation in which the dissertation has been written.

4). The terms of reference for the second-cycle diploma examination in the branches of chemistry set out in the § 3, section 1, point 2. The scope is prepared by a team of

academic staff identified by the HTU and is attached as Appendix No. 2 to the resolution.

5). The chairperson of the examination committee may instruct the student to draw consecutive questions (having refused to answer the previous question), however, in total the number of questions drawn by the student from the pool shall not exceed two. One of the prerequisites for obtaining at least a minimum pass mark in the diploma examination is to give a positively evaluated answer to a drawn question.

6). The final result of the diploma examination is the arithmetic mean of the marks obtained in response to the randomly drawn question and the questions of the committee members.

7). The assessment of the diploma dissertation shall comply with § 46, section 13 of the Rules and Regulations of Studies in force at the UW.

8). The study final result within the meaning of § 52, section 2, point 2 of the Rules and Regulations of Studies in force at the UW is calculated as the sum of the average grade from the studies (0.5), the diploma dissertation grade (0.4), and the diploma examination grade (0.1). This final grade is rounded off pursuant to § 52, section 3 of the Rules and Regulations of Studies in force at the UW.

9). Minutes of the diploma examination shall be drawn up as a form of recording the proceedings of the diploma examination and the committee's decision to award the degree.

§ 4

In order to obtain credit for the master's thesis workshop, it is necessary to submit a diploma dissertation approved by the dissertation supervisor.

§ 5

1. The detailed rules for monitoring the graduation process are laid down in the guidelines for the graduation process in force at the UW (URK Monitor No. 4, § 4).

1) The analysis of the graduation process takes place between 1 October and 31 December each academic year, and concerns diploma examinations carried out up to 30 September of the previous academic year.

2) The Teaching Council of the Faculty of Chemistry appoints a person responsible for the annual monitoring of the graduation process, in particular the timeliness of making diploma dissertation reviews available to students.

3) A randomly selected diploma dissertation (20% of the defended dissertations) is analysed in detail, as well as those in which the grades of the supervisor and the reviewer differ by at least 1 grade. The correctness of the protocol, the compliance of the review with the guidelines (§ 2, section 5) and the compliance of the questions asked with the requirements in Appendix No. 2 will be verified.

4) The protocol from the monitoring of the graduation process, including its evaluation, shall be presented at the January meeting of the Teaching Council of the Faculty of

Chemistry, and following its analysis and listing corrective actions for implementation, it shall be sent to the URK.

§ 6

1. In any given academic year, an academic staff member with a doctoral degree may supervise a maximum of one diploma dissertation at the level of the second-cycle studies in all fields of study, whereas an academic staff member with the degree of doctor habilitowany or the title of professor may supervise a maximum of three diploma dissertation at the level of the second-cycle studies in all fields of study.

2. Co-supervising of diploma dissertations is acceptable at the master's dissertation stage. If the dissertation is interdisciplinary in nature, another academic staff member may be appointed as co-supervisor from the Faculty be means of the decision adopted by the HTU Where the diploma dissertation supervisor has not declared chemistry as the leading discipline, the HTU shall appoint a co-supervisor from the Faculty of Chemistry.

3. A student reserves the right to prepare the master's dissertation outside the University of Warsaw. In this case, the dissertation supervisor is required to submit an application to the Teaching Council of the Faculty of Chemistry requesting permission for an external person to co-supervise the dissertation.

4. The Teaching Council establishes a template for the request for permission to be co-supervisor by an external person, Appendix No. 3, which is posted on the Faculty of Chemistry website.

5. The dissertation supervisor has the right to appoint a laboratory supervisor for the diploma dissertation whom can only become an assistant or doctoral student.

§ 7

The resolution shall enter into force on the date of its adoption and shall apply for diploma dissertations prepared and diploma examinations conducted since 1 June 2023.

Appendix No 2.

to Resolution No. 11 of the Teaching Council of the Faculty of Chemistry of 12 April 2023 on the detailed rules and regulations of graduation at the Faculty of Chemistry of the University of Warsaw;

REQUIREMENTS FOR THE DIPLOMA EXAMINATION AT THE SECOND-CYCLE STUDIES CONDUCTED AT THE FACULTY OF CHEMISTRY OF THE UNIVERSITY OF WARSAW IN THE FIELD OF STUDY OF CHEMISTRY

INORGANIC AND ANALYTICAL CHEMISTRY

1). Discuss the analytical parameters that characterise the capabilities of the measurement procedure (qualitative parameters, quantitative parameters, properties of measurement results).
2). Discuss key aspects of the analytical method validation process.
3). Discuss the specific problems of trace component analysis and speciation analysis.
4). Discuss the basics of atomic optical methods used in chemical analysis (radiation range, distribution, temperature dependence).
5). Discuss the basics of molecular optical methods used in chemical analysis (radiation range, distribution, temperature dependence).
6). Discuss the Lambert-Beer law and deviations from it (nature and causes of observed phenomena) and its applicability in analytical measurement.
7). Discuss the principle of the mass spectrometer, the analytical capabilities and advantages and disadvantages of mass spectrometry and the detectors used.
8). Discuss the principles (similarities and differences) of techniques applicable to imaging and surface composition studies (SEM, TEM, AFM/STM, XPS, EDS, …).
9). Atomic spectrometry - theoretical basis of the method (electron transitions), apparatus used in ASA and ESA.
10). Discuss the theoretical basis and mechanisms of the separation process in adsorption, partition, ion exchange and gel filtration chromatography.
11). Discuss the similarities and differences between liquid and gas chromatography.
12). Discuss the parameters that characterise the chromatographic separation process (retention time, partition constant, retention factor, separation capacity?
13). Discuss the theoretical basis of potentiometry and the construction and division of ion-selective electrodes by type of membrane.
14). Discuss the principles of ion-selective electrode measurements using a pH measurement system as an example.
15). Discuss the basics of the division of current electro-analytical methods, the measurement system used and the role of individual electrodes.
16). Ways of lowering the detection limit of electrochemical current methods and capacitive current elimination methods.
17). Advantages and limitations of electro-analytical methods over spectroscopic methods (molecular and atomic).
18). Concentration polarisation in current electrochemical methods - effects on assay results, electro-analytical stationary and non-stationary methods.

19). Types of working electrodes used in electroanalysis - influence of electrode material on measurement conditions and method of determination (mercury, platinum, carbon, gold electrodes).
20). Pulse methods in voltammetry, advantages and disadvantages, method of current sampling.
21). Discuss the advantages of using microelectrodes in electro-analysis, the formula describing the limiting current, diffusion into the microelectrode.
22). Flow analysis - effect of measurement conditions on the recorded analytical signal, detection methods, applications.
23). Chemical sensors - analytical parameters, types, design, applications, comparison with apparatus methods.
24). Relative and absolute analytical methods - examples, advantages and limitations.
25). Volumetric versus nanostructured materials, types of nanostructured materials (materials and types of structures), their properties, metallic and polymer nanostructures, synthesis, applications.
26). Complex compounds - crystal field theory, its possibilities and limitations, what properties can be explained using this theory.
27). Examples, structure and function of biologically important complexes.
28). Self-organisation on the surface of electrodes, construction of monolayers, ways of studying monolayers, applications.
29). Molecular layers - subdivision, methods of obtaining, methods of studying layer properties.
30). Fuel cells - types, principle of operation, applications.
31). Supramolecular systems, examples of applications of supramolecular systems in nanotechnology, medicine and microelectronics.
32). Chemical oscillatory reactions - what are the conditions for such reactions? Discuss a selected example of an oscillatory reaction.
33). Discuss the process of electrocatalysis using a selected example (reduction of oxygen, CO^2, oxidation of ethanol).
34). Conductive polymers - preparation, electrochemical and optical properties, applications including analytical.
35). Applications of rapid prototyping techniques in the chemistry laboratory.
36). Metal alloys, deposition of alloyed protective coatings, manufacturing methods, composition analysis.
37). Discuss methods to determine protein structures and their interaction with lipid membranes.
38). Methods of environmental sampling (water, sediment, soil samples) and preparation for testing. Choice of analytical method by type and concentration of constituents to be determined.
39). Analytical methods versus the possibility of determining the different forms of analyte present in a sample (free ions, complexes, isotopes).
40). Methods of calibration of analytical methods - standard addition method, calibration curve, use of internal standard.

ORGANIC CHEMISTRY, CHEMICAL TECHNOLOGY AND BIOCHEMISTRY

1). Alkanes - states of aggregation, structure, reactivity, production and economic importance.
2). Discuss the phenomenon of isomerism of organic compounds, with particular reference to stereochemistry.

3). Reactions of alkenes as model polar organic transformations. Regio- and stereoselective processes resulting from mechanism.
4). Redox reactions in organic chemistry: oxidation-reduction processes of saturated and unsaturated hydrocarbons, alcohols and carbonyl compounds.
5). Discuss the acid-base properties of organic compounds, including scale and the effect of substituents, using phenols, carboxylic acids and amines as examples.
6). Reactions with radical mechanism: mechanism, selectivity, product distribution and examples.
7). Competing substitution and elimination processes using the reactions of alkyl halides and alcohols as examples. Factors controlling the course of the reaction.
8). Coupling as a cause of different reactivity and physicochemical properties of organic compounds.
9). Causes and consequences of aromaticity, examples of compounds and their reactions.
10). Induction and resonance effects of substituents, exemplified by the properties of aromatic and carbonyl compounds.
11). Application of Grignard compounds in organic chemistry: preparation, limitations, synthetic possibilities.
12). Organic derivatives of water and hydrogen sulphide: synthesis and transformations.
13). Addition, substitution, substitution at the α position as elementary reactions of carbonyl compounds.
14). Acidity of carbonyl compounds and resulting reactions.
15). Nitrogen-containing organic compounds: properties, synthesis and transformations.
16). Electrophilic aromatic substitution reactions: examples, mechanism, orientation and reactivity, limitations.
17). Geometry of C, N, O atoms in organic compounds, hybridisation and valence angles, types of stresses in molecules, conformers and their equilibria.
18). Ability to interpret simple ^{1}H-NMR, ^{13}C-NMR and infrared spectra (knowledge of vibrational frequencies for basic functional groups) to identify compounds.
19). Crude oil - composition, processing, types of products obtained in refineries and petrochemical plants.
20). Polymers - definition, polymerisation methods and ways to study the physicochemical properties of polymers.
21). Types and characteristics of homo- and heterogeneous catalysts used in the chemical industry.
22). Relationships between chemistry, industry and business: discuss and explain the steps involved in the commercialisation of research results using a selected example from chemistry (or biotechnology/environment)
23). The structure of the nucleosides and nucleotides that make up nucleic acids.
24). DNA structure and interactions stabilising the double helix structure.
25). The replication process (general regularities of the course, stages, enzymes involved). PCR reaction.
26). Types of RNA - their structure and functions.
27). The processes that make up gene expression (where and how they occur).
28). Primary, secondary, tertiary and quaternary structures of proteins. Supra-secondary structures and their examples. Protein denaturation and the factors causing it

29). Methods for the determination and prediction of protein structure.
30). The functions that proteins perform in the body. The relationship between structure and function.
31). Structure, characterisation and classification of enzymes.
32). Mechanism of enzyme action and role of the active centre.
33). Factors affecting the rate of enzymatic reaction. Michaelis - Menten kinetics.
34). Strategies for regulating enzyme activity in the body.
35). ATP as the main energy carrier in the cell - structure, mode of formation (substrate and oxidative phosphorylation) and action.
36). Characteristics and steps involved in cellular respiration.

PHYSICAL CHEMISTRY AND SPECTROSCOPY

1). Principles of thermodynamics in isolated, closed and open systems.
2). Description of thermodynamic equilibrium through changes in thermodynamic functions.
3). Definition of chemical potential and temperature dependence of chemical potential at constant pressure.
4). The phenomenon of osmosis and its practical use.
5). Kinetics of chemical reactions (0, 1st and 2nd order reactions, determination of reaction rate constants, determination of order of reaction, half-life).
6). Adsorption (physical and chemical adsorption - comparison, Langmuir isotherm - derivation and graph).
7). Surface tension (definition, units, temperature and concentration dependence, Gibbs isotherm), influence of other substances).
8). Types of colloidal systems (division, properties of lyophilic and lyophobic colloids, Tyndall effect).
9). Electrodes (classification, potential, equilibrium at the electrode-solution interface).
10). Galvanic cell vs. electrolytic cell (principle of operation, examples, characteristics and principle of operation of zinc-manganese, lithium hydride, lithium-ion cells).
11). Thermodynamically and chemically reversible processes (criteria for determining reversibility).
12). Diffusion (cause of diffusion, Fick's 1st law, diffusion coefficient - what it depends on and ways of determining it).
13). Fluid viscosity (kinematic and dynamic viscosity - definitions and units, laminar and turbulent flow).
14). Dipole moment (permanent and induced dipole moment, permanent dipole moment vs chemical structure of molecules, molar polarisation and refraction).
15). What information about molecules do we get from microwave, infrared ultraviolet and visible light spectroscopy?
16). Description of chemical bonding (harmonic and anharmonic oscillator, dissociation and chemical bond energy - how to determine dissociation energy from electron spectra).
17). Application of molecular spectroscopy in quantitative and qualitative chemical analysis.
18). Raman spectrum versus infrared spectrum.
19). Dipole moment of transition. Relationship to the intensity of optical spectra.
20). Selection rules in microwave, infrared ultraviolet and visible light spectroscopy.
21). Lasers (types, examples, conditions for obtaining laser action, applications).

22). Types of nuclear radiation. The concept of half-life.
23). Interaction of ionising radiation with matter.
24). Applications of radioactive isotopes in medicine and technology.
25). Nuclear energy - nuclear reactors, safety issues.
26). The concept of nanomaterials, their classification and their types.
27). Methods for the synthesis of nanomaterials.
28). Selected microscopic methods: AFM, STM, SEM together with EDS, in the study and shaping of nanostructures.
29). Applications of nanomaterials in catalysis, photocatalysis, electrocatalysis and photovoltaics.
30). NMR (conditions necessary to obtain a spectrum, information obtained from a spectrum).
31). Concepts used in NMR (magnetic shielding of the atomic nucleus, spin-spin coupling, nuclear relaxation).
32). NMR spectra in liquids and in solids (comparison and reasons for differences).

THEORETICAL CHEMISTRY AND CRYSTALLOGRAPHY

1). The wave function: probabilistic interpretation and method of determination. Time-dependent Schrödinger equation and Schrödinger equation for stationary states.
2). Solutions of the Schrödinger equation for model systems: particle-in-a-box, harmonic oscillator, rigid rotator, hydrogen atom and hydrogen-like ions.
3). Hartree-Fock method. Form of one-electron functions and construction of multi-electron functions. Interpretation of solutions and limitations of the Hartree-Fock method.
4). Electron correlation. Computational methods to determine the correlation energy, based on the wave function or density functional theory.
5). Molecular orbitals in the LCAO-MO method. Formation of a chemical bond in two-atom molecules, bond order.
6). Electron structure of multi-electron atoms, two-atom molecules and multi-atom molecules. Hund's rules and thermae.
7). The Born-Oppenheimer approximation and the concept of potential energy surfaces. The electron-oscillation-rotation structure of the energy levels of diatomic molecules. Equilibrium geometry and vibrations of multi-atomic molecules.
8). Theoretical modelling of the course of a chemical reaction: internal coordinate of reaction, transition state, activation energy.
9). Molecule interaction energy: definition, super-molecular approach and perturbation calculus approach. Physical interpretation of interaction energy components. Behaviour of interaction energy for large distances between molecules.
10). The microcanonical ensemble and the statistical definition of entropy. Statistical summation in a canonical ensemble: definition, calculation for molecular systems, relation to thermodynamic parameters of the system. Quantum statistics.
11). List the components of the classical (empirical) force field. Why exactly is it called classical/empirical?
12). Discuss the Monte Carlo method with the Metropolis scheme.

13). Discuss the molecular dynamics method.
14). List the fundamental differences between the Monte Carlo modelling method and molecular dynamics.
15). Define the primary, secondary, tertiary and quaternary structure of proteins. What interactions are responsible for their formation?
16). Second-order structure of proteins: sketch a Ramachandran map, mark the areas corresponding to each type of secondary structure.
17). Describe what structures the DNA double helix adopts.
18). Explain the concept of protein homology. How do paralogues differ from orthologues?
19). How is the ubiquitination of two protein sequences determined and what questions does it help to answer? What is the computational complexity of this problem?
20). Symmetry operations: definitions, types (including point, translational, crystallographic), examples, matrix notation; symmetry operation vs symmetry element.
21). Symmetry groups: definition of a group, (crystallographic) point groups, space groups, Laue groups; how they differ and their applications for describing the structure of molecules, crystals and diffraction images.
22). Definitions of a crystal and the main features that distinguish the crystalline state from other states of matter.
23). Crystal lattice: definition, concept of elementary cell (and how to calculate its volume), classification and applications of Bravais lattice, construction and applications of inverse lattice.
24). Crystallographic systems: definitions, properties, assignment of objects to the appropriate system; crystallographic system vs. physicochemical properties.
25). The phenomenon of diffraction and description of a diffraction experiment: Bragg equation, Ewald construction, concepts of resolution and completeness of diffraction data, factors affecting the intensity of the X-ray beam deflected on the crystal.
26). Structure factor and atomic scattering factors: definitions, relationship to the intensity of the deflected radiation in a diffraction experiment; properties of the diffraction image that depend on the positions of the atoms in the elementary cell.
27). Radiation sources used in structural studies: basics of operation, similarities and differences (atomic/nuclear scattering factors), examples of applications.
28). Solving and refining a crystal structure: what is a phase problem in crystallography and examples of methods to solve it, what is crystal structure refinement, discrepancy indicators in crystal structure studies (what are they for), other methods for validating crystal structures.
29). Crystal structures of inorganic, molecular and macromolecular compounds (proteins, nucleic acids): similarities, differences and key experimental challenges.

Attachment No. 3
to Resolution No. 11 of the Teaching Council of the Faculty of Chemistry of 12 April 2023 on the detailed rules and regulations of graduation at the Faculty of Chemistry of the University of Warsaw;

TEMPLATE APPLICATION FOR APPLICATION FOR CONSENT FOR CO-SUPERVISING THE DIPLOMA DISSERTATION BY A PERSON FROM OUTSIDE THE UNIVERSITY OF WARSAW

<table>
<tr><td colspan="3">Application for the appointment of a co-supervisor of the diploma dissertation</td></tr>
<tr><td colspan="3">……..
type of diploma dissertation

…….
name and surname, academic title
diploma dissertation supervisor (UW Faculty of Chemistry employee)</td></tr>
<tr><td>…….
student’s name and surname</td><td>…….
student’s record book number</td><td>…….
field of study</td></tr>
<tr><td colspan="3">…….
name and surname, academic title
proposed co-supervisor of the diploma dissertation
(from outside the UW)

…….
place of employment</td></tr>
<tr><td colspan="3"></td></tr>
</table>

Title of the diploma project

Justification for cooperation

We would like to kindly remind that if the results of the research carried out by the student in the course of the diploma dissertation are published, the student should also place the University of Warsaw affiliation next to his/her name; furthermore, we would like to remind that the co-supervisor of the diploma dissertation is obliged to write a review of the dissertation in accordance with the rules and regulations of graduation in force at the FCH UW.

……..……..……

name and surname proposed co-supervisor (from outside the FCH UW)	name and surname supervisor from the FCH UW