Department Physical Chemistry
Kurpińskiego 5 street, 85-950 Bydgoszcz
www.chemfiz.cm.umk.pl
piotr.cysewski@cm.umk.pl
+48 (052) 585-36-11

TEACHING REGULATIONS

academic year 2024/2025

Course: **Physical Chemistry**

Field of study: **Pharmacy**

Composition of the teaching staff

Lectures: prof. dr hab. Piotr Cysewski

Seminars: prof. dr hab. Piotr Cysewski

Exercises: dr inż. Przemysław Czeleń
dr inż. Tomasz Jeliński

1. General information and organization of classes

Physical Chemistry classes include 30 hours of lectures, 45 hours of exercises and 15 hours of seminars.

Lectures are held during 15 weeks of the winter semester (Thursday 14.00-15.30).
Exercises take place during weeks 5-14 of the winter semester (Friday 15.30-18.35). A colloquium for the exercises is held in the 15th week of the semester (Wednesday 9.00-11.55).
Seminars are held during weeks 13-15 of the winter semester (Friday 12.30-15.15).

All classes take place in the building of the Department of Physical Chemistry, Karola Kurpińskiego 5 street: room 3 for lectures and seminars; room 3 (exercises 7-11) or 13 (exercises 1-6) for exercises.

Exercises are carried out in individual teams. The following scheme shows the exercises assigned to each team.

team	exercise number / week of classes										
	5	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1	7	8	9	10	11	1	2	3	4	5	C
2	7	8	9	10	11	2	3	4	5	6	C
3	7	8	9	10	11	3	4	5	6	1	C

Schedule and summary of classes

Wednesday		**type of classes**	**weeks**	**teacher**
9.00	11.55	colloquium (exercises)	15	dr inż. Przemysław Czeleń / dr inż. Tomasz Jeliński
Thursday		**type of classes**	**weeks**	**teacher**
14.00	15.30	lecture	1-15	prof. dr hab Piotr Cysewski
Friday		**type of classes**	**weeks**	**teacher**
11.30	15.15	seminar	13-15	prof. dr hab Piotr Cysewski
15.30	18.35	exercises	5-14	dr inż. Przemysław Czeleń / dr inż. Tomasz Jeliński

2. Requirements for students and conditions for passing the course

2.1. Rules of participation in classes

The following rules for participation in classes are established:

a) Attendance
• Attendance at seminars, practical classes, and quizzes is mandatory.
• Any absence must be justified as soon as possible (but no later than two weeks after it occurs).

b) Course conduct, grading, and scoring
• Every class (except those held in the first week of the semester) begins with a "pre-class quiz".
• The "pre-class quiz" covers the material related to the exercise conducted during that specific class.
• Points for the report will only be awarded if it is submitted to the instructor within the specified deadline. If the report is not submitted on time, the student will receive 0 points, but is still required to submit it by the end of the semester.
• The instructor may question the accuracy of the report and request corrections, but such corrections will not change the originally awarded number of points.
• The condition for passing the course is submitting all reports and having them approved by the instructor.

• Points for the colloquium will be awarded only if at least 30% of the total possible points are obtained.
• If fewer than 30% of the total possible points are obtained, no points will be awarded.
• The condition for passing the lectures is attending more than 50% of the lectures held. If this criterion is not met, it is necessary to demonstrate knowledge of the lecture content by answering at least 50% of the questions covering the topics from the lectures.

c) Other
• If a class does not take place due to objective reasons, the maximum number of points will be reduced by the points allocated to that class.
• Consultations take place during individual meetings at the Department of Physical Chemistry during the office hours of the respective instructors.

2.2. Conditions for passing exercises and seminars

If the attendance requirements (specified in point 2.1.) are met, the basis for passing and final grade will be the number of points obtained according to the following algorithm:

Scoring	**quantity**	**points**	**sum**
Exercises	10	10	96*
Seminars	1	60	60
Colloquium	1	60	60
		sum	216

* there is no pre-class quiz during the exercises taking place in the 1st week of classes

The passing and final grade are determined by the total number of points earned by the student throughout the course, according to the table below. The student may receive a bonus on the exam, based on the total points earned from practical classes and seminars, as outlined in the table below.

Grading scale (linear):

very good	5.0	>90%	194.5-216.0	**bonus 7 points on the exam*(7/20)**
good plus	4.5	>80%	172.9-194.4	**bonus 5 points on the exam*(5/20)**
good	4.0	>70%	151.1-172.8	**bonus 3 points on the exam*(3/20)**
satisfactory plus	3.5	>60%	126.3-151.2	a kind invitation to the exam
satisfactory	3.0	>50%	108.1-129.6	invitation to the exam
fail		<50%	000.0-108.0	

* receiving the bonus is dependent on passing the colloquium on the first attempt

2.3. Grading system

2.3.1. Exercises

During each of the ten tutorial classes, the student can earn a maximum of 10 points. These consist of:

- Pre-class quiz: 0 - 4 points
- Assessment of the quality of exercise performance: 0 - 2 points
- Presentation of obtained results in the form of a report: 0 - 4 points

Students completing the exercises must submit their reports no later than the start of the next class.

2.3.2. Colloquium

The final colloquium for the Pharmacy course is in a written form and covers all exercises. The maximum number of points that can be earned from the colloquium is 60. If less than 30% of the total possible points are obtained, the result for the colloquium is zero points.

2.4. Rules for passing the course (exam)

The Physical Chemistry course is passed based on a written exam consisting of 15 multiple-choice questions and 5 open-ended questions (short answers). For each correct answer to a multiple-choice question, the student receives 1 point. For each full answer to an open-ended question, 1 point can be earned. A necessary condition for passing the exam is meeting both of the following criteria: obtaining more than 50% of the total possible points (from both parts of the exam) and achieving at least 30% in the open-ended section (only in this case are bonuses calculated).

Grading scale (linear):

very good	5.0	>90%	18-20
good plus	4.5	>80%	16-17
good	4.0	>70%	14-15
satisfactory plus	3.5	>60%	12-13
satisfactory	3.0	>50%	11
fail		<50%	0-10

<u>The condition for taking the exam is obtaining a pass in the exercises and seminars.</u>

3. Scope of the course

The content of the course, presentations given during the lectures, sample tests for the colloquium and exam, as well as other teaching aids, are available on the Department of Physical Chemistry's website at:

http://www.chemfiz.cm.umk.pl

The goal of teaching is to familiarize students with the basics of physical chemistry, enabling them to understand the laws governing physicochemical processes in nature, master terminology and mathematical tools, and acquire and consolidate the ability to apply this knowledge to solve basic problems and interpret observed physicochemical phenomena. Laboratory exercises reinforce the knowledge conveyed during lectures and develop practical skills in using experimental and theoretical methods to solve problems in physical chemistry. The course covers topics such as the basics of chemical thermodynamics, descriptions of physicochemical equilibrium, properties of pure substances and their mixtures, chemical kinetics, phenomena of catalysis and biocatalysis, and the electrical conductivity of aqueous electrolyte solutions.

3.1. Lecture Content

1. Introduction to Physical Chemistry
   - 1.1. The subject and tasks of physical chemistry
   - 1.2. Physicochemical measurements
   - 1.3. Statistical processing of results - errors in direct measurements
   - 1.4. Statistical processing of results - errors in indirect measurements
   - 1.5. Auxiliary computational methods
2. Thermodynamics
   - 2.1. Basic concepts
   - 2.2. The first law of thermodynamics
   - 2.3. Thermochemistry
   - 2.4. The dependence of heat on temperature – Kirchhoff’s law
   - 2.5. The second law of thermodynamics
   - 2.6. Entropy changes in physicochemical processes
   - 2.7. The physical and chemical significance of entropy
   - 2.8. Calculating entropy changes
   - 2.9. Criteria for the spontaneity of chemical processes
   - 2.10. Calculating free enthalpy changes
   - 2.11. Relationships between thermodynamic functions
   - 2.12. Chemical affinity
   - 2.13. Chemical equilibrium and the law of mass action
   - 2.14. Le Chatelier's principle
   - 2.15. Calculating standard affinities and equilibrium constants

3. Solutions and Phase Equilibria
   3.1. Single-component systems - Ideal gases
   3.2. Single-component systems - Real gases
   3.3. Single-component systems - Liquid state
   3.4. Single-component systems - Solid state
   3.5. Colloidal systems
   3.6. Surface phenomena
   3.7. Equilibria in multiphase systems
   3.8. Thermodynamics of phase equilibria
   3.9. Gibbs' phase rule
   3.10. The Clausius-Clapeyron equation
4. Chemical Kinetics
   4.1. Basic concepts
   4.2. Rate of homogeneous reactions
   4.3. Kinetics of simple reactions - zero-order, first-order, and second-order reactions
   4.4. Kinetics of complex reactions – reversible, parallel, consecutive, and chain reactions
   4.5. Kinetic theories
   4.6. Catalysis
   4.7. Enzymes and enzymatic reactions
5. Elements of Electrochemistry
   5.1. Conductivity of aqueous electrolyte solutions
   5.2. Galvanic cells
   5.3. Thermodynamics of galvanic cells
   5.4. Oxidation-reduction potential
   5.5. Characteristics of half-cells
   5.6. Electrochemical conventions
   5.7. Examples of electrochemical measurements
   5.8. Electrolysis
   5.9. Faraday's laws
   5.10. Corrosion phenomena

After the lecture, the student should:

- know and understand the concepts necessary to explain physicochemical phenomena and processes in nature,
- be able to use basic concepts from chemical thermodynamics, thermochemistry, chemical statics and kinetics, and electrochemistry,
- understand cause-and-effect relationships characterizing the equilibrium and dynamics of physicochemical processes,
- be able to explain the essence of physicochemical phenomena and processes occurring in nature,
- know how to apply appropriate formulas for qualitative and quantitative descriptions of physicochemical phenomena,
- be able to predict the direction of processes when physicochemical parameters change,
- know which experimental methods can be used to study physicochemical reactions and processes,
- be able to experimentally determine physicochemical quantities and parameters characterizing processes and systems,
- know which experimental methods can be used to study physicochemical reactions and processes.

Seminars
During seminars, the discussed topics focus on the practical use of elements of physical chemistry in pharmaceutical sciences.

3.2. Exercise content

Exercise 1. Chemical Kinetics
Objective: Determining the rate constant of ethyl acetate hydrolysis in an acidic medium.
Topics: reaction rate constant, reaction rate, kinetics of zero, first, and second-order reactions, temperature dependence of reaction rate constant, Arrhenius equation, enzyme kinetics, activation energy, kinetics of consecutive reactions, activation energy constant.

Exercise 2. Surface Phenomena
Objective: Determining and comparing adsorption isotherms of CH_3COOH from aqueous solution on activated carbon.

Topics: adhesion, cohesion, adsorption, catalysis, monolayer isotherms (Langmuir isotherms) and multilayer isotherms, surface tension, surfactants, chemisorption, physical adsorption, Gibbs surface excess equation, differential heat of adsorption, capillary phenomena.

Exercise 3. Potentiometric Methods

Objective: Potentiometric titration of glycine, determination of acetic acid content, determination of ascorbic acid content.

Topics: galvanic cells, half-cells, SEM cells, redox potential, standard potential, electrodes (types and storage), cell voltage, Nernst equation, equilibrium constant for electrochemical reactions, half-cell potential, voltage series, pH, buffer solutions, buffer capacity, types of potentiometric titration.

Exercise 4. Conductometry

Objective: Determination of dissociation constants of weak electrolytes from conductivity measurements, conductometric titration, and determination of the solubility product of salts.

Topics: ionic conductivity, electronic conductivity, equivalent conductivity, specific conductivity, limiting conductivity, conductometric titration endpoint, cell constant, conductometric solubility product measurement, conductometric probe standardization, titration curves, units of molar conductivity, units of equivalent conductivity and limiting conductivity, law of independent ion migration.

Exercise 5. Phase Rule

Objective: Determining the partition coefficient of acetic acid between water and an organic solvent.

Topics: law of mass action, extraction process, partition coefficient, extraction coefficient, phase rule, Nernst distribution law, independent component, logP, degrees of freedom, Nernst distribution law.

Exercise 6. Thermodynamics

Objective: Determining the enthalpy of dissolution of 1 mole of sodium hydroxide depending on the ratio of moles of hydroxide and water, and determining and comparing the enthalpy of neutralization of sodium hydroxide by a strong acid and a weak acid.

Topics: state function, heat capacity, molar and specific heat, enthalpy of reaction, internal energy of reaction, Hess's law, Kirchhoff's law, the first law of thermodynamics, the second law of thermodynamics, entropy of a system, work, heat, internal energy, isothermal process, isochoric process, isobaric process, calorimeter.

Exercise 7. Heat Balance

Problems:

- Heat balance of physical processes
- Determining specific heat
- Determining heat of dissolution

Topics: first law of thermodynamics; heat, work, internal energy, heat balance, specific heat – heat capacity, state functions

Exercise 8. Thermochemistry – Hess's Law

Problems:

- Determining molar heat of reaction
- Practical application of Hess's Law

Topics: enthalpy, Hess's law, Kirchoff's law

Exercise 9. Spontaneity of Chemical Reactions

Problems:

- Spontaneity of reactions versus complementarity in DNA
- Calculation of standard free energy change of reaction
- Predicting the direction of physico-chemical processes
- Effect of temperature and concentration on the value of free energy

Topics: entropy, free enthalpy, and free energy, chemical affinity, chemical potential, citeria for spontaneity of chemical processes

Exercise 10. Reaction Enthalpy and Van't Hoff Isobar

Problems:

- Using the Van't Hoff isobar to determine the reaction enthalpy

Topics: equilibrium constant, law of mass action, Le Chatelier's principle, classification of processes and chemical reactions based on enthalpy values, definition of the Van't Hoff isobar

Exercise 11. Acid-Base Equilibria

Problems:

- Alkacymetric determination of the concentration of strong acids and bases
- Alkacymetric determination of the concentration of weak acids and bases
- Determining dissociation constants of acids and bases
- Characteristics of buffer solutions

Topics: acid-base theories, definitions of acid dissociation constant (Ka) and base dissociation constant (Kb), concepts of buffer and buffer capacity (examples), hydrolysis reactions, degree of hydrolysis, amphoteric electrolytes, isoelectric point

4. Recommended additional literature

in polish

- Atkins P.W, Podstawy chemii fizycznej, PWN 2001.
- Pigoń K., Ruziewicz Z., „Chemia fizyczna”, PWN, Warszawa, 2005.
- Atkins P.W, Trapp C.A, Cady M.P, Giunta C., CHEMIA FIZYCZNA Zbiór zadań, PWN, Warszawa
- A.G. Whittaker, A.R. Mount, M.R. Heal, Krótkie wykłady, Chemia fizyczna, PWN, Warszawa, 2003.
- L. Sobczyk, A. Kisza, K. Gatner, A. Koll, Eksperymentalna chemia fizyczna, PWN, Warszawa 1982.
- J. Demichowicz-Pigoniowa, Obliczenia fizykochemiczne, PWN, Warszawa 1984.
- W. Ufnalski, Obliczenia fizykochemiczne, OWPW, Warszawa 1995.
- series Wykłady z chemii fizycznej, WNT, Warszawa:
  - H. Buchowski, W. Ufnalski, Fizykochemia gazów i cieczy, 1998.
  - H. Buchowski, W. Ufnalski, Roztwory, 1995.
  - W. Ufnalski, Równowagi chemiczne, 1995.
  - H. Buchowski, W. Ufnalski, Podstawy termodynamiki, 1994,1998.
  - Molski, Wprowadzenie do kinetyki chemicznej, 2001.
  - Kisza, Elektrochemia I, Jonika, 2000.
  - Kisza, Elektrochemia II, Elektrodyka, 2001.

in english

- Physical Chemistry: A Molecular Approach by Donald A. McQuarrie
- Physical Chemistry by Peter Atkins
- Physical Chemistry by Ira N. Levine
- Energy, Entropy and Engines: An Introduction to Thermodynamics by Sanjeev Chandra
- The Laws of Thermodynamics: A Very Short Introduction by Peter Atkins
- Chemical Thermodynamics at a Glance by H. Donald Brooke Jenkins
- Modern Thermodynamics: From Heat Engines to Dissipative Structures by Dilip Kondepudi

5. Order regulations and occupational health and safety rules applicable at the Department of Physical Chemistry

NOTE: Students are obliged to comply with all epidemiological regulations issued by the competent authorities, in particular those regarding social distancing and disinfection of the workstation.

1. **General rules:**
   1. Outerwear should be left in the locker room located in the basement of the Department of Physical Chemistry.
   2. A lab coat must be worn at all times in the instrumental physical chemistry laboratory.
   3. It is prohibited to consume food and liquids in the laboratory.
   4. After completing your exercise, be sure to thoroughly wash any glassware you use and tidy up your workspace.
   5. Many of the reagents in the lab are potential poisons. Therefore, when performing exercises, hands should be washed in case of contamination with reagents and absolutely before leaving the lab.
   6. Save reagents and glassware used during exercises.
   7. Smoking is prohibited in the entire building of the Department of Physical Chemistry.

2. **Laboratory activities:**
   1. Do not light a fire if you are working with flammable substances (ethers, benzene, acetone, etc.). Electric plates do not protect against ignition of vapors of most organic solvents!
   2. Any activities involving concentrated acids and bases, ammonia, and bromine may only be performed under a fume hood – wearing a rubber apron, goggles, and gloves.
   3. Never pour water into concentrated SULPHURIC acid – the mixture becomes very hot and may spurt out of the container!
   4. Do not pipette corrosive substances (including concentrated acids and bases), bromine, and cyanide solutions by mouth. Use special pumps or rubber bulbs.
   5. Immediately rinse the pipette used for concentrated acids or bases with water. Immediately wipe up any concentrated acid or lye spilled on the laboratory table.
   6. Alkaline solutions should not be stored in ground-joint vessels (burettes, ground-joint bottles).
   7. Use a separate pipette for each solution.

8. Do not insert the pipette into bottles of reagents, especially standard solutions and those that decompose easily. Never pour a solution taken from it back into the bottle.
9. On an analytical balance, weigh using a clean spoon and clean, dry weighing vessels. Weights should be moved only with tongs. After weighing, the balance should be locked and dirt removed.
10. When using centrifugation, remember the following details: the liquid level in the test tubes should be approximately 1 cm lower than the length of the test tube, the bottom of the test tube during centrifugation should rest on a rubber pad, the test tubes (and sleeves) should be balanced by pairs of test tubes placed oppositely in the centrifuge rotor. The liquid level in the balanced test tubes should be similar, in the event of a test tube cracking during centrifugation, the centrifuge should be immediately switched off and thoroughly cleaned of glass fragments and spilled liquid.
11. Use only thoroughly washed glassware. Immediately after use, rinse the vessel with running water, wash with warm water and detergent using a clean brush, rinse with running water until the detergent is completely removed, and then at least 3 times with distilled water.
12. Pipettes should be rinsed with running water immediately after use and placed in a cylinder with detergent solution. To wash, connect the glass pipette to a water pump and rinse with tap water, then 3x with distilled water.
13. Glassware can be dried in an oven at 120 $^{\circ}$C, with the exception of calibrated measuring vessels and thick-walled centrifuge tubes.
14. Do not throw solid waste down the sink.
15. If you need to pour concentrated acid or base down the sink, remember the 'acid to water' rule and rinse the sink thoroughly with water.

3. Procedure in emergency situations

1. In case of skin burn with acid or alkali, rinse the burned area thoroughly with running water and wash with 2-3% sodium bicarbonate solution (acid burn) or 1-2% acetic or citric acid solution (alkali burn), and then wash with loosely rolled hygroscopic gauze.
2. In case of eye burns, rinse them abundantly with water, applying a stream to the outer corners, under the eyelids. Immediate medical examination is necessary.
3. If acid or alkali gets into the mouth, rinse immediately with a large amount of water and then with a suitably diluted solution of sodium bicarbonate or acetic or citric acid. If acid or alkali solution is swallowed, drink a large amount of milk or water with raw egg white or olive oil and see a doctor immediately.
4. In case of thermal burn of the skin with symptoms of the first degree (redness, swelling, pain), its surface should be washed with ethanol or pyoctanin or 10% solution of potassium permanganate. In more serious cases of burns (with blisters), the area around the wound should be washed with ethanol, covered with hygroscopic gauze and see a doctor.
5. In case of spillage of flammable liquids, wipe them up immediately and rinse the cloth under running water. Extinguish burning organic solvents only with an asbestos blanket or an appropriate fire extinguisher (powder or snow).
6. Familiarize yourself with the building's evacuation plan.