Amirkabir University of Technology

(Tehran Polytechnic)

Syllabus for M.Sc. Semester I-IV for M.Sc. Analytical Chemistry

(2016-2017)

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Compulsory courses Master of Chemistry - Analytical Chemistry

Course No.	Course Title	Unit	Hours
1480133	Advanced Analytical Chemistry	3	48
1484103	Analytical Electro-chemistry	3	48
1484123	Physical and chemical separation methods	3	48
1484113	Analytical spectroscopy (I)	3	48

Elective Courses Master of Chemistry - Analytical Chemistry

Course No.	Course Title	Unit	Hours
1480123	Advanced Organic Chemistry	3	48
1484113	Advanced Inorganic Chemistry	3	48
1495403	Separation and Bioseparation methods	3	48

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Research courses Master of Chemistry - Analytical Chemistry

Course No.	Course Title	Unit	Hours
1485901	Seminar	1	
1481900	Project	9	

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<< Semester I >>

Advanced Analytical Chemistry

Objective: Familiarity with the principles and concepts of Analytical Chemistry

Chapters

1. Application of statistical methods in evaluating the obtained results
   - Statistics of repeated measurement
   - Significance tests
   - Linear and nonlinear regression and curve-fitting
   - Calibration methods
   - Non-parametric methods
2. Sampling, sampling strategy, number of samples, the introduction of different quality control methods, familiarity with different types of control curves, and method evaluation
3. Equilibria and activity
4. Acid and base equilibria in water
5. Acid-base equilibria in non-aqueous solvents
6. Chemical standards
7. Application of acid and base titrations
8. Solubility and sediments
9. Formation and properties of sediments and contaminants
10. Functional aspects of sedimentary reactions
11. Complex formation equilibria
12. Reduction oxidation reactions and electrode potential

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Evaluation method

Curriculum research	Final exam	Midterm exam	Continuous assessment
+	+	+	+

References

1. Gary D. Christian, Analytical Chemistry, Last Edition
2. D. Pletcher, R. Greff, R. Peat, L.M. Peter, J. Robinson, Instrumental methods in electrochemistry, Woodhead Publishing, Last Edition
3. Daniel C. Harris, Quantitative Chemical Analysis, W.H. Freeman, 2010.
4. Galen w. Ewing, Instrumental methods of Chemical Analysis, 4Th Edition, International Student Edition.
5. Bryan M. Ham, Aihui MaHam, Analytical Chemistry: A Chemist and Laboratory Technician's Toolkit, John Wiley & Sons.
6. Brian M. Tissue, Basic of Analytical Chemistry and Chemical Equilibria, John Wiley & Sons.
7. J. N. Miller, J. C. Miller, Statistics and chemometrics for analytical chemistry, Pearson, Last edition.
8. S. R. Ellison, V. J. Barwick. T. J. D. Farrant, Practical statistics for the analytical scientist, RSC, 2009.
9. P. C. Meier, R. E. Zund, Statistical methods in analytical chemistry, John Wiley & Sons, 2000.
10. Dhruba Charan Dash, Analytical Chemistry, Second Edition, PHI Learning Pvt. Ltd. Delhi.

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Advanced Organic Chemistry

Objective: Familiarity with atomic and molecular decomposition spectroscopy methods

Chapters

1. Nucleophilic substitution:
   Limit cases (SN_1, SN_2) and borderline mechanisms, Carbocations, Nucleophilicity and Solvent Effect, Raw material structure, Steric effects on reactions rate, Stereochemistry, mechanism of rearrangement of Carbocations, The Norbornyl cations, and other non-classical carbocations.
2. Polar Addition and Elimination Reactions:
   Addition of Hydrogen Halides to Alkenes, Acid-Catalyzed Hydration and Related Addition Reactions, Addition of Halogens, Electrophilic Additions Involving Metal Ions, Additions to Alkynes and Allenes, The E2, E1, and E1cb Mechanisms, Regiochemistry of Elimination Reactions, Stereochemistry, Dehydration of Alcohols, Eliminations Reactions Not Involving C−H Bonds, Thermal Elimination, Nucleophilic Addition of Multiple Bonds, Structural Effects on Rate, Electrophilic Aromatic Substitution Reactions, Nucleophilic Aromatic Substitution
3. Carbanions and Other Carbon Nucleophiles:
   The acidity of Hydrocarbons, Carbanions Stabilized by Functional Groups, Enols and Enamines Carbanions as Nucleophiles in SN_2Reactions, Substitution Reactions of Organometallic Reagents, Substitution Reactions of Enolates, Electrophilic Aromatic Substitution Reactions,
   Benzene
4. Carbenes:
   Singlet and Triplet Carbenes, Stereochemistry, Addition Reactions
5. Addition, Condensation, and Substitution Reactions of Carbonyl Compounds:
   Reactivity of Carbonyl Compounds toward Addition, Hydration and Addition of Alcohols to Aldehydes and Ketones, Condensation Reactions of Aldehydes and Ketones with Nitrogen Nucleophiles, Substitution

Reactions of Carboxylic Acid Derivatives, Ester Hydrolysis and Exchange, Aminolysis of Esters, Amide Hydrolysis, Acylation of Nucleophilic Oxygen and Nitrogen Group, Intramolecular Catalysis of Carbonyl Substitution Reactions.

6. Free Radical Reactions:
   Generation and Characterization of Free Radicals, Free Radical Substitution Reactions, Oxygenation, Halogenation, Free Radical Addition Reactions, Addition of Hydrogen Halides, Addition of Halomethanes, Addition of Other Carbon Radicals, Intramolecular Hydrogen Atom Transfer Reactions, Rearrangement Reactions of Free Radicals, Substitution Processes.

Evaluation method

Curriculum research	Final exam	Midterm exam	Continuous assessment
+	+	+	+

References

1. F.A. Carey, R.J. Sundberg, Advanced Organic Chemistry, Part A: Structure and Mechanisms, Fourth Edition, Springer, 2007.
2. F.A. Carey, R.J. Sundberg, Advanced Organic Chemistry, Part B: Reaction and Synthesis, Fourth Edition, Springer, 2007.
3. M.B. Smith, March's Advanced Organic Chemistry; Reactions, Mechanisms, and Structure, Wiley, last Edition.

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Advanced Inorganic Chemistry

Objective: Familiarity with the advanced concepts and fundamental topics of inorganic chemistry

Chapters

1. Symmetry: Definitions of group theory, the introduction of symmetry and related operations, point groups, bipolar moment, optical activity, matrices, reduced and irreducible representations, identification tables, Moliken symbols.
2. Applications of symmetry in chemistry: Determination of central atom hybridization and central atom orbitals involved in sigma bond formation, Determination of atomic orbitals involved in π bond formation, Molecular vibrations and interpretation of IR spectrum composition, Identification of metal-carbonyl complexes
3. Investigation of bonds and spectral properties (using the quantitative view of molecular orbital theory): Different bond theories, molecular orbital theory, quantitative calculations of energy levels in molecular orbitals, AOM approximation and energy calculations of molecular orbital levels in different molecular orbital fields Structural superiority of different arrangements in different fields based on AOM, evidence of fracture of d orbitals in AOM theory, Jahn–Teller effect, calculation of Jahn–Teller's type of deviation based on AOM, Jahn–Teller deviation constraints based on AOM
4. The structure of compounds and its relationship with spectral properties: electron spectrum in metal complexes, types of electronic transfers, selection rules, factors affecting the intensity of electronic transitions, electronic arrangement, microstates, spectral terms, and fission of terms in the complex field, Orgel and Tanabe–Sugano diagrams, Electronic Transfers and Spectral Interpretations, Calculation Δ_0 in d^n Arrays Based on Electronic Transfers.

5. Kinetics of chemical reactions, coordination compounds, and their reactions

Evaluation method

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+	+	+	+

References

1. FA Cotton and G. Wilkinson, Advanced Inorganic Chemistry, Sixth Ed., Wiley (1999).

2. J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th ed., Harper-Collins, New York (2008).

3. Keith F. Purcell, John C. Kotz, Inorganic Chemistry, Thomson (1977).

4. Wai-Kee Li, Gong-Du Zhou, Thomas Mak, Advanced Structural Inorganic Chemistry (International Union of Crystallography Texts on Crystallography), Oxford University Press, USA (2008).
5. Duward Shriver, Mark Weller, Tina Overton, Jonathan Rourke, Fraser Armstrong, Inorganic Chemistry, 6th ed. , Macmillan Education (W. H. Freeman) (2014).
6. Miessler G., Fischer P., Tarr D., Inorganic chemistry, 5ed., Pearson (2014).
7. Atkins and Shriver, Inorganic Chemistry, Oxford University Press, 5nd Ed., (2010).

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Seminar

The student should study a topic from the scientific content of the day with the supervisor's opinion and present it in the form of a lecture to increase the power of analysis and expression of the problem by the student and increase his knowledge of others. The seminar is presented in a time frame of one hour. The presence of master's and doctoral students in the relevant field is mandatory in the sessions of these seminars according to the regulations that the Graduate Research Council will approve of the Faculty.

<< Semester II >>

Analytical Electro-Chemistry

Objective: Familiarity with electrochemical methods in Analytical Chemistry

Chapters

1. Classification of Electrochemical methods, Potentiostat methods, Electrodynamic methods
2. Potentiometric indicator electrodes; Principles, functions, and types
3. Double-layer: theoretical foundations and explanation of different models
4. Controlled currents with charge transfer kinetics
5. Controlled currents with mass transfer
6. Cyclic voltammetry and Cyclic voltammetry linear scan: principles, and applications
7. Hydrodynamic voltammetry: principles, foundations, and applications
8. Methods of Elimination of capacitive current in voltammetry
9. Chronoamprometry: principles and application
10. Chronocolometry: Principles and application
11. Chronopotentiometry: principles, foundations, and Theoretical application
12. Foundations of ultramicroelectrodes and their applications

13. Electrochemical Sensors
14. Spectroelectrochemical methods

Evaluation method

Curriculum research	Final exam	Midterm exam	Continuous assessment
+	+	+	+

References

1. A. J. Bard, L. R. Faulkner, Electrochemical methods, fundamentals and applications, Wiely-VCH, 2001.
2. C. M. A. Brett, A. M. O. Brett, Electrochemistry, Principals, methods and applications, Oxford university press, 1994.
3. D. Pletcher, R. Greff, R. Peat, L. M. Peter, J. Robinson, Instrumental method in electrochemistry, Woodhead Publishing Limited, 2011.
4. J. Wang, Analytical Electrochemistry, Wiely-VCH, 2000.

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Analytical Spectroscopy

Objective: Familiarity with atomic and molecular Analytical Spectroscopy methods

Chapters

1. Theoretical principles of absorption and emission by various atomic elements in Flame and plasma, sources of radiation, and excitation.
2. Flame and non-flame atomic absorption spectroscopy, types of furnaces in terms of geometric shape and material, types of modifiers, hydride methods, the concept of temperature in Flame, spectroscopy methods and other methods of measuring flame temperature, use of laser in Atomic fluorescence, use of lasers in atomic absorption spectroscopy, types of plasma-based methods and their comparison with each other, types of nebulizers, methods of induction-coupled plasma optimization, types of temperature in plasma and how to determine it, optical fiber and its application in analysis chemistry Advantages of using optical fiber in spectroscopic methods, detection limit and its definitions (European and American), detection limit determination method.
3. Principles and applications of atomic fluorescence spectroscopy, radiofrequency plasma, and microwaves, X-ray fluorescence.
4. Theoretical principles of emission spectrography and its qualitative and quantitative applications, various methods of X-ray based
5. Analysis electron Spectroscopy Methods
6. Application of Electron Spectroscopy in Chemical Analysis (ESCA), Photoelectron Spectroscopy (PES), Auger Spectroscopy, theoretical Principles of Radiochemical
7. UV spectroscopy, derivative methods, and their comparison.
8. Qualitative and quantitative analysis using complex formation and determination of stability constants.
9. Qualitative analysis and determination of molecular structure by infrared spectroscopy and the origin of measurement errors.
10. Light spectrum.
11. Raman spectroscopy and its types.

12. X-ray methods, electron spectroscopy methods, application of electron spectroscopy in chemical analysis, photoelectron spectroscopy, Auger spectroscopy, principles of radiochemical methods, thermal analysis methods, scattering-based methods, including opacimetry and microscopy, electron microscopy, electron microscopy.
13. Principles of the spectrum and mass spectrometry Instrumentation.

Evaluation method

Curriculum research	Final exam	Midterm exam	Continuous assessment
+	+	+	+

References

1. Winefordner JD, *Spectrochemical Methods Of Analysis*, Wiley (1971).
2. Gulick M.V., *Instrumental Analysis*, Haper & Row, Publishers (1974).
3. Ahuja S., Jespersen N., *Modern Instrumental Analysis*, Elsevier (2006)
4. Petrozzi S., *Practical Instrumental Analysis: Methods, Quality Assurance and Laboratory Management*, Wiley (2012).
5. Gulick M.V., *Instrumental Analysis*, Harper & Row Publishers, New York (1974).
6. Hodern O., *Modern Optical Methods of Chemical Analysis*, Mc Graw Hill (1975).
7. Svanberg S., *Atomic, and Molecular Spectroscopy: Basic Aspects and Practical Applications*, Springer (2004).

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Physical and chemical methods of separation

Objective: Familiarity with physical and chemical processes of separation

chapters

1. Phase separation methods (evaporation, regional melting, general principles of distillation, azeotropic - distillation, extraction distillation, steam distillation, and distillation with immiscible solvents, vacuum distillation, molecular distillation, sublimation, and desiccation).
2. Extraction-based separation methods (continuous extraction, reverse flow extraction, solid-phase extraction, and supercritical fluid extraction).
3. Flotation Separation methods (Purge and trapping).
4. Chromatography-based separation methods (review of gas, liquid, and supercritical fluid chromatography).
5. Chromatography: Chromatography of surface adsorption, its basis and different ways of chromatography of surface adsorption,
6. Including results for partition chromatography
7. Search only for partial chromatography
8. the separation of components between two liquid phases viz original solvent and the film of solvent used in the column. It is also known as Liquid-liquid chromatography (LLC). If gas is the mobile phase, it is called Gas-liquid chromatography (GLC)
9. Partition chromatography, and its different ways.
10. Paper chromatography
11. Thin-layer chromatography
12. Ion exchange Chromatography
13. HPLC (liquid chromatography)
14. Ion chromatography
15. Electrochromatography
16. New chromatographic methods such as supercritical fluid chromatography (Scfc (or) Sfc.)
17. Capillary electrophoresis and electrochromatography.

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Evaluation method

Curriculum research	Final exam	Midterm exam	Continuous assessment
+	+	+	+

References

1. Berg E.W., *Physical and Chemical Methods of Separation,* 1st Edition, McGraw-Hill, 1963.
2. Dean J.A., *Chemical Separation Methods*, Van Nostrand Reinhold Company, 1969.
3. Hieftie P.H., *Chemical Separation and Meamements*, Saunders, 1974.
4. Pinnau I., Freeman B.D., *Advanced Materials for Membrane Separations*, ACS, 2004.
5. Tarleton E.S., Wakeman R.J., *Solid/Liquid Separation: Equipment selection and process design*, Butterworth-Heinemann, 2007.
6. Berg E.W., *Physical and Chemical Methods of Separation*, McGaw-Hill, 1963.
7. Dean J.A., *Chemistry Separation Method*, Van Nostrand Crop, 1974.
8. Heftmann E., *Chromatography*: *Fundamentals and Applications of Chromatography and Related Differential Migration Methods*, 6th Ed., Academic Press, Elsevier, 2004.

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Separation and Bioseparations method

Objective: Familiarity with Separation and Bioseparations methods

chapters

1. Overview of bioseparations engineering
2. Properties of biological material
3. Bioseparation techniques
4. Properties of biological material
5. Mass transfer
6. Cell disruption
7. Precipitation
8. Centrifugation
9. Reverse osmosis (RO)
10. Light absorption
11. Fluorescence
12. Membrane-based bioseparation
13. Membrane separation: types of Membranes, types of Membranes processes, Membrane transport theory, Membranes, and modules
14. Membrane chromatography, Electrodialysis
15. Membrane extraction in analytical chemistry
16. Medical application of Membranes
17. Miscellaneous bioseparation processes

Evaluation method

Curriculum research	Final exam	Midterm exam	Continuous assessment
+	+	+	+

References

1. R. Ghosh, Principles of Bioseparations Engineering, World Scientific Publishing Co. Pte. Ltd.
2. Y.Chisti, Bioseparation, and Bioprocessing: A Handbook, Publisher: Wiley-VCH.

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<< Semester III & IV>>

Project

The student must select his / her master's dissertation topic at the beginning of the second semester and submit his / her proposal to the Faculty before the third semester, which the supervisor approves. If the Faculty Graduate Research Council approves the dissertation proposal, the student's research work will officially begin. In choosing the topic of the dissertation, it is recommended to observe the following points:

A. The subject and plan in question are to identify or solve the problems of society.

B. The desired method or solution is new and innovative.

After the student prepares the dissertation, the supervisor announces the student's readiness to hold a dissertation defense ceremony to the Vice-Chancellor for Graduate Studies. A copy of the dissertation will be delivered to the Faculty for consideration by the Graduate Research Council. After the Graduate Research Council approves the dissertation defense, a jury consisting of a supervisor, an internal referee, and an out-of-college arbitrator will be appointed to hold a dissertation defense session. If the dissertation has a consultant professor, it is not necessary to select an internal guest professor. The Graduate Research Council may appoint a faculty member to attend and oversee the defense session. The defense of the dissertation will be done in a public meeting with the presence of the jury and the representative of the Graduate Research Council (if necessary). After presenting the research papers related to the dissertation, the student answers the questions of the jury. The jury convenes its secret session to announce its opinion and decide whether to approve or disapprove and determine the grade of the dissertation. If the dissertation is not approved, the jury will decide how to proceed with the student.