Chemistry PhD Qualifying Exam
Paper 1 – Syllabus

Preface

This document comprises all topics relevant for Paper 1 of the Ph.D. Qualifying Exam in Chemistry at Eastern Mediterranean University, in accordance with the Department's Rules and Regulations for Graduate Studies (valid until the change of the Department's Rules and Regulations for Graduate Studies is made). The subjects covered in Paper 1 are from Analytical Chemistry, Organic Chemistry, Physical Chemistry, Polymer Chemistry (Polymer Chemistry Group) and Electrochemistry (Organic Chemistry Group) corresponding to the MSc courses taught in our department. The reference textbooks are indicated at the end of each subject.

Analytical Chemistry

Topics covered

1. The Nature of Analytical Chemistry
2. Chemicals, Apparatus, and Unit Operations of Analytical Chemistry
3. Calculations Used in Analytical Chemistry
4. Errors in Chemical Analyses
5. Random Errors in Chemical Analysis
6. Statistical Data Treatment and Evaluation
7. Sampling, Standardization, and Calibration
8. Aqueous Solutions and Chemical Equilibria
   - 8.1. Acid-Base
   - 8.2. Solubility
   - 8.3. Complexation
   - 8.4. Partition
9. Effect of Electrolytes on Chemical Equilibria
10. Solving Equilibrium Problems for Complex Systems
11. Gravimetric Methods of Analysis
12. Titrations in Analytical Chemistry
    - 12.1. Principles of Neutralization Titrations
    - 12.2. Complex Acid/Base Systems
    - 12.3. Applications of Neutralization Titrations
    - 12.4. Complexation and Precipitation Reactions and Titrations
13. Introduction to Electrochemistry
14. Applications of Standard Electrode
15. Applications of Oxidation/Reduction
16. Fundamentals of spectroscopy
17. Solvent extraction and introduction to chromatography.

Bibliography

Fundamentals of Analytical Chemistry, Ninth Edition, 2014, Brooks/Cole. By Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch)

Organic Chemistry

Topics covered

1. IUPAC nomenclature of organic compounds
   - 1.1 How to Name Alkanes, Alkyl Halides, and Alcohols
   - 1.2 How to Name Cycloalkanes
   - 1.3 How to Name Alkenes and Cycloalkenes
   - 1.4 How to Name Alkynes
   - 1.5 Nomenclature of Alcohols and Ethers:
   - 1.6 Nomenclature of Benzene Derivatives
   - 1.7 Nomenclature of Aldehydes and Ketones
   - 1.8 Nomenclature of Carboxylic Acids
   - 1.9 Nomenclature of Amines
   - 1.10 Nomenclature of Phenols
2. Stereochemistry and Chirality
   - 2.1. Chirality and Stereochemistry
   - 2.2. Isomerism: Constitutional Isomers and Stereoisomers
   - 2.3. Enantiomers and Chiral Molecules
   - 2.4. Molecules Having One Chirality Center
   - 2.5. How to Test for Chirality: Planes of Symmetry
   - 2.6. Naming Enantiomers: The R,S-System
   - 2.7. Molecules with More than One Chirality Center
   - 2.8. Fischer Projection Formulas
   - 2.9. Stereoisomerism of Cyclic Compounds
3. Nucleophilic substitution
   - 3.1. Nucleophiles
   - 3.2. Leaving Groups
   - 3.3. Kinetics of a Nucleophilic Substitution Reaction: An SN2 Reaction
   - 3.4. A Mechanism for the SN2 Reaction
   - 3.5. Transition State Theory: Free-Energy Diagrams
   - 3.6. The Stereochemistry of SN2 Reactions
   - 3.7. A Mechanism for the SN1 Reaction
   - 3.8. Carbocations
   - 3.9. The Stereochemistry of SN1 Reactions
   - 3.10. Factors Affecting the Rates of SN1 and SN2 Reactions
   - 3.11. Organic Synthesis: Functional Group Transformations Using SN2 Reactions
4. Addition and Elimination Reaction
   - 4.1. Elimination Reactions of Alkyl Halides
   - 4.2. The E2 Reaction
   - 4.3. The E1 Reaction
   - 4.4. How to Determine Whether Substitution or Elimination Is Favored
5. Radicalic Reactions
   - 5.1. Introduction: How Radicals Form and How They React
   - 5.2. Homolytic Bond Dissociation Energies
   - 5.3. Reactions of Alkanes with Halogens
   - 5.4. Chlorination of Methane: Mechanism of Reaction
   - 5.5. Halogenation of Higher Alkanes
   - 5.6. The Geometry of Alkyl Radicals
   - 5.7. Reactions That Generate Tetrahedral Chirality Centers
   - 5.8. Allylic Substitution and Allylic Radicals
   - 5.9. Benzylic Substitution and Benzylic Radicals

1.1. Radical Addition to Alkenes: The Anti-Markovnikov Addition of Hydrogen Bromide

6. Electrophilic aromatic substitution reactions
   6.1. Electrophilic Aromatic Substitution Reactions
   6.2. A General Mechanism for Electrophilic Aromatic Substitutions
   6.3. Halogenation of Benzene
   6.4. Nitration of Benzene
   6.5. Sulfonation of Benzene
   6.6. Friedel–Crafts Alkylation
   6.7. Friedel–Crafts Acylation

Bibliography

Graham Solomon, Craig Fryhle, Scott Snyder (2014) Organic Chemistry (11th ed) New York, NY: Wiley
ISBN: 978-1-118-32379-3

Polymer Chemistry

Topics covered

1. Definitions, Nomenclature
2. Polymer Structure
   2.1. Stereochemistry
   2.2. Molecular Interactions
   2.3. Structure-Property Relationship
   2.4. The Amorphous and the Crystalline States
   2.5. Cross-Linking
3. Solutions of Polymers
   3.1. Solubility
   3.2. Average Molecular Weight Values
   3.3. Molecular Weight Determination Methods: Primary Methods
   3.4. Molecular Weight Determination Methods: Secondary Methods
   3.5. Thermodynamics of Polymer Solutions
4. Synthesis of Polymers
   4.1. Step-Growth Polymerization
   4.2. Chain-Growth Polymerization; Free Radical Polymerization
   4.3. Copolymerization
   4.4. Polymerization Techniques
   4.5. Thermodynamics of Polymerization
   4.6. Chain-Growth Polymerization; Anionic Polymerization
   4.7. Chain-Growth Polymerization; Cationic Polymerization
   4.8. Coordination Polymerization
5. Polymerization Kinetics
   5.1. Step-Growth Polymerization
   5.2. Chain-Growth Polymerization; Free Radical, Anionic and Cationic Polymerization
6. Reactions of Polymers
   6.1. Principles of Polymer Reactivity
   6.2. Main Chain Reactions
   6.3. Side Group Reactions

Bibliography

1. Carraher, CE Jr., Carraher's Polymer Chemistry (2014), 9th Ed., CRC Press, FL,. ISBN 13: 978-1-4665-5220-3 (eBook - PDF)
2. Ravve A, Principles of Polymer Chemistry (2012), 3rd ed., Springer, NY, ISBN 978-1-4614-2212-9 (eBook)

Special Topics in Electrochemistry

Topics covered

1. Redox Chemistry
   - 1.1 Half-reaction method
   - 1.2 Electrolytic cell
   - 1.3 Galvanic Cell
   - 1.4 Electrolysis
   - 1.5 Standard cells and cell potentials
2. Cyclic and Linear Voltammetry
   - 2.1. Voltammetry
   - 2.2. Voltammetric Measurement
   - 2.3. Voltammetric Electrochemical Cell
   - 2.4. Anodic Stripping, Adsorptive Cathodic Stripping
   - 2.5. Working Electrodes
   - 2.6. Mercury Electrode
   - 2.7. Auxiliary Electrode
   - 2.8. Reference Electrodes
   - 2.9. Electrolytes
   - 2.10. Reversible oxidation, irreversible oxidation
   - 2.11. Anodic peak current, Cathodic peak current
   - 2.12. Anodic peak potential, Cathodic peak potential
   - 2.13. Reversible, irreversible and Quasi-reversible systems
   - 2.14. Half Wave Potentials
   - 2.15. Electrochemical Stability
3. Square-Wave Voltammetry
   - 3.1 Theory and application
4. Different Electronic Materials
   - 4.1. Insulators, Conductors, Semiconductors
   - 4.2. Electronic properties
   - 4.3. Energies of LUMO Levels
   - 4.4. Energies of HOMO Levels
   - 4.5. Optical Band Gap Energies
   - 4.6. Diffusion constants

5. Experimental Setup
   - 5.1. The working electrode
   - 5.2. The reference electrode
   - 5.3. The counter electrode
   - 5.4. Instrumental parameters and wiring
   - 5.5. Nonaqueous media
   - 5.6. Elimination of electrical noise

Bibliography

1. Bagotsky, V. S., Fundamentals of Electrochemistry (2006), 2nd ed., John Wiley and Sons, ISBN: 978-0-471-70058-6

2 .Rudolf Holze , Experimental Electrochemistry (2009), John Wiley and Sons, Inc. 2009. ISBN: 978-3-527-31098-2

Physical Chemistry

Topics covered

1. Zeroth Law of Thermodynamics and Equations of State
   1.1. State of a System
   1.2. The Zeroth Law of Thermodynamics
   1.3. The Ideal Gas Temperature Scale
   1.4. Ideal Gas Mixtures and Dalton's Law
   1.5. Real Gases and the Virial Equation
   1.6. Critical Phenomena
   1.7. The van der Waals Equation
   1.8. Description of the State of a System without Chemical Reactions
2. First Law of Thermodynamics
   2.1. Work and Heat
   2.2. First Law of Thermodynamics and Internal Energy
   2.3. Exact and Inexact Differentials
   2.4. Work of Compression and Expansion of a Gas at Constant Temperature
   2.5. Various Kinds of Work
   2.6. Change in State at Constant Volume
   2.7. Enthalpy and Change of State at Constant Pressure
   2.8. Heat Capacities
   2.9. Joule Thomson Expansion
   2.10. Adiabatic Processes with Gases
   2.11. Thermochemistry
   2.12. Enthalpy of Formation
   2.13. Calorimetry
3. Second and Third Laws of Thermodynamics
   3.1. Entropy as a State Function
   3.2. The Second Law of Thermodynamics
   3.3. Entropy Changes in Reversible Processes
   3.4. Entropy Changes in Irreversible Processes
   3.5. Entropy of Mixing Ideal Gases
   3.6. Entropy and Statistical Probability
   3.7. Calorimetric Determination of Entropies
   3.8. The Third Law of Thermodynamics
4. Fundamental Equations of Thermodynamics
   4.1. Fundamental Equation for the Internal Energy
   4.2. Definitions of Additional Thermodynamic Potentials Using Legendre Transforms
   4.3. Effect of Temperature on the Gibbs Energy
   4.4. Effect of Pressure on the Gibbs Energy
   4.5. Fugacity and Activity
   4.6. Chemical Potential
   4.7. Additivity of Partial Molar Properties with Applications to Ideal Gases
   4.8. Gibbs–Duhem Equation

Bibliography

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