Course Description

Physical Chemistry provides an in-depth understanding of the fundamental principles that govern chemical systems, focusing on the interplay between energy, matter, and molecular interactions. The course begins with an exploration of Quantum Mechanics, introducing the mathematical framework and principles underlying atomic and molecular behavior. Students will delve into Chemical Energy, examining the thermodynamic and kinetic aspects of energy transformations in chemical processes.

The course also covers Chemical Bonding, with a detailed study of atomic and molecular orbitals, offering insights into how atoms combine to form molecules and the role of orbital theory in predicting chemical properties. Finally, the course addresses Intermolecular Bonds, highlighting the forces that dictate the interactions between molecules and their implications in physical and chemical phenomena.

By combining theoretical concepts with practical problem-solving, this course equips students with the skills and knowledge essential for advanced studies and applications in Chemical Engineering.

Course Identity

Course Name	: Physical Chemistry
Course Code	: F170-1CELA
Credits	: 2 SKS
ECTS	: 3 ECTS
Semester	: 4
Degree	: Bachelor
Study Program	: Chemical Engineering – Pharmaceutical Engineering Concentration
Faculty	: Life Sciences and Technology
Classroom	: 28 hours
Self Study	: 56 hours
Total Workload	: 84 hours
Course Status	: Mandatory
Prerequisite/s	: -
Applied for Batch Year	: 2020
Lecturer	: Dr. Hery Sutanto
Responsible Lecturer	: Dr. Hery Sutanto

Objectives

The objective of the Physical Chemistry course is to provide Chemical Engineering students with a comprehensive understanding of the fundamental principles and theories that govern chemical systems. The course aims to:

1. Develop a solid foundation in quantum mechanics and its application to atomic and molecular structures.
2. Equip students with the knowledge to analyze and interpret energy transformations and chemical thermodynamics.
3. Foster an understanding of chemical bonding, focusing on atomic and molecular orbitals and their role in predicting chemical behavior.
4. Explore intermolecular forces and their impact on physical and chemical properties of substances.
5. Enhance analytical and problem-solving skills through the application of mathematical models and theoretical principles to practical chemical engineering problems.
6. Cultivate independent learning and critical thinking by encouraging students to connect theoretical knowledge with real-world applications.
7. This course is designed to prepare students for advanced studies and professional challenges in the field of Chemical Engineering.

Competency

Student Competencies

1. **Foundational Knowledge in Physical Chemistry**
   - Demonstrate a solid understanding of quantum mechanics principles and their applications in chemical systems.
   - Comprehend and articulate concepts of chemical energy, atomic and molecular orbitals, and intermolecular bonds.
2. **Analytical and Problem-Solving Skills**
   - Apply mathematical and theoretical models to solve complex problems related to energy transformations and bonding.
   - Analyze and interpret the behavior of matter based on physical chemistry principles.
3. **Critical Thinking and Application**
   - Relate theoretical knowledge to practical chemical engineering contexts, enabling students to bridge the gap between theory and real-world applications.
4. **Independent and Lifelong Learning**
   - Develop the ability to learn independently through self-paced review of the video materials.
   - Enhance skills in self-assessment and identifying areas for further improvement.
5. **Technical Communication**
   - Communicate complex concepts and problem-solving approaches clearly and effectively, both verbally and in written form, aligning with professional standards in chemical engineering.

These competencies align with the broader goals of equipping students with the knowledge, skills, and mindset necessary for success in both academic and professional contexts.

Teaching & Learning Approach

Method/Approach	: Lectures, question & answer, discussion and problem solving
Media	: Digital videos, white board, Presentations, E-Learning
Assignments	: Quiz, presentation

Evaluation

Attendance, quiz, presentation, final exam

Lesson Content

1. Energy and Chemical Potential
2. Quantum Mechanics
3. Chemical Energy
4. Atomic orbitals
5. Molecular Orbitals
6. Covalent Bonding
7. Intermolecular bonds

Lecturing Plans

Week 1: Introduction to Physical Chemistry

- Overview of the course: Structure, objectives, and expectations
- Introduction to key concepts: Quantum Mechanics, Chemical Energy, Bonding, and Intermolecular Forces
- Importance of Physical Chemistry in Chemical Engineering
- **Activity:** Ice-breaking activity and Q&A
- **Homework/Preparation:** Read Chapter 1: Introduction to Quantum Mechanics

Week 2: Quantum Mechanics - Part 1

- Historical development and basic principles of Quantum Mechanics
- Wave-particle duality and the Schrödinger equation
- **Video Review:** Basics of Quantum Mechanics and the Schrödinger Equation (Online)
- **Quiz 1:** Covering basic concepts introduced in Week 1 and Week 2

Week 3: Quantum Mechanics - Part 2

- Atomic orbitals and the hydrogen atom
- Quantum numbers and their significance
- **In-Class Activity:** Simple calculations with atomic orbitals
- **Video Review:** Quantum Numbers and Atomic Orbitals (Online)

Week 4: Quantum Mechanics - Part 3

- The Pauli exclusion principle and Hund's rule
- Electron configuration and periodic table trends
- **Homework/Preparation:** Read Chapter 2 on Chemical Energy

Week 5: Chemical Energy - Part 1

- Introduction to chemical thermodynamics
- Energy, work, and heat
- **Video Review:** Chemical Energy and Thermodynamics (Online)

Week 6: Chemical Energy - Part 2

- Enthalpy, entropy, and Gibbs free energy
- Spontaneity of reactions
- **Quiz 2:** Covering Chemical Energy and related concepts

Week 7: Chemical Energy - Part 3

- First and second laws of thermodynamics
- Practical examples of energy transformations
- **Activity:** Problem-solving session on energy calculations

Week 8: Chemical Bonding - Atomic Orbitals

- Overview of chemical bonding theories
- Atomic orbitals and their role in bonding
- **Video Review:** Atomic Orbitals in Chemical Bonding (Online)

Week 9: Chemical Bonding - Molecular Orbitals

- Molecular orbital theory and bonding/antibonding orbitals
- The role of molecular orbitals in bonding
- **Presentation:** Student presentation on Molecular Orbitals

Week 10: Chemical Bonding - Hybridization and Bonding Models

- Hybridization in covalent bonding
- Valence bond theory and its applications
- **Homework/Preparation:** Read Chapter 4 on Intermolecular Forces

Week 11: Intermolecular Bonds - Part 1

- Types of intermolecular forces: Van der Waals, hydrogen bonding, dipole-dipole interactions
- **Video Review:** Intermolecular Forces and Their Importance (Online)

Week 12: Intermolecular Bonds - Part 2

- The effect of intermolecular forces on physical properties (boiling point, solubility)
- **Activity:** Group problem-solving on molecular interactions

Week 13: Review and Application

- Review of all topics covered: Quantum Mechanics, Chemical Energy, Bonding, and Intermolecular Forces
- Application of knowledge through case studies and practical examples in chemical engineering
- **In-Class Activity:** Collaborative discussion and problem-solving
- **Video Review:** Comprehensive review video covering all course topics

Week 14: Final Review and Q&A

- Final Q&A session
- Preparation for the final exam and overall course wrap-up
- **Feedback Collection:** Students complete a feedback form on the video review materials and the course
- **Final Presentation:** Summarize key concepts learned throughout the semester

References

1. Robert J. Silbey, Robert A. Alberty, Moungi G. Bawendi, "Physical Chemistry". ISBN: 0-471-6589
2. David W. Ball, "Physical Chemistry", 2011, Thomson Brooks/Cole, ISBN: 0-534-26658-4
3. Ira N. Levine, Physical Chemistry, 6th Edition, 2009, The McGraw-Hill Companies, Inc, ISBN 978-0-07-253862-5