Anan College	Year	2024	Course Title	Physical Chemistry 1

Course Information

Course Code	1413D04	Course Category	Specialized / Compulsory
Class Format	Lecture	Credits	School Credit: 2
Department	Course of Chemical Engineering	Student Grade	3rd
Term	Year-round	Classes per Week	前期:2 後期:2
Textbook and/or Teaching Materials	Textbook: 千原秀昭・稲葉章・鈴木晴(訳)「アトキンス物理化学要論」東京化学同人 and 福地賢治編 Professional Engineering Library 「物理化学」 実教出版		
Instructor	Konishi Tomoya		

Course Objectives

Physical chemistry is a branch of science that attempts to understand chemical phenomena essentially from atomic and molecular structures based on knowledge of physics (e.g., thermodynamics and quantum mechanics) and to express various properties quantitatively (quoted from the textbook "Foreword"). The goals of the lecture are as follows:
1. Explains the states of matter, their characteristics, and the changes of state between phases, and solves related applied problems
2. Explains the difference between ideal gas and real gas and their treatment by equation of state, and solves related application problems
3. Explains radiation and radioactive decay in radioactive materials and solves application problems related to the use of radiation and nuclear energy.
4. Describes equilibrium, kinetics and analysis of chemical reaction by using thermodynamics and solve relevant problems.
5. Describes basics of quantum mechanics and solves basic problms.

Rubric

	Ideal Level	Standard Level	Unacceptable Level
Achievement 1	Solves exercises on the three states of matter and intermediate phases.	Explains the characteristics of the three states of matter and intermediate phases, as well as critical points, and solves example problems.	Cannot explain the three states of matter and changes of state.
Achievement 2	Treats theoretically the kinetic theory of molecules and velocity distributions for ideal gases and solves exercises.	Treats theoretically the kinetic theory of molecules and velocity distributions for ideal gases and solves example problems.	Unable to explain the properties and laws of ideal gases and solve basic problems using the equation of state.
Achievement 3	Explains the equation of state and generalized diagram of a real gas and solves exercises.	Explains the equation of state and generalized diagram of a real gas and solves example problems.	Cannot explain the difference between an ideal gas and a real gas.
Achievement 4	Explains the properties and uses of radiation and nuclear energy, and solves exercises.	Explains the properties and uses of radiation and nuclear energy, and solves example problems.	Cannot explain the difference between radioactive material, radioactivity, and radiation.
Achievement 5	Solves the problems of eqilibrium with few errors.	Demonstrates the general knowlege of eqilibrium.	Demonstrates little or no knowlege of eqilibrium.
Achievement 6	Solves the problems of chemical kinetics with few errors.	Demonstrates the general knowlege of chemical kinetics.	Demonstrates little or no knowlege of chemical kinetics.
Achievement 7	Solves the problems of reaction analysis with few errors.	Demonstrates the general knowlege of reaction analysis.	Demonstrates little or no knowlege of reaction analysis.
Achievement 8	Solves the problems of basic quantum mechanics with few errors.	Demonstrates the general knowlege of basic quantum mechanics.	Demonstrates little or no knowlege of basic quantum mechanics.

Assigned Department Objectives

学習・教育到達度目標 D-1

Teaching Method

Outline	The course will be offered once a week. In this course, students learn about states of matter, ideal gases, and real gases, and understand how to handle gases using the equation of state. This concept is very useful for handling high-pressure gases in the chemical industry and for designing pressure-resistant vessels and high-pressure reaction vessels. Students will also learn about nuclear reactions of radioactive materials and the characteristics of radiation to deepen their understanding of the use of radiation and nuclear energy. Next, students learn to describe chemical eqilibrium, chemical kinetics, and the property of chmical reaction using the knowledge of thermodynamics. This knowledge is indispensable to the manufacturers of chmicals designing materials, temperature, aging, and yield. Students also study basic quantum mechanics for the introduction of quantum chemistry.
Style	Students are expected to read the textbook and solve preparatory problems in advance. The class will mainly consist of (1) a confirmation test, (2) explanations in the textbook, and (3) exercises. (2) The explanations in the textbook will be based on familiar phenomena and concrete examples, and visual learning through slides and videos will be incorporated. (3) In the exercises, after confirming how to solve example problems, students work alone or in groups to solve exercises to promote the retention of knowledge and skills through experience and to acquire the ability to apply them. Each class will be reviewed using the LMS (manaba) to organize the main points of the study content. 【30 hours of class time + 15 hours of self-study】
Notice	Students are expected to make sure that their knowledge and skills are firmly established through preparation and exercises. The contents covered in physical chemistry cannot be expected to have any learning effect unless the students actually tackle the exercises by themselves.

Characteristics of Class / Division in Learning

☐ Active Learning	☐ Aided by ICT	☑ Applicable to Remote Class	☐ Instructor Professionally Experienced

Course Plan

			Theme	Goals

1st Semester	1st Quarter	1st	States of matter (1) - Three states of matter and state change	Explains the mutual changes in the three states of matter.
		2nd	States of matter (2) - gases and liquids	Basic calculations using the equation of state for ideal gases, the van der Waals equation for real gases, and the Clausius-Clapeyron equation.
		3rd	States of matter (3) - solids and intermediate phases	Explains the crystal structure of solids and the characteristics of liquid crystals and soft viscous crystals as intermediate phases.
		4th	Ideal gas (1) - Properties of ideal gas	Understands the equation of state and be able to calculate temperature, pressure, and volume.
		5th	Ideal gas (2) - Properties of mixed gases	Understands the partial and total pressures of a mixture of gases and be able to calculate the partial and total pressures of an ideal gas from its mole fraction and equation of state.
		6th	Ideal gas (3) - Theory of gas molecular kinetics	Calculates gas pressure from gas molecular kinetics and explains the relationship between temperature and molecular motion.
		7th	Ideal gas (4) - Molecular velocity distribution	Explains that the Maxwell-Boltzmann distribution represents the velocity distribution of molecules, and calculates the mean velocity and mean free path of molecules.
		8th	Exercises	Solves exercises on the content studied in weeks 1-7.
	2nd Quarter	9th	Real gas (1) - Deviation from ideal gas	Explains why real gases deviate from the ideal gas law in terms of molecular size and intermolecular forces of attraction. Explains critical temperatures.
		10th	Real gas (2) - Equation of state	Calculates the p-Vm-T relationship for real gases using the van der Waals or virial equation of state.
		11th	Real gas (3) - Correspondence state principle	Obtains the p-Vm-T relationship for real gases using the generalized Z diagram based on the corresponding state principle.
		12th	Real gases (4) - Application to mixtures	Obtains the p-Vm-T relationship for real mixed gases using the van der Waals equation, the virial equation of state, and a generalized Z diagram.
		13th	Nuclear Reactions and Radiation (1) - Radiation and its Properties	Explains the types and properties of radiation.
		14th	Nuclear Reactions and Radiation (2) - Radioactive Material, Radioactivity, Radiation	Explains the difference between radioactive materials, radioactivity, and radiation, and solves various calculation problems related to radioactive decay.
		15th	Nuclear Reactions and Radiation (3) - Radiation and Nuclear Energy Applications	Explains how radiation and nuclear energy is used and calculate nuclear energy.
		16th	Exercise	Solves exercises on the content studied in weeks 9-15.
2nd Semester	3rd Quarter	1st	Chemical equilitrium (1)	1) Explains the law of mass action. 2) Explains Le Chatelier's principle. 3) Describes the direction of equilibrium shift when concentration, pressure, and temperature change in equilibrium.
		2nd	Chemical equilitrium (2)	1) Explains concentration and pressure equilibrium constants. 2) Describes the pressure equilibrium constant in terms of Gibbs energy. 3) Calculates equilibrium composition (partial pressure) using equilibrium constants.
		3rd	Chemical equilitrium (3)	1) Explains the effect of pressure on chemical equilibrium in terms of pressure equilibrium constants. 2) Explains the effect of temperature on chemical equilibrium using the pressure equilibrium constant. 3) Calculates pressure equilibrium constants at different temperatures using the van’t Hoff’s equation.
		4th	Chemical equilitrium (4)	1) Describes equilibrium constants for heterogeneous reactions. 2) Describes the temperature dependence of the dissociation pressure. 3) Solves problems involving chemical equilibria of reactions involving solid phases.
		5th	Chemical kinetics (1)	1) Describes and calculates reaction rates in terms of concentrations. 2) Describes reaction rate equations and explain reaction orders. 3) Explains how to determine reaction orders experimentally.
		6th	Chemical kinetics (2)	1) Calculates rate equations for first-order reactions. 2) Calculates rate equations for second-order reactions (unimolecular and bimolecular reactions). 3) Calculates half-lives of reactions.

		7th	Exercise	Solves exercises on the content studied in weeks 1-6.
		8th	Midterm exam.	
	4th Quarter	9th	Property of chemical reaction (1)	1) Formulates rate equations for consecutive reactions and solve problems. 2) Formulates rate equations for reversible reactions and solve problems.
		10th	Property of chemical reaction (2)	1) Explains elementary reactions and rate-limiting steps. 2) Derives rate equations for a group of elementary reactions including a rate-limiting step. 3) Derives rate equations for concomitant reactions.
		11th	Property of chemical reaction (3)	1) Describes the temperature dependence of activation energy and reaction rate. 2) Determines the activation energy using the Arrhenius equation. 3) Describes a catalyst and explains the mechanism of accelerating the rate of a reaction.
		12th	Basic quantum mechanics (1)	1) Describes the background of the birth of quantum theory. 2) Describes the blackbody radiation distribution and the quantum energy hypothesis. 3) Describes the photoelectric effect and the quantum photon hypothesis.
		13th	Basic quantum mechanics (2)	1) Describes the photoelectric effect and the light quantum hypothesis. 2) Describes the line spectrum of hydrogen atoms. 3) Describes Bohr's atomic model.
		14th	Basic quantum mechanics (3)	1) Describes Bohr's quantum condition and frequency condition. 2) Describes the uncertainty principle. 3) Describes the outline of Schrödinger's equation.
		15th	Basic quantum mechanics (4)	1) Derives the time-independent Schrödinger equation. 2) Describes the meaning and properties of wave functions. 3) Solves the Schrödinger equation for a particle in a one-dimensional box.
		16th	Exercise	Solves exercises on the content studied in weeks 9-15.

Evaluation Method and Weight (%)

	Examination	Portfolio	Homework	Total
Subtotal	70	5	25	100
Basic Proficiency	30	5	10	45
Specialized Proficiency	40	0	15	55
Cross Area Proficiency	0	0	0	0