[Title]			[Instructor]		
Advanced Physical Chemistry			Kenji Miyatake / Shinji Nohara / Akiyoshi Kuzume		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG531	2	Special Educational Program for Green Energy Conversion Science and Technology	2nd Semester	Fri.／I	English／Japanese

[Outline and purpose]

Physical chemistry is one of the most important basic subjects in the field of green energy conversion technology. In this class, basics of physical chemistry will be studied in preparation for the advanced classes.

[Objectives]

To understand physical properties of gases, thermodynamics, phase equilibrium, electrochemistry, and reaction kinetics

[Requirements]

Basic knowledge on physical chemistry

[Evaluation]

Report and examination: 60%
Mark given for class participation: 40%

[Textbooks]

None

[References]

Physical Chemistry (Gordon M. Barrow), ISBN-10: 0070051119

[Schedule]

1. The properties of gases
2. Thermodynamics and the first law
3. Thermochemistry
4. Entropy, the second and the third law
5. Free energy and chemical equilibrium
6. Temperature and pressure dependence of phase equilibrium
7. Thermodynamics of solutions
8. Colligative properties of solutions
9. Phase and surface properties
10. Electrolytes in solutions
11. Electrochemical cells
12. Kinetics of chemical reactions
13. Reaction rate and mechanism
14. Spectroscopies and diffractions
15. Summary

[Title]			[Instructor]		
Advanced Inorganic Chemistry			Satoshi Wada / Hiroshi Yanagi		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG532	2	Special Educational Program for Green Energy Conversion Science and Technology	2nd Semester	Thu.／I	English／Japanese

[Outline and purpose]

Students learn the basics and application of electron behavior in solids

[Objectives]

To understand fundamental principle of electronic and optical properties of solids

[Requirements]

A good grounding in Physical Chemistry, Inorganic Chemistry, and Quantum Chemistry.

[Evaluation]

1 Midterm examination　30%
2 homework　30%
3 class participation　40%

[Textbooks]

[References]

[Schedule]

*The lectures from 1 to 5 are held with Zoom or Teams.
*The lectures from 6 to 10 are held on demand.
*The lectures from 10 to 15 are held with Zoom.

1. Introduction
2. Crystal Structure
3. Chemical bonding and band structure
4. Spectroscopic methods
5. Material design based on electronic structure
6. The essence of electronic structure
7. Material design based on electronic structure
8. Mechanism of electric polarization
9. Complex dielectric constant and dielectric relaxation
10. Evaluation of dielectric properties
11. Electrical conductivity
12. Defect and nonstoichiometry in solid
13. Mechanism of electronic conductivity
14. Mechanism of ionic conductivity
15. Evaluation of electrical conductivity

[Title]			[Instructor]		
Advanced Inorganic Chemistry			Satoshi Wada / Hiroshi Yanagi		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG532	2	Special Educational Program for Green Energy Conversion Science and Technology	2nd Semester	Thu.／I	English／Japanese

[Outline and purpose]

Students learn the basics and application of electron behavior in solids

[Objectives]

To understand fundamental principle of electronic and optical properties of solids

[Requirements]

A good grounding in Physical Chemistry, Inorganic Chemistry, and Quantum Chemistry.

[Evaluation]

1 Midterm examination　30%
2 homework　30%
3 class participation　40%

[Textbooks]

[References]

[Schedule]

1. Introduction
2. Crystal Structure
3. Chemical bonding and band structure
4. Spectroscopic methods
5. Other evaluation method
6. The essence of electronic structure
7. Material design based on electronic structure
8. Midterm examination
9. Mechanism of electric polarization
10. Complex dielectric constant and dielectric relaxation
11. Evaluation of dielectric properties
12. Ferroelectrics and ferroelectric domain configuration
13. Piezoelectricity
14. Application of dielectrics and ferroelectrics
15. Summative assessment for total score

[Title]			[Instructor]		
Advanced Materials Chemistry			Isao Tanaka / Takahiro Takei / Eiichi Kondoh		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG533	2	Special Educational Program for Green Energy Conversion Science and Technology	2st Semester	Tue.／I	English／Japanese

[Outline and purpose]

Synthesis and crystal growth techniques for solid state materials are acquired on the base of phase equilibrium in this course. Also crystal chemistry and characterization for solid state materials are acquired. For various synthesis processes, the mechanism and their theories are acquired.

[Objectives]

1. to understand relationship between defect concentration and physical properties by lattice defect formation in crystalline materials
2. to understand formation mechanism in various synthesis processes for solid state materials
3. to gain ability to use binary phase diagrams

[Requirements]

inorganic chemistry, solid state chemistry, materials engineering, physical chemistry, electronic physical properties

[Evaluation]

homework/ examination : 70%
audit attitude : 10%
presentation : 20%

[Textbooks]

Anthony R. West, Solid State Chemistry and Its Applications, Second Edition, JOHN WILEY & SONS, LTD, ISBN:978-1-119-94294-8

[References]

[Schedule]

1. Function and property by crystal defects
2. Non-stoichiometry and lattice defects in oxides
3. Defect concentration and defect equilibrium
4. Relationship between defect concentration and electrical conductivity
5. Interim summary I
6. Synthesis of inorganic materials by solid state reaction
7. Sol-gel synthesis of inorganic materials
8. Synthesis by hydrothermal and solvothermal reactions
9. Thin film preparation by gas phase reaction
10. Solid-liquid interface & Interim summary II
11. Phase rule and phase diagram
12. Phase diagram and microstructures
13. Solid-liquid interface and its equilibrium
14. Basic theories of solution chemistry and phase diagram
15. Nucelation and crystal growth Summary

[Title]			[Instructor]		
Advanced Course of Materials Design for Fuel Cells			Kenji Miyatake / Akihiro Iiyama /Shinji Nohara / Junpei Miyake		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG534	2	Special Educational Program for Green Energy Conversion Science and Technology	2nd Semester	Tue.／II	English／Japanese

[Outline and purpose]

Fuel cells are electric power supply devices, which convert chemical energy to electric energy directly and reciprocally. Among them, polymer electrolyte fuel cells (PEFCs) for electric vehicles, portable devices, and residential power supply and solid oxide fuel cells (SOFCs) as on-site power generation have attracted a considerable attention. In this class, principle, design and evaluation of these fuel cells and their component materials will be discussed.

[Objectives]

To understand principle and evaluation of PEFCs and SOFCs and their component materials

[Requirements]

Basic knowledge on electrochemistry and physical chemistry

[Evaluation]

Report and examination: 50%
Mark given for class participation: 50%

[Textbooks]

None

[References]

Denkikagakugairon (co-authored by Matsuda and Iwakura), Maruzen, ISBN: 4621039962

[Schedule]

1. Electrochemistry of fuel cells 1
2. Electrochemistry of fuel cells 2
3. Principle and research trend of fuel cells 1
4. Principle and research trend of fuel cells 2
5. Design of fuel cell electrocatalysts: cathode catalysts 1
6. Design of fuel cell electrocatalysts: cathode catalysts 2
7. Design of fuel cell electrocatalysts: anode catalysts 1
8. Design of fuel cell electrocatalysts: anode catalysts 2
9. Methanol oxidation catalysts 1
10. Methanol oxidation catalysts 2
11. Design of highly dispersed catalysts 1
12. Design of highly dispersed catalysts 2
13. Design of functional materials 1
14. Design of functional materials 2
15. Summary

[Title]			[Instructor]		
Advanced Course of Engineering for Solar Energy Conversion			Hiroshi Irie / Hiroshi Yanagi /ToshihiroTakashima		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG535	2	Special Educational Program for Green Energy Conversion Science and Technology	1st Semester	Mon.／Ⅱ	English／Japanese

[Outline and purpose]

A light-related system is one of the candidate technologies for sustainable energy conversion and environmental preservation. We will learn such light-related systems based on mainly physical chemistry as well as quantum chemistry and solid state physics. Students also learn the fundamental principle of standard and new concept solar cells.

[Objectives]

1. To understand the interaction of light with solids, and successive phenomena
2. To understand the fundamental principle of standard and new concept solar cells

[Requirements]

Physical Chemistry, Quantum chemistry, Solid state physics, Inorganic Chemistry, and Semiconductor Physics

[Evaluation]

1 final examination　20%
2 midterm examination　20%
3 homework / reports 20%
4 class participation / presentation 40%

[Textbooks]

[References]

魚崎浩平、米田龍、高橋誠、金子晋（共訳）：固体の電子構造と化学、技報堂出版、1989 年（in Japanese）
山口　真史・M･A･グリーン・大下　祥雄・小島　信晃, 太陽電池の基礎と応用, 丸善 (in Japanese)
Martin A. Green, Solar Cells, University of New South Wales
Peter Wurfel, 太陽電池の物理, 丸善 (in Japanese)
Peter Würfel, Physics of Solar Cells: From Basic Principles to Advanced Concepts, Wiley-VCH

[Schedule]

1.Introduction
2. Light energy conversion, Basic theory
3. Solar energy conversion : To chemical energy 1
4. Solar energy conversion : To chemical energy 2
5 Solar energy conversion : To hydrogen energy
6. Thermal energy conversion : Basic theory
7. Thermal energy conversion : To electricity
8. Solar cells and sunlight
9. Semiconductor properties
10. Carrier generation and recombination
11. Si based solar cells
12. Compound-semiconductor Solar cells
13. Organic solar cells
14. Future view
15. Final examination / presentation

[Title]			[Instructors]		
Advanced Course of Science for Surfaces and Interfaces			Junji Inukai, Akiyoshi Kuzume, Toshihiro Miyao		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG536	2	Special Educational Program for Green Energy Conversion Science and Technology	1st Semester	Fri.／I	English／Japanese

[Outline and purpose]

Comprehending basic surface crystallography, surface analytical methods, and surface reactions to be applied to students' researches.

[Objectives]

Understanding basic ideas of the following topics:
1) Surface and interface science.
2) Surface crystallography at the atomic level.
3) Surface analytical methods.
4) Surface reactions on model and real surfaces.
5) Adsorption and reactions on solid surfaces.

[Requirements]

Basic knowledge on solid crystallography and quantum chemistry.

[Evaluation]

Class participation 40%
Reports, quiz, and examination 60%

[Textbooks]

[References]

Atkins' Physical Chemistry, Peter Atkins.

[Schedule]

1. Introduction
   Surface crystallography I: Single crystal surfaces
2. Surface crystallography II: Notification of surface structures; adlayers
3. Surface crystallography III: Reciprocal lattice
4. Surface crystallography IV: Reciprocal lattice to real lattice
5. Quiz on surface crystallography
6. Surface analysis method I: Electrochemistry on Single crystal surfaces
7. Surface analysis method II: Morphological study with Scanning Probe Microscopy
8. Surface analysis method III: Infrared absorption spectroscopy
9. Surface analysis method IV: Surface enhanced Raman spectroscopy
10. Quiz on surface analysis method
11. Adsorption at solid surfaces I: (interpretation of adsorption isotherms)
12. Adsorption at solid surfaces II: (surface characterization using adsorption phenomena)
13. Adsorption at solid surfaces III: (chemisorption and surface catalysis)
14. Adsorption at solid surfaces IV: (catalytic reaction mechanisms at solid surfaces)
15. Quiz on adsorption at solid surfaces

[Title]			[Instructor]		
Advanced Course of Polymer Material Chemistry			Hidenori Okuzaki		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG537	2	Special Educational Program for Green Energy Conversion Science and Technology	2nd Semester	Thu.／II	English／Japanese

[Outline and purpose]

Polymer is one of three major materials together with metals and ceramics, which has been widely utilized in the fields of aerospace, electronics, telecommunication, transportation, and medicines. In this class, basic and advanced technologies in structure and function of various functional polymer materials such as gels, liquid crystals, conducting polymers, piezoelectric polymers, and intelligent materials will be discussed.

[Objectives]

To understand advanced technology in structure and function of various functional polymer materials.

[Requirements]

Basic knowledge on organic chemistry, physical chemistry, and polymer chemistry.

[Evaluation]

Mark given for class participation and report: 50%
Presentation and examination: 50%

[Textbooks]

None

[References]

Zukai Kobunshi zairyou saizensen (Kunihiro Ozaki and Kazuo Matsuura), Kogyotyosakai, ISBN:476934161X

[Schedule]

1. Polymer materials chemistry (introduction)
2. Research and development of polymer materials
3. Structure of polymer materials (molecular weight and distribution)
4. Structure of polymer materials (tacticity)
5. Structure of polymer materials (crystallinity, crystallite size, and crystalline orientation)
6. Structure of polymer materials (cross-linking and gels)
7. Function of polymer materials (high modulus and high strength polymers)
8. Function of polymer materials (biocompatibility and medical polymers)
9. Function of polymer materials (polymer gels)
10. Function of polymer materials (semiconducting polymers)
11. Function of polymer materials (conducting polymers)
12. Function of polymer materials (plastic electronics)
13. Function of polymer materials (intelligent polymer materials)
14. Function of polymer materials (biomimetic polymers)
15. Summary

[Title]			[Instructor]		
Advanced Course of English for Green Energy Science and Technology, Elementary Level			D. A. Tryk / M. E. Brito		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG538	2	Special Educational Program for Green Energy Conversion Science and Technology	1st Semester	Mon.／I	English／Japanese

[Outline and purpose]

This course will cover reading, writing, speaking and listening for scientific and engineering English, including special emphasis on green energy and technology. Presentation and discussion skills will be particularly emphasized.

[Objectives]

The specific achievements or milestones will include: (1) ability to read a technical paper and summarize it briefly in English; (2) ability to write a short paper; (3) ability to confidently give a short technical presentation in English; (4) ability to ask questions at an oral technical presentation.

[Requirements]

M1 status

[Evaluation]

Attendance: 20%; presentations: 40%; reports: 40%

[Textbooks]

None

[References]

None

[Schedule]

1. Introduction; overview; basic pronunciation;
2. Pronunciation of general chemical terms, specific terms for student research themes; self-introductions;
3. Brief self-introductions
4. Short, informal oral presentations 1
5. Short, informal oral presentations 2
6. Short, informal oral presentations 3
7. Brief oral introduction to your research field for non-specialists 1
8. Brief oral introduction to your research field for non-specialists 2
9. Brief oral introduction to your research field for non-specialists 3
10. Brief oral introduction to your research field for non-specialists 4
11. Final oral presentations 1
12. Final oral presentations 2
13. Final oral presentations 3
14. Final oral presentations 4
15. Final oral presentations 5

[Title]			[Instructor]		
Exercises for Green Energy Conversion IA			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG612	1	Special Educational Program for Green Energy Conversion Science and Technology	1nd Semester	／	English／Japanese

[Outline and purpose]

The purpose is to acquire knowledge about the green energy conversion science and technology.

[Objectives]

Students will have will have acquired the ability to address following issues through our instructional approach, which integrates basic and practical studies; Fuel cells, Solar energy conversion, Energy-conversion materials, New energy technology

[Requirements]

Physical chemistry, Materials Physics and Chemistry, Catalyst Science, Environmental Science, etc.

[Evaluation]

Laboratory work, Technical report

[Textbooks]

[References]

[Schedule]

・Students have opportunities to present the results of their studies in monthly research meetings.
・Subjects of interactive discussion between students and faculty are provided. A particular focus is on developing debate skills in English through interactive discussion subjects presented by foreign faculty.
・The number of faculty is large enough to maintain a student to faculty ratio of 1.5 to 1, creating small-group instruction, with close attention to each student.

[Title]			[Instructor]		
Exercises for Green Energy Conversion IB			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG613	1	Special Educational Program for Green Energy Conversion Science and Technology	2nd Semester	／	English／Japanese

[Outline and purpose]

The purpose is to acquire knowledge about the green energy conversion science and technology.

[Objectives]

Students will have will have acquired the ability to address following issues through our instructional approach, which integrates basic and practical studies; Fuel cells, Solar energy conversion, Energy-conversion materials, New energy technology

[Requirements]

Physical chemistry, Materials Physics and Chemistry, Catalyst Science, Environmental Science, etc.

[Evaluation]

Laboratory work, Technical report

[Textbooks]

[References]

[Schedule]

・Students have opportunities to present the results of their studies in monthly research meetings.
・Subjects of interactive discussion between students and faculty are provided. A particular focus is on developing debate skills in English through interactive discussion subjects presented by foreign faculty.
・The number of faculty is large enough to maintain a student to faculty ratio of 1.5 to 1, creating small-group instruction, with close attention to each student.

[Title]			[Instructor]		
Exercises for Green Energy Conversion IIA			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG614	1	Special Educational Program for Green Energy Conversion Science and Technology	1nd Semester	／	English／Japanese

[Outline and purpose]

The purpose is to acquire knowledge about the green energy conversion science and technology.

[Objectives]

Students will have will have acquired the ability to address following issues through our instructional approach, which integrates basic and practical studies; Fuel cells, Solar energy conversion, Energy-conversion materials, New energy technology

[Requirements]

Physical chemistry, Materials Physics and Chemistry, Catalyst Science, Environmental Science, etc.

[Evaluation]

Laboratory work, Technical report

[Textbooks]

[References]

[Schedule]

・Students have opportunities to present the results of their studies in monthly research meetings.
・Subjects of interactive discussion between students and faculty are provided. A particular focus is on developing debate skills in English through interactive discussion subjects presented by foreign faculty.
・The number of faculty is large enough to maintain a student to faculty ratio of 1.5 to 1, creating small-group instruction, with close attention to each student.

[Title]			[Instructor]		
Exercises for Green Energy Conversion IIB			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG615	1	Special Educational Program for Green Energy Conversion Science and Technology	2nd Semester	／	English／Japanese

[Outline and purpose]

The purpose is to acquire knowledge about the green energy conversion science and technology.

[Objectives]

Students will have will have acquired the ability to address following issues through our instructional approach, which integrates basic and practical studies; Fuel cells, Solar energy conversion, Energy-conversion materials, New energy technology

[Requirements]

Physical chemistry, Materials Physics and Chemistry, Catalyst Science, Environmental Science, etc.

[Evaluation]

Laboratory work, Technical report

[Textbooks]

[References]

[Schedule]

・Students have opportunities to present the results of their studies in monthly research meetings.
・Subjects of interactive discussion between students and faculty are provided. A particular focus is on developing debate skills in English through interactive discussion subjects presented by foreign faculty.
・The number of faculty is large enough to maintain a student to faculty ratio of 1.5 to 1, creating small-group instruction, with close attention to each student.

[Title]			[Instructor]		
Professional Research for Green Energy Conversion IA			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG616	2	Special Educational Program for Green Energy Conversion Science and Technology	1st Semester	／	English／Japanese

[Outline and purpose]

The purpose is to acquire knowledge about the green energy conversion science and technology.

[Objectives]

Students will have accomplished the following general and specific learning objectives.
・Develop innovative technology in order to efficiently and economically convert and store green energy to establish a low-carbon, sustainable society.
・Achieve the best balance of various energy conversion devices and through these studies

[Requirements]

Physical chemistry, Materials Physics and Chemistry, Catalyst Science, Environmental Science, etc.

[Evaluation]

Laboratory work, Technical report

[Textbooks]

[References]

[Schedule]

・Students are required to research green energy conversion-related issues in each laboratory.
・Students have opportunities to present the results of their studies in monthly research meetings.
・Subjects of interactive discussion between students and faculty are provided. A particular focus is on developing debate skills in English through interactive discussion subjects presented by foreign faculty.
・The number of faculty is large enough to maintain a student to faculty ratio of 1.5 to 1, creating small-group instruction, with close attention to each student.

[Title]			[Instructor]		
Professional Research for Green Energy Conversion IB			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG617	2	Special Educational Program for Green Energy Conversion Science and Technology	2nd Semester	／	English／Japanese

[Outline and purpose]

The purpose is to acquire knowledge about the green energy conversion science and technology.

[Objectives]

Students will have accomplished the following general and specific learning objectives.
・Develop innovative technology in order to efficiently and economically convert and store green energy to establish a low-carbon, sustainable society.
・Achieve the best balance of various energy conversion devices and through these studies

[Requirements]

Physical chemistry, Materials Physics and Chemistry, Catalyst Science, Environmental Science, etc.

[Evaluation]

Laboratory work, Technical report

[Textbooks]

[References]

[Schedule]

・Students are required to research green energy conversion-related issues in each laboratory.
・Students have opportunities to present the results of their studies in monthly research meetings.
・Subjects of interactive discussion between students and faculty are provided. A particular focus is on developing debate skills in English through interactive discussion subjects presented by foreign faculty.
・The number of faculty is large enough to maintain a student to faculty ratio of 1.5 to 1, creating small-group instruction, with close attention to each student.

[Title]			[Instructor]		
Professional Research for Green Energy Conversion IIA			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG618	2	Special Educational Program for Green Energy Conversion Science and Technology	1st Semester	／	English／Japanese

[Outline and purpose]

The purpose is to acquire knowledge about the green energy conversion science and technology.

[Objectives]

Students will have accomplished the following general and specific learning objectives.
・Develop innovative technology in order to efficiently and economically convert and store green energy to establish a low-carbon, sustainable society.
・Achieve the best balance of various energy conversion devices and through these studies

[Requirements]

Physical chemistry, Materials Physics and Chemistry, Catalyst Science, Environmental Science, etc.

[Evaluation]

Laboratory work, Technical report

[Textbooks]

[References]

[Schedule]

・Students are required to research green energy conversion-related issues in each laboratory.
・Students have opportunities to present the results of their studies in monthly research meetings.
・Subjects of interactive discussion between students and faculty are provided. A particular focus is on developing debate skills in English through interactive discussion subjects presented by foreign faculty.
・The number of faculty is large enough to maintain a student to faculty ratio of 1.5 to 1, creating small-group instruction, with close attention to each student.

[Title]			[Instructor]		
Professional Research for Green Energy Conversion IIB			all academic supervisors		
[Code]	[Credits]	[Program]	[Semester]	[Hours]	[Language of instruction]
GTG619	2	Special Educational Program for Green Energy Conversion Science and Technology	2nd Semester	／	English／Japanese

[Outline and purpose]

The purpose is to acquire knowledge about the green energy conversion science and technology.

[Objectives]

Students will have accomplished the following general and specific learning objectives.
・Develop innovative technology in order to efficiently and economically convert and store green energy to establish a low-carbon, sustainable society.
・Achieve the best balance of various energy conversion devices and through these studies

[Requirements]

Physical chemistry, Materials Physics and Chemistry, Catalyst Science, Environmental Science, etc.

[Evaluation]

Laboratory work, Technical report

[Textbooks]

[References]

[Schedule]

・Students are required to research green energy conversion-related issues in each laboratory.
・Students have opportunities to present the results of their studies in monthly research meetings.
・Subjects of interactive discussion between students and faculty are provided. A particular focus is on developing debate skills in English through interactive discussion subjects presented by foreign faculty.
・The number of faculty is large enough to maintain a student to faculty ratio of 1.5 to 1, creating small-group instruction, with close attention to each student.