Academic Year	AY19/20	**Semester**	2
Course Coordinator	Atsushi Goto (Assoc Prof) Lu Yunpeng (Lecturer)		
Course Code	CM2041		
Course Title	Physical and Biophysical Chemistry 1		
Pre-requisites	CM1041 or CM1021 or CM9001 or CY1101 or by permission		
No of AUs	3		
Contact Hours	Lectures: 39 hours		

Course Aims

On completing this course, you will understand the basic principles in physical and biophysical chemistry and how these principles can be applied to explain and predict chemical changes. You will grow rigorous analytical ability to study chemistry based on scientific calculations and reasoning. You will appreciate the power of physical chemistry in chemical research and industry activities.

Intended Learning Outcomes (ILO)

By the end of this course, you (as a student) would be able to:

Thermodynamics:

1. Explain the differences between ideal gas and real gas from microscopic point of view
2. Calculate real gas state variables based on several real gas equations
3. Explain the real gas behaviour based on calculation results
4. Describe thermodynamics first law in close system
5. Calculate internal energy change and enthalpy change in close system in a thermodynamic process
6. Describe spontaneity in physical and chemical processes
7. Describe Carnot Cycle of Heat Engine and derive Clausius equality/inequality
8. Explain spontaneity based on universe entropy change
9. Apply thermodynamics second law to calculate entropy change for several thermodynamic processes
10. Identify the physical meaning of thermodynamics third law
11. Give the definition of free energy and explain its usage to predict spontaneity
12. Apply Gibbs energy to study chemical equilibrium

Kinetics:

13. Describe the rate of chemical reactions using differential equations.
14. Describe the rate of chemical reactions in the integrated forms.
15. Explain the concept of rate determining step.
16. Explain the concept of steady-state approximation.
17. Explain the concept of equilibrium.
18. Explain the mechanism and rate of sequential reactions.
19. Explain the mechanism and rate of chain reactions.
20. Explain the mechanism and rate of enzyme catalysis and inhibition.

Interfaces:

21. Explain the electronic properties of molecules
22. Explain the interaction between molecules
23. Explain the concept of the surface tensions and contact angles.
24. Explain the concept of the adsorption and desorption at the interface.
25. Explain the concept of colloids.
26. Explain the concept of electric double layer.
27. Describe the mechanisms of the formation of micelles and biological membranes

Course Content

Thermodynamics:

1. Real Gas and Its State Equations

2. Thermodynamics First Law and Its Applications

3. Thermodynamics Second and Third Laws and Applications

4. Free Energy and Chemical Equilibrium

Kinetics:

5. Rates of Chemical Reactions

6. Kinetics of Complex Reactions

Interfaces:

7. Molecular Interactions and Surfaces

8. Self-assemblies

Assessment (includes both continuous and summative assessment)

Component	Course ILO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/Individual	Assessment rubrics
1. Midterm Test 1	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	Competence, Creativity	20%	Individual	Point-based marking (not rubrics based)
2. Midterm Test 2	13, 14, 15, 16, 17, 18, 19,20	Competence, Creativity	20%	Individual	Point-based marking (not rubrics based)

3. Examination (Multiple Choice Questions)	*All*	Competence, Creativity	60%	Individual	Point-based marking (not rubrics based)
Total			*100%*		

Formative feedback

You will be given feedback in three ways:
1. By response to postings on the course discussion board.
2. Through the marking of the mid-term.
3. General feedback will be provided to the students following the final exam.

Learning and Teaching approach

Lectures (39 hours)	You will be spending time to learn details for the course content in lecture theatre. Topics in course content will be introduced in lecture. Application questions will be discussed and explained.

Reading and References

Recommended textbook: David W. Ball, Physical Chemistry, 2nd Ed (2015), Cengage Learning; ISBN-10: 1-133-95843-5

Recommended textbook: Peter Atkins & Julio De Paula, Physical Chemistry, 9th Ed (2010), Oxford University Press; ISBN: 978-0-19-954337-3

Course Policies and Student Responsibilities

(1) General

You are expected to attend all lecture classes punctually or watch the recorded lecture videos and take all scheduled tests.

(2) Absenteeism

Absence from the midterm without a valid reason will affect your overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies. There will be make-up opportunities for CA components.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip

yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
Atsushi Goto (Assoc Prof)	SPMS-CBC-05-05	63168900	agoto@ntu.edu.sg
LU Yunpeng (Lecturer)	SPMS-CBC-06-23	65132747	yplu@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course ILO	Readings/Activities
1	Real Gas and Its State Equations	1, 2, 3	Lecture Notes, Chapter 1 in textbook "Physical Chemistry" by David Ball. Chapter 1 in textbook "Physical Chemistry by Atkins & Julio
2	Real Gas and Its State Equations Thermodynamics First Law and Its Applications	1, 2, 3, 4, 5	Lecture Notes, Chapter 1 and 2 in textbook "Physical Chemistry" by David Ball. Chapter 1 and 2 in textbook "Physical Chemistry by Atkins & Julio
3	Thermodynamics First Law and Its Applications	4, 5	Lecture Notes, Chapter 2 in textbook "Physical Chemistry" by David Ball. Chapter 2 in textbook "Physical Chemistry by Atkins & Julio
4	Thermodynamics First Law and Its Applications Thermodynamics Second and Third Laws and Applications	4, 5, 6, 7	Lecture Notes, Chapter 2 and 3 in textbook "Physical Chemistry" by David Ball. Chapter 2 and 3 in textbook "Physical Chemistry by Atkins & Julio

5	Thermodynamics Second and Third Laws and Applications	6, 7, 8, 9	Lecture Notes, Chapter 3 in textbook “Physical Chemistry” by David Ball. Chapter 3 in textbook “Physical Chemistry by Atkins & Julio
6	Thermodynamics Second and Third Laws and Applications Free Energy and Chemical Equilibrium	9, 10, 11	Lecture Notes, Chapter 3 and 6 in textbook “Physical Chemistry” by David Ball. Chapter 3 and 6 in textbook “Physical Chemistry by Atkins & Julio
7	Free Energy and Chemical Equilibrium	11, 12	Lecture Notes, Chapter 6 in textbook “Physical Chemistry” by David Ball. Chapter 6 in textbook “Physical Chemistry by Atkins & Julio
8	Differential and Integrated Rate laws	13,14	Lecture Notes, Chapter 20 in textbook “Physical Chemistry” by Atkins & Julio Chapter 6 in
9	Reaction mechanisms and Sequential reaction and equilibrium	15,16,17,18	Lecture Notes, Chapter 20 in textbook “Physical Chemistry” by Atkins
10	Chain reaction	19	Lecture Notes, Chapter 20 in textbook “Physical Chemistry” by Atkins
11	Enzyme catalysis	20	Lecture Notes, Chapter 20 in textbook “Physical Chemistry” by Atkins
12	Molecular Interactions and Surfaces	21, 22, 23, 24	Lecture Notes, Chapters 16 and 22 in textbook “Physical Chemistry” by Atkins

13	Self-assemblies	25, 26, 27	Lecture Notes, Chapter 17 in textbook “Physical Chemistry” by Atkins

CBC Programme Learning Outcome

The Division of Chemistry and Biological Chemistry (CBC) offers an undergraduate degree major in Chemistry that satisfies the American Chemical Society (ACS) curricular guidelines and equips students with knowledge relevant to the industry. Graduates of the Division of Chemistry and Biological Chemistry should have the following key attributes:

1. Competence
Graduates should be well-versed in the foundational and advanced concepts of chemical science, be able to evaluate chemistry-related information critically and independently, and be able to use complex reasoning to solve emergent chemical problems.

2. Creativity
Graduates should be able to synthesize and integrate multiple ideas across the curriculum, and propose innovative solutions to emergent chemistry-related problems based on their training in chemistry.

3. Communication
Graduates should be able to demonstrate clarity of thought, independent thinking, and sound scientific analysis and reasoning through written and oral reports to audiences with varying technical backgrounds. They should also be able to effectively engage other professional chemists in collaborative endeavours.

4. Character
Graduates should be able to act in responsible ways and uphold the high ethical standards that the society expects of professional chemists.

5. Civic-mindedness
Graduates should be aware of the impact of chemistry on society, and how chemistry can be applied to benefit mankind. They should also be aware of and uphold the best chemical safety practices.