Course Specification

(Postgraduate Programs)

Course Title:	**Advanced kinetics - Heterogeneous Kinetics**
Course Code:	**CHM 6143**
Program:	Master of science in chemistry
Department:	Chemistry
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University
Version:	*Course Specification Version Number*
Last Revision Date:	*Pick Revision Date.*

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A. General information about the course:

1. Course Identification:

1. Credit hours: 3 (3 Lectures, 0 Lab, 0 Tutorials)

2. Course type

A.	☐University	☐College	☐Department	☐Track
B.	☐Required		☒ Elective	

3. Level/year at which this course is offered: Level 2/Year 1

4. Course General Description:

The course is designed to cover the reaction mechanisms, order of reaction, the reaction rate theory and collision theory. This course will extend to cover the basis for the Catalysis and the Transition State Theory of Surface Reactions, Surface Reactivity, The Solid Surface, Work Function, and Kinetics of Reactions on Surfaces.

5. Pre-requirements for this course (if any):

Advanced Physical Chemistry – CHM 6141

6. Pre-requirements for this course (if any):

None

7. Course Main Objective(s):

- Improve their knowledge of the fundamentals and concepts of advanced kinetics.
- Recognize the mechanisms of heterogeneous catalytic reactions
- Develop their knowledge of the reaction order and reaction rate theory.
- Be familiar with Surface Reactivity.
- Interpret reactions on the surface kinetically.

2. Teaching Mode: (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	45	100 %
2	E-learning		
3	Hybrid • Traditional classroom • E-learning		

No	Mode of Instruction	Contact Hours	Percentage
4	Distance learning		

3. Contact Hours: (based on the academic semester)

No	Activity	Contact Hours
1.	**Lectures**	45
2.	**Laboratory/Studio**	0
3.	**Field**	0
4.	**Tutorial**	0
5.	**Others (specify)……**	0
	Total	45

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods:

Code	Course Learning Outcomes	Code of CLOs aligned with program	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**			
1.1	**To list the mechanisms of catalytic reactions, and Kinetics of different types of reactions.**	**K1. *Phy.*; K2. *Phy.*; K4. *Phy.***	▪ Five hours/week lectures. ▪ Self-study Home-exam.	▪ Regular Exams ▪ Assignments ▪ Short Quizzes ▪ Oral Discussion Participation.
1.2	**To state the application of kinetics mechanisms in the Heterogeneous Catalysis field.**	**K1. *Phy.*; K2. *Phy.*; K3. *Phy.***	▪ Five hours/week lectures. ▪ *Think* to *justify* the application of kinetics mechanisms in the heterogeneous catalysis, using available references (SDL) online. Open discussion.	▪ Oral Discussion marks ▪ Literatures Survey ▪ Mini-seminar. ▪ Participation.

Code	Course Learning Outcomes	Code of CLOs aligned with program	Teaching Strategies	Assessment Methods
1.3	**To describe the Surface Reaction Kinetics and the simulation with different models.**	**K1. *Phy.*; K2. *Phy.*; K3. *Phy.***	▪ Five hours/week lectures. *Group Discussion* using available references (SDL) online.	▪ Midterm. ▪ Assignments. ▪ Group Discussions. ▪ Literatures Survey ▪ Mini-seminar. ▪ Participation.
1.4	**To list Reaction Mechanisms principles.**	**K2. *Phy.*; K3. *Phy.*; K4. *Phy.***	▪ Five hours/week lectures. *Group Discussion* on Reaction Mechanisms principles using available references (SDL) online.	▪ Assignments ▪ Open Discussions. ▪ Literatures Survey ▪ Mini-seminar. Participation.
2.0	**Skills**			
2.1	**To explain the concepts and principles of Homogeneous Catalysis.**	**S1. *Phy.*; S2. *Phy.*; S4. *Phy.***	▪ Lectures activity ▪ Self-study. *Group Discussion* deeply on the principles of homogeneous catalysis.	▪ Questions in Lectures. ▪ Short Quizzes and Exams. ▪ Open Discussions. ▪ Participation Mini -seminar.
2.2	**To analyze problems and explore strategies for Heterogeneous Kinetics, justifying the optimum approaches to appropriate mechanisms.**	**S1. *Phy.*; S2. *Phy.*; S4. *Phy.***	▪ *Practice* some examples of heterogeneous catalysis to optimize appropriate mechanisms achieving. ▪ Brainstorming. Self-study.	▪ Questions in Lectures. ▪ Participation ▪ Oral Discussion Short Quizzes.
2.3	**To illustrate the mechanisms of Heterogeneous Catalytic Reactions.**	**S1. *Phy.*; S2. *Phy.*; S4. *Phy.***	▪ Lectures ▪ Oral Discussions. ▪ Brainstorming. Self-study	▪ Questions in Lectures. ▪ Short Quizzes and Exams. ▪ Oral Discussion. Participation.

Code	Course Learning Outcomes	Code of CLOs aligned with program	Teaching Strategies	Assessment Methods
2.4	**To operate communication to Reaction Rate Theory applications, accompanying writing of mini- Reports, operating electronic mail, and Network in communicating with others. Reaction.**	**S1. *Phy.*; S2. *Phy.*; K4. *Phy.***	▪ *Group Discussion* and Assignments. ▪ *Suggest* several examples for evaluations Reaction Rate Theory applications, for reading, writing, and oral presentation in groups. Encourage students to use electronic mail to submit Home Exams and Assignments.	▪ Oral Discussion. ▪ Quizzes, and Exams. ▪ Giving marks for Oral Discussion in Lectures. Marks given for Assignments.
3.0	**Values, autonomy, and responsibility**			
3.1	**To perform a scientific presentation, research, and work independently and integrate with a collaborated group, Using IT to acquire, analyze, and communicate information.**	**V1. *Phy.***	▪ Brainstorming. ▪ Exercises ▪ Group Discussion. ▪ Team work.	▪ Oral Discussion. ▪ Group Discussion ▪ Assignments.
3.2	**To demonstrate his ability to the effectively collaboration and inter-professionalism in class discussions or team works, as well as independently.**	**V1. *Phy.*;V2. *Phy.***	▪ Small Group tasks ▪ Open discussion at classroom. ▪ Office hour guiding. Group Presentation of mini-projects.	▪ Participation ▪ Homework's Mini-project(s).

C. Course Content:

No	List of Topics	Contact Hours
1.	***Reaction Mechanisms:*** Langmuir–Hinshelwood or Eley–Rideal Mechanisms, Langmuir–Hinshelwood Kinetics, The Complete Solution, the Steady State Approximation, The Quasi-Equilibrium Approximation, Steps with Similar Rates, Irreversible Step Approximation, The MARI Approximation, Nearly Empty Surface, Reaction Order, Apparent Activation Energy, Entropy, Entropy Production, Auto Catalysis and Oscillating Reactions, Kinetics of Enzyme-catalyzed Reactions.	**8**
2.	***Reaction Rate Theory*:** Introduction, The Boltzmann Distribution and the Partition Function, Partition Functions of Atoms and Molecules: The Boltzmann Distribution , Justification for Equating k2 with 1/T, Maxwell–Boltzmann Distribution of Velocities, Total Partition Function of System, Translational Partition Function, Vibrational Partition Function, Rotational (and Nuclear) Partition Function, Electronic and Nuclear Partition Functions, Molecules in Equilibrium, Collision Theory: Rate of Surface Collisions, Reaction Probability, Fundamental Objection Against Collision Theory, Activation of Reacting Molecules by Collisions: The Lindemann Theory, Transition State Theory: Thermodynamic Form of the Rate Transition State Expression, Transition State Theory of Surface Reactions: Adsorption of Atoms, Indirect Adsorption, Direct Adsorption, Adsorption of Molecules, Precursor-mediated or Indirect Adsorption, Direct Adsorption, Reaction Between Adsorbates, Desorption of Molecules.	**12**
3.	***Surface Reactivity:*** Introduction, Physisorption: The Van der Waals Interaction, Including the Repulsive Part, Chemical Bonding: Bonding in Molecules, Diatomic Molecule, Homonuclear Diatomic Molecules, Heteronuclear System, The Solid Surface, Work Function, Free Electron Gas and the Jellium Model, Tight Binding Model, Simple Model of a Transition Metal, Chemisorption: Newns–Anderson Model, Atomic Adsorption on a Transition or d Metal, Adsorption of a Molecule on a Transition Metal, Electrostatic Effects in Atomic Adsorbates on Jellium, Important Trends in Surface Reactivity, Trend in Atomic Chemisorption Energies, Trends in Molecular Chemisorption, Trends in Dissociative Adsorption, Transition States and the Effect of Coverage:Ethylene Hydrogenation, Sabatier's Principle, Opportunities for Tuning Surface Reactivity, Universality in Heterogeneous Catalysis	**13**
4.	***Kinetics of Reactions on Surfaces:*** Elementary Surface Reactions: Adsorption and Sticking , Determination of Sticking Coefficients, Desorption, Quantitative Interpretation of TPD Data, Compensation Effect in Temperature Programmed Desorption, Lateral Interactions in Surface Reactions, Dissociation Reactions on Surfaces, Intermediates in Surface Reactions, Association Reactions, Kinetic Parameters from Fitting Langmuir–Hinshelwood Models, Micro-kinetic Modeling: Reaction	**12**

Scheme and Rate Expressions, Activation Energy and Reaction Orders, Ammonia Synthesis Catalyst under Working Conditions	
Total	45

D. Students Assessment Activities:

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.)

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	**Class Activities (Open Discussion, Mini-reports, Oral Presentation, solving questions)**	**weekly**	**30 %**
2.	**Midterm Exam**	**9 th week**	**30 %**
3.	**Final Exam**	**17 th week**	**40 %**
4.	**Total**		**100%**

E. Learning Resources and Facilities:

1. References and Learning Resources:

Essential References	*Concepts of Modern Catalysis and Kinetics,* I. Chorkendorff, J. W. Niemantsverdriet, 2nd, Revised and Enlarged Edition, 2007, Wiley-VCH. ISBN: 978-3-527-31672-4. *Kinetics of Heterogeneous catalytic Reactions*, M. Boudart, G. Djega-Mariadassou, 2016, Princeton University Press, 2016, ISBN: 9780691640488. *Adsorption onto Heterogeneous Porous Materials: Equilibria and Kinetics, Mexmat,* Aarden F.B.,2001.
Supportive References	**None**
Electronic Materials	Saudi Digital Library
Other Learning Materials	• Blackboard • Multimedia associated with the text book and the relevant websites.

2. Educational and Research Facilities and Equipment Required:

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	**Each of the classroom should be equipped with a whiteboard and a projector, with a maximum of 20 students.**

Items	Resources
Technology equipment (projector, smart board, software)	**The rooms are equipped with data show, Smart Board, WI-FI access.**
Other equipment (depending on the nature of the specialty)	**None**

F. Assessment of Course Quality:

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Students	**Direct:** Questionnaire.
	Course Responsible	**Direct:** Course e-Portfolio. **Indirect:** Second examiner checklist-Course report.
	Peer Reviewer	**Direct:** Questionnaire. **Indirect:** External assessor report.
Effectiveness of students assessment	Program Leaders	**Direct:** Course e-Portfolio. **Indirect:** Course report.
Quality of learning resources	Students	**Indirect:** Second examiner checklist-Course report.
	Faculty (Academic Advisory-GCC)	**Direct:** course Entrance/Exit. **Indirect:** Observations - Accreditation review.
	Program Leaders	**Direct:** Course e-Portfolio. **Indirect:** Course evaluation survey- Observations- Syllabus review- Accreditation review.
	Course Responsible	
The extent to which CLOs have been achieved	Course Responsible	**Direct:** Exams - Course e-Portfolio. **Indirect:** Second examiner checklist-Course report.
	Program Leaders	**Indirect:** Exams.
Other		

Assessor (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)
Assessment Methods (Direct, Indirect)

G. Specification Approval Data:

COUNCIL /COMMITTEE	Council of Chemistry Department
REFERENCE NO.	10 (No. 2/10)
DATE	21/04/1444- 15/11/2022