	Universitas Negeri Surabaya **Faculty of Mathematics and Natural Sciences** **Undergraduate Chemistry Education Study Program**	**Document Code**

SEMESTER LEARNING PLAN

Courses	**CODE**	**Course Family**	**Credit Weight**			**SEMESTER**	**Compilation Date**
Chemical Kinetics	8420403306	Physical Chemistry	**T=3**	**P=0**	**ECTS=4.77**	4	June 20, 2022

AUTHORIZATION	**SP Developer**	**Course Cluster Coordinator**	**Study Program Coordinator**
	Prof. Dr. Suyono, M.Pd.	Prof. Dr. Suyono, M.Pd.	Prof. Dr. Utiya Azizah, M.Pd.

Learning model	**Case Studies**

Program Learning Outcomes (PLO)

PLO study program which is charged to the course

PLO-6	Able to adapt to various developments in chemical science, continue to develop and learn throughout life to continue education, both formal and informal (CPL 8)
PLO-11	Able to demonstrate knowledge related to theoretical concepts about structure, dynamics and energy, as well as basic principles of separation, analysis, synthesis and characterization of chemicals (CPL 1)

Program Objectives (PO)

PO - 1	Students have the ability to communicate experimental results so that they are able to develop a conceptual framework to formulate actions or alternative actions in solving chemical problems in life. (PLO6)
PO - 2	Students are skilled in using tools to determine reaction rates and reaction mechanisms based on empirical facts (inductive dimension) and submit theoretical arguments to explain the empirical facts that occur (deductive dimension) in the field of reaction kinetics (PLO8)
PO - 3	Students have knowledge of reaction rate laws and reaction mechanisms based on empirical facts (inductive dimension) and submit theoretical arguments to explain the empirical facts that occur (deductive dimension) in the field of reaction kinetics (PLO1)
PO - 4	Students have the ability to collaborate and are responsible for studying reaction rates as a function of concentration, temperature, and catalyst as well as interpreting reaction rate laws for discussing and designing reaction mechanisms (including photochemistry). (PLO5)

PLO-PO Matrix

P.O	PLO-6	PLO-11
PO-1		
PO-2		
PO-3		
PO-4		

PO Matrix at the end of each learning stage (Sub-PO)

P.O	Week															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PO-1																
PO-2																
PO-3																
PO-4																

Short Course Description	Empirical and theoretical studies of reaction rates as a function of concentration, temperature and catalyst as well as interpretation of reaction rate laws for the discussion and design of reaction mechanisms (including photochemistry).

References	**Main :**	

	1. Wilkinson, Frank. 1975.Chemical Kinetics and Reaction Mechanisms. Victoria: Van Nostrand Reinhold Company. 2. Atkins, P. W. 1995.Psysical Chemistry. Third Edition. New York: W. H. Freeman and Company. 3. Castelan, Gilbert W. 1983.Psysical Chemistry. Third Edition.Tokyo: Addison-Wesley Publishing Company.	
	Supporters:	
Supporting lecturer	Prof. Dr. Suyono, M.Pd. Nur Hayati, S.Si., M.Si. Bertha Yonata, S.Pd., M.Pd.	

Week-	Final abilities of each learning stage (Sub-PO)	Evaluation		Help Learning, Learning methods, Student Assignments, [Estimated time]		Learning materials [References]	Assessment Weight (%)
		Indicator	Criteria & Form	Offline (*offline*)	Online (*online*)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	1.Explain the physical meaning of the reaction rate law. 2.2. Skilled in using tools to determine reaction orders to be able to write rate laws based on empirical facts (inductive dimension). 3.3. Communicate experimental results related to determining the reaction order in order to determine the reaction rate law. 4.4. Able to collaborate and be responsible in studying reaction rates as a function of concentration.	Formulate the reaction rate law, if given data on the function of concentration versus time.	**Criteria:** 1.85 < A < 100 2.80 < A- < 85 3.75 < B < 80 4.70 < B < 75 5.65 < B- < 70 6.60 < C < 65 7.55 < C < 60 8.40 < D < 55 9.0 < E < 40 **Form of Assessment** : Participatory Activities	Discussion regarding the selection of methods and how to determine the correct reaction order. 3 X 50		**Material:** Determination of reaction order **References:** *Wilkinson, Frank. 1975. Chemical Kinetics and Reaction Mechanisms. Victoria: Van Nostrand Reinhold Company.* **Material:** Determination of reaction order **References:** *Atkins, PW 1995. Psychological Chemistry. Third Edition. New York: WH Freeman and Company.*	5%
2	1.Explain the physical meaning of the reaction rate law. 2.2. Skilled in using tools to determine reaction orders to be able to write rate laws based on empirical facts (inductive dimension). 3.3. Communicate experimental results related to determining the reaction order in order to determine the reaction rate law. 4.4. Able to collaborate and be responsible in studying reaction rates as a function of concentration.	Formulate the reaction rate law, if given data on the function of concentration versus time.	**Criteria:** 1.85 < A < 100 2.80 < A- < 85 3.75 < B < 80 4.70 < B < 75 5.65 < B- < 70 6.60 < C < 65 7.55 < C < 60 8.40 < D < 55 9.0 < E < 40 **Form of Assessment** : Participatory Activities	Discussion regarding the selection of methods and how to determine the correct reaction order and communicate it. Calculate the reaction order, if given the concentration function data against time 3 X 50		**Material:** Determination of reaction order **References:** *Wilkinson, Frank. 1975. Chemical Kinetics and Reaction Mechanisms. Victoria: Van Nostrand Reinhold Company.* **Material:** Determination of reaction order **References:** *Atkins, PW 1995. Psychological Chemistry. Third Edition. New York: WH Freeman and Company.*	10%

3	1.1. Explain the physical meaning of the reaction rate law. 2.2. Skilled in using tools to determine reaction orders to be able to write rate laws based on empirical facts (inductive dimension). 3.3. Communicate experimental results related to determining the reaction order in order to determine the reaction rate law. 4.4. Able to collaborate and be responsible in studying reaction rates as a function of concentration. 5.5. Write a draft document to communicate the results of the problem solving carried out	1.Formulate the reaction rate law, if given data on the function of concentration versus time. 2.Skilled in using tools in determining orders. 3.Communicate experimental results related to determining the reaction order in order to determine the reaction rate law. 4.Able to collaborate and be responsible in studying reaction rates as a function of concentration	**Criteria:** 1.85 < A < 100 2.80 < A- < 85 3.75 < B < 80 4.70 < B < 75 5.65 < B- < 70 6.60 < C < 65 7.55 < C < 60 8.40 < D < 55 9.0 < E < 40 **Form of Assessment** : Participatory Activities, Portfolio Assessment	Calculate the reaction order, if given data on the function of concentration versus time. Formulate the reaction rate law, if given data on the function of concentration versus time. [studying; practicum] Structured assignments (BKT KF3 KPM) 3 X 50		**Material:** Reaction Rate Law (r) Function: x(t); r = d/dt (x) r = k [ax]α[bx]□ **References:** *Wilkinson, Frank. 1975. Chemical Kinetics and Reaction Mechanisms. Victoria: Van Nostrand Reinhold Company.*	5%
4	1.1. Explain the physical meaning of the reaction rate law. 2.2. Skilled in using tools to determine reaction orders to be able to write rate laws based on empirical facts (inductive dimension). 3.3. Communicate experimental results related to determining the reaction order in order to determine the reaction rate law. 4.4. Able to collaborate and be responsible in studying reaction rates as a function of concentration. 5.5. Write a draft document to communicate the results of the problem solving carried out	Use the rate law to predict the rate of a reaction at another known concentration.	**Criteria:** 1.85 < A < 100 2.80 < A- < 85 3.75 < B < 80 4.70 < B < 75 5.65 < B- < 70 6.60 < C < 65 7.55 < C < 60 8.40 < D < 55 9.0 < E < 40 **Forms of Assessment** : Participatory Activities, Portfolio Assessment, Practical Assessment	1. The accuracy of calculating the reaction order, if data is given as a function of concentration versus time. 2. Formulate the reaction rate law, if given data on the function of concentration versus time. 3. Calculate the value of the reaction rate constant (k). Use the rate law to predict the reaction rate at other known concentrations. [Studying; practicum] 4. Structured assignments (BKT KF3 KA Part IV pp. 14-15) 3 X 50		**Material:** Reaction Rate Law (r) Function: x(t); r = d/dt (x) r = k [ax]α[bx]□ Determination of reaction order **References:** *Wilkinson, Frank. 1975. Chemical Kinetics and Reaction Mechanisms. Victoria: Van Nostrand Reinhold Company.*	5%

5	1. 1. Explain the physical meaning of the reaction rate law. 2. 2. Skilled in using tools to determine reaction orders to be able to write rate laws based on empirical facts (inductive dimension). 3. 3. Communicate experimental results related to determining the reaction order in order to determine the reaction rate law. 4. 4. Able to collaborate and be responsible in studying reaction rates as a function of concentration. 5. 5. Write a draft document to communicate the results of the problem solving carried out	Use the rate law to predict the rate of a reaction at another known concentration.	**Criteria:** 1. 85 < A < 100 2. 80 < A- < 85 3. 75 < B < 80 4. 70 < B < 75 5. 65 < B- < 70 6. 60 < C < 65 7. 55 < C < 60 8. 40 < D < 55 9. 0 < E < 40 **Form of Assessment** : Participatory Activities, Portfolio Assessment	1. The accuracy of formulating the reaction rate law, if given data on the function of concentration versus time. 2. Calculate the value of the reaction rate constant (k). Use the rate law to predict the rate of a reaction at another known concentration. 3. Skilled in using laboratory equipment to determine the reaction rate in order to determine the reaction order and the correct method for calculating the reaction order 3 X 50		**Material:** Reaction Rate Law (r) Function: x(t); r = d/dt (x) r = k [ax]α[bx]□ **References:** *Wilkinson, Frank. 1975. Chemical Kinetics and Reaction Mechanisms. Victoria: Van Nostrand Reinhold Company.*	10%

6	1. Explain the physical meaning of the function of reaction rate against reaction temperature. 2. Communicate experimental results related to the function of temperature on reaction rates so as to be able to develop a conceptual framework for formulating actions or alternative actions in solving chemical problems in life.	1. 1.Using Arrhenius‘ law to analyze data (more than two) k functions on temperature. 2. Using Arrhenius‘ law to analyze data (two data) on the function of k on temperature. Communicate experimental results related to the function of temperature on reaction rates so as to be able to develop a conceptual framework for formulating actions or alternative actions in solving chemical problems in life. 2. 2. Using Arrhenius‘ law to analyze data (two data) on the function of k on temperature. 3. 3. Communicate experimental results related to the function of temperature on reaction rates so as to be able to develop a conceptual framework for formulating actions or alternative actions in solving chemical problems in life.	**Criteria:** 1. 85 < A < 100 2. 80 < A- < 85 3. 75 < B < 80 4. 70 < B < 75 5. 65 < B- < 70 6. 60 < C < 65 7. 55 < C < 60 8. 40 < D < 55 9. 0 < E < 40 **Form of Assessment** : Participatory Activities	1. Predict the reaction rate at the second temperature (T2) if the reaction rate value at the initial temperature (T1) and the reaction temperature coefficient are known. 2. Modify Arrhenius‘ law into a linear equation that can be used to determine the Ea value (activation energy) and the A value (preexponential factor) of a reaction. 3. Predict the reaction rate at the second temperature (T2) if you know the reaction rate at the initial temperature (T1), the Ea value, and the gas constant. 4. Calculate the Ea value of a reaction, if given reaction rate data at two different temperatures. 5. Calculate the reaction rate at a certain temperature (under the same conditions), if data on the reaction rate at two different temperatures is given. 6. Skilled in using laboratory equipment to determine reaction rates at several temperatures. 3 X 50		**Material:** Function: r(T) Arrhenius Law: ln k = ln A – Ea/RT **References:** *Wilkinson, Frank. 1975. Chemical Kinetics and Reaction Mechanisms. Victoria: Van Nostrand Reinhold Company.*	10%

7	1. Explain the physical meaning of the reaction rate function on a catalyst. 2. Skilled in using tools to determine the effect of catalysts on reaction rates based on empirical facts (inductive dimension). 3. Communicate experimental results related to the function of catalysts on reaction rates so as to be able to develop a conceptual framework for formulating actions or alternative actions in solving chemical problems in life. 4. Able to collaborate and be responsible in assessing reaction rates as a catalyst function.	1. 1. Using Arrhenius' law to predict changes in reaction rates due to the addition of a catalyst at a certain temperature. 2. 2. Skilled in using tools to determine the effect of catalysts on reaction rates based on empirical facts (inductive dimension). 3. 3. Communicate experimental results related to the function of catalysts on reaction rates so as to be able to develop a conceptual framework for formulating actions or alternative actions in solving chemical problems in life. 4. 4. Able to collaborate and be responsible in assessing the reaction rate as a function of the catalyst.	**Criteria:** 1. 85 < A < 100 2. 80 < A- < 85 3. 75 < B < 80 4. 70 < B < 75 5. 65 < B- < 70 6. 60 < C < 65 7. 55 < C < 60 8. 40 < D < 55 9. 0 < E < 40 **Forms of Assessment** : Participatory Activities, Portfolio Assessment, Practical Assessment	1. Application of Arrhenius' law to predict changes in reaction rates due to the addition of a catalyst at a certain temperature. 2. Calculate Ea, if you know the magnitude of the change in the reaction rate due to the addition of a catalyst at a certain temperature. 3. Skilled in using laboratory equipment to determine reaction rates with the addition of catalysts [Lecture; practicum] 4. BKT KF3 KA structured assignments pp. 18-20 3 X 50		**Material:** Function: r(catalyst) Arrhenius Law: ln k = ln A – Ea/RT Catalyst reduces the value of Ea **References:** *Wilkinson, Frank. 1975. Chemical Kinetics and Reaction Mechanisms. Victoria: Van Nostrand Reinhold Company.*	5%
8	UTS	Confluence indicators 1-7	**Form of Assessment** : Test	2 X 50			0%
9	1. Explain how to determine the mechanism using the reaction kinetics approach. 2. Write a statement and include the reasons given for saying that the statement is false.	Testing the correctness of the reaction mechanism design, both simple reactions and complex (chain) reactions.	**Criteria:** 1. 85 < A < 100 2. 80 < A- < 85 3. 75 < B < 80 4. 70 < B < 75 5. 65 < B- < 70 6. 60 < C < 65 7. 55 < C < 60 8. 40 < D < 55 9. 0 < E < 40 **Form of Assessment** : Participatory Activities, Portfolio Assessment	1. Write down the steps for testing the correctness of the reaction mechanism design, if given data on reactant concentrations and rate values for reactions whose stoichiometry is also known. 2. Formulate assumptions so that the reaction mechanism design created has scientific truth (supported by facts). [Lecture] BKT KF3 KA structured assignments pp. 21-22 3 X 50		**Material:** Interpretation of the reaction rate law on reaction mechanisms. **Reference:** *Wilkinson, Frank. 1975. Chemical Kinetics and Reaction Mechanisms. Victoria: Van Nostrand Reinhold Company.*	5%

10	Explain how to determine the mechanism using the reaction kinetics approach.	Testing the correctness of the reaction mechanism design, both simple reactions and complex (chain) reactions.	**Criteria:** 1.85 < A < 100 2.80 < A- < 85 3.75 < B < 80 4.70 < B < 75 5.65 < B- < 70 6.60 < C < 65 7.55 < C < 60 8.40 < D < 55 9.0 < E < 40 **Form of Assessment** : Participatory Activities	1. Write down the steps for testing the correctness of the reaction mechanism design, if given data on reactant concentrations and rate values for reactions whose stoichiometry is also known. 2. Formulate assumptions so that the reaction mechanism design created has scientific truth (supported by facts). 3 X 50		**Material:** Interpretation of the reaction rate law on reaction mechanisms. **Reference:** *Wilkinson, Frank. 1975. Chemical Kinetics and Reaction Mechanisms. Victoria: Van Nostrand Reinhold Company.*	5%
11	Explain how to determine the mechanism using the reaction kinetics approach.	1.1. Test the correctness of the reaction mechanism design, both simple reactions and complex (chain) reactions. 2.2. Test quantitative measures to gain advantages in implementing the chain length concept.	**Criteria:** 1.85 < A < 100 2.80 < A- < 85 3.75 < B < 80 4.70 < B < 75 5.65 < B- < 70 6.60 < C < 65 7.55 < C < 60 8.40 < D < 55 9.0 < E < 40 **Form of Assessment** : Participatory Activities	1. Write down the different characteristics of the initiation, propagation and termination stages that make up a parallel reaction. 2. Describe the physical meaning of the concept of chain length in chain reactions. 3. Establish quantitative measures to gain benefits in implementing the chain length concept. 3 X 50		**Material:** Interpretation of the reaction rate law on reaction mechanisms. **Reference:** *Wilkinson, Frank. 1975. Chemical Kinetics and Reaction Mechanisms. Victoria: Van Nostrand Reinhold Company.*	10%
12	Explain how to determine the mechanism using the reaction kinetics approach.	1.1. Test quantitative measures to gain advantages in implementing the chain length concept. 2.2. Determine the alignment of ideas about reaction mechanisms.	**Criteria:** 1.85 < A < 100 2.80 < A- < 85 3.75 < B < 80 4.70 < B < 75 5.65 < B- < 70 6.60 < C < 65 7.55 < C < 60 8.40 < D < 55 9.0 < E < 40 **Form of Assessment** : Participatory Activities	1. Establish quantitative measures to gain profits in implementing the chain length concept. 2. Predict the supporting facts that must exist for ideas about the mechanism of radical recombination reactions to be accepted. 3. Predict the supporting facts that must exist in order to think about the unimolecular decomposition reaction mechanism (Lindemann mechanism). 3 X 50		**Material:** Interpretation of the reaction rate law on reaction mechanisms. **Reference:** *Wilkinson, Frank. 1975. Chemical Kinetics and Reaction Mechanisms. Victoria: Van Nostrand Reinhold Company.*	10%

13	Explain the mechanisms for homogeneous catalysis reactions in solution.	1.1. Evaluate the type of activated complex in the Herzfeld mechanism (general homogeneous catalytic reaction in solution). 2.2. Evaluate the Herzfeld mechanism of the Arrhenius complex type for the case of extremely different substrate and catalyst concentrations.	**Criteria:** 1.85 < A < 100 2.80 < A- < 85 3.75 < B < 80 4.70 < B < 75 5.65 < B- < 70 6.60 < C < 65 7.55 < C < 60 8.40 < D < 55 9.0 < E < 40 **Form of Assessment** : Participatory Activities	1. Predict the supporting facts that must be present to evaluate the type of activated complex in the Herzfeld mechanism (general homogeneous catalysis reaction in solution) including the type of Arrhenius complex or van‘t Hoff complex. 2. Predict the supporting facts that must exist in the Herzfeld mechanism of the Arrhenius complex type for the case that the substrate concentration is much greater than the catalyst concentration. 3. Predict the supporting facts that must exist in the Arrhenius complex type Herzfeld mechanism for the case that the substrate concentration is much smaller than the catalyst concentration. 3 X 50		**Material:** Reaction Mechanism for homogeneous catalysis reactions in solution **References:** *Wilkinson, Frank. 1975. Chemical Kinetics and Reaction Mechanisms. Victoria: Van Nostrand Reinhold Company.*	5%
14	Explain the mechanism of acid or base catalyzed reactions.	1.1. Determine the intermediate and solvent species for different types of catalysts (strong acid, weak acid, strong base, or weak base). 2.2. Distinguish between the protolytic type and prototropic type acid catalysis mechanisms.	**Criteria:** 1.85 < A < 100 2.80 < A- < 85 3.75 < B < 80 4.70 < B < 75 5.65 < B- < 70 6.60 < C < 65 7.55 < C < 60 8.40 < D < 55 9.0 < E < 40 **Form of Assessment** : Participatory Activities	1. Write down the intermediate and solvent species for different types of catalysts (strong acid, weak acid, strong base, or weak base), if given the general acid or base catalyzed reaction mechanism. 2. Predict the supporting facts that must be present to distinguish between protolytic type acid catalysis mechanisms (transfer of protons to the solvent) and prototropic type (transfer of protons to the solute). 3 X 50		**Material:** Reaction Mechanism for acid catalysis reactions. **References:** *Wilkinson, Frank. 1975. Chemical Kinetics and Reaction Mechanisms. Victoria: Van Nostrand Reinhold Company.*	5%

15	1. Explain the mechanism of acid or base catalyzed reactions. 2. Proposing theoretical arguments (reaction mechanisms) to explain the empirical facts that occur (deductive dimension). 3. Able to collaborate and be responsible in reviewing the interpretation of reaction rate laws to the discussion and design of reaction mechanisms (including photochemistry).	1. The accuracy of distinguishing the specific protolytic type and general protolytic type base catalysis mechanisms. 2. Proposing theoretical arguments (reaction mechanisms) to explain the empirical facts that occur (deductive dimension). 3. Able to collaborate and be responsible in reviewing the interpretation of reaction rate laws to the discussion and design of reaction mechanisms (including photochemistry).	**Criteria:** 1. 85 < A < 100 2. 80 < A- < 85 3. 75 < B < 80 4. 70 < B < 75 5. 65 < B- < 70 6. 60 < C < 65 7. 55 < C < 60 8. 40 < D < 55 9. 0 < E < 40 **Form of Assessment** : Participatory Activities	Predict the supporting facts that must be present to differentiate the specific protolytic type and general protolytic type base catalysis mechanisms. 3 X 50		**Material:** Reaction Mechanism for base catalysis reactions. **References:** *Wilkinson, Frank. 1975. Chemical Kinetics and Reaction Mechanisms. Victoria: Van Nostrand Reinhold Company.*	10%
16	UAS						0%

Evaluation Percentage Recap: Case Study

No	Evaluation	Percentage
1.	Participatory Activities	83.34%
2.	Portfolio Assessment	13.34%
3.	Practical Assessment	3.34%
		100%

Notes

1. **Learning Outcomes of Study Program Graduates (PLO - Study Program)** are the abilities possessed by each Study Program graduate which are the internalization of attitudes, mastery of knowledge and skills according to the level of their study program obtained through the learning process.
2. **The PLO imposed on courses** are several learning outcomes of study program graduates (CPL-Study Program) which are used for the formation/development of a course consisting of aspects of attitude, general skills, special skills and knowledge.
3. **Program Objectives (PO)** are abilities that are specifically described from the PLO assigned to a course, and are specific to the study material or learning materials for that course.
4. **Subject Sub-PO (Sub-PO)** is a capability that is specifically described from the PO that can be measured or observed and is the final ability that is planned at each learning stage, and is specific to the learning material of the course.
5. **Indicators for assessing** ability in the process and student learning outcomes are specific and measurable statements that identify the ability or performance of student learning outcomes accompanied by evidence.
6. **Assessment Criteria** are benchmarks used as a measure or measure of learning achievement in assessments based on predetermined indicators. Assessment criteria are guidelines for assessors so that assessments are consistent and unbiased. Criteria can be quantitative or qualitative.
7. **Forms of assessment:** test and non-test.
8. **Forms of learning:** Lecture, Response, Tutorial, Seminar or equivalent, Practicum, Studio Practice, Workshop Practice, Field Practice, Research, Community Service and/or other equivalent forms of learning.
9. **Learning Methods:** Small Group Discussion, Role-Play & Simulation, Discovery Learning, Self-Directed Learning, Cooperative Learning, Collaborative Learning, Contextual Learning, Project Based Learning, and other equivalent methods.
10. **Learning materials** are details or descriptions of study materials which can be presented in the form of several main points and sub-topics.
11. **The assessment weight** is the percentage of assessment of each sub-PO achievement whose size is proportional to the level of difficulty of achieving that sub-PO, and the total is 100%.
12. TM=Face to face, PT=Structured assignments, BM=Independent study.