	Universitas Negeri Surabaya Faculty of Engineering, Mechanical Engineering Undergraduate Study Program	Document Code

SEMESTER LEARNING PLAN

Courses	CODE	Course Family	Credit Weight	SEMESTER	Compilation Date
Basic chemistry	2120103110	Compulsory Study Program Subjects	T=3 P=0 ECTS=4.77	1	October 3, 2022

AUTHORIZATION	SP Developer	Course Cluster Coordinator	Study Program Coordinator
	Bellina Yunitasari, S.Si., M.Si.	Bellina Yunitasari, S.Si., M.Si.	Ir. Priyo Heru Adiwibowo, S.T., M.T.

Learning model: Project Based Learning

Program Learning Outcomes (PLO)

PLO study program that is charged to the course

PLO-14	Science and engineering knowledge

Program Objectives (PO)

PO - 1	Demonstrate an understanding of chemistry and be able to explain the general principles, laws, and theories of chemistry basis for further study
PO - 2	Be able to Use critical thinking and logic in the solution of chemistry problems. Able to formulate and solve chemical problems
PO - 3	Apply learned chemistry skills to analyze new issue/ Able to analyze the relationship between molecular behavior and observable physical properties

PLO-PO Matrix

P.O	PLO-14
PO-1	
PO-2	
PO-3	

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																

Short Course Description: Introduction to chemistry, atomic structure, periodic table of elements, chemical bonds, stoichiometry, thermochemistry, chemical kinematics, chemical equilibrium, electrochemistry, polymers, fuel chemistry, and nuclear chemistry as well as basic chemical knowledge related to the field of mechanical engineering.

References

Main :

1. Petrucci, Ralph H., dkk. 2011. General Chemistry: Priciples and Modern Application. 10th ed. Pearson Prentice Hall: USA;
2. Laird, Brian B. 2009. University of Chemistry.New York: McGraw-Hil
3. Whitten KW, et. al. General Chemistry London, Saunders College
4. Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/details/books/chemistry-2e.

Supporters:

1. Bellina, Yunitasari.2022. Buku Ajar Kimia Dasar Untuk Mahasiswa Teknik Mesin.Unipres, Unesa.

Supporting lecturer: Dr. Mohammad Effendy, S.T., M.T.
Bellina Yunitasari, S.Si., M.Si.
Hanna Zakiyya, S.T., M.T.

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	Understanding The Chemistry in Context, Classification of Matter and Physical and Chemical Properties	1. Describe how chemistry and engineering helped transform aluminum from a precious metal into an inexpensive structural material. 2. Explain the usefulness of the macroscopic, microscopic, and symbolic perspectives in understanding chemical systems. 3. Identify properties of and changes in matter as physical or chemical 4. Identify properties of matter as extensive or intensive 5. Draw pictures to illustrate simple chemical phenomena (like the differences among solids, liquids, and gases) on the molecular scale. 6. Use appropriate ratios to convert measurements from one unit to another. 7. Express the results of calculations using the correct number of significant figures.	**Criteria:** According to the Assessment Rubric **Form of Assessment** : Test	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	**Material:** Aluminum The Study of Chemistry The Science of Chemistry: Observations and Models Numbers and Measurements in Chemistry Problem Solving in Chemistry and Engineering Material Selection and Bicycle Frames Phases and Classification of Matter Physical and Chemical Properties **References:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....*	20%
2	Understanding The Atoms Structure, Molecules, and Ions	1. Outline milestones in the development of modern atomic theory 2. Summarize and interpret the results of the experiments of Thomson, Millikan, and Rutherford 3. Describe the three subatomic particles that compose atoms 4. Define isotopes and give examples for several elements 5. Describe the wave nature of light 6. Describe the Bohr model of the hydrogen atom 7. Extend the concept of wave–particle duality that was observed in electromagnetic radiation to matter as well 8. Understand the general idea of the quantum mechanical description of electrons in an atom, and that it	**Criteria:** According to the Assessment Rubric **Form of Assessment** : Test	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	**Material:** Atoms and Electronic Structure, Molecules, and Ions **References:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....*	0%

		uses the notion of three-dimensional wave functions, or orbitals, that define the distribution of probability to find an electron in a particular part of space 9. List and describe traits of the four quantum numbers that form the basis for completely specifying the state of an electron in an atom 10. Write and interpret symbols that depict the atomic number, mass number, and charge of an atom or ion 11. Define the atomic mass unit and average atomic mass 12. Derive the predicted ground-state electron configurations of atoms 13. Identify and explain exceptions to predicted electron configurations for atoms and ions 14. Relate electron configurations to element classifications in the periodic table					

3	Understanding The Periodic Table	1. Describe and explain the observed trends in atomic size, ionization energy, and electron affinity of the 3.2 elements 2. State the periodic law and explain the organization of elements in the periodic table 3. Predict the general properties of elements based on their location within the periodic table 4. Identify metals, nonmetals, and metalloids by their properties and/or location on the periodic table 5. Define ionic and molecular (covalent) compounds 6. Predict the type of compound formed from elements based on their location within the periodic table 7. Determine formulas for simple ionic compounds 8. Derive names for common types of inorganic compounds using a systematic approach 9. Symbolize the composition of molecules using molecular formulas and empirical formulas 10. Represent the bonding arrangement of atoms within molecules using structural formulas	**Criteria:** According to the Assessment Rubric **Form of Assessment** : Test	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	**Material:** The Periodic Table **References:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....* **Material:** Periodic Variations in Element Properties, Molecular and Ionic Compounds, Chemical Nomenclature, Chemical Formulas **References:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....*	25%

4	Chemical Bonding and Molecular Geometry	1. Explain the formation of cations, anions, and ionic compounds Predict the charge of common metallic and nonmetallic elements, and write their electron configurations 2. Describe the formation of covalent bonds Define electronegativity and assess the polarity of covalent bonds 3. Write Lewis symbols for neutral atoms and ions Draw Lewis structures depicting the bonding in simple molecules 4. Explain the concepts of polar covalent bonds and molecular polarity 5. Assess the polarity of a molecule based on its bonding and structure	**Criteria:** According to the Assessment Rubric **Form of Assessment** : Project Results Assessment / Product Assessment, Test	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	**Material:** Ionic Bonding, Covalent Bonding, Lewis Symbols and Structures, Molecular Structure and Polarity **References:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....*	25%

5	Understanding The Composition of Substances and Solutions	1. Calculate formula masses for covalent and ionic compounds Define the amount unit mole and the related quantity Avogadro's number 2. Explain the relationship between mass, moles, and numbers of atoms or molecules, and perform calculations deriving these quantities from one another 3. Compute the percent composition of a compound 4. Determine the empirical formula of a compound 5. Determine the molecular formula of a compound 6. Describe the fundamental properties of solutions 7. Calculate solution concentrations using molarity 8. Perform dilution calculations using the dilution equation 9. Define the concentration units of mass percentage, volume percentage, mass-volume percentage, parts-permillion (ppm), and parts-per-billion (ppb) 10. Perform computations relating a solution's concentration and its components' volumes and/or masses using these units	**Criteria:** According to the Assessment Rubric **Form of Assessment** : Project Results Assessment / Product Assessment	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	**Material:** Formula Mass and the Mole Concept, Determining Empirical and Molecular Formulas, Molarity, Other Units for Solution Concentrations **References:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....*	0%

6	Understanding The Stoichiometry of Chemical Reactions	1. Derive chemical equations from narrative descriptions of chemical reactions. 2. Write and balance chemical equations in molecular, total ionic, and net ionic formats. 3. Define three common types of chemical reactions (precipitation, acid-base, and oxidation-reduction) 4. Classify chemical reactions as one of these three types given appropriate descriptions or chemical equations 5. Identify common acids and bases 6. Predict the solubility of common inorganic compounds by using solubility rules 7. Compute the oxidation states for elements in compounds 8. Explain the concept of stoichiometry as it relates to chemical reactions 9. Use balanced chemical equations to derive stoichiometric 10. factors relating amounts of reactants and products 11. Perform stoichiometric calculations involving mass, moles, and solution molarity	**Criteria:** According to the Assessment Rubric **Forms of Assessment** : Project Results Assessment / Product Assessment, Practical Assessment	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	**Material:** Writing and Balancing Chemical Equations, Classifying Chemical Reactions, Reaction Stoichiometry, Reaction Yields **Literature:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....*	0%

7	Understanding The Stoichiometry of Chemical Reactions	1. Derive chemical equations from narrative descriptions of chemical reactions. 2. Write and balance chemical equations in molecular, total ionic, and net ionic formats. 3. Define three common types of chemical reactions (precipitation, acid-base, and oxidation-reduction) 4. Classify chemical reactions as one of these three types given appropriate descriptions or chemical equations 5. Identify common acids and bases 6. Predict the solubility of common inorganic compounds by using solubility rules 7. Compute the oxidation states for elements in compounds 8. Explain the concept of stoichiometry as it relates to chemical reactions 9. Use balanced chemical equations to derive stoichiometric 10. factors relating amounts of reactants and products 11. Perform stoichiometric calculations involving mass, moles, and solution molarity	**Criteria:** According to the Assessment Rubric **Form of Assessment** : Project Results Assessment / Product Assessment	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	**Material:** Writing and Balancing Chemical Equations, Classifying Chemical Reactions, Reaction Stoichiometry, Reaction Yields **Literature:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....*	0%
8	U.S.S	U.S.S	**Criteria:** According to the Assessment Rubric **Form of Assessment** : Test	SUB ASSESSMENT 3 X 50	SUB ASSESSMENT 3 X 50	**Material:** meeting material 1 to 7 **References:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....*	0%

9	Understanding The Electrochemistry	1. Define electrochemistry and a number of important associated terms 2. Split oxidation-reduction reactions into their oxidation half-reactions and reduction half-reactions 3. Produce balanced oxidation-reduction equations for reactions in acidic or basic solutions 4. Identify oxidizing agents and reducing agents 5. Use cell notation to describe galvanic cells 6. Describe the basic components of galvanic cells 7. Determine standard cell potentials for oxidation-reduction reactions 8. Use standard reduction potentials to determine the better oxidizing or reducing agent from among several possible choices 9. Relate cell potentials to free energy changes 10. Use the Nernst equation to determine cell potentials at nonstandard conditions 11. Perform calculations that involve converting between cell potentials, free energy changes, and equilibrium constants 12. Classify batteries as primary or secondary 13. List some of the characteristics and limitations of batteries 14. Provides a general description of a fuel cell 15. Define corrosion List some of the methods used to prevent or slow corrosion 16. Describe electrolytic cells and their relationship to galvanic cells 17. Perform various calculations related to electrolysis	**Criteria:** According to the Assessment Rubric **Form of Assessment** : Project Results Assessment / Product Assessment	Presentations, Lectures, discussions, questions and answers, exercises and assignments 3 X 50	Presentations, Lectures, discussions, questions and answers, exercises and assignments 3 X 50	**Material:** Balancing Oxidation-Reduction Reactions, Galvanic Cells, Standard Reduction Potentials, The Nernst Equation, Batteries and Fuel Cells, Corrosion, Electrolysis **References:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....*	0%

10	Understanding The Electrochemistry	1. Define electrochemistry and a number of important associated terms 2. Split oxidation-reduction reactions into their oxidation half-reactions and reduction half-reactions 3. Produce balanced oxidation-reduction equations for reactions in acidic or basic solutions 4. Identify oxidizing agents and reducing agents 5. Use cell notation to describe galvanic cells 6. Describe the basic components of galvanic cells 7. Determine standard cell potentials for oxidation-reduction reactions 8. Use standard reduction potentials to determine the better oxidizing or reducing agent from among several possible choices 9. Relate cell potentials to free energy changes 10. Use the Nernst equation to determine cell potentials at nonstandard conditions 11. Perform calculations that involve converting between cell potentials, free energy changes, and equilibrium constants 12. Classify batteries as primary or secondary 13. List some of the characteristics and limitations of batteries 14. Provides a general description of a fuel cell 15. Define corrosion List some of the methods used to prevent or slow corrosion 16. Describe electrolytic cells and their relationship to galvanic cells 17. Perform various calculations related to electrolysis	**Criteria:** According to the Assessment Rubric **Form of Assessment** : Project Results Assessment / Product Assessment	Presentations, Lectures, discussions, questions and answers, exercises and assignments 3 X 50	Presentations, Lectures, discussions, questions and answers, exercises and assignments 3 X 50	**Material:** Balancing Oxidation-Reduction Reactions, Galvanic Cells, Standard Reduction Potentials, The Nernst Equation, Batteries and Fuel Cells, Corrosion, Electrolysis **References:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....*	0%

11	Understanding The Entropy and the Second Law of Thermodynamics	1. describe the scientific and economic obstacles to more widespread recycling of plastics 2. explain the concept of entropy in your own words. deduce the sign of DS for many chemical reactions by examining the physical state of the reactants and products 3. state the second law of thermodynamics in words and equations and use it to predict spontaneity. 4. states the third law of thermodynamics. 5. use tabulated data to calculate the entropy change in a chemical reaction. 6. derive the relationship between the free energy change of a system and the entropy change of the universe. 7. use tabulated data to calculate the free energy change in a chemical reaction. 8. explain the role of temperature in determining whether a reaction is spontaneous. 9. use tabulated data to determine the temperature range for which a reaction will be spontaneous.	**Criteria:** According to the Assessment Rubric **Form of Assessment** : Test	Presentations, discussions, questions and answers, exercises and assignments 3 X 50	Presentations, discussions, questions and answers, exercises and assignments 3 X 50	**Material:** Recycling of Plastics Spontaneity Entropy, The Second Law of Thermodynamics, The Third Law of Thermodynamics, Gibbs Free Energy, Free Energy and Chemical Reactions **References:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....*	0%

12	Understanding Thermochemistry	1. Define energy, distinguish types of energy, and describe the nature of energy changes that accompany chemical and physical changes 2. Distinguish the related properties of heat, thermal energy, and temperature 3. Define and distinguish specific heat and heat capacity, and describe the physical implications of both 4. Perform calculations involving heat, specific heat, and temperature change 5. Explain the technique of calorimetry and Calculate and interpret heat and related properties using typical calorimetry data 6. State the first law of thermodynamics 7. Define enthalpy and explain its classification as a state function 8. Write and balance thermochemical equations 9. Calculate enthalpy changes for various chemical reactions 10. Explain Hess's law and use it to compute reaction enthalpies	**Criteria:** According to the Assessment Rubric **Form of Assessment** : Test	Presentations, discussions, questions and answers, exercises and assignments 3 X 50	Presentations, discussions, questions and answers, exercises and assignments 3 X 50	**Material:** Energy Basics, Calorimetry, Enthalpy **References:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....* **Material:** Thermochemistry **Bibliography:** *Laird, Brian B. 2009. University of Chemistry. New York: McGraw-Hil*	0%

13	Understanding the Chemical Kinetics	1.explain the role of chemical kinetics in the formation and destruction of ozone in the atmosphere. 2.define the rate of a chemical reaction and express the rate in terms of the concentrations of individual reactants or products 3.use the method of initial rates to determine rate laws from experimental data. 4.use graphical methods to determine rate laws from experimental data 5.explain the role of a catalyst in the design of practical chemical reactions	**Criteria:** According to the Assessment Rubric **Form of Assessment** : Test	Presentations, discussions, questions and answers, exercises and assignments 3 X 50	Presentations, discussions, questions and answers, exercises and assignments 3 X 50	**Material:** Ozone Depletion, Rates of Chemical Reactions, Rate Laws and the Concentration Dependence of Rates, Catalysis **Literature:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....*	0%
14	Understanding the chemical equilibrium	1.explain that equilibrium is dynamic and that at equilibrium, the forward and backward reaction rates are equal. State these ideas in your own words. 2.write the equilibrium constant expression for any reversible reaction. 3.calculate equilibrium constants from experimental data. 4.calculate molar solubility from Ksp or vice versa. 5.write equilibrium constants for the dissociation of weak acids and weak bases and use them to calculate pH or the degree of ionization. 6.calculate the new equilibrium composition of a system after an applied stress 7.explain the importance of both kinetic and equilibrium considerations in the design of industrial chemical processes. 8.list important chemical reactions in the production and weathering of concrete	**Criteria:** According to the Assessment Rubric **Form of Assessment** : Test	Lectures, discussions, questions and answers, exercises and assignments 3X 50	Lectures, discussions, questions and answers, exercises and assignments 3X 50	**Material:** Chemical Equilibrium Equilibrium Constants Equilibrium Concentrations LeChatelier's Principle Solubility Equilibria Acids and Bases Free Energy and Chemical Equilibrium Concrete Production and Weathering Borates and Boric Acid **Reference:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....* **Material:** Chemical Equilibrium Equilibrium Constants Equilibrium Concentrations LeChatelier's Principle Solubility Equilibria Acids and Bases Free Energy and Chemical Equilibrium Concrete Production and Weathering Borates and Boric Acid **Bibliography:** *Laird, Brian B. 2009. University of Chemistry. New York: McGraw-Hil*	0%

15	Understanding of Nuclear Chemistry	1.Describe nuclear structure in terms of protons, neutrons, and electrons 2.Explain trends in the relative stability of nuclei 3.Write and balance nuclear equations 4.Recognize common modes of radioactive decay 5.Identify common particles and energies involved in nuclear decay reactions 6.Calculate kinetic parameters for decay processes, including half-life 7.Relate the concepts of critical mass and nuclear chain reactions 8.Summarize basic requirements for nuclear fission and fusion reactors 9.List of common applications of radioactive isotopes 10.Describe the biological impact of ionizing radiation Define units for measuring radiation exposure Explain the operation of common tools for detecting radioactivity	**Criteria:** According to the Assessment Rubric **Form of Assessment** : Test	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	**Material:** Nuclear Structure and Stability Nuclear Equations Radioactive Decay Transmutation and Nuclear Energy Uses of Radioisotopes Biological Effects of Radiation **Bibliography:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....* **Material:** Nuclear Structure and Stability Nuclear Equations Radioactive Decay Transmutation and Nuclear Energy Uses of Radioisotopes Biological Effects of Radiation **Bibliography:** *Laird, Brian B. 2009. University of Chemistry. New York: McGraw-Hil*	0%
16	Understanding of Nuclear Chemistry		**Criteria:** According to the Assessment Rubric **Form of Assessment** : Project Results Assessment / Product Assessment	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	Lectures, discussions, questions and answers, exercises and assignments 3 X 50	**Material:** Nuclear Structure and Stability Nuclear Equations Radioactive Decay Transmutation and Nuclear Energy Uses of Radioisotopes Biological Effects of Radiation **Bibliography:** *Flower, Paul, et. al. Chemistry 2e. OpenStax, Rice University. https://openstax.org/....* **Material:** Nuclear Structure and Stability Nuclear Equations Radioactive Decay Transmutation and Nuclear Energy Uses of Radioisotopes Biological Effects of Radiation **Bibliography:** *Laird, Brian B. 2009. University of Chemistry. New York: McGraw-Hil*	30%

Evaluation Percentage Recap: Project Based Learning

No	Evaluation	Percentage
1.	Project Results Assessment / Product Assessment	42.5%
2.	Test	57.5%
		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.