Unit 03: Equilibrium (Weeks 13-18)

Content Area: **Template**
Course(s):
Time Period: **Full Year**
Length: **FY**
Status: **Published**

Standards Alignment

New Jersey Student Learning Standards

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Select appropriate tools to collect, record, analyze, and evaluate data.

Practice 4. Analyzing and interpreting data

Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Practice 8. Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to

evaluating the validity and reliability of the claims, methods, and designs.

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Connections to the Nature of Science: Most Closely Associated with Practices

Scientific Knowledge is Based on Empirical Evidence

Science knowledge is based on empirical evidence.

Science disciplines share common rules of evidence used to evaluate explanations about natural systems.

Science includes the process of coordinating patterns of evidence with current theory.

Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

SCI.HS-PS1	Matter and Its Interactions
SCI.HS-PS1-5	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
SCI.HS-PS1-6	Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
SCI.HS-PS1-7	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Integration of Career Readiness, Life Literacies and Key Skills

CRP.K-12.CRP1	Act as a responsible and contributing citizen and employee.
CRP.K-12.CRP2	Apply appropriate academic and technical skills.
CRP.K-12.CRP3	Attend to personal health and financial well-being.
CRP.K-12.CRP4	Communicate clearly and effectively and with reason.
CRP.K-12.CRP5	Consider the environmental, social and economic impacts of decisions.
CRP.K-12.CRP6	Demonstrate creativity and innovation.
CRP.K-12.CRP7	Employ valid and reliable research strategies.
CRP.K-12.CRP8	Utilize critical thinking to make sense of problems and persevere in solving them.
CRP.K-12.CRP9	Model integrity, ethical leadership and effective management.
CRP.K-12.CRP10	Plan education and career paths aligned to personal goals.
CRP.K-12.CRP11	Use technology to enhance productivity.
CRP.K-12.CRP12	Work productively in teams while using cultural global competence.

Technology / Integration of Computer Science and Design Thinking

TECH.8.1.12	Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.

TECH.8.1.12.A	Technology Operations and Concepts: Students demonstrate a sound understanding of technology concepts, systems and operations.
TECH.8.1.12.A.3	Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue.
TECH.8.1.12.A.4	Construct a spreadsheet workbook with multiple worksheets, rename tabs to reflect the data on the worksheet, and use mathematical or logical functions, charts and data from all worksheets to convey the results.

Interdisciplinary Connections: NJSLS for ELA, Social Studies, Science and/or Math Section

LA.K-12.NJSLSA.R	Reading
LA.K-12.NJSLSA.R3	Analyze how and why individuals, events, and ideas develop and interact over the course of a text.
LA.K-12.NJSLSA.W	Writing
	Text Types and Purposes
LA.RI.11-12.3	Analyze a complex set of ideas or sequence of events and explain how specific individuals, ideas, or events interact and develop over the course of the text.
LA.K-12.NJSLSA.W1	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
LA.W.11-12.1	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
LA.W.11-12.1.A	Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences claim(s), counterclaims, reasons, and evidence.
LA.W.11-12.1.C	Use transitions (e.g., words, phrases, clauses) to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

Integration of Diversity, Equity and Inclusion; Climate Change; Informational and Media LiteracyNew Section

see Crosswalks

21st Century Life and Careers

CRP.K-12.CRP2.1	Career-ready individuals readily access and use the knowledge and skills acquired through experience and education to be more productive. They make connections between abstract concepts with real-world applications, and they make correct insights about when it is appropriate to apply the use of an academic skill in a workplace situation.
CRP.K-12.CRP4.1	Career-ready individuals communicate thoughts, ideas, and action plans with clarity, whether using written, verbal, and/or visual methods. They communicate in the workplace with clarity and purpose to make maximum use of their own and others' time. They are excellent writers; they master conventions, word choice, and organization, and use

	effective tone and presentation skills to articulate ideas. They are skilled at interacting with others; they are active listeners and speak clearly and with purpose. Career-ready individuals think about the audience for their communication and prepare accordingly to ensure the desired outcome.
CRP.K-12.CRP6.1	Career-ready individuals regularly think of ideas that solve problems in new and different ways, and they contribute those ideas in a useful and productive manner to improve their organization. They can consider unconventional ideas and suggestions as solutions to issues, tasks or problems, and they discern which ideas and suggestions will add greatest value. They seek new methods, practices, and ideas from a variety of sources and seek to apply those ideas to their own workplace. They take action on their ideas and understand how to bring innovation to an organization.

Stage I: Desired Results

Transfer/Overview/Rationale

Transfer / Overview / Rationale

Unit Rationale

The purpose of this unit…

... is to have students examine the balance that compounds have in a chemical reaction. When reactions move forward, both the energy and the compounds seek to find a position of equilibrium. These positions of equilibrium can be measured and recorded.

Meaning

Essential Questions

Essential Questions

How are bond formation and bond breaking in a dynamic competition?

How are equilibrium systems sensitive to initial conditions and external perturbations?

How do reactions reach equilibrium?

Enduring Understanding/Indicators of Understanding

Enduring Understanding/Indicators of Understanding

Students will understand that:

1) Any bond or intermolecular attraction that can be formed can be broken.

2) Chemical equilibrium is a dynamic, reversible state in which rates of opposing processes are equal.

3) Systems at equilibrium are responsive to external perturbations, with the response leading to a change in the composition of the system. [EU 6.2]

4) Chemical equilibrium plays an important role in acid-base chemistry and in solubility. [EU 6.3]

5) The equilibrium constant is related to temperature and the difference in Gibbs free energy between reactants and products. [EU 6.4]

Acquisition (Student Learning Objectives)

Knowledge

Knowledge

Students will know…

1) … in many classes of reactions, it is important to consider both the forward and reverse reaction. [EK 6.A.1]

2) … the current state of a system undergoing a reversible reaction can be characterized by the extent to which reactants have been converted to products. the relative quantities of reaction components are quantitatively described by the reaction quotient, *Q*. [EK 6.A.2]

3) … when a system is at equilibrium, all macroscopic variables, such as concentrations, partial pressures, and temperature, do not change over time. equilibrium results from an equality between the rates of the forward and reverse reactions, at which point $Q = K$. [EK 6.A.3]

4) … the magnitude of the equilibrium constant, *K*, can be used to determine whether the equilibrium lies toward the reactant side or product side. [EK 6.A.4]

5) … systems at equilibrium respond to disturbances by partially countering the effect of the disturbance (LeChatelier's principle). [EK 6.B.1]

6) … a disturbance to a system at equilibrium causes *Q* to differ from *K*, thereby taking the system out of the original equilibrium state. the system responds by bringing *Q* back into agreement with *K*, thereby establishing a new equilibrium state. [EK 6.B.2]

7) … chemical equilibrium reasoning can be used to describe the proton-transfer reactions of acid-base chemistry. [EK 6.C.1]

8) … the pH is an important characteristic of aqueous solutions that can be controlled with buffers. Comparing ph to p*Ka*allows one to determine the protonation state of a molecule with a labile proton. [EK 6.C.2]

9) … the solubility of a substance can be understood in terms of chemical equilibrium. [EK 6.C.3]

10) … when the difference in Gibbs free energy between reactants and products ($\Delta G°$) is much larger than the thermal energy (*RT*), the equilibrium constant is either very small (for $\Delta G° > 0$) or very large (for $\Delta G° < 0$). When $\Delta G°$ is comparable to the thermal energy (*RT*), the equilibrium constant is near 1. [EK 6.D.1]

11) … to explain the relative strengths of acids and bases based on molecular structure, interparticle forces, and solution equilibrium.

Lab [LO 2.2]

12) … how, given a manipulation of a chemical reaction or set of reactions (e.g., reversal of reaction or addition of two reactions), to determine the effects of that manipulation on *Q* or *K*. [LO 6.2]

13) … to connect kinetics to equilibrium by using reasoning about equilibrium, such as LeChatelier's principle, to infer the relative rates of the forward and reverse reactions. [LO 6.3]

14) … how, given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, *K*, to use the tendency of *Q* to approach *K* to predict and justify the prediction as to whether the reaction will proceed toward products or reactants as equilibrium is approached. [LO 6.4]

15) … how, given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, *K*, to use stoichiometric relationships and the law of mass action (*Q* equals *K* at equilibrium) to determine qualitatively and/or quantitatively the conditions at equilibrium for a system involving a single reversible reaction. [LO 6.6]

16) … how, for a reversible reaction that has a large or small *K*, to determine which chemical species will have very large versus very small concentrations at equilibrium. [LO 6.7]

17) … to use LeChatelier's principle to predict the direction of the shift resulting from various possible stresses on a system at chemical equilibrium. [LO 6.8]

18) … to connect LeChatelier's principle to the comparison of *Q* to *K* by explaining the effects of the stress on *Q* and *K*. [LO 6.10]

19) … how, based on the dependence of $K_w$on temperature, to reason that neutrality requires $[H^+] = [OH^–]$ as opposed to requiring pH = 7, including especially the applications to biological systems. [LO 6.14]

20) … how, given an arbitrary mixture of weak and strong acids and bases (including polyprotic systems), to determine which species will react strongly with one another (i.e., with $K > 1$) and what species will be present in large concentrations at equilibrium. [LO 6.17]

21) … how to relate the predominant form of a chemical species involving a labile proton (i.e., protonated/deprotonated form of a weak acid) to the pH of a solution and the p$K_a$associated with the labile proton. [LO 6.19]

22) … how to express the equilibrium constant in terms of $\Delta G°$ and *RT* and use this relationship to estimate the magnitude of *K* and, consequently, the thermodynamic favorability of the process. [LO 6.25]

Skills

Skills

Student will be skilled at …

1) … designing, and/or interpreting data from, an experiment that uses titration to determine the concentration of an analyte in a solution. [LO 1.20]

2) … using LeChatelier's principle to make qualitative predictions for systems in which coupled reactions that share a common intermediate drive formation of a product**.** [LO 5.16]

3) … making quantitative predictions for systems involving coupled reactions that share a common intermediate, based on the equilibrium constant for the combined reaction. [LO 5.17]

4) … given a set of experimental observations regarding physical, chemical, biological, or environmental processes that are reversible, constructing an explanation that connects the observations to the reversibility of the underlying chemical reactions or processes. [LO 6.1]

5) … given data (tabular, graphical, etc.) from which the state of a system at equilibrium can be obtained, calculating the equilibrium constant, *K*. [LO 6.5]

6) … using LeChatelier's principle to design a set of conditions that will optimize a desired outcome, such as product yield. [LO 6.9]

7) … generating or using a particulate representation of an acid (strong or weak or polyprotic) and a strong base to explain the species that will have large versus small concentrations at equilibrium. [LO 6.11]

8) … reasoning about the distinction between strong and weak acid solutions with similar values of pH, including the percent ionization of the acids, the concentrations needed to achieve the same pH, and the amount of base needed to reach the equivalence point in a titration. [LO 6.12]

9) … interpreting titration data for monoprotic or polyprotic acids involving titration of a weak or strong acid by a strong base (or a weak or strong base by a strong acid) to determine the concentration of the titrant and the p*Ka*for a weak acid, or the p*Kb*for a weak base. [LO 6.13]

10) … identifing a given solution as containing a mixture of strong acids and/or bases and calculate or estimate the pH (and concentrations of all chemical species) in the resulting solution. [LO 6.15]

11) … identifing a given solution as being the solution of a monoprotic weak acid or base (including salts in which one ion is a weak acid or base), calculating the pH and concentration of all species in the solution, and/ or inferring the relative strengths of the weak acids or bases from given equilibrium concentrations. [LO 6.16]

12) … designing a buffer solution with a target pH and buffer capacity by selecting an appropriate conjugate acid-base pair and estimating the concentrations needed to achieve the desired capacity. [LO 6.18]

13) … identifying a solution as being a buffer solution and explain the buffer mechanism in terms of the reactions that would occur on addition of acid or base. [LO 6.20]

14) … predicting the solubility of a salt, or rank the solubility of salts, given the relevant *Ksp*values. [LO 6.21]

15) … interpreting data regarding solubility of salts to determine, or rank, the relevant *Ksp*values. [LO 6.22]

16) … interpreting data regarding the relative solubility of salts in terms of factors (common ions, pH) that influence the solubility. [LO 6.23]

17) … analyzing the enthalpic and entropic changes associated with the dissolution of a salt, using particulate level interactions and representations. [LO 6.24]

Stage 3: Learning Plan

Resource and Mentor Texts

Resources and Mentor Texts

Walsh's YouTube Channel

https://www.youtube.com/channel/UCNxaVQOaYbnBjpf3fZ9k33Q?view_as=subscriber

Print Texts

Chemistry by Kotz and Treichel

Princeton Reveiw

Digital Resources

Chemistry, The Central Science by Brady and Holum

Old AP Exams

Albert.io

Formative Assessment Strategies

Formative Assessment Strategies

POGIL activity

Pyramid of understanding

Questions during lecture

Sample AP questions

Homework problems

Learning Activities/Unit of Study

Learning Activities/Unit of Study

Do nows

Students will be delivered all notes through flipped learning best practices

WSQs

At home assessments

Video watching

Self Assessments

During class, students will work through practice problems

Students will engage in peer learning

When appropriate, Albert.io will be used in class.

Students will work through old AP problems that apply to this unit

Modifications and/or Accommodations

Suggested Modifications (ELL, Sp. Ed, GIfted, At-risk of Failure)

English Language Learners

Native language support: The teacher provides auditory or written content to students in their native language.

Adjusted Speech: The teacher changes speech patterns to increase student comprehension. This could include facing the students, paraphrasing, clearly indicating the most important ideas, and speaking more slowly.

Visuals: The teacher uses graphics, pictures, visuals, and manipulatives. This helps ELL students better understand and comprehend the subjects at hand.

Front-Loading Vocabulary: The teacher front loads vocabulary. This means providing students with a list of important vocabulary words they will need to know for a book, lesson, etc. prior to the lesson being taught. Including pictures to go with the vocabulary words is also very beneficial for the students.

Special Education Students

Chunking: The teacher presents information in a way that makes it easy for students to understand and remember. Chunking is based on the presumption that our working memory is easily overloaded by excessive detail. The best way to deliver information is to organize it into meaningful units. Because students with special needs get overloaded easily, chunking is an effective strategy to use with them.

Checking for Understanding: It is important to constantly check for understanding, especially for students who have accommodations. Teachers want to make sure students understand the concepts being covered in a way that makes sense to them.

Extra time: The teacher provides students with special needs extra time to complete work or answer questions. It is important to give students enough time to process their thoughts.

Oral Reading: The teacher will read work orally to students. Class work such as tests and literature circles may need to be read aloud to the student.

Timers: The teacher will use timers as an instructional tool. The use of timers is beneficial for students who have trouble completing tasks. Timers can be helpful so the student is aware of how much time they have to complete an assignment.

Students with 504 Plans

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Gifted & Talented Strategies

Extensions/Enrichments: Teachers will provide gifted and talented students with extension/enrichment projects. Students will be challenged to further their understanding, to apply acquired knowledge, and/or to produce something in reference to acquired knowledge.

Modify/Change Activities: Teachers will monitor and modify activities to accommodate those students who need to be challenged further. Additional reading, problem-solving, writing, or project work is necessary for those students who are ready to move on at a rate more accelerated than their peers. In this way, G & T students are provided the same opportunity for support as special needs students.

Students at Risk of School Failure

Directions or Instructions: Make sure directions and/or instructions are given in limited numbers. Give directions/instructions verbally and in simple written format. Ask students to repeat the instructions or directions to ensure understanding occurs. Check back with the student to ensure he/she hasn't forgotten.

Peer Support: Peers can help build confidence in other students by assisting in peer learning. Many teachers use the 'ask 3 before me' approach. This is fine, however, a student at risk may have to have a specific student or two to ask. Set this up for the student so he/she knows who to ask for clarification before going to you.

Alternate or Modified Assignments: Always ask yourself, "How can I modify this assignment to ensure the students at risk are able to complete it?" Sometimes you'll simplify the task, reduce the length of the assignment or allow for a different mode of delivery. For instance, many students may hand something in, the at-risk student may jot notes and give you the information verbally. Or, it just may be that you will need to assign an alternate assignment.

Increase One to One Time: When other students are working, always touch base with your students at risk and find out if they're on track or needing some additional support. A few minutes here and there will go a long way to intervene as the need presents itself.

Contracts: It helps to have a working contract between you and your students at risk. This helps prioritize the tasks that need to be done and ensure completion happens. Each day write down what needs to be completed, as the tasks are done, provide a checkmark or happy face. The goal of using contracts is to eventually have the student come to you for completion sign-offs.

Hands On: As much as possible, think in concrete terms and provide hands-on tasks. This means a child doing math may require a calculator or counters. The child may need to tape record comprehension activities instead of writing them. A child may have to listen to a story being read instead of reading it him/herself.

Tests/Assessments: Tests can be done orally if need be. Break tests down in smaller increments by having a portion of the test in the morning, another portion after lunch and the final part the next day.

Seating: Seat students near a helping peer or with quick access to the teacher. Those with hearing or sight issues need to be close to the instruction which often means near the front.