12 - Reaction Rates and Equilibrium

Content Area: **Science**
Course(s):
Time Period: **Full Year**
Length: **7 Blocks**
Status: **Published**

General Overview, Course Description or Course Philosophy

Chemistry CP aims to provide students with a fundamental understanding of the composition, structure, properties, and transformations of matter. Through a combination of theoretical concepts, laboratory investigations, and real-world applications, students will explore the principles and laws that govern chemical reactions and interactions. The course emphasizes the development of scientific inquiry skills, critical thinking abilities, and the application of problem-solving strategies. Students will actively engage in the process of scientific discovery, asking questions, seeking answers, and making connections between theory and practical applications. Laboratory experiences will integrate with theoretical knowledge, fostering the development of practical skills, scientific inquiry, and responsible practices. Students will also explore the ethical considerations and societal implications of chemistry, promoting informed decision-making as responsible citizens. By the end of the course, students will have a deepened appreciation for the relevance of chemistry in everyday life and will be prepared for further study and careers in scientific fields.

OBJECTIVES, ESSENTIAL QUESTIONS, ENDURING UNDERSTANDINGS

Objectives:

- Define and describe reaction rates and the factors that affect them, such as concentration, temperature, surface area, and catalysts.
- Conduct experiments and use data to determine reaction rates and express them using appropriate units.
- Explain collision theory and relate it to the factors that influence reaction rates.
- Apply the concept of reaction rates to explain how changes in variables affect the speed of a chemical reaction.
- Define chemical equilibrium and distinguish between dynamic equilibrium and non-equilibrium states.
- Interpret and analyze equilibrium expressions and constants for chemical reactions.
- Predict the effects of changes in concentration, temperature, and pressure on the position of equilibrium using Le Chatelier's principle.
- Solve equilibrium-related problems, including calculations involving equilibrium constants and concentrations.
- Analyze and interpret data, graphs, and models related to reaction rates and equilibrium.
- Apply the concepts of reaction rates and equilibrium to real-world examples and scenarios, such as environmental processes, industrial applications, and biological systems.

Essential Questions:

- What factors influence the rate of a chemical reaction, and how can the rate be measured or determined?
- How does collision theory explain the relationship between reaction rates and the frequency, energy, and orientation of molecular collisions?

- What is chemical equilibrium, and how does it differ from a non-equilibrium state?
- How can the position of equilibrium be influenced by changes in concentration, temperature, and pressure according to Le Chatelier's principle?
- In what ways do reaction rates and equilibrium play a role in chemical systems and practical applications?

Enduring Understandings:

- Chemical reactions occur at different rates influenced by various factors, including concentration, temperature, surface area, and catalysts.
- The rate of a chemical reaction can be determined by measuring the change in concentration of reactants or products over time.
- The concept of reaction rates can be related to collision theory, which explains how particles must collide with sufficient energy and proper orientation for a reaction to occur.
- Chemical equilibrium is a dynamic state in which the forward and reverse reactions occur at the same rate, resulting in no net change in the concentration of reactants and products.
- Le Chatelier's principle helps predict and understand how changes in concentration, temperature, and pressure affect the position of equilibrium.

CONTENT AREA STANDARDS

SCI.9-12.HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
SCI.9-12.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.9-12.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.

RELATED STANDARDS (Technology, 21st Century Life & Careers, ELA Companion Standards are Required)

MA.N-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
MA.N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
TECH.K-12.1.3.d	build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.
LA.RST.9-10.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
LA.RST.9-10.2	Determine the central ideas, themes, or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
TECH.K-12.1.4.a	know and use a deliberate design process for generating ideas, testing theories, creating

	innovative artifacts or solving authentic problems.
LA.RST.9-10.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

STUDENT LEARNING TARGETS

Refer to the 'Declarative Knowledge' and 'Procedural Knowledge sections.

Declarative Knowledge

Students will understand that:

- A reversible reaction will reach equilibrium when the rate of the forward reaction equals the rate of the reverse reaction.
- LeChatelier's Principle can be used to predict the direction that a reaction will shift in response to an external stress.
- Chemical reactions involve the collisions of reacting particles, and vary widely in the speed (rate) at which they occur.
- Factors that influence a rate of reaction include:
    - Concentration of reactants
    - Pressure (for reactions involving gases)
    - Surface area (for a solid)
    - Temperature (increased temperature = faster reaction)
    - Presence of a catalyst.

Procedural Knowledge

Students will be able to:

- Integrate evidence, facts, and scientific principles to construct the explanation:
    - Molecules that collide can break bonds and form new bonds, producing new molecules.
    - The probability of bonds breaking in the collision depends on the kinetic energy of the collision being sufficient to break the bond since bond breaking requires energy.
    - Since temperature is a measure of average kinetic energy, a higher temperature means that molecular collisions will, on average, be more likely to break bonds and form new bonds.
    - At a fixed concentration, molecules that are moving faster also collide more frequently, so molecules with higher kinetic energy are likely to collide more often.
    - A high concentration means that there are more molecules in a given volume and thus more particle collisions per unit of time at the same temperature.
- Use evidence to describe the relative quantities of a product before and after changes to a given chemical reaction system and will explicitly use Le Chatelier's principle, including:
    - How, at a molecular level, stress involving a change to one component of an equilibrium system affects other components;

    - That changing the concentration of one of the components of the equilibrium system will change the rate of the reaction (forward or backward) in which it is a reactant until the forward and backward rates are again equal; and
    - A description of a system at equilibrium that includes the idea that both the forward and backward reactions are occurring at the same rate, resulting in a system that appears stable at the macroscopic level.
- Use evidence to develop a model in which they identify and describe the relevant components, including:
    - The chemical reaction, the system, and the surroundings under study;
    - The bonds that are broken during the course of the reaction;
    - The bonds that are formed during the course of the reaction;
    - The energy transfer between the systems and their components or the system and surroundings;
    - The transformation of potential energy from the chemical system interactions to kinetic energy in the surroundings (or vice versa) by molecular collisions; and
    - The relative potential energies of the reactants and the products.
- Identify and describe potential changes in a component of the given chemical reaction system that will increase the amounts of particular species at equilibrium. Students use evidence to describe the relative quantities of a product before and after changes to a given chemical reaction system (e.g., concentration increases, decreases, or stays the same), and will explicitly use Le Chatelier's principle, including:
    - How, at a molecular level, stress involving a change to one component of an equilibrium system affects other components;
    - That changing the concentration of one of the components of the equilibrium system will change the rate of the reaction (forward or backward) in which it is a reactant until the forward and backward rates are again equal; and
    - A description of a system at equilibrium that includes the idea that both the forward and backward reactions are occurring at the same rate, resulting in a system that appears stable at the macroscopic level.

EVIDENCE OF LEARNING

Refer to the 'Formative Assessments' and 'Summative Assessments' sections.

Formative Assessments

- POGIL Activities:
    - Equilibrium
- Labs
    - Exploring Equilibrium
    - Restoring Balance
    - Iodine Clock Reaction
- Group practice
    - Factors That Affect the Rate of a Reaction
    - Equilibrium Tables
    - LeChatlier's Prinicple

- Performance Scale/ Student Tracking Chart
- Whiteboards
- Exit Tickets
- Homework

Summative Assessments

- Benchmarks – departmental benchmark given at the end of MP1, MP2, and MP3 based on lab practices
- Alternative Assessments
    - Lab inquiries and investigations
    - Lab Practicals
    - Exploratory activities based on phenomenon
    - Gallery walks of student work
    - Creative Extension Projects
    - Build a model of a proposed solution
    - Let students design their own flashcards to test each other
    - Keynote presentations made by students on a topic
    - Portfolio
- Reaction Rates and Equilibrium Test
- Exploring Equilibrium Lab Report

RESOURCES (Instructional, Supplemental, Intervention Materials)

CK-12 Online Textbook

POGIL Chemistry

Gizmos Simulations

PhET Simulations

Khan Academy

Bozeman Science

American Chemical Society

INTERDISCIPLINARY CONNECTIONS

ELA/Literacy

Mathematics

Technology

ACCOMMODATIONS & MODIFICATIONS FOR SUBGROUPS

See link to Accommodations & Modifications document in course folder.