HIGH SCHOOL CHEMISTRY: MANIPULATING CHEMICAL REACTIONS

Standards Bundle:

Standards are listed within the bundle. Bundles are created with potential instructional use in mind, based upon potential for related phenomena that can be used throughout a unit.

HS-PS1-5 Construct an explanation based on evidence about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. (SEP: 6; DCI: PS1.B; CCC: Patterns) [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] *[Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]*

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. (SEP: 6; DCI: PS1.B, ETS1.C; CCC: Stability/Change) [Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.]*[Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]*

Content Overview

This section provides a generic overview of the content or disciplinary core ideas as an entry point to the standards.

Several factors affect the rate of chemical reactions. Conditions can be altered to either speed up or slow down chemical reactions. Changing the temperature, the concentration of reactants, or the surface area of reactants; using a catalyst; or adjusting the nature of reactants, will all affect the rate of a chemical reaction. Each factor affects the number of collisions between particles. The increase or decrease of collisions is the foundation for speeding up or slowing down a chemical reaction.

When a chemical reaction is in equilibrium, the forward reaction (reactants to products) proceeds at the same rate as the reverse reaction (products to reactants). The concentration of reactants and products are not necessarily equal at equilibrium, but they are constant. Altering the equilibrium position of a chemical reaction can be accomplished by adding or removing reactants or products. In addition, altering the temperature that a reaction is carried out in can change the equilibrium position. When a chemical reaction experiences a change in concentration, temperature, or pressure it will increase the forward reaction or reverse reaction in order to re-establish the equilibrium. This is known as Le Chatelier's principle.

Phenomena

Phenomena can be used at varying levels of instruction. One could be used to anchor an entire unit, while another might be more supplemental for anchoring just a unit. Please remember that phenomena should allow students to engage in the SEP and use the CCC/DCI to understand and explain the phenomenon.

- Hydrangea flower color differs according to the pH of the soil.
- It is illegal to smoke at a grain elevator.
- If you like your coffee sweet immediately, choose 2 tsp of coffee instead of sugar cubes.
- Potatoes that are cut up cook at a different rate than whole potatoes in boiling water.
- Rubbing alcohol is sold in clear containers, but hydrogen peroxide is always sold in a brown bottle.
- A bottle of old aspirin smells like strong vinegar.
- Undiluted glue makes stiffer slime than diluted glue.
- Gas mileage is is different in the summer than in the winter.

Storyline

This section aims to decode not only the DCI connections, but also the SEP and CCC in a detailed account of how they possibly fit together in a progression for student learning, including both rationale and context for the bundle.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions ● Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.	**PS1.B Chemical reactions** ● Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. ● In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. **ETS1.C Optimizing the design solution** ● Determining the best possible design for a solution under a given set of prioritized constraints. Utilizing a design matrix to aide the process of optimization.	**Patterns** ● Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. **Stability/Change** ● Much of science deals with constructing explanations of how things change and how they remain stable.

Through scientific experiments, evidence can be observed to explain the phenomena of chemical reaction manipulation. Reactions may be manipulated by changing the temperature, kinetic energy, surface area, or concentration of reactants or products. Chemical reactions in a state of equilibrium can be manipulated to shift from products to reactants or vice versa. By understanding the patterns to these manipulations, it is possible to design a solution to maintain the desired equilibrium and construct an explanation to the process. Recognizing patterns in reactivity rates allow students to redesign an investigation to suit a specific goal. Students can collect evidence of the patterns in reactivity rates that correlate to the number of collisions between reactants. The scientific principle, the conservation of matter, must be applied,regardless of the variables manipulated, while constructing explanations of how things change or remain stable in chemical reactions.

Formative Assessment

Formative assessment is crucial because all learners benefit from timely and focused feedback from others. It promotes self-reflection, self-explanation, and social learning. It can also make learning more relevant. Each of the questions below might be used throughout the formative assessment process. Specific prompts may focus on individual practices, core ideas, or crosscutting concepts, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given bundle, standard or lesson-level performance expectation.

SEP Constructing Explanations and Designing Solutions

- Collect evidence from chemical reactions to explain the effect on a reaction when the temperature is changed.
- Collect evidence from chemical reactions to explain the effect on a reaction when the concentration of reactants or products is changed.
- Collect evidence from chemical reactions to explain the effect on a reaction when a catalyst is added.
- Construct an explanation of how changing the concentration of a reactant affects the equilibrium.
- Construct an explanation of how changing the volume of a container affects the equilibrium of a chemical reaction.
- Construct an explanation of how changing the temperature of a reaction affects the equilibrium.
- Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

CCC Patterns

- What pattern on equilibrium position can you identify when heat is added to an endothermic reaction?
- What pattern on equilibrium position can you identify when heat is added to an exothermic reaction?
- What pattern on equilibrium position can you identify when the concentration of a reactant is increased?
- What pattern on equilibrium position can you identify when a product is removed from a reaction?
- What patterns in reaction rate can you identify when the temperature of an endothermic reaction or exothermic reaction is increased?
- What patterns in reaction rate can you identify when the concentration of reactants or products in a reaction is increased?

CCC Stability/Change

- In terms of collisions, how does the reaction rate change when the surface area of reactants increases?
- In terms of kinetic energy and collisions, why does the reaction rate change when the temperature changes?
- In terms of kinetic energy and collisions, why does the reaction rate change when the concentration of reactants changes?
- How can Le Chatelier's principle be utilized to maintain a chemical reaction in equilibrium?
- How does a catalyst change the equilibrium position of a chemical reaction?
- How does increasing the concentration of a reactant affect equilibrium position?
- How does removing a product affect the equilibrium position?

Performance Outcomes

These are statements of how students use knowledge and are similar to the standards in how they blend DCI, SEP, and CCC, but at a smaller grain-size. These are potential outcomes for instruction as it plays out in lessons and activities in the classroom. It is important to also think of these as smaller outcomes that build toward the larger goal of mastering the standards.

- **Apply scientific evidence to explain** chemical processes in terms of the patterns that exist when collisions occur on the molecular level.
- **Create explanations** *using patterns* to communicate that the rates of chemical reactions are based on the number of collisions between molecules or atoms.
- **Analyze** *the effects of changing the temperature and the surface area of reactants in a chemical reaction.*
- **Analyze** Le Chatelier's principle as equilibrium is shifted from reactants to products and from products to reactants.
- **Explain how** the number of molecular collisions that occur during a chemical reaction has an effect on the rate of a chemical reaction.
- **Explain the** *effect of variable amounts of reactants or products* on an equilibrium position in a chemical reaction.

- **Create a definition** of equilibrium at the molecular level that implements the products and reactants in a chemical reaction.