Unit 4: Chemical Reactions

Content Area:	**Science**
Course(s):	**AP Chemistry**
Time Period:	**Semester 2**
Length:	**6 weeks**
Status:	**Published**

Standards - NJCCS/CCSS

SCI.9-12.5.2.12.C	Knowing the characteristics of familiar forms of energy, including potential and kinetic energy, is useful in coming to the understanding that, for the most part, the natural world can be explained and is predictable.
SCI.9-12.5.2.12.C.1	Use the kinetic molecular theory to describe and explain the properties of solids, liquids, and gases.
SCI.9-12.5.2.12.C.2	Account for any trends in the melting points and boiling points of various compounds.
SCI.9-12.5.2.12.C.a	Gas particles move independently and are far apart relative to each other. The behavior of gases can be explained by the kinetic molecular theory. The kinetic molecular theory can be used to explain the relationship between pressure and volume, volume and temperature, pressure and temperature, and the number of particles in a gas sample. There is a natural tendency for a system to move in the direction of disorder or entropy.
SCI.9-12.5.2.12.C.b	Heating increases the energy of the atoms composing elements and the molecules or ions composing compounds. As the kinetic energy of the atoms, molecules, or ions increases, the temperature of the matter increases. Heating a pure solid increases the vibrational energy of its atoms, molecules, or ions. When the vibrational energy of the molecules of a pure substance becomes great enough, the solid melts.
SCI.9-12.5.2.12.D.2	Describe the potential commercial applications of exothermic and endothermic reactions.
SCI.9-12.5.2.12.D.3	Describe the products and potential applications of fission and fusion reactions.
SCI.9-12.5.2.12.D.4	Measure quantitatively the energy transferred between objects during a collision.
SCI.9-12.5.2.12.D.5	Model the change in rate of a reaction by changing a factor.
SCI.9-12.5.2.12.D.b	The driving forces of chemical reactions are energy and entropy. Chemical reactions either release energy to the environment (exothermic) or absorb energy from the environment (endothermic).
SCI.9-12.5.2.12.D.d	Energy may be transferred from one object to another during collisions.
SCI.9-12.5.2.12.D.e	Chemical equilibrium is a dynamic process that is significant in many systems, including biological, ecological, environmental, and geological systems. Chemical reactions occur at different rates. Factors such as temperature, mixing, concentration, particle size, and surface area affect the rates of chemical reactions.

Big Idea 4

Big Idea 4: Rates of chemical reactions are determined by the details of the molecular collisions.

Enduring understanding 4.A

Enduring understanding 4.A: Reaction rates that depend on temperature and other environmental factors are determined by measuring changes in concentrations of reactants or products over time.

Essential knowledge 4.A.1

Essential knowledge 4.A.1: The rate of a reaction is influenced by the concentration or pressure of reactants, the phase of the reactants and products, and environmental factors such as temperature and solvent.

a. The rate of a reaction is measure by the amount of reactants coverted to products per unit of time.

b. A variety of means exist to experimentally measure the loss of reactants or increase of products as a function of time. One important method involves the spectroscopic determination of concentration through Beer's law.

c. The rate of a reaction is influnenced by reactant concentrations (except in zero-order processes), temperature, surface area, and other enviromental factors.

Learning Objective for 4.A.1

Learning Objective 4.1 The Student is able to design and/or interpret the results of an experiment regarding the factors (i.e., temperature, concentration, surface area) that may influence the rate of a reaction

Essential knowledge 4.A.2

Essential Knowledge 4.A.2: The rate law shows how the rate depends on reactant concentrations.

a. The rate law expresses the rate of a reaction as proportional to the concentration of each reactant raised to a power. The power of each reeactant in the rate law is the order of the reaction with respect to that reactant. The sum of the powers of the reactant concentration in the rate law is the overall order of the reaction. When the rate is independent of the concentration of a reactant, the reaction is zeroth order in that reactant, since raising the reactant concentration to the power zero is equivalent to the reactant concentration ebing absent from the rate law.

b. In cases in which the concentration of any other reactants remain essentially constant during the course of the reaction, the order of a reaction with respect to a reactant concentration can be inferred from plots of the concentration of reactant versus time. An appropriate laboratory experience would be for students to use spectrophotometry to determine how concentration varies with time.

c. The method of initial rates is useful for developing conceptual understanding of what a rate law represents, but simple algorithmic application should not be considered mastery of the concept. Investigation of data for initial rates enables prediction of how concentration will vary as the reaction progresses.

Enduring understanding 4.B

Enduring understanding 4.B: Elementary reactions are mediated by collisions between molecules. Only collisions having sufficient energy and proper relative orientation of reactants lead to products.

Essential knowledge 4.B.1

Essential knowledge 4.B.1: Elementary reactions can be unimolecular or involve collisions between two or more molecules.
a. The order of an elementary reaction can be inferred from the number of molecules participating in a collision: unimolecular reactions are first order, reactions involving bimolecular collisions are second order, etc.
b. Elementary reactions involving the simultaneous collision of three particles are rare.

Learning Objective 4.4

LO 4.4 The student is able to connect the rate law for an elementary reaction to the frequency and success of molecular collisions, including connecting the frequency and success to the order and rate constant, respectively.

Essential knowledge 4.B.2

Essential knowledge 4.B.2: Not all collisions are successful. To get over the activation energy barrier, the colliding species need sufficient energy. Also, the orientations of the reactant molecules during the collision must allow for the rearrangement of reactant bonds to form product bonds.
a. Unimolecular reactions occur because collisions with solvent or background molecules activate the molecule in a way that can be understood in terms of a Maxwell-Boltzmann thermal distribution of particle energies.
b. Collision models provide a qualitative explanation for order of elementary reactions and the temperature dependence of the rate constant.
c. In most reactions, only a small fraction of the collisions leads to a reaction. Successful collisions have both sufficient energy to overcome activation energy barriers and orientations that allow the bonds to rearrange in the required manner.
d. The Maxwell-Boltzmann distribution describes the distribution of particle energies; this distribution can be used to gain a qualitative estimate of the fraction of collisions with sufficient energy to lead to a reaction, and also how that fraction depends on temperature.

Learning Objective 4.5

LO 4.5 The student is able to explain the difference between collisions that convert reactants to products and those that do not in terms of energy distributions and molecular orientation.

Essential knowledge 4.B.3

Essential knowledge 4.B.3: A successful collision can be viewed as following a reaction path with an associated energy profile.
a. Elementary reactions typically involve the breaking of some bonds and the forming of new ones. It is usually possible to view the complex set of motions involved in this rearrangement as occurring along a single reaction coordinate.

b. The energy profile gives the energy along this path, which typically proceeds from reactants, through a transition state, to products.
c. The Arrhenius equation can be used to summarize experiments on the temperature dependence of the rate of an elementary reaction and to interpret this dependence in terms of the activation energy needed to reach the transition state.

Learning Objective 4.6

LO 4.6 The student is able to use representations of the energy profile for an elementary reaction (from the reactants, through the transition state, to the products) to make qualitative predictions regarding the relative temperature dependence of the reaction rate.

Enduring understanding 4.C

Enduring understanding 4.C: Many reactions proceed via a series of elementary reactions.

Learning Objective 4.7

LO 4.7 The student is able to evaluate alternative explanations, as expressed by reaction mechanisms, to determine which are consistent with data regarding the overall rate of a reaction, and data that can be used to infer the presence of a reaction intermediate.

Essential knowledge 4.C.2

Essential knowledge 4.C.2: In many reactions, the rate is set by the slowest elementary reaction, or rate-limiting step.
a. For reactions in which each elementary step is irreversible, the rate of the reaction is set by the slowest elementary step (i.e., the rate-limiting step).

Enduring understanding 4.D

Enduring understanding 4.D: Reaction rates may be increased by the presence of a catalyst.

Essential knowledge 4.D.1

Essential knowledge 4.D.1: Catalysts function by lowering the activation energy of an elementary step in a reaction mechanism, and by providing a new and faster reaction mechanism.
a. A catalyst can stabilize a transition state, lowering the activation energy and thus increasing the rate of a reaction.
b. A catalyst can increase a reaction rate by participating in the formation of a new reaction intermediate, thereby providing a new reaction pathway or mechanism.

Learning Objective 4.8

LO 4.8 The student can translate among reaction energy profile representations, particulate representations, and symbolic representations (chemical equations) of a chemical reaction occurring in the presence and absence of a catalyst.

Essential knowledge 4.D.2

Essential knowledge 4.D.2: Important classes in catalysis include acidbase catalysis, surface catalysis, and enzyme catalysis.
a. In acid-base catalysis, a reactant either gains or loses a proton; this changes the rate of the reaction.
b. In surface catalysis, either a new reaction intermediate is formed, or the probability of successful collisions is modified.
c. Some enzymes accelerate reactions by binding to the reactants in a way that lowers the activation energy. Other enzymes react with reactant species to form a new reaction intermediate.

Learning Objective 4.9

LO 4.9 The student is able to explain changes in reaction rates arising from the use of acid-base catalysts, surface catalysts, or enzyme catalysts, including selecting appropriate mechanisms with or without the catalyst present.

Resources

Powerpoint -

Gases

Chemical Kinetics

Chemical Equilibrium

Assessments

https://docs.google.com/document/d/1wR7bQF-8AQoRrt0g4C3hKja0yjwDjC9_BiAmONWbTcI/edit?usp=sharing

Modifications

https://docs.google.com/document/d/1ODqaPP69YkcFiyG72fIT8XsUIe3K1VSG7nxuc4CpCec/edit