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HS-PS1-5 Matter and its Interactions

California Science Test—Item Content Specifications

# HS-PS1-5 Matter and its Interactions

Students who demonstrate understanding can:

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.

[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.*]

| Science and Engineering Practices | Disciplinary Core Ideas | Crosscutting Concepts |
| --- | --- | --- |
| Constructing Explanations and Designing SolutionsConstructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.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**7. 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. | PatternsDifferent 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. |

## Assessment Targets

Assessment targets describe the focal knowledge, skills, and abilities for a given three-dimensional Performance Expectation. Please refer to the Introduction for a complete description of assessment targets.

### Science and Engineering Subpractice(s)

Please refer to appendix A for a complete list of Science and Engineering Practices (SEP) subpractices. Note that the list in this section is not exhaustive.

6.1 Ability to construct explanations of phenomena

### Science and Engineering Subpractice Assessment Targets

Please refer to appendix A for a complete list of SEP subpractice assessment targets. Note that the list in this section is not exhaustive.

6.1.1 Ability to construct quantitative and/or qualitative explanations of observed relationships based on valid and reliable evidence

6.1.2 Ability to apply scientific concepts, principles, theories, and big ideas to construct an explanation of a real-world phenomenon

6.1.3 Ability to use models and representations in scientific explanations

### Disciplinary Core Idea Assessment Targets

#### PS1.B.7

* Recognize that the collision of molecules may result in the breaking of bonds and the forming of new bonds
* Quantify energy transfer associated with the breaking of bonds (energy required) and forming of bonds (energy released)
* Use ideas regarding probability and kinetic energy to describe chemical reactions in terms of a chance collision between molecules with sufficient kinetic energy (i.e., activation energy) to undergo a chemical change
* Use temperature as a measure of the average kinetic energy of molecules and, by extension, of the average mass or average speed of the molecules
* Describe the relationship between temperature and reaction rate in terms of temperature’s impact on frequency of collisions and on the percentage of molecules that have sufficient kinetic energy to meet activation energy requirements
* Describe the relationship between concentration in solution, collision frequency, and number of collisions producing the reaction
* Describe a mathematical rate law that considers the number of successful collisions and its dependence on the temperature and concentration of the reactants
* Describe that the reactants and products have different potential energies or total bond energies because of the different arrangement of atoms, resulting in a net energy change in the chemical system

### Crosscutting Concept Assessment Target(s)

CCC1 Identify different patterns at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena

## Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides a chemical equation representing simple two-reactant reaction and rate data:

* Uses the data to make a conclusion about the relationship between concentration and rate of reaction (6.1.1, PS1.B.7, and CCC1)
* Uses the data to explain an observed pattern between concentration and the rate of reaction (6.1.1, PS1.B.7, and CCC1)

Task provides observations of a simple two-reactant reaction that illustrates the temperature or concentration dependence of reaction rate:

* Explains the observations using concepts of collision theory (6.1.2, PS1.B.7, and CCC1)

Task provides observations of a simple two-reactant reaction that illustrates a pattern of temperature or concentration dependence of reaction rate:

* Identifies the model that best explains the systematic pattern of observations (6.1.3, PS1.B.7, and CCC1)

Task provides a model of a simple two-reactant reaction that illustrates collision theory:

* Uses the model to construct an explanation of the temperature or concentration dependence of the reaction rate (6.1.3, PS1.B.7, and CCC1)

## Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

* Measurements or observations of a property of a reaction (e.g., color change or mass of product) carried out at different temperatures
* Data that show how a chemical system responds if the concentrations of each reactant are changed
* Real-world examples of the temperature or concentration dependence of reaction rates on catalysts and enzymes
* Graphs of changes in concentration vs. time for a reactant at different initial concentrations that show the relationship between instantaneous rate changes and collision frequency

## Common Misconceptions

Note that the list in this section is not exhaustive.

* Matter is continuous rather than particulate.
* Any collision of particles will result in a chemical reaction.
* All reaction rates increase or remain constant over time.
* Reactions are purposeful.

## Additional Assessment Boundaries

None listed at this time.

## Additional References

HS-PS1-5 Evidence Statement [https://www.nextgenscience.org/sites/default/files/evidence\_statement/black\_white/HS-PS1-5 Evidence Statements June 2015 asterisks.pdf](https://www.nextgenscience.org/sites/default/files/evidence_statement/black_white/HS-PS1-5%20Evidence%20Statements%20June%202015%20asterisks.pdf)

The *2016 Science Framework for California Public Schools Kindergarten through Grade 12*

Appendix 1: Progression of the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts in Kindergarten through Grade 12 <https://www.cde.ca.gov/ci/sc/cf/documents/scifwappendix1.pdf>

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