

HS-PS1-6 Matter and its Interactions

California Science Test—Item Content Specifications

# HS-PS1-6 Matter and its Interactions

Students who demonstrate understanding can:

Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

[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.*]

| Science and Engineering Practices | Disciplinary Core Ideas | Crosscutting Concepts |
| --- | --- | --- |
| Constructing Explanations and Designing Solutions  Constructing 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.  Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. | PS1.B: Chemical Reactions   1. 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   1. Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. *(secondary to HS-PS1-6)* | Stability and Change  Much of science deals with constructing explanations of how things change and how they remain stable. |

## 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.

6E.2 Ability to evaluate and/or refine solutions to design problems

### 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.

6E.2.1 Ability to compare or critique competing design solutions based on design criteria

6E.2.2 Ability to evaluate and/or refine (optimize) design solutions based on scientific knowledge or evidence

### Disciplinary Core Idea Assessment Targets

#### PS1.B.8

* Recognize that for a reversible chemical reaction at equilibrium, both reactants and products are present in concentrations that do not change over time
* Explain that although the concentrations of the reactants and products remain unchanged at the macroscopic level, chemical changes are occurring at the molecular level
* Explain that for a reversible reaction at equilibrium, the rates of the forward and reverse reactions are equal
* Explain that a change to one component (e.g., increasing the concentration of a reactant) in a chemical system at equilibrium affects the other components
* Explain that rates of the forward and reverse reactions will change and the equilibrium will shift in response to a change to the system (i.e., a stress) until equilibrium is re-established

#### ETS.1.C.5

* Explain that criteria for solving complex real-world problems, such as the optimization of a chemical system, may need to be broken down into simpler ones that can be evaluated systematically
* Explain that the prioritization of criteria or constraints (tradeoffs) may be necessary for the selection of a design solution

### Crosscutting Concept Assessment Target(s)

CCC7 Construct explanations of how things change and how they remain stable

## Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides a description of a chemical reaction system at equilibrium, criteria (e.g., increase the amount of product formed), and a list of possible changes, or stresses, to the system:

* Identifies the change(s) to the system that will meet the criteria (6E.2.1, PS1.B.8, and CCC7)

Task provides a description of a chemical reaction system at equilibrium, criteria (e.g., increase the amount of product formed), constraints, and a list of possible changes, or stresses, to the system:

* Assesses how well each change meets the criteria and constraints (6E.2.1, PS1.B.8, and CCC7)

Task provides a description of a chemical reaction system at equilibrium, criteria (e.g., increase the amount of product formed), and two or more possible changes, or stresses, to the system to meet the criteria:

* Identifies tradeoffs or advantages and disadvantages for each change (6E.2.1, PS1.B.8, and CCC7)

Task provides a description of a chemical reaction system at equilibrium and two or more changes to the system, one of which is identified as best meeting the criteria and/or constraints, and data related to the changes to the system:

* Identifies the prioritized criteria and/or constraints that resulted in selection of one change over the alternatives (6E.2.1, PS1.B.8, and CCC7)

Task provides a description of a chemical reaction system at equilibrium, a list of possible changes to the system, data related to the changes to the system, and prioritized criteria or constraints:

* Selects the change that best meets the prioritized criteria or constraints and provides justification for the selection based on prioritization of criteria (6E.2.1, PS1.B.8, and CCC7)

Task provides a description of a chemical reaction system at equilibrium, criteria (e.g., increase the amount of product formed), and a change to the system:

* Identifies or describes the scientific principles that support the effectiveness of the change to meet the criteria (e.g., an increase in the concentration of a reactant results in an increase in the rate of the forward reaction) (6E.2.2, PS1.B.8, and CCC7)

Task provides a description of a chemical reaction system at equilibrium, a list of possible changes to the system, and data related to the changes to the system:

* Selects the change that best meets the criteria and justifies the change using the data (6E.2.2, PS1.B.8, and CCC7)

## Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

* Effect of pressure changes on concentrations in simple gas-phase reactions
* Effect of enzymes on reaction rates
* Effect of changing concentrations in
  + Carbonic acid reactions (to show changes in acidity or blood pH); or
  + Equilibrium reactions involving nitrogen oxides in the atmosphere.

## Common Misconceptions

Note that the list in this section is not exhaustive.

* At equilibrium, both the forward and reverse reactions stop.
* The amounts of reactants and products are equal at equilibrium.
* Catalysts affect the equilibrium concentration of the components in a chemical system.
* The amount of solids present affects the equilibrium concentration of the components in a chemical system.

## Additional Assessment Boundaries

None listed at this time.

## Additional References

HS-PS1-6 Evidence Statement [https://www.nextgenscience.org/sites/default/files/evidence\_statement/black\_white/HS-PS1-6 Evidence Statements June 2015 asterisks.pdf](https://www.nextgenscience.org/sites/default/files/evidence_statement/black_white/HS-PS1-6%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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