

MS-PS1-4 Matter and its Interactions

California Science Test—Item Content Specifications

# MS-PS1-4 Matter and its Interactions

Students who demonstrate understanding can:

Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

[Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawing and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]

Continue to the next page for the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts.

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| Science and Engineering Practices | Disciplinary Core Ideas | Crosscutting Concepts |
| Developing and Using Models  Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.  Develop a model to predict and/or describe phenomena. | PS1.A: Structure and Properties of Matter  9. Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.  10. In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.  12. The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.  PS3.A: Definitions of Energy  4. The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. *(secondary to MS-PS1-4)* | Cause and Effect  Cause and effect relationships may be used to predict phenomena in natural or designed systems. |
| Continuation of the previous row:  Not applicable | Continuation of the previous row:  5. The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system’s material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. *(secondary to MS-PS1-4)* | Continuation of the previous row:  Not applicable |

## 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.

2.1 Ability to develop models

2.2 Ability to use models

### 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.

2.1.1 Ability to determine components of a scientific event, system, or design solution

2.1.2 Ability to determine the relationships among multiple components of a scientific event, system, or design solution

2.1.3 Ability to determine scope, scale, and grain-size of models, as appropriate for their intended use

2.2.1 Ability to use models to identify concepts and relationships represented in the models

2.2.2 Ability to use models to generate explanations and predictions about a scientific phenomenon

### Disciplinary Core Idea Assessment Targets

#### PS1.A.9

* Describe liquid and gaseous substances in terms of the movement of their smaller constituent particles

#### PS1.A.10

* Differentiate states of matter of a substance by the spacing of the constituent particles
* Describe a solid state of matter in terms of particles vibrating in fixed positions

#### PS1.A.12

* Make inferences about the ways that changes in temperature or pressure affect states of matter
* Describe the pressure of a gas in terms of the motion of its particles and the collisions of those particles with other materials

#### PS3.A.4

* Identify “heat” as the transfer of thermal energy from objects of greater temperature to objects of lesser temperature

#### PS3.A.5

* Define temperature as the average kinetic energy of particles to explain the relationship between the motion of particles, their mass, and the bulk temperature of a substance
* Distinguish between transfer of thermal energy and temperature
* Calculate the total thermal energy of a system from the temperature, total number of atoms in the system, and the state of matter

### Crosscutting Concept Assessment Target(s)

CCC2 Use cause and effect relationships to predict phenomena in natural or designed systems

## Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides a description of a class of phenomena (e.g., change of state) in which thermal energy transfers to or from a substance. The task provides a particle-level model for the energy transfer that may need refinement:

* Selects or labels the components/features of the model that represent relevant cause-and-effect relationships during a particular energy transfer phenomenon (2.1.1, PS1.A.10, and CCC2
* Selects or labels the components/features of the model that are relevant in making a prediction regarding the effect of adding or removing thermal energy from the system (2.1.1, PS1.A.12, and CCC2)

Task provides an incomplete model of a phenomenon that involves the transfer of thermal energy to/from a substance and a list of relevant and irrelevant components to complete the model:

* Completes the model in a way that assists in making a prediction about how the system will change when thermal energy is added or removed (2.1.1, PS1.A.12, and CCC2)

Task provides a description of a phenomenon that involves the transfer of thermal energy to or from a substance and several models that represent the energy transfer at different scales (i.e., particle level, bulk level, something halfway between the two):

* Selects the appropriate scales to illustrate the relative change(s) that occurred due to the transfer of thermal energy (2.1.2, PS3.A.4, and CCC2)
* Provides correct reasoning for the selection of scale considering a goal to predict changes in a system as a result of thermal energy transfer (2.1.2, PS3.A.4, and CCC2)

Task provides a model of a phenomenon that illustrates the changes to temperature, kinetic energy, pressure, and/or motion of particles after adding or removing thermal energy from the system:

* Uses the model to explain the causal relationships between the addition or release of thermal energy and the other components (2.2.1, PS3.A.5, and CCC2)
* Identifies evidence illustrated in the model that changes in features of the system/substance were due to the addition or removal of thermal energy (2.2.1, PS3.A.5, and CCC2)
* Generates (or selects) an accurate statement predicting the likely outcome of the addition or removal of thermal energy to some aspect of the system that highlights a cause-effect relationship illustrated in the model (2.2.2, PS1.A.12, and CCC2)

## Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

* Changes of state because of thermal energy transfer to or from a substance
* Feeling of heat or cold resulting from contact with a substance
* Changes in pressure or temperature of particles in a closed system
* Particle diagrams representing the effect of adding or removing thermal energy

## Common Misconceptions

Note that the list in this section is not exhaustive.

* Thermal energy, heat, and temperature are interchangeable terms.
* Temperature is an extensive quantity, and it is a measure of heat.
* Particles expand or break up when thermal energy is added and contract when thermal energy is released.

## Additional Assessment Boundaries

None listed at this time.

## Additional References

MS-PS1-4 Evidence Statement [https://www.nextgenscience.org/sites/default/files/evidence\_statement/black\_white/MS-PS1-4 Evidence Statements June 2015 asterisks.pdf](https://www.nextgenscience.org/sites/default/files/evidence_statement/black_white/MS-PS1-4%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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