Educational Resources from *Phenomenon Science Education*

Student Proficiency Goals for **NGSS MS-PS1-4**

Information about MS-PS1-4

NGSS Performance Expectation MS-PS1-4.

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.

Assessment Limits.

No specific assessment limits are listed for this Performance Expectation.

Science and Engineering Practice (Developing and Using Models)

- Develop a model to predict and/or describe phenomena.

Disciplinary Core Idea (PS1.A: Structure and Properties of Matter)

- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- 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.
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

Disciplinary Core Idea (PS3.A: Definitions of Energy)

- 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)

- 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)

Crosscutting Concept (Cause and Effect)

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

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Student Proficiency Goals

SEP (Developing and Using Models):

- Students identify and assign roles for the components required for their models.
- Students develop models capable of addressing phenomena related to the motion of particles in pure substances.
- Students develop models capable of describing states of matter of particles of pure substances under specific conditions of temperature and pressure.
- Students use models to predict and demonstrate changes in particle motion when thermal energy is added or removed from systems under study.

DCI (PS1.A Structure and Properties of Matter):

- Students know that particles in a gas are widely spaced and constantly and independently moving relative to each other, such that the particles collide and move away.
- Students know that particles in a liquid are in contact with each other and are constantly moving relative to each other.
- Students know that particles in a solid are closely spaced and do not change locations compared to other particles, but that they do vibrate in position.
- Students know that changes of state can involve changes in temperature that cause particles to move more quickly or more slowly.
- Students know that changes in state can involve changes in pressure that force particles to be closer or further apart.

CCC (Cause and Effect):

- Students consider the roles of particle motion in observed states (i.e., solid, liquid, or gas).
- Students predict how changes in thermal energy change the motions of particles in pure substances.
- Students consider the cause-and-effect relationships of temperature and pressure effects on particles in pure substances which result in states of matter.

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Student Proficiency Goals for **NGSS MS-PS1-4**

DCI (PS3.A Definitions of Energy): • Students know that the term *heat* refers to the energy transferred due to a temperature difference between two objects. • Students know that the temperature of a system is proportional to the average kinetic energy and potential energy of particles in that system. • Students know that temperature is not a direct measure of a system's total thermal energy. • Students know that a system's total thermal energy depends on the temperature, the total number of atoms in the system, and the state of the material (i.e., solid, liquid, or gas).	