

## 1 Identify a Cluster of PEs

Performance Expectations related to Energy and Particles of Matter: MS-PS1-1 MS-PS1-4 MS-PS3-4

**MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substances 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.

## 2a Unpack Science Practices

### Developing Models

Component	Evidence
Model elements	<b>Specifies</b> only the appropriate and necessary elements (and their attributes) in the model
Relationships among elements	<b>Represents</b> only the appropriate relationships and/or interactions among the elements in the model
Correspondence	<b>Represents</b> the correspondence between model elements and the real world phenomenon or available data
Limitations	<b>Specifies</b> the appropriate limitations of the model

### Using Models

Component	Evidence
Model elements	<b>Identifies</b> the appropriate and necessary elements (and their attributes) in the model
Relationships among elements	<b>Describes</b> the appropriate relationships and/or interactions among the elements in the model
Correspondence	<b>Describes</b> the correspondence between model elements and the real world phenomenon or available data
Limitations	<b>Identifies</b> the appropriate limitations of the model
Explanation/prediction	<b>Explains</b> or predicts phenomena using the model

## 2b Unpack Disciplinary Core Ideas

### PS1.A Structure and Properties of Matter

#### Identify and further elaborate major ideas

- Substances can be in the form of simple molecules or extended structures. The atoms that join together can be the same or different types of atoms.
- Simple molecules are composed of two or more atoms joined together as a groups of atoms, and we know the actual number of atoms in the molecule. Examples:  $\text{CO}_2$ ,  $\text{H}_2\text{O}$ ,  $\text{CH}_3\text{OH}$ ,  $\text{NH}_3$ ,  $\text{C}_6\text{H}_{12}\text{O}_6$ ,  $\text{CH}_2\text{Cl}_2$ .
- Matter is made of atoms and molecules. These atoms and molecules are constantly in motion. All particles of matter have kinetic energy because they are in motion.

#### Define boundary conditions

- Students are not expected to know the relationship between heat and temperature.
- Students are not expected to compare situations where both the number of particles and the temperature of the objects vary.

#### Describe prior knowledge

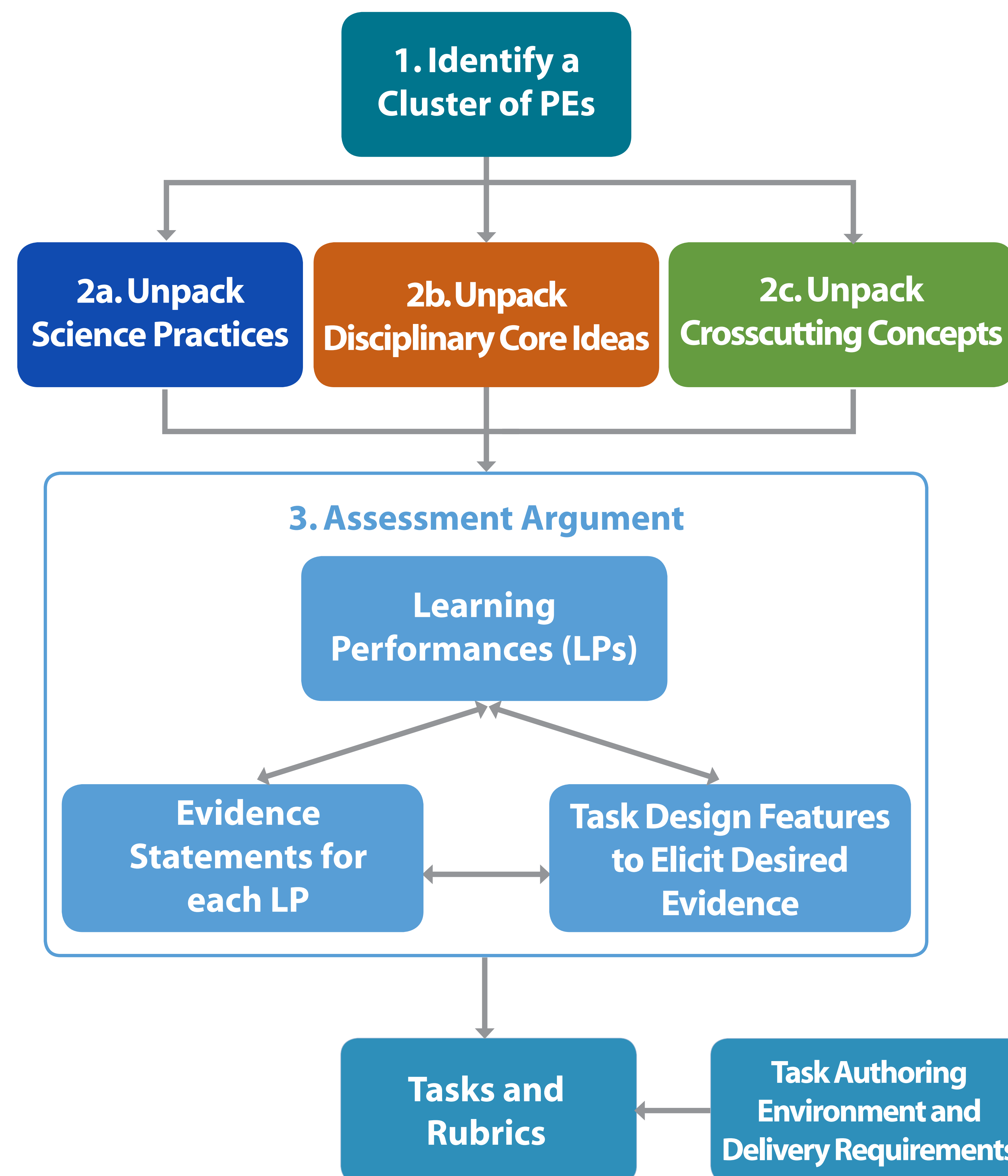
5-PS1-1: Develop a model to describe that matter is made of particles too small to be seen.

#### Student challenges

- Particle sizes of substances are increased when changing states from liquid to gas (Pereira & Pestana, 1991; Griffiths & Preston, 1989).

## A Design Process for Developing Next Generation Science Assessments

High-quality assessments of student learning that are aligned with standards are critical to developing a coherent and consistent approach to K-12 science education. Here we showcase our design process for creating next generation science assessments. We illustrate this process with one performance expectation related to energy and matter at the middle school level. This design process incorporates principles of evidence-centered design and state-of-the-art psychometric methods within an integrated validity framework to develop, test and analyze diagnostic, classroom-based assessments that address science practices and crosscutting concepts in the area of physical science. A range of classrooms and curricula are involved in the research, including classrooms using a science curriculum designed to help students learn the scientific practices and content specified in Next Generation Science Standards. A unique feature of the research is the inclusion of teachers in co-developing resources for formative use of the assessments. The design framework and the assessments will serve as timely models for next generation science assessments.



## 2c Unpack Crosscutting Concepts

### Patterns

#### Important components

- Identification:** Identifying patterns in phenomena or data
- Characterization:** Characterizing the strength, direction, and/or nature of patterns in phenomena or data
- Categorization:** Organizing and classifying objects or relationships into types according to similarities or differences

#### Intersection with practices

- Construct explanations** about how and why particular patterns occur
- Develop and use models** to describe observed patterns or predict patterns
- Analyze data** to identify/characterize patterns
- Plan investigations** to discover patterns
- Construct arguments** about the validity of observed patterns

#### Patterns that manifest in the MS chemistry core ideas

- Spatially or temporally repeating occurrences (e.g. extended atomic structures, phase changes)
- Similarities, differences, comparisons, and categories (e.g. comparing physical properties before and after substances interact, distinguishing states or types of matter)
- Correlations and trends (e.g. Relating particle motion, mass, temperature, kinetic energy, changes in thermal energy)

## 3 Develop the Assessment Argument

### Learning performance

Students are able to develop a model to describe how particle motion changes when thermal energy is added and removed

### Evidence

**Model elements:** Model includes two or more atoms in motion, addition and/or removal of thermal energy, and representation of motion/kinetic energy

**Relationships among elements:** Model shows that particles move faster (slower) if thermal energy is added (removed)

**Correspondence:** Model elements corresponds to real world phenomena (e.g., describes how M&M dye expands faster when M&M is in hot water vs. cold water)

### Additional KSAs

- Knowledge matter is made of particles too small to be seen
- Knowledge of atoms and common simple molecules
- Knowledge that a model should include important elements, relationships among elements
- Ability to construct a paper-pencil drawing or use a technology-based drawing tool

### Characteristic task features

- Task presents real-world phenomenon
- Task includes situation where thermal energy varies
- Models do not need to include components of sub-particles, shells and bonds.
- The relative size of different types of atoms and ratio is not considered for the middle school level

### Variable task features

- Types of models: drawing, 3D-ball and stick model, sphere model or computer simulation
- Types of substances
- State of matter of substances (i.e., solid, liquid, or gas state)
- Level of scaffolding to develop models