Chemistry	Form 2

Science Assessment Teacher's Guide

ASSESSMENT GUIDELINES

About this Assessment

This assessment is offered as an instructional tool for schools implementing the Next Generation Science Standards.* Teachers will administer this assessment to gauge student understanding of science related to the performance expectations outlined in the Test Specifications on the next page.

The specifications, or test blueprint, lists the item types, item position, and depth of knowledge level coded to each item. Callouts of the three dimensions—Science and Engineering Practices (SEP), Disciplinary Core Ideas (DCI), and Crosscutting Concepts (CCC)—are also listed with each Performance Expectation.**

The assessment consists of 10 questions and is organized into two sections. Each section includes 5 questions (selected-response and constructed-response items).

Section I includes 5 stand-alone questions.

Section II includes 5 questions clustered together as a performance task. The performance task includes a stimulus or context for the set of questions.

Administering the Assessment

The estimated administration time for this assessment is 90–100 minutes. The Performance Task portion of the assessment should take 50–60 minutes.

You may administer each section in two separate sessions or two class periods if more time is needed.

Students will be writing their answers on a separate sheet of paper.

Scoring the Assessment

You may use the answer key, rubrics, and sample student responses provided in the Scoring Guide to score the student responses. All selected-response items include distractor rationales to support the analysis of student responses. Distractors provide insight to student misconceptions.

After the Assessment

Teachers in their department or grade level may use the results to discuss instructional implications, using protocols such as "Consultancy" or any other protocol or process they see fit.

** Note that due to the complexity of the PEs, individual assessment items may not address all three dimensions.

Specifications

Section I—Item Bundle

Item Position	Performance Expectation(s)	Item Type	Point Value	DOK
1	HS-PS1-1 Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. SEP: Developing and Using Models DCI: PS1.A Structure and Properties of Matter CCC: Patterns	SR	1	2
2	HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. SEP: Constructing Explanations and Designing Solutions DCI: PS1.A Structure and Properties of Matter CCC: Patterns	SR	1	2
3	HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. SEP: Using Mathematical and Computational Thinking DCI: PS1.B Chemical Reactions CCC: Energy and Matter	SR	1	2
4	HS-PS1-1 Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. SEP: Developing and Using Models DCI: PS1.A Structure and Properties of Matter CCC: Patterns	CR	2	3
5	HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. SEP: Constructing Explanations and Designing Solutions DCI: PS1.A Structure and Properties of Matter CCC: Patterns	ECR	3	3

Item Types: (SR) selected-response, (CR) constructed-response, (ECR) extended-constructed-response

** The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.*

Section II—Performance Task

Focus

The phenomenon being studied in this assessment is thermal energy transfer.

Item Position	Performance Expectation(s)	Item Type	Point Value	DOK
6	HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. SEP: Using Mathematical and Computational Thinking DCI: PS3.A Definitions of Energy; PS3.B Conservation of Energy and Energy Transfer CCC: System and System Models	SR	1	2
7	HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. SEP: Using Mathematical and Computational Thinking DCI: PS3.A Definitions of Energy; PS3.B Conservation of Energy and Energy Transfer CCC: System and System Models	CR	2	3
8	HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects). SEP: Developing and Using Models DCI: PS3.A Definitions of Energy CCC: System and System Models	SR	1	2
9	HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). SEP: Planning and Carrying Out Investigations DCI: PS3.B Conservation of Energy and Energy Transfer; PS3.D Energy in Chemical Processes CCC: System and System Models	CR	2	3

Item Types: (SR) selected-response, (CR) constructed-response, (ECR) extended-constructed-response

** The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.*

Section II—Performance Task (continued)

Item Position	Performance Expectation(s)	Item Type	Point Value	DOK
10	HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. SEP: Developing and Using Models DCI: ESS2.A Earth's Materials and Systems; ESS2.B Plate Tectonics and Large-Scale System Interactions CCC: Energy and Matter	CR	2	3

Item Types: (SR) selected-response, (CR) constructed-response, (ECR) extended-constructed-response

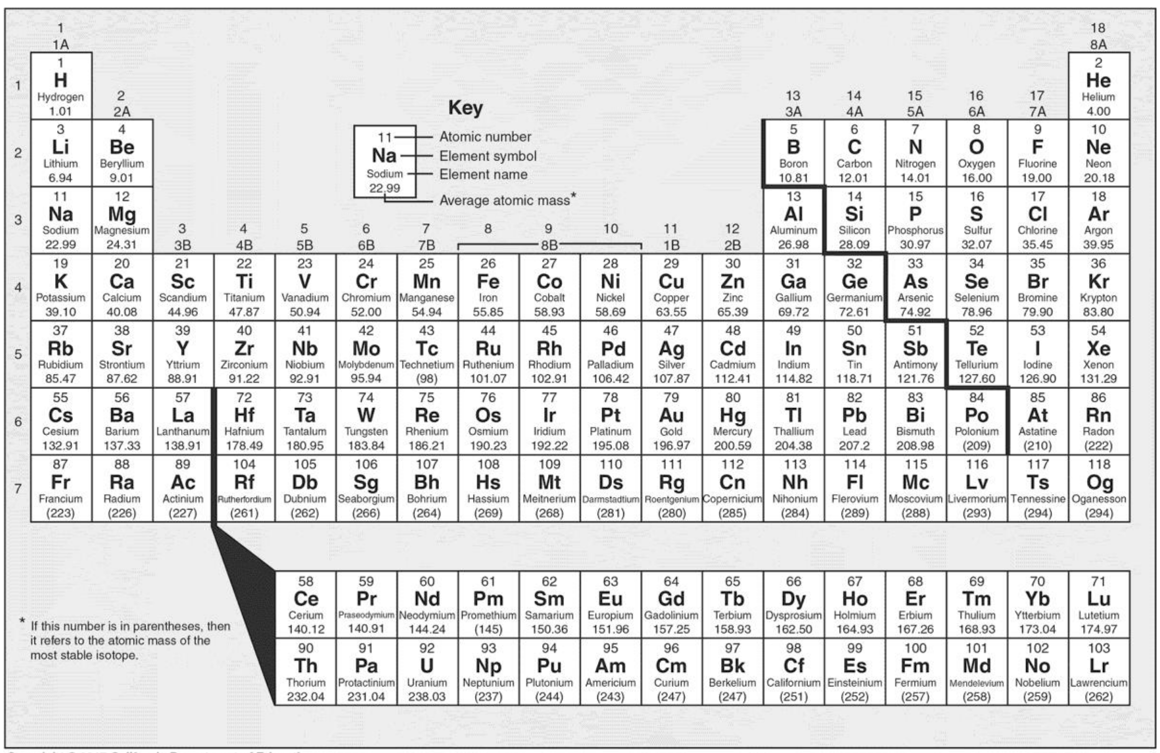
** The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.*

Scoring Guide | Chemistry | Form 1

Section I—Item Bundle

	Performance Expectation	Item Type	DOK
HS-PS1-1	Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. SEP: Developing and Using Models DCI: PS1.A Structure and Properties of Matter CCC: Patterns	SR	2

1. Carlos goes on a field trip to a local aquarium and learns that sea water contains various types of salt compounds. He also learns that most of the salt compounds in sea water are sodium chloride (NaCl). Carlos then reviews the periodic table, as shown.



Which elements would bond to form a salt compound **most** like sodium chloride?

A potassium (K), fluorine (F)

B magnesium (Mg), bromine (Br)

C calcium (Ca), carbon (C), oxygen (O)

D calcium (Ca), sulfur (S), oxygen (O), hydrogen (H)

Distractor Rationales	
A	**Key. This is similar to the sodium chloride salt because it is also formed by a halogen and an alkali metal.**
B	This would require 2 bromides instead of 1, like sodium chloride.
C	A salt from these elements would be more dissimilar than similar to sodium chloride.
D	A salt from these elements would be more dissimilar than similar to sodium chloride.

Performance Expectation		Item Type	DOK
HS-PS1-2	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. SEP: Constructing Explanations and Designing Solutions DCI: PS1.A Structure and Properties of Matter CCC: Patterns	SR	2

2. A chemistry teacher asks Louise to predict whether this reaction will occur.

$$Cl_2 + 2KBr \rightarrow Br^2 + 2KCl$$

What is the **best** prediction for the results of the combined substances?

A The reaction will occur, because chlorine (Cl) has a smaller atomic radius than bromine (Br) and will attract more electrons.

B The reaction will occur, because chlorine (Cl) has a larger atomic radius than bromine (Br) and will attract fewer electrons.

C The reaction will not occur, because chlorine (Cl) has a larger atomic radius than bromine (Br) and will attract fewer electrons.

D The reaction will not occur, because chlorine (Cl) has a smaller atomic radius than bromine (Br) and will attract more electrons.

Distractor Rationales	
A	**Key. This is a single replacement reaction that will produce two molecules of potassium chloride (KCl) and one molecule of bromide (Br_2).**
B	Chlorine has a smaller atomic radius and attracts more electrons.
C	Chlorine (Cl) has a smaller atomic radius, which attracts more electrons and the reaction does occur.
D	Chlorine (Cl) has a smaller atomic radius and the reaction does occur.

Performance Expectation		Item Type	DOK
HS-PS1-7	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. SEP: Using Mathematical and Computational Thinking DCI: PS1.B Chemical Reactions CCC: Energy and Matter	SR	2

3. In chemistry class, Melissa observes an exothermic reaction when she combines magnesium and oxygen under a fume hood. The equation for the reaction is shown.

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s) + energy$$

Which statement **best** describes the reactants and products?

A More atoms are in the products than in the reactants.

B Fewer overall atoms are in the products than in the reactants.

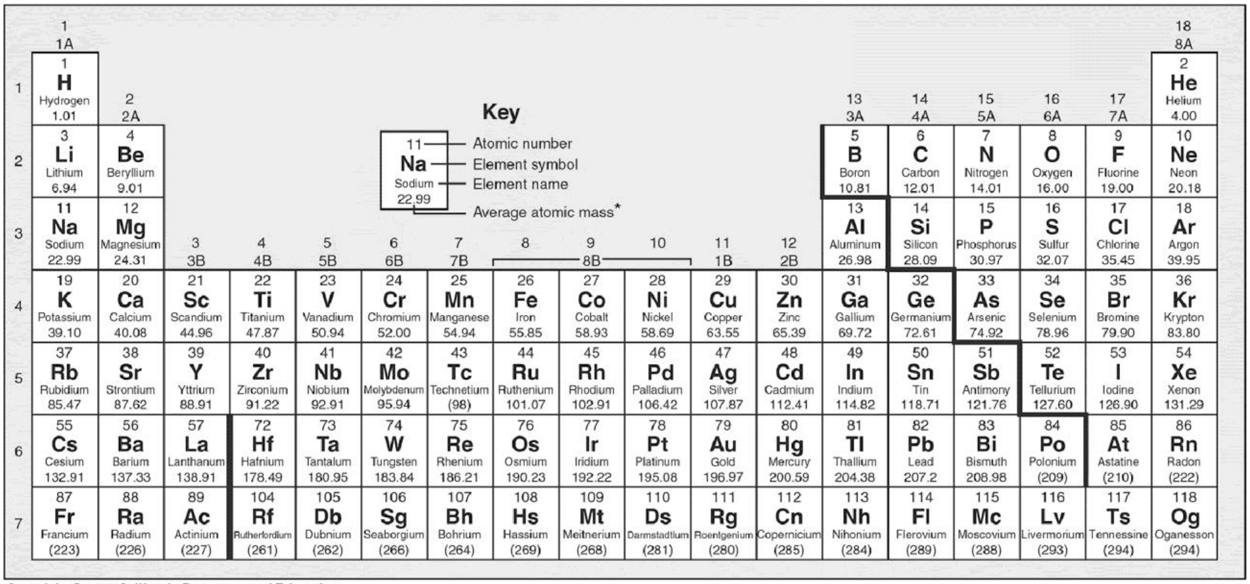
C Twice as many oxygen atoms are in the reactants as in the products.

D Equal numbers of magnesium atoms are in the reactants as in the products.

Distractor Rationales	
A	This would not follow the law of conservation. The number of atoms in the products is equal to the number of atoms in the reactants.
B	This would not follow the law of conservation. The number of atoms in the reactants is equal to the number of atoms in the products.
C	This would not follow the law of conservation. Matter can neither be created nor destroyed; the number of oxygen atoms should be the same on both sides of the equation.
D	**Key. This is a correct description of the number of atoms because it follows the law of conservation.**

Performance Expectation		Item Type	DOK
HS-PS1-1	Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. SEP: Developing and Using Models DCI: PS1.A Structure and Properties of Matter CCC: Patterns	CR	3

4. Tom is studying electronegativity in chemistry class and is asked to place several elements in order from greatest to least amount of electronegativity. He uses the periodic table, as shown, to help him.



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The elements that Tom must order are: bromine, chlorine, fluorine, iodine.

a. List the four elements in order from greatest to least amount of electronegativity.

b. Explain why these elements have different electronegativities.

CR Rubric	
Score	**Description**
2	Student response provides **clear** evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems. Student is able to: • determine the order of the elements; **AND** • explain why these elements have different electronegativities.
1	Student response provides **partial** evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems. The response lacks some critical information and details or contains some errors. Student is able to: • complete **one** of the tasks listed in the two-point score description; **OR** • do **both** of the tasks listed in the two-point score description, but they contain errors.
0	Student does not respond or student response is inaccurate, irrelevant, or contains insufficient evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems.
* As outlined in the Performance Expectations (PE) of the NGSS, the three dimensions are the disciplinary core ideas (DCI), science and engineering practices (SEP), and crosscutting concepts (CCC). Note that due to the complexity of the PEs, individual assessment items may not address all three dimensions.	

Scoring Notes and Sample Response

Sample Response

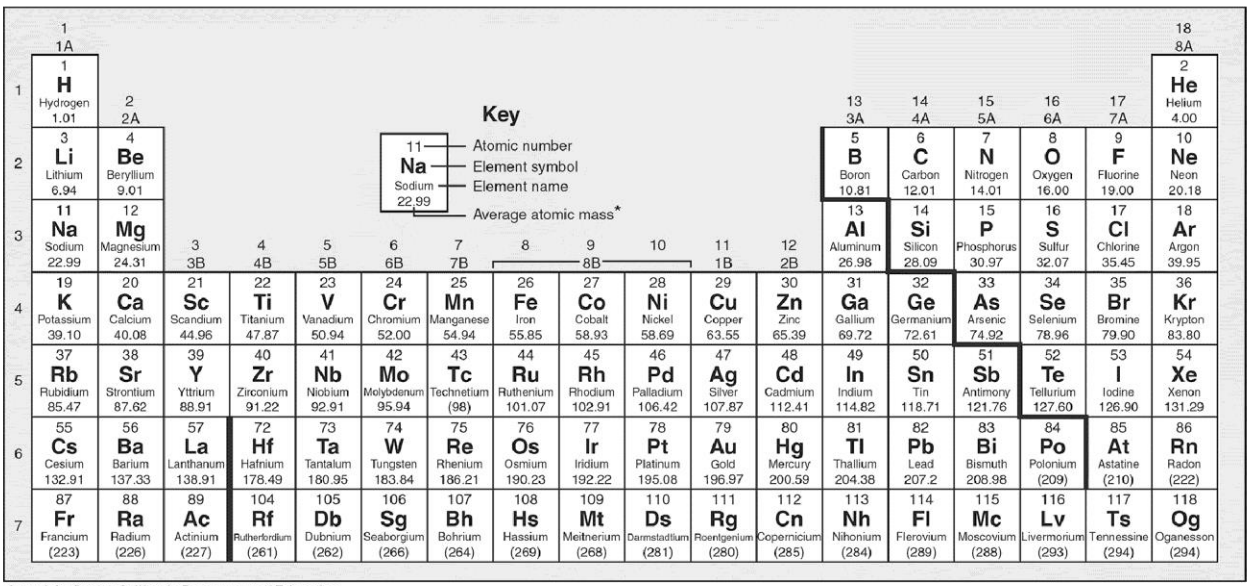
Possible answers include:

a. fluorine, chlorine, bromine, iodine

b. Since the atomic number increases down a group, the distance increases between the valence electrons and the nucleus, or a greater atomic radius, which translates to less electronegativity.

Performance Expectation		Item Type	DOK
HS-PS1-2	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. SEP: Constructing Explanations and Designing Solutions DCI: PS1.A Structure and Properties of Matter CCC: Patterns	ECR	3

5. Michael reviews the periodic table, as shown, in chemistry class.



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Michael is then asked to sort various compounds into two groups. This table shows his results.

Group X	Group Y
NaCl	N_2O_4
$CaCl_2$	F_2
BaO	CO_2
Na_2O	CF_3

a. For each group, identify the characteristic that the compounds have in common.

b. Based on the characteristics that you identified in part (a), explain how the elements bond together to form compounds in group X and in group Y.

ECR Rubric	
Score	**Description**
3	Student response provides **clear** evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems. Student is able to: • identify the characteristic that the compounds have in common, for each group; **AND** • explain how the compounds bond together to form compounds in group X and group Y, based on the characteristics that they identified in part (a).
2	Student response provides **partial** evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems. The response lacks some critical information and details or contains some errors. Student is able to: • complete **one** of the tasks listed in the three-point score description; **OR** • do **both** of the tasks listed in the three-point score description, but they contain errors.
1	Student response is incomplete or provides minimal evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems.
0	Student does not respond or student response is inaccurate, irrelevant, or contains insufficient evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems.
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Scoring Notes and Sample Response

Sample Response
Possible answers include:

a. Group X is compounds with ionic bonds while group Y is compounds with covalent bonds.

OR

Group X includes compounds with metals and nonmetals and group Y includes compounds with just nonmetals.

b. The compounds in group X are ionic compounds, which form when a metal from groups 1 through 3 gives its outer shell electrons to a nonmetal from groups 5 through 7. As a result, the atoms for both elements become ions and are bonded due to an electrochemical attraction.

The compounds in group Y are covalent compounds, which form when nonmetals from groups 3 through 7 share valence electrons with one another. Some of the compounds share one bond while others have double and triple bonds.

Section II—Performance Task

In this performance task, you will learn about two investigations about thermal energy transfer.

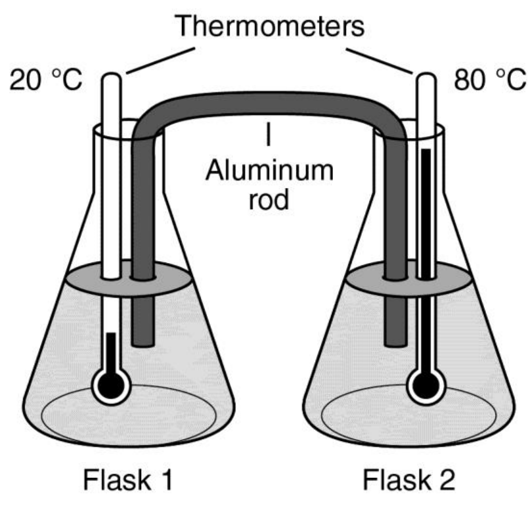
In a chemistry class, Trina and Fan perform several investigations to show how thermal energy is transferred between substances. During the investigations, both students wear goggles, wear a lab apron, use thermal mitts, and perform the investigations in a science lab.

Investigation 1: Thermal energy transfer

1. Measure 250 milliliters of 20°C water and pour it into an Erlenmeyer flask.
2. Measure 250 milliliters of 80°C water and pour it into a second Erlenmeyer flask.
3. Place a thermometer in each flask, ensuring that the thermometers do not touch the bottom of the flasks.
4. Place a bent aluminum rod so that one end is in each flask.
5. Record the temperature in each flask every five minutes for 30 minutes.

Figure 1 shows the setup for Investigation 1.

Investigation 1 Setup



Performance Expectation		Item Type	DOK
HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. SEP: Using Mathematical and Computational Thinking DCI: PS3.A Definitions of Energy; PS3.B Conservation of Energy and Energy Transfer CCC: System and System Models	SR	2

6. Trina and Fan want to calculate the energy change in the system's components in Investigation 1.

What experimental data do Trina and Fan need in order to make their calculation?

A the maximum size of each flask

B the kinetic energy of the hot water molecules

C the potential energy of a single water molecule

D the initial and final temperatures of the components

Distractor Rationales	
A	The maximum size (volume) of the flask is not used in the calculation of heat, but rather the volume of the water **in** the flask.
B	The kinetic energy of the water does not help calculate the change in energy.
C	Calculating the potential energy of a single water molecule would not provide the needed information to calculate the change in energy of the system.
D	**Key. The change in energy can be determined using the initial and final temperatures of the components.**

Performance Expectation		Item Type	DOK
HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. SEP: Using Mathematical and Computational Thinking DCI: PS3.A Definitions of Energy; PS3.B Conservation of Energy and Energy Transfer CCC: System and System Models	CR	3

7. a. Explain how Trina and Fan could calculate the change in energy in Flask 1.

b. Create a computational model to show how the energy change in Flask 1 relates to the energy change in Flask 2.

CR Rubric	
Score	**Description**
2	Student response provides **clear** evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems. Student is able to: • explain Trina and Fan could calculate the change in energy in Flask 1; **AND** • create a computational model to show how the energy change in Flask 1 relates to the energy change in Flask 2
1	Student response provides **partial** evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems. The response lacks some critical information and details or contains some errors. Student is able to: • complete **one** of the tasks listed in the two-point score description; **OR** • do **both** of the tasks listed in the two-point score description, but they contain errors.
0	Student does not respond or student response is inaccurate, irrelevant, or contains insufficient evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems.
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Scoring Notes and Sample Response

Sample Response

Possible answers include:

a. Trina and Fan could use specific heat calculations to predict the energy changes of the water and of the aluminum.

b. Qf1 = –Qf2

[Student should create some kind of equation, such as the one here, showing that the heat from one flask transfers into the other. Note: It is permissible but not required of the student to account for the aluminum bar.]

Section II—Performance Task

Investigation 2: Hot and cold water

1. Fill two bottles to the brim with 80°C hot water and label them.
2. Fill two bottles to the brim with 20°C cold water and label them.
3. Place a few drops of yellow food coloring into each hot water bottle.
4. Place a few drops of blue food coloring into each cold water bottle.
5. Place a card over the mouth of one of the hot water bottles. Invert the hot water bottle and place it on top of one of the cold water bottles, as shown in Figure 1.

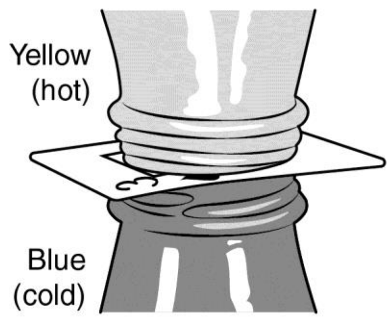

Figure 1

6. Place a card over the mouth of the other cold water bottle. Invert the cold water bottle and place it on top of the other hot water bottle, as shown in Figure 2.

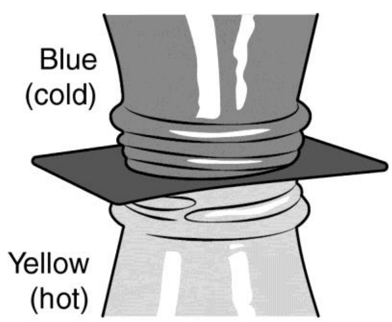

Figure 2

7. Remove the cards carefully and record your observations. Observe that when a cold water bottle is placed on top of a hot water bottle, the cold, blue water moves to the bottom of the bottle with the hot, yellow water, as shown in Figure 3.

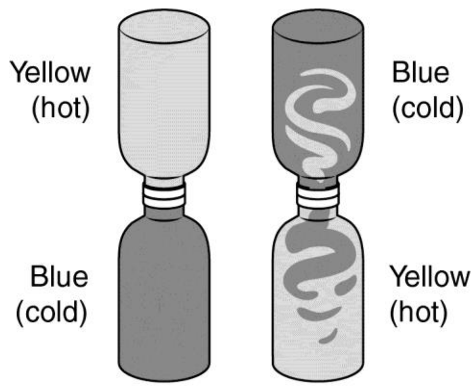

Figure 3

Performance Expectation		Item Type	DOK
HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects). SEP: Developing and Using Models DCI: PS3.A Definitions of Energy CCC: System and System Models	SR	2

8. Which statement **best** explains why the thermal energies in cold water and in hot water are different?

A Thermal energy is a measure of the kinetic energy of molecules. The hot water molecules move slower than cold water molecules, so they have different thermal energies.

B Thermal energy is a measure of the kinetic energy of molecules. The hot water molecules move faster than the cold water molecules, so they have different thermal energies.

C Thermal energy is a measure of the potential energy of molecules. The cold water molecules have more potential energy than hot water molecules, so they have different thermal energies.

D Thermal energy is a measure of the potential energy of molecules. The cold water molecules have less potential energy than hot water molecules, so they have different thermal energies.

Distractor Rationales	
A	Cold water molecules move slower than hot water molecules.
B	**Key. The hot water molecules move faster, so they have a higher thermal energy than the cold water molecules.**
C	Kinetic energy, not potential energy, is a measurement of thermal energy.
D	Kinetic energy, not potential energy, is a measurement of thermal energy.

Performance Expectation		Item Type	DOK
HS-PS3-4	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). SEP: Planning and Carrying Out Investigations DCI: PS3.B Conservation of Energy and Energy Transfer; PS3.D Energy in Chemical Processes CCC: System and System Models	CR	3

9. Trina and Fan discover that the energy gained by the cold water is not equal to the energy lost by the hot water.

a. Describe **one** change to Investigation 1 that will keep more energy within the investigation's system.

b. Explain why this change should be made to the investigation.

CR Rubric	
Score	**Description**
2	Student response provides **clear** evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems. Student is able to: • describe **one** change to Investigation 1 that will keep more energy within the investigation's system.; **AND** • explain why this change should be made to the investigation.
1	Student response provides **partial** evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems. The response lacks some critical information and details or contains some errors. Student is able to: • complete **one** of the tasks listed in the two-point score description; **OR** • do **both** of the tasks listed in the two-point score description, but they contain errors or are incomplete.
0	Student does not respond or student response is inaccurate, irrelevant, or contains insufficient evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems.
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Scoring Notes and Sample Response

Sample Response
Possible answers include:

a. Trina and Fan should insulate the flasks.
OR
Trina and Fan should place tops on the flasks.

b. This change would allow less energy to escape to the environment.

Performance Expectation		Item Type	DOK
HS-ESS2-3	Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. SEP: Developing and Using Models DCI: ESS2.A Earth's Materials and Systems; ESS2.B Plate Tectonics and Large-Scale System Interactions CCC: Energy and Matter	CR	3

10. a. Explain why the cold water sinks in Investigation 2.

b. Explain how the concepts in your answer to part (a) are important to the understanding of Earth's interior and crust.

ECR Rubric	
Score	**Description**
3	Student response provides **clear** evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems. Student is able to: • explain why the cold water sinks in investigation 2; **AND** • explain how these concepts are important to the understanding of Earth's interior and crust.
2	Student response provides **partial** evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems. The response lacks some critical information and details or contains some errors. Student is able to: • complete **one** of the tasks listed in the three-point score description; **OR** • do **both** of the tasks listed in the three-point score description, but they contain errors.
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Scoring Notes and Sample Response

Sample Response

Possible answers include:

a. Investigation 2 is about convection currents, temperature, and density. Colder, denser water sinks to the bottom while warm water moves to the top.

b. This movement shows how convection currents occur. Convection currents are found in the mantle and are how plates on Earth move.