



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.

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** 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	<p>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.</p> <p>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</p>	SR	1	2
7	<p>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.</p> <p>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</p>	CR	2	3
8	<p>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).</p> <p>SEP: Developing and Using Models DCI: PS3.A Definitions of Energy CCC: System and System Models</p>	SR	1	2
9	<p>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).</p> <p>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</p>	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

- 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.

Key																																																																								
11	Na	Atomic number	Element symbol	Element name	Average atomic mass*																																																																			
11	Na	Sodium	22.99																																																																					
1	1A	1	H	Hydrogen	1.01	2	2A	3	3A	4	4A	5	5A	6	6A	7	7A	8	8A	2	He	Helium	4.00																																																	
2	3	Li	Lithium	6.94	4	Be	Beryllium	9.01	5	B	Boron	10.81	6	C	Carbon	12.01	7	N	Nitrogen	14.01	8	O	Oxygen	16.00	9	F	Fluorine	19.00	10	Ne	Neon	20.18																																								
3	11	Na	Sodium	22.99	12	Mg	Magnesium	24.31	13	Al	Aluminum	26.98	14	Si	Silicon	28.09	15	P	Phosphorus	30.97	16	S	Sulfur	32.07	17	Cl	Chlorine	35.45	18	Ar	Argon	39.95																																								
4	19	K	Potassium	39.10	20	Ca	Calcium	40.08	21	Sc	Scandium	44.96	22	Ti	Titanium	47.87	23	V	Vanadium	50.94	24	Cr	Chromium	52.00	25	Mn	Manganese	54.94	26	Fe	Iron	55.85	27	Co	Cobalt	58.93	28	Ni	Nickel	58.69	29	Cu	Copper	63.55	30	Zn	Zinc	65.39	31	Ga	Gallium	69.72	32	Ge	Germanium	72.61	33	As	Arsenic	74.92	34	Se	Selenium	78.96	35	Br	Bromine	79.90	36	Kr	Krypton	83.80
5	37	Rb	Rubidium	85.47	38	Sr	Strontium	87.62	39	Y	Yttrium	88.91	40	Zr	Zirconium	91.22	41	Nb	Niobium	92.91	42	Mo	Molybdenum	95.94	43	Tc	Technetium	(98)	44	Ru	Ruthenium	101.07	45	Rh	Rhodium	102.91	46	Pd	Palladium	106.42	47	Ag	Silver	107.87	48	Cd	Cadmium	112.41	49	In	Indium	114.82	50	Sn	Tin	118.71	51	Sb	Antimony	121.76	52	Te	Tellurium	127.60	53	I	Iodine	126.90	54	Xe	Xenon	131.29
6	55	Cs	Cesium	132.91	56	Ba	Barium	137.33	57	La	Lanthanum	138.91	72	Hf	Hafnium	178.49	73	Ta	Tantalum	180.95	74	W	Tungsten	183.84	75	Re	Rhenium	186.21	76	Os	Osmium	190.23	77	Ir	Iridium	192.22	78	Pt	Platinum	195.08	79	Au	Gold	196.97	80	Hg	Mercury	200.59	81	Tl	Thallium	204.38	82	Pb	Lead	207.2	83	Bi	Bismuth	208.98	84	Po	Polonium	(209)	85	At	Astatine	(210)	86	Rn	Radon	(222)
7	87	Fr	Francium	(223)	88	Ra	Radium	(226)	89	Ac	Actinium	(227)	104	Rf	Rutherfordium	(261)	105	Db	Dubnium	(262)	106	Sg	Seaborgium	(266)	107	Bh	Bohrium	(264)	108	Hs	Hassium	(269)	109	Mt	Mendelevium	(268)	110	Ds	Darmstadtium	(281)	111	Rg	Roentgenium	(280)	112	Cn	Copernicium	(285)	113	Nh	Nihonium	(284)	114	Fl	Flerovium	(289)	115	Mc	Moscovium	(288)	116	Lv	Livermorium	(293)	117	Ts	Tennesine	(294)	118	Og	Oganesson	(294)
* If this number is in parentheses, then it refers to the atomic mass of the most stable isotope.																																																																								
58	Ce	Cerium	140.12	59	Pr	Praseodymium	140.91	60	Nd	Neodymium	144.24	61	Pm	Promethium	(145)	62	Sm	Samarium	150.36	63	Eu	Europium	151.96	64	Gd	Gadolinium	157.25	65	Tb	Terbium	158.93	66	Dy	Dysprosium	162.50	67	Ho	Holmium	164.93	68	Er	Erbium	167.26	69	Tm	Thulium	168.93	70	Yb	Ytterbium	173.04	71	Lu	Lutetium	174.97																	
90	Th	Thorium	232.04	91	Pa	Protactinium	231.04	92	U	Uranium	238.03	93	Np	Neptunium	(237)	94	Pu	Plutonium	(244)	95	Am	Americium	(243)	96	Cm	Curium	(247)	97	Bk	Berkelium	(247)	98	Cf	Californium	(251)	99	Es	Einsteinium	(252)	100	Fm	Fermium	(257)	101	Md	Mendelevium	(258)	102	No	Nobelium	(259)	103	Lr	Lawrencium	(262)																	

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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)

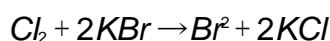
Distractor Rationales

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.



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

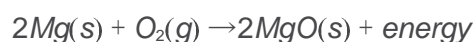
- A The reaction will occur, because chlorine (Cl) has a smaller atomic radius than bromine (Br) and will attract more electrons.
- B The reaction will occur, because chlorine (Cl) has a larger atomic radius than bromine (Br) and will attract fewer electrons.
- C The reaction will not occur, because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



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.	CR	3
	SEP: Developing and Using Models		
	DCI: PS1.A Structure and Properties of Matter		
	CCC: Patterns		

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.

Key																																																																																																										
11	Na	Atomic number		Element symbol		Element name												Average atomic mass*																																																																																								
11	Na	Sodium		22.99																																																																																																						
1	1A	1	H	Hydrogen	1.01	2	2A	4	Be	Beryllium	9.01	13	3A	5	B	Boron	10.81	6	4A	6	C	Carbon	12.01	7	5A	7	N	Nitrogen	14.01	8	6A	8	O	Oxygen	16.00	9	7A	9	F	Fluorine	19.00	10	8A	10	Ne	Neon	20.18																																																											
2	3	Li	Lithium	6.94	11	3A	11	Na	Sodium	22.99	12	4A	12	Mg	Magnesium	24.31	13	5A	13	Al	Aluminum	26.98	14	6A	14	Si	Silicon	28.09	15	7A	15	P	Phosphorus	30.97	16	8A	16	S	Sulfur	32.07	17	9A	17	Cl	Chlorine	35.45	18	10A	18	Ar	Argon	39.95																																																						
3	19	K	Potassium	39.10	20	2A	20	Ca	Calcium	40.08	21	3B	21	Sc	Scandium	44.96	22	4B	22	Ti	Titanium	47.87	23	5B	23	V	Vanadium	50.94	24	6B	24	Cr	Chromium	52.00	25	7B	25	Mn	Manganese	54.94	26	8B	26	Fe	Iron	55.85	27	9B	27	Co	Cobalt	58.93	28	10B	28	Ni	Nickel	58.69	29	11B	29	Cu	Copper	63.55	30	12B	30	Zn	Zinc	65.39	31	13B	31	Ga	Gallium	69.72	32	14B	32	Ge	Germanium	72.61	33	15B	33	As	Arsenic	74.92	34	16B	34	Se	Selenium	78.96	35	17B	35	Br	Bromine	79.90	36	18B	36	Kr	Krypton	83.80
4	37	Rb	Rubidium	85.47	38	2A	38	Sr	Strontium	87.62	39	3B	39	Y	Yttrium	88.91	40	4B	40	Zr	Zirconium	91.22	41	5B	41	Nb	Niobium	92.91	42	6B	42	Mo	Molybdenum	95.94	43	7B	43	Tc	Technetium	(98)	44	8B	44	Ru	Ruthenium	101.07	45	9B	45	Rh	Rhodium	102.91	46	10B	46	Pd	Palladium	106.42	47	11B	47	Ag	Silver	107.87	48	12B	48	Cd	Cadmium	112.41	49	13B	49	In	Indium	114.82	50	14B	50	Sn	Tin	118.71	51	15B	51	Sb	Antimony	121.76	52	16B	52	Te	Tellurium	127.60	53	17B	53	I	Iodine	126.90	54	18B	54	Xe	Xenon	131.29
5	55	Cs	Cesium	132.91	56	2A	56	Ba	Barium	137.33	57	3B	57	La	Lanthanum	138.91	72	4B	72	Hf	Hafnium	178.49	73	5B	73	Ta	Tantalum	180.95	74	6B	74	W	Tungsten	183.84	75	7B	75	Re	Rhenium	186.21	76	8B	76	Os	Osmium	190.23	77	9B	77	Ir	Iridium	192.22	78	10B	78	Pt	Platinum	195.08	79	11B	79	Au	Gold	196.97	80	12B	80	Hg	Mercury	200.59	81	13B	81	Tl	Thallium	204.38	82	14B	82	Pb	Lead	207.2	83	15B	83	Bi	Bismuth	208.98	84	16B	84	Po	Polonium	(209)	85	17B	85	At	Astatine	(210)	86	18B	86	Rn	Radon	(222)
6	87	Fr	Francium	(223)	88	2A	88	Ra	Radium	(226)	89	3B	89	Ac	Actinium	(227)	104	4B	104	Rf	Rutherfordium	(261)	105	5B	105	Db	Dubnium	(262)	106	6B	106	Sg	Seaborgium	(266)	107	7B	107	Bh	Bohrium	(264)	108	8B	108	Hs	Hassium	(269)	109	9B	109	Mt	Mendelevium	(268)	110	10B	110	Ds	Darmstadtium	(281)	111	11B	111	Rg	Roentgenium	(280)	112	12B	112	Cn	Copernicium	(285)	113	13B	113	Nh	Nihonium	(284)	114	14B	114	Fl	Flerovium	(289)	115	15B	115	Mc	Moscovium	(288)	116	16B	116	Lv	Livermorium	(293)	117	17B	117	Ts	Tennessine	(294)	118	18B	118	Og	Oganesson	(294)

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

- List the four elements in order from greatest to least amount of electronegativity.
- Explain why these elements have different electronegativities.



CR Rubric	
Score	Description
2	<p>Student response provides clear evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems.</p> <p>Student is able to:</p> <ul style="list-style-type: none">determine the order of the elements; <p>AND</p> <ul style="list-style-type: none">explain why these elements have different electronegativities.
1	<p>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.</p> <p>Student is able to:</p> <ul style="list-style-type: none">complete one of the tasks listed in the two-point score description; <p>OR</p> <ul style="list-style-type: none">do both of the tasks listed in the two-point score description, but they contain errors.
0	<p>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.</p>

* 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.

1												13		14	15	16	17	18										
1A												3A		4A	5A	6A	7A	8A										
1	H Hydrogen 1.01											5	B Boron 10.81	6	C Carbon 12.01	7	N Nitrogen 14.01	8	O Oxygen 16.00	9	F Fluorine 19.00	10	Ne Neon 20.18					
2	3 Li Lithium 6.94	4 Be Beryllium 9.01											11	Na Sodium 22.99	12	Mg Magnesium 24.31	13	Al Aluminum 26.98	14	Si Silicon 28.09	15	P Phosphorus 30.97	16	S Sulfur 32.07	17	Cl Chlorine 35.45	18	Ar Argon 39.95
3	19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.39	31 Ga Gallium 69.72	32 Ge Germanium 72.61	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80										
4	37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29										
5	55 Cs Cesium 132.91	56 Ba Barium 137.33	57 La Lanthanum 138.91	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)										
6	87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (280)	112 Cn Copernicium (285)	113 Nh Nihonium (284)	114 Fl Flerovium (289)	115 Mc Moscovium (288)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)										

Key:
 11 — Atomic number
 Na — Element symbol
 Sodium — Element name
 22.99 — Average atomic mass*

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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 ₂ O ₄
CaCl ₂	F ₂
BaO	CO ₂
Na ₂ O	CF ₃

- For each group, identify the characteristic that the compounds have in common.
- 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	<p>Student response provides clear evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems.</p> <p>Student is able to:</p> <ul style="list-style-type: none">identify the characteristic that the compounds have in common, for each group; <p>AND</p> <ul style="list-style-type: none">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	<p>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.</p> <p>Student is able to:</p> <ul style="list-style-type: none">complete one of the tasks listed in the three-point score description; <p>OR</p> <ul style="list-style-type: none">do both of the tasks listed in the three-point score description, but they contain errors.
1	<p>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.</p>
0	<p>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.</p>

* 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. 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

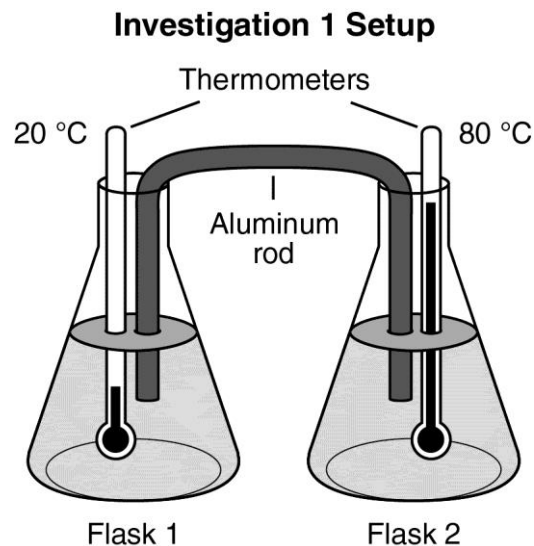
In this performance task, you will learn about two investigations about thermal energy transfer.

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.





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	<p>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.</p> <p>SEP: Using Mathematical and Computational Thinking</p> <p>DCI: PS3.A Definitions of Energy; PS3.B Conservation of Energy and Energy Transfer</p> <p>CCC: System and System Models</p>	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	<p>Student response provides clear evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems.</p> <p>Student is able to:</p> <ul style="list-style-type: none">explain Trina and Fan could calculate the change in energy in Flask 1; <p>AND</p> <ul style="list-style-type: none">create a computational model to show how the energy change in Flask 1 relates to the energy change in Flask 2
1	<p>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.</p> <p>Student is able to:</p> <ul style="list-style-type: none">complete one of the tasks listed in the two-point score description; <p>OR</p> <ul style="list-style-type: none">do both of the tasks listed in the two-point score description, but they contain errors.
0	<p>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.</p>

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

b. $Q_{f1} = -Q_{f2}$

[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.

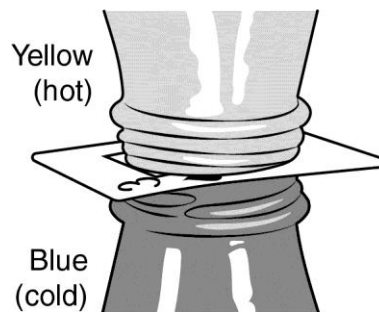


Figure 1

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.

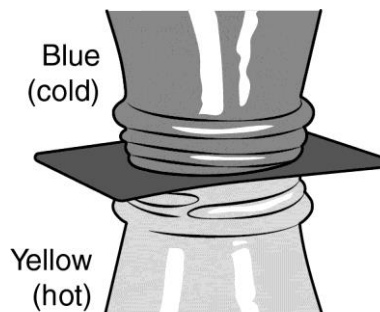


Figure 2

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.

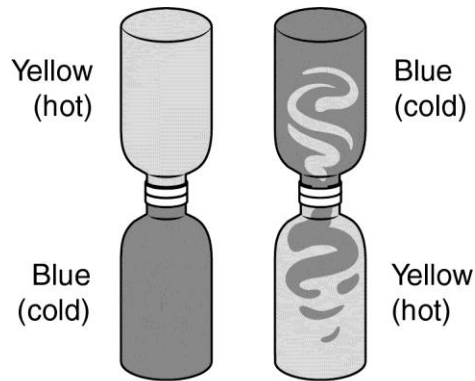


Figure 3



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	<p>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).</p> <p>SEP: Planning and Carrying Out Investigations</p> <p>DCI: PS3.B Conservation of Energy and Energy Transfer; PS3.D Energy in Chemical Processes</p> <p>CCC: System and System Models</p>	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.
- Describe **one** change to Investigation 1 that will keep more energy within the investigation's system.
 - Explain why this change should be made to the investigation.



CR Rubric	
Score	Description
2	<p>Student response provides clear evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems.</p> <p>Student is able to:</p> <ul style="list-style-type: none">describe one change to Investigation 1 that will keep more energy within the investigation's system.; <p>AND</p> <ul style="list-style-type: none">explain why this change should be made to the investigation.
1	<p>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.</p> <p>Student is able to:</p> <ul style="list-style-type: none">complete one of the tasks listed in the two-point score description; <p>OR</p> <ul style="list-style-type: none">do both of the tasks listed in the two-point score description, but they contain errors or are incomplete.
0	<p>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.</p>

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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	<p>Student response provides clear evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems.</p> <p>Student is able to:</p> <ul style="list-style-type: none">explain why the cold water sinks in investigation 2; <p>AND</p> <ul style="list-style-type: none">explain how these concepts are important to the understanding of Earth's interior and crust.
2	<p>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.</p> <p>Student is able to:</p> <ul style="list-style-type: none">complete one of the tasks listed in the three-point score description; <p>OR</p> <ul style="list-style-type: none">do both of the tasks listed in the three-point score description, but they contain errors.
1	<p>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.</p>
0	<p>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.</p>

* 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. 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.