Ohio’s State Tests

ITEM RELEASE

SPRING 2015

PHYSICAL SCIENCE
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<th>Answer Key</th>
<th>Points</th>
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<td>Graphic Response</td>
<td>Study of Matter</td>
<td>Periodic Trends of the Elements</td>
<td>---</td>
<td>2 points</td>
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<td>2</td>
<td>Short Response</td>
<td>Forces and Motion</td>
<td>Dynamics</td>
<td>---</td>
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<tr>
<td>3</td>
<td>Multiple Choice</td>
<td>The Universe</td>
<td>Galaxy Formation</td>
<td>D</td>
<td>1 point</td>
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<td>Multiple Choice</td>
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<td>Stars</td>
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<td>1 point</td>
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<td>5</td>
<td>Multiple Choice</td>
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<td>6</td>
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<td>Study of Matter</td>
<td>Reactions of Matter</td>
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<td>7</td>
<td>Graphic Response</td>
<td>The Universe</td>
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<td>---</td>
<td>1 point</td>
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<tr>
<td>8</td>
<td>Graphic Response</td>
<td>Energy and Waves</td>
<td>Conservation of Energy</td>
<td>---</td>
<td>1 point</td>
</tr>
<tr>
<td>9</td>
<td>Multiple Choice</td>
<td>Study of Matter</td>
<td>Reactions of Matter</td>
<td>D</td>
<td>1 point</td>
</tr>
<tr>
<td>10</td>
<td>Graphic Response</td>
<td>Study of Matter</td>
<td>Reactions of Matter</td>
<td>---</td>
<td>1 point</td>
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<tr>
<td>11</td>
<td>Multiple Choice</td>
<td>Energy and Waves</td>
<td>Electricity</td>
<td>D</td>
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<td>Graphic Response</td>
<td>Forces and Motion</td>
<td>Motion</td>
<td>---</td>
<td>1 point</td>
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<tr>
<td>13</td>
<td>Multiple Choice</td>
<td>Study of Matter</td>
<td>Classification of Matter</td>
<td>B</td>
<td>1 point</td>
</tr>
<tr>
<td>14</td>
<td>Multiple Choice</td>
<td>The Universe</td>
<td>Galaxy Formation</td>
<td>C</td>
<td>1 point</td>
</tr>
<tr>
<td>15</td>
<td>Graphic Response</td>
<td>Study of Matter</td>
<td>Atoms</td>
<td>---</td>
<td>1 point</td>
</tr>
</tbody>
</table>
### Physical Science
Spring 2015 Item Release
Content Summary and Answer Key

<table>
<thead>
<tr>
<th>Question No.</th>
<th>Item Type</th>
<th>Topic</th>
<th>Subtopic</th>
<th>Answer Key</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Multiple Choice</td>
<td>Study of Matter</td>
<td>Periodic Trends of the Elements</td>
<td>D</td>
<td>1 point</td>
</tr>
<tr>
<td>17</td>
<td>Graphic Response</td>
<td>Study of Matter</td>
<td>Bonding and Compounds</td>
<td>---</td>
<td>2 points</td>
</tr>
<tr>
<td>18</td>
<td>Multiple Choice</td>
<td>Study of Matter</td>
<td>Reactions of Matter</td>
<td>D</td>
<td>1 point</td>
</tr>
<tr>
<td>19</td>
<td>Graphic Response</td>
<td>Forces and Motion</td>
<td>Motion</td>
<td>---</td>
<td>1 point</td>
</tr>
</tbody>
</table>
Physical Science
Spring 2015 Item Release

Question 1

Question and Scoring Guidelines
Question 1

The table shows the physical and chemical properties of two elements.

<table>
<thead>
<tr>
<th>Physical and Chemical Properties</th>
<th>Element Q</th>
<th>Element X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Conductivity</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Chemical Reactivity</td>
<td>High</td>
<td>None</td>
</tr>
<tr>
<td>State/Phase</td>
<td>Gas</td>
<td>Gas</td>
</tr>
<tr>
<td>Ionic Charge</td>
<td>Negative</td>
<td>None</td>
</tr>
</tbody>
</table>

A. Based on these elements’ properties, move “Element Q” and “Element X” into the correct Group (1, 17 or 18) on the periodic table.

B. “Element Z” belongs in Group 1. Click on all of the properties in the “Properties of Element” that support “Element Z” being placed in Group 1 of the periodic table.

Points Possible: 2

See Alignment for more detail.

Scoring Guidelines

For this item, a full-credit (2 point) response includes:

- “Element Q” in the Group 17 region and “Element X” in the Group 18 region (1 point);

AND

- “+ Ionic Charge,” “Is Conductive” and “High Reactivity” are selected (1 point).
For this item, a partial-credit (1 point) response includes:

- “Element Q” in the Group 17 region and “Element X” in the Group 18 region (1 point);

OR

- “+ Ionic Charge,” “Is Conductive” and “High Reactivity” are selected (1 point).

Alignment

**Topic**
Study of Matter

**Subtopic**
Periodic Trends of the Elements

**Content Elaboration**
When elements are listed in order of increasing atomic number, the same sequence of properties appears over and over again; this is the periodic law. The periodic table is arranged so that elements with similar chemical and physical properties are in the same group or family. Metalloids are elements that have some properties of metals and some properties of nonmetals. Metals, nonmetals, metalloids, periods and groups or families (including the alkali metals, alkaline earth metals, halogens and noble gases) can be identified by their position on the periodic table. Elements in Groups 1, 2 and 17 have characteristic ionic charges that will be used to predict the formulas of compounds.

**Cognitive Demand**
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students' knowledge of science fact, information, concepts, tools, procedures and basic principles.

**Explanation of the Item**
This two-point, machine-scored, constructed-response item requires the student to determine the position in the periodic table of two elements, given various physical and chemical properties, and then to determine the properties of a third element, given its location on the periodic table. Elements in the same group or family have similar chemical and physical properties that are different from the chemical and physical properties of elements in other groups. Group 18 consists of the noble gases,
which are nonreactive gases that do not tend to conduct electricity or form ions. Since these are the properties of Element X, it should be placed somewhere in the vertical column of Group 18. Group 17 are the halogens, which are highly reactive elements that form negative ions and do not conduct electricity. Since these are the properties of Element Q, it should be placed somewhere in the vertical column of Group 17. Group 1 consists of the alkali metals, which are highly reactive solids that form positive ions and conduct an electric current. Since Element Z belongs in Group 1, “+ Ionic Charge,” “Is Conductive” and “High Reactivity” are identified as properties.
Physical Science
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Question 1

Sample Responses
Notes on Scoring

This response earns full credit (2 points). “Element Q" is correctly placed in Group 17, “Element X" is correctly placed in Group 18, and “+ Ionic Charge," “Is Conductive" and “High Reactivity" are identified as properties of “Element Z."
Sample Response: 1 point

The table shows the physical and chemical properties of two elements.

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</tr>
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<td>Gas</td>
</tr>
<tr>
<td>Ionic Charge</td>
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</tr>
</tbody>
</table>

A. Based on these elements’ properties, move “Element Q” and “Element X” into the correct Group (1, 17 or 18) on the periodic table.

B. “Element Z” belongs in Group 1. Click on all of the properties in the “Properties of Element” that support “Element Z” being placed in Group 1 of the periodic table.

Notes on Scoring

This response earns partial credit (1 point). While “Element X” is correctly placed in Group 18, credit is not awarded for Part A because “Element Q” is incorrectly placed in Group 1 rather than Group 17. Both elements must be placed correctly to earn credit for Part A. One point is earned for Part B because the properties of “Element Z” are correctly identified as “+ Ionic Charge,” “Is Conductive” and “High Reactivity.”
Sample Response: 1 point

The table shows the physical and chemical properties of two elements.

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A. Based on these elements' properties, move "Element Q" and "Element X" into the correct Group (1, 17 or 18) on the periodic table.

B. "Element Z" belongs in Group 1. Click on all of the properties in the "Properties of Element" that support "Element Z" being placed in Group 1 of the periodic table.

Notes on Scoring

This response earns partial credit (1 point). Credit is awarded for Part A because "Element Q" is placed in Group 17 and "Element X" is placed in Group 18. Credit is not awarded for Part B. While the response correctly identifies "Is Conductive" as a property of "Element Z," it incorrectly identifies additional properties as "No Reactivity" and "Is Not Conductive." In order to earn credit for Part B, all three properties must be correctly identified.
Notes on Scoring

This response earns no credit (0 points). Credit is not awarded for Part A because “Element Q” is incorrectly placed in Group 18 rather than Group 17 and “Element X” is incorrectly placed in Group 1 rather than Group 18. Credit is also not awarded for Part B. While the response correctly identifies “Is Conductive” as a property of “Element Z,” it incorrectly identifies additional properties as “No Reactivity” and “Is Not Conductive.” In order to earn credit for Part B, all three properties must be correctly identified.
Sample Response: 0 points

The table shows the physical and chemical properties of two elements.

<table>
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</tr>
</tbody>
</table>

A. Based on these elements' properties, move "Element Q" and "Element X" into the correct Group (1, 17 or 18) on the periodic table.

B. "Element Z" belongs in Group 1. Click on all of the properties in the "Properties of Element" that support "Element Z" being placed in Group 1 of the periodic table.

Notes on Scoring

This response earns no credit (0 points). While "Element X" is correctly placed in Group 18, credit is not awarded for Part A because "Element Q" is incorrectly placed in Group 18 rather than Group 17. Both elements must be placed correctly to earn credit for Part A. While the response correctly identifies "Is Conductive" and "+ Ionic Charge" as properties of "Element Z," it incorrectly identifies an additional property as "No Ionic Charge." In order to earn credit for Part B, all three properties must be correctly identified.
Physical Science
Spring 2015 Item Release

Question 2

Question and Scoring Guidelines
Question 2

Two objects fall near Earth’s surface. One object’s mass is 100 kg, and the other object’s mass is 10 kg. Assume that there is no air resistance.

- Explain why the forces acting on the objects are different by using words or an equation. If you use an equation, you must explain the equation.
- Explain why the accelerations of the objects are the same by using words or an equation. If you use an equation, you must explain the equation.

Type your answer in the space provided.

Points Possible: 2
See Alignment for more detail.

Scoring Guidelines

<table>
<thead>
<tr>
<th>Score Point</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 points</td>
<td>The response provides a complete interpretation and/or correct solution. It demonstrates a thorough understanding of the concept or task. It indicates logical reasoning and conclusions. It is accurate, relevant and complete. The response correctly:</td>
</tr>
<tr>
<td></td>
<td>• Explains why the forces acting on the objects are different;</td>
</tr>
<tr>
<td></td>
<td>AND</td>
</tr>
</tbody>
</table>
• Explains why the accelerations of the objects are the same.

1 point The response provides evidence of a partial interpretation and/or solution process. It demonstrates an incomplete understanding of the concept or task. It contains minor flaws in reasoning. It neglects to address some aspect of the concept or task.

The response correctly:

• Explains why the forces acting on the objects are different;

OR

• Explains why the accelerations of the objects are the same.

0 points The response does not meet the criteria required to earn one point. The response indicates inadequate or no understanding of the task.

Alignment

Topic
Forces and Motion

Subtopic
Dynamics

Content Elaboration
The field concept is developed in physical science. The stronger the field, the greater the force exerted on objects placed in the field. The field of an object is always there, even if the object is not interacting with anything else. The gravitational force (weight) of an object is proportional to its mass. Weight, $F_g$, can be calculated from the equation $F_g = mg$, where $g$ is the gravitational field strength of an object, which is equal to 9.8 N/kg (m/s$^2$) on the surface of Earth.

An object does not accelerate (remains at rest or maintains a constant speed and direction of motion) unless an unbalanced net force acts on it. The rate at which an object changes its speed or direction (acceleration) is proportional to the vector sum of the applied forces (net force, $F_{net}$) and inversely proportional to the mass ($a = F_{net}/m$). When the vector sum of the forces (net force) acting on an object is zero, the object does not accelerate. For an object that is moving, this means the object will remain moving without changing its speed or direction. For an object that is not moving, the object will continue to remain stationary. These laws will be applied to systems that consist of a single object upon which multiple forces act. Vector addition will be limited to one dimension (positive and negative). While both horizontal and vertical forces can be acting on an object simultaneously, one of the dimensions must have a net force of zero.
Cognitive Demand
Interpreting and Communicating Science Concepts (C)

Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.

Explanation of the Item
This two-point, hand-scored, constructed-response item requires the student to explain why two objects with different masses will have different gravitational forces but will have the same acceleration on Earth. The student is given the option of answering in words or using equations. These two approaches are explained below.

Mathematical Approach:
The gravitational force of an object can be calculated using the equation \( F_g = m \cdot g \), where \( g \) is the gravitational field strength of an object, which can be assumed to be 10 N/kg (m/s\(^2\)) on the surface of Earth (this is the value given on the reference sheet). Therefore, the force of gravity acting on the 100 kg object will be \( F_g = (100 \text{ kg})(10 \text{ N/kg}) = 1000 \text{ N} \). The force of gravity acting on the 10 kg object will be \( F_g = (10 \text{ kg})(10 \text{ N/kg}) = 100 \text{ N} \). This shows that the force of gravity on the two objects is different.

The acceleration of an object, \( a \), can be calculated using the equation \( a = F_{\text{net}}/m \), where \( F_{\text{net}} \) is the vector sum of the forces acting on the object and \( m \) is the mass of the object. In the absence of air resistance, the net force acting on the 100 kg and 10 kg objects will be the gravitational force acting on them. The gravitational forces have already been calculated to be 1000 N and 100 N, respectively, in the previous paragraph. Using the equation \( a = F_{\text{net}}/m \), the acceleration of the 100 kg object can be calculated as \( a = (1000 \text{ N})/(100 \text{ kg}) = 10 \text{ m/s}^2 \). The acceleration of the 10 kg object can be calculated as \( a = (100 \text{ N})/(10 \text{ kg}) = 10 \text{ m/s}^2 \). This shows the two objects have the same acceleration.

Verbal Approach:
The force acting on each object is the force of gravity or weight. Since the force of gravity acting on the object depends upon the mass and the two objects have different masses, they must have different forces acting on them.

The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass. The 100 kg object has ten times the mass and ten times the weight of the 10 kg object. Since it is directly proportional to the force and inversely proportional to the mass, the tenfold increase in both cancels out and the 100 kg object will have the same acceleration as the 10 kg object.
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Question 2

Sample Responses
Notes on Scoring

This response earns full credit (2 points). The response correctly explains why the forces are different (1 point):

• “. . . because gravity pulls down on an object by its . . . mass, the more mass the more force that is applied onto that object.”

The response also correctly explains why the accelerations are the same (1 point):

• “The accelerations of the objects are the same because there is no air resistance. Say there was a feather and an elephant jumped off a building at the same time with air resistance. The elephant would fall faster because of its mass the air resistance would have little affect on the elephant, the feather on the other hand would fall much slowly because of its light mass also because of the air resistances oushing upward on it.”
Notes on Scoring

This response earns partial credit (1 point). The response correctly identifies why the objects have different forces:
• “The law of gravity says that the gravity will be greater on an object that has more mass.”

However, the response earns no credit for explaining why the accelerations are the same. The student states that:
• “The acceleration of an object is greater when the object has less mass.”

While this may be true when the two objects being compared have equal forces acting upon them, these two objects do not. In addition, this suggests that the accelerations for the two objects will be different when the prompt asks for an explanation for why they are the same.
Sample Response: 1 point

Two objects fall near Earth's surface. One object's mass is 100 kg, and the other object's mass is 10 kg. Assume that there is no air resistance.

- Explain why the forces acting on the objects are different by using words or an equation. If you use an equation, you must explain the equation.
- Explain why the accelerations of the objects are the same by using words or an equation. If you use an equation, you must explain the equation.

Type your answer in the space provided.

The forces acting on the objects are different because the two objects are both different masses.
The accelerations of the objects are the same because of the gravitational pull of 9.8 m/s.

Notes on Scoring

This response earns partial credit (1 point). The response weakly indicates why the objects experience different forces and earns credit for:
- "The forces acting on the objects are different because the two objects are both different masses."

However, this response does not correctly indicate why the accelerations are the same:
- "Gravitational pull" is a force that is not the same for the two objects. The 9.8 value represents acceleration, but it is not identified as such and is shown to have units of "m/s" instead of "m/s2."
Sample Response: 1 point

Two objects fall near Earth’s surface. One object’s mass is 100 kg, and the other object’s mass is 10 kg. Assume that there is no air resistance.

- Explain why the forces acting on the objects are different by using words or an equation. If you use an equation, you must explain the equation.
- Explain why the accelerations of the objects are the same by using words or an equation. If you use an equation, you must explain the equation.

Type your answer in the space provided.

The forces are different because the objects have different masses but the accelerations are the same because of newton’s 2nd law.

Notes on Scoring

This response earns partial credit (1 point). The response weakly indicates why the objects experience different forces and earns credit for:
- “the forces are different because the objects have different masses”

However, this response does not correctly indicate why the accelerations are the same:
- “. . . because of newton’s 2nd law” is not specific enough to earn credit.
Sample Response: 1 point

Two objects fall near Earth’s surface. One object’s mass is 100 kg, and the other object’s mass is 10 kg. Assume that there is no air resistance.

- Explain why the forces acting on the objects are different by using words or an equation. If you use an equation, you must explain the equation.
- Explain why the accelerations of the objects are the same by using words or an equation. If you use an equation, you must explain the equation.

Type your answer in the space provided.

The gravitational force acting on the object with the mass of 100 kg will be greater than the gravitational force acting on the object with the mass of 10 kg because it has a mass of 100 kg which is much larger than a mass of 10 kg. Greater mass = greater gravitational force acting upon it; however, the acceleration of the objects will be the same, this is because of the equation for acceleration: \( a = \frac{v_2 - v_1}{t} \). Or, the change in velocity divided by total time for change to occur. The change in velocity for both objects will be the same, so the acceleration divided by the time will be the same, which means the acceleration of both objects will be the same.

Notes on Scoring

This response earns partial credit (1 point). One point is awarded for correctly explaining why the forces of the two objects are different:

- “The gravitational force acting on the object with the mass of 100 kg will be greater than the gravitational force acting on the object with the mass of 10 kg because it has a mass of 100 kg which is much larger than a mass of 10 kg. Greater mass = greater gravitational force acting upon it.”

However, no credit is awarded for explaining why the accelerations are the same. While the student gives an equation for acceleration, this equation does not explain why the 100 kg and 10 kg objects will have the same acceleration.
Sample Response: 1 point

Two objects fall near Earth’s surface. One object’s mass is 100 kg, and the other object’s mass is 10 kg. Assume that there is no air resistance.

• Explain why the forces acting on the objects are different by using words or an equation. If you use an equation, you must explain the equation.

• Explain why the accelerations of the objects are the same by using words or an equation. If you use an equation, you must explain the equation.

Type your answer in the space provided.

100 kg will have a greater force of gravity because it has more mass. They are both dropped from the same point.

Notes on Scoring

This response earns partial credit (1 point). The response indicates why the objects experience different forces and earns credit for:
• “100 kg will have a greater force of gravity because it has more mass.”

However, this response does not correctly indicate why the accelerations are the same. The statement “They are both dropped from the same point.” does not explain why the two objects have the same acceleration.
Two objects fall near Earth's surface. One object's mass is 100 kg, and the other object's mass is 10 kg. Assume that there is no air resistance.

- Explain why the forces acting on the objects are different by using words or an equation. If you use an equation, you must explain the equation.

- Explain why the accelerations of the objects are the same by using words or an equation. If you use an equation, you must explain the equation.

Type your answer in the space provided.

The forces acting on the objects are different because the objects have different masses. The one with the greater mass means it's going to be pulled on by a greater force. The accelerations are the same because every object falls at about 10 m/s. Both of the objects have a terminal velocity.

Notes on Scoring

This response earns partial credit (1 point). The response weakly indicates why the objects experience different forces and earns credit for:

- "The forces acting on the objects are different because the objects have different masses. The one with the greater mass means it's going to be pulled on by a greater force."

However, this response does not correctly indicate why the accelerations are the same. It incorrectly states that "every object falls at about 10 m/s." This statement claims that all objects fall with the same constant velocity of 10 m/s, which is not true. The response also incorrectly states that "both of the objects have a terminal velocity." Terminal velocity only occurs when air resistance is acting on an object. The prompt states "Assume that there is no air resistance."
Sample Response: 0 points

Two objects fall near Earth’s surface. One object’s mass is 100 kg, and the other object’s mass is 10 kg. Assume that there is no air resistance.

• Explain why the forces acting on the objects are different by using words or an equation. If you use an equation, you must explain the equation.

• Explain why the accelerations of the objects are the same by using words or an equation. If you use an equation, you must explain the equation.

Type your answer in the space provided.

The objects would fall at the same speed due to the Law of Inertia, which states an object in motion tends to stay in motion and an object at rest tends to stay at rest.

Notes on Scoring

This response earns no credit (0 points). It does not attempt to answer why the objects have different forces acting on them. Saying that “The objects would fall at the same speed” does not address acceleration.
Sample Response: 0 points

Two objects fall near Earth’s surface. One object’s mass is 100 kg, and the other object’s mass is 10 kg. Assume that there is no air resistance.

• Explain why the forces acting on the objects are different by using words or an equation. If you use an equation, you must explain the equation.

• Explain why the accelerations of the objects are the same by using words or an equation. If you use an equation, you must explain the equation.

Type your answer in the space provided.

When the object with the mass of 100 kg falls near Earth’s surface it will hit the ground slower than the object that weighs 10 kg because the kg weights less than the object that weighs 100 kg.

Notes on Scoring

This item earns no credit (0 points). It does not explain why the objects experience different forces, nor does it explain why the objects have the same acceleration. The statement “will hit the ground slower” does not address acceleration. The statement “the object that weighs 10 kg because the kg weights less than the object that weighs 100 kg” demonstrates a lack of understanding about the differences between weight and mass.
Two objects fall near Earth’s surface. One object’s mass is 100 kg, and the other object’s mass is 10 kg. Assume that there is no air resistance.

- Explain why the forces acting on the objects are different by using words or an equation. If you use an equation, you must explain the equation.
- Explain why the accelerations of the objects are the same by using words or an equation. If you use an equation, you must explain the equation.

Type your answer in the space provided.

The 100kg object would have more gravity pulling it down the acceleration would be quicker on the 100kg because it has more gravity

Notes on Scoring

This response earns no credit (0 points). The statement “The 100kg object would have more gravity pulling it down” is true, but it doesn’t explain that it is due to the greater mass. The response does not explain why the acceleration would be the same. In fact, the response states that “the acceleration would be quicker on the 100kg.”
Notes on Scoring

This response earns no credit (0 points). The statement “the greater the mass the more the objects attract” is not specific enough to earn credit for explaining why there are different forces acting on the objects. The statement “ALL objects fall at the rate of 9.8 m/s² so they should have the same terminal velocity” is inconsistent and demonstrates a lack of understanding of what 9.8 m/s² and terminal velocity represent. The rate of 9.8 m/s² is the acceleration of the two objects. This means the objects continue to get faster as they fall, increasing by 9.8 m/s every second. Terminal velocity is the constant speed at which an object falls. Terminal velocity only occurs when there is an opposing force of air resistance. The prompt states “Assume that there is no air resistance.”
Physical Science
Spring 2015 Item Release

Question 3

Question and Scoring Guidelines
**Question 3**

*Which statement explains why the majority of stars are found in galaxies?*

- **A** Thermal energy is greatest when stars are in galaxies.
- **B** Magnetic forces among the stars hold them in galaxies.
- **C** Electrical energy is conducted by the stars inside galaxies.
- **D** Gravitational forces among stars are strongest inside galaxies.

**Points Possible:** 1

See *Alignment* for more detail.

**Scoring Guidelines**

**Rationale for Option A:** This is incorrect. Thermal energy is greatest when stars are together in a galaxy, but thermal energy does not hold the stars together and thus does not explain why the majority of stars are found in galaxies. Gravitational forces hold the stars together in galaxies.

**Rationale for Option B:** This is incorrect. Magnetic forces are not acting between the stars to hold them together in a galaxy. Gravitational forces hold the stars together in galaxies.

**Rationale for Option C:** This is incorrect. Stars do not conduct electrical energy. Gravitational forces hold the stars together in galaxies.

**Rationale for Option D:** **Key** – Stars are held together in galaxies by gravitational forces.
Alignment

**Topic**
The Universe

**Subtopic**
Galaxy Formation

**Content Elaboration**
A galaxy is a group of billions of individual stars, star systems, star clusters, dust and gas bound together by gravity. There are billions of galaxies in the universe, and they are classified by size and shape. The Milky Way is a spiral galaxy. It has more than 100 billion stars and a diameter of more than 100,000 light years. At the center of the Milky Way is a collection of stars bulging outward from the disk, from which spiral arms of gas, dust and most of the young stars extend. The solar system is part of the Milky Way galaxy.

**Cognitive Demand**
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students' knowledge of science fact, information, concepts, tools, procedures and basic principles.

**Explanation of the Item**
This one-point, multiple-choice question requires the student to identify that most stars exist in galaxies due to the attractive gravitational forces between stars.

**Sample Response: 1 point**

Which statement explains why the majority of stars are found in galaxies?

- **A** Thermal energy is greatest when stars are in galaxies.
- **B** Magnetic forces among the stars hold them in galaxies.
- **C** Electrical energy is conducted by the stars inside galaxies.
- **D** Gravitational forces among stars are strongest inside galaxies.
Physical Science
Spring 2015 Item Release

Question 4

Question and Scoring Guidelines
Question 4

What reaction occurs in the interior of stars similar to the sun that produces most of the energy that is released?

- A. the conversion of hydrogen into helium
- B. the splitting of uranium into lighter nuclei
- C. the combination of elements to form molecules
- D. the combustion of hydrocarbons and oxygen gas

Points Possible: 1
See Alignment for more detail.

Scoring Guidelines

Rationale for Option A: **Key** – The basic nuclear reaction that produces the energy of the sun and stars of similar size is the fusion of hydrogen into helium.

Rationale for Option B: This is incorrect. The splitting of uranium into lighter nuclei is nuclear fission. Nuclear fusion reactions occur in stars.

Rationale for Option C: This is incorrect. Forming molecules from elements involves chemical reaction. Nuclear fusion reactions occur in stars.

Rationale for Option D: This is incorrect. Combustion reactions between oxygen and hydrocarbons are chemical reactions. Nuclear fusion reactions occur in stars.
Early in the formation of the universe, stars coalesced out of clouds of hydrogen and helium and clumped together by gravitational attraction into galaxies. When heated to a sufficiently high temperature by gravitational attraction, stars begin nuclear reactions, which convert matter to energy and fuse the lighter elements into heavier ones. These and other fusion processes in stars have led to the formation of all the other elements. All of the elements, except for hydrogen and helium, originated from the nuclear fusion reactions of stars.

Cognitive Demand
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students’ knowledge of science fact, information, concepts, tools, procedures and basic principles.

Explanation of the Item
This one-point, multiple-choice item requires the student to identify the reaction that produces energy in the sun and similar stars. Stars form from clouds of hydrogen and helium that coalesce due to gravitational attraction so great that the atoms undergo nuclear fusion. These fusion reactions generate the intense energy that is released from stars. The sun and stars similar to the sun are composed primarily of hydrogen that fuses to form helium.
Sample Response: 1 point

What reaction occurs in the interior of stars similar to the sun that produces most of the energy that is released?

- the conversion of hydrogen into helium
- the splitting of uranium into lighter nuclei
- the combination of elements to form molecules
- the combustion of hydrocarbons and oxygen gas
Physical Science
Spring 2015 Item Release

Question 5

Question and Scoring Guidelines
Question 5

Which situation describes a person doing work on a book?

A. holding a book overhead  
B. holding a book at arm’s length  
C. releasing a book from arm’s length  
D. lifting a book from a table to a shelf

Points Possible: 1
See Alignment for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. There is no change in the mechanical energy of the book due to the person holding the book overhead, so no work is done.

Rationale for Option B: This is incorrect. There is no change in the mechanical energy of the book due to the person holding the book at arm’s length, so no work is done.

Rationale for Option C: This is incorrect. The action of releasing the book from arm’s length does not change the total mechanical energy of the book, so no work is done.

Rationale for Option D: Key – Work is a change in the mechanical energy of an object due to a force applied to the object over a distance. When a person applies a force to the book to lift it, he or she is increasing the gravitational potential energy of the book and thus doing work on the book.
Content Elaboration
As long as the force, $F$, and displacement, $\Delta x$, are in the same or opposite directions, work, $W$, can be calculated from the equation $W = F\Delta x$. Energy transformations for a phenomenon can be represented through a series of pie graphs or bar graphs. Equations for work, kinetic energy and potential energy can be combined with the law of conservation of energy to solve problems. When energy is transferred from one system to another, some of the energy is transformed to thermal energy. Since thermal energy involves the random movement of many trillions of subatomic particles, it is less able to be organized to bring about further change. Therefore, even though the total amount of energy remains constant, less energy is available for doing useful work.

Cognitive Demand
Recalling Accurate Science (R)
Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students’ knowledge of science fact, information, concepts, tools, procedures and basic principles.

Explanation of the Item
This one-point, multiple-choice item requires the student to identify a real-life scenario in which work is done. Work is one way that energy can be transferred from one object to another. In order for work to be done and energy to be transferred, there must be a force between the two objects involved that causes a displacement in the same or opposite direction of the force. Holding a book overhead and holding a book at arm’s length both involve forces. However, there is no displacement involved, so there is no work done and no transfer of energy. When a book is released from arm’s length, there is a displacement, but this is caused by the force between the book and Earth, not a force between the book and a person. Since there is no force between the book and the person that is causing the displacement, there is no work done and no energy transferred between the person and the book. Lifting a book
from a table to a shelf involves a force between the book and a person, as well as a displacement in the same direction as the force. Therefore, work is done and energy is transferred between the person and the book.

Sample Response: 1 point

Which situation describes a person doing work on a book?

A. holding a book overhead
B. holding a book at arm’s length
C. releasing a book from arm’s length
D. lifting a book from a table to a shelf
Physical Science
Spring 2015 Item Release

Question 6

Question and Scoring Guidelines
Question 6

A chemical reaction between hydrogen gas and oxygen gas produces water. Which equation, showing the combination of hydrogen and oxygen to produce water, is balanced?

A. \( H_2 + O_2 \rightarrow H_2O \)
B. \( 2H_2 + O_2 \rightarrow 2H_2O \)
C. \( H_2 + 2O_2 \rightarrow H_2O \)
D. \( 2H_2 + 2O_2 \rightarrow 4H_2O \)

Points Possible: 1
See Alignment for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. While there are two hydrogen atoms on both sides of the equation, oxygen is not balanced. There are two oxygen atoms on the reactant side and only one oxygen on the product side.

Rationale for Option B: Key – There are four hydrogen atoms and two oxygen atoms on both sides of the equation so the equation is balanced.

Rationale for Option C: This is incorrect. While there are two hydrogen atoms on both sides of the equation, oxygen is not balanced. There are four oxygen atoms on the reactant side and only one oxygen atom on the product side.

Rationale for Option D: This is incorrect. While there are four oxygen atoms on both sides of the equation, hydrogen is not balanced. There are four hydrogen atoms on the reactant side and eight hydrogen atoms on the product side.
Content Elaboration
In physical science, conservation of matter is expressed by writing balanced chemical equations. Reactants and products can be identified from an equation, and simple equations can be written and balanced given either the formulas of the reactants and products or a word description of the reaction.

Cognitive Demand
Recalling Accurate Science (R)
Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students' knowledge of science fact, information, concepts, tools, procedures and basic principles.

Explanation of the Item
This one-point, multiple-choice item requires the student to identify a balanced equation for the formation of water. When a chemical reaction occurs, matter is always conserved. This means that there are the same type and number of atoms before and after the reaction. Balanced equations are ways to represent chemical reactions. A balanced equation will have the same type and number of atoms on each side. This can be accomplished by adding the appropriate coefficients. For the formation of water from hydrogen and oxygen gases, the correctly balanced equation is:

$$2H_2 + O_2 \rightarrow 2H_2O$$

This equation gives four hydrogen atoms and two oxygen atoms on both sides of the equation, making it balanced.
A chemical reaction between hydrogen gas and oxygen gas produces water. Which equation, showing the combination of hydrogen and oxygen to produce water, is balanced?

A. \( \text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O} \)

B. \( 2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O} \)

C. \( \text{H}_2 + 2\text{O}_2 \rightarrow \text{H}_2\text{O} \)

D. \( 2\text{H}_2 + 2\text{O}_2 \rightarrow 4\text{H}_2\text{O} \)
Physical Science
Spring 2015 Item Release

Question 7

Question and Scoring Guidelines
A list of events describing the formation and early history of the universe is provided.

Move a number label into the blank box next to each event to order the events chronologically.

- Move only one number into each blank box.

**Events in the Formation of the Universe**

- Stars were formed from clouds of hydrogen and helium.
- Atoms were formed once the expanding universe cooled down.
- Heavier elements were formed from lighter ones due to nuclear fusion.
- The universe expanded explosively from a hot, dense state.
- Atoms were pulled into gas clouds because of gravity.

**Number Labels**

1 2 3 4 5

**Points Possible:** 1

See **Alignment** for more detail.
**Scoring Guidelines**

For this item, a full-credit response includes:

- “1” in “The universe expanded explosively from a hot, dense state.”
  
  AND

- “2” in “Atoms were formed once the expanding universe cooled down.”
  
  AND

- “3” in “Atoms were pulled into gas clouds because of gravity.”
  
  AND

- “4” in “Stars were formed from clouds of hydrogen and helium.”
  
  AND

- “5” in “Heavier elements were formed from lighter ones due to nuclear fusion.”
  (1 point).

All five numbers must be correctly placed to earn credit. No partial credit is awarded for this item.

**Alignment**

**Topic**
The Universe

**Subtopic**
History of the Universe

**Content Elaboration**

According to the “big bang” theory, the contents of the known universe expanded explosively into existence from a hot, dense state 13.7 billion years ago. After the big bang, the universe expanded quickly (and continues to expand) and then cooled down enough for atoms to form. Gravity pulled the atoms together into gas clouds that eventually became stars, which comprise young galaxies. Foundations for the big bang model introduce the supporting evidence for the expansion of the known universe (e.g., Hubble’s law and red shift, or cosmic microwave background radiation).
Early in the formation of the universe, stars coalesced out of clouds of hydrogen and helium and clumped together by gravitational attraction into galaxies. When heated to a sufficiently high temperature by gravitational attraction, stars begin nuclear reactions, which convert matter to energy and fuse the lighter elements into heavier ones. These and other fusion processes in stars have led to the formation of all the other elements. All of the elements, except for hydrogen and helium, originated from the nuclear fusion reactions of stars.

**Cognitive Demand**
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students’ knowledge of science fact, information, concepts, tools, procedures and basic principles.

**Explanation of the Item**
This one-point, machine-scored, constructed-response item requires the student to put events of the history of the universe in chronological order. According to the “big bang” model of the universe, all the content of the known universe existed as a hot, dense state. Then, 13.7 billion years ago, this content expanded explosively and continues to expand today. Eventually, the material cooled down enough for atoms to form. Gravity pulled the atoms together into gas clouds that eventually became stars. When heated to a sufficiently high temperature by gravitational attraction, stars began nuclear reactions, which converted matter to energy and fused the lighter elements into heavier ones. These and other fusion processes in stars have led to the formation of all the other elements.
Physical Science
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Question 7

Sample Responses
Notes on Scoring

This response earns full credit (1 point). It has correctly ordered all the events:
1. The universe expanded explosively from a hot, dense state.
2. Atoms were formed once the expanding universe cooled down.
3. Atoms were pulled into gas clouds because of gravity.
4. Stars were formed from clouds of hydrogen and helium.
5. Heavier elements were formed from lighter ones due to nuclear fusion.
Notes on Scoring

This response earns no credit (0 points). While the response identifies the first event as “The universe expanded explosively from a hot, dense state.”, the other statements are out of order. This demonstrates a misunderstanding of how the universe was formed. The correct sequence is:

1. The universe expanded explosively from a hot, dense state.
2. Atoms were formed once the expanding universe cooled down.
3. Atoms were pulled into gas clouds because of gravity.
4. Stars were formed from clouds of hydrogen and helium.
5. Heavier elements were formed from lighter ones due to nuclear fusion.
A list of events describing the formation and early history of the universe is provided.

Move a number label into the blank box next to each event to order the events chronologically.

• Move only one number into each blank box.

### Notes on Scoring

This response earns no credit (0 points). While the response correctly identifies the second event as “Atoms were formed once the expanding universe cooled down.”, all other statements are out of order. This demonstrates a misunderstanding of the how the universe was formed. The correct sequence is:

1. The universe expanded explosively from a hot, dense state.
2. Atoms were formed once the expanding universe cooled down.
3. Atoms were pulled into gas clouds because of gravity.
4. Stars were formed from clouds of hydrogen and helium.
5. Heavier elements were formed from lighter ones due to nuclear fusion.
Physical Science
Spring 2015 Item Release

Question 8

Question and Scoring Guidelines
A student holds a 2 kg (kilogram) book at rest 1 m (meter) above the ground. He releases the book and it falls to the ground.

A. Create a bar graph of the gravitational potential energy relative to the ground ($E_g$) and kinetic energy ($E_k$) of the book before it is released (initial energy). Click on a line above each label in the graph to select the value.

B. Create a bar graph of the gravitational potential energy relative to the ground ($E_g$) and kinetic energy ($E_k$) of the book the moment just before it hits the ground (final energy). Click on a line above each label in the graph to select the value.

**Points Possible: 1**

See **Alignment** for more detail.
Scoring Guidelines

For this item, a full-credit response includes:

- “20” selected for Initial $E_g$;
  
  AND

- “0” or nothing selected for Initial $E_k$;
  
  AND

- “0” or nothing selected for Final $E_g$;
  
  AND

- “20” selected for Final $E_k$ (1 point).

All four criteria must be present to earn credit for this item. No partial credit is awarded.

Alignment

**Topic**
Energy and Waves

**Subtopic**
Conservation of Energy

**Content Elaboration**
Energy has no direction and has units of Joules (J). Kinetic energy, $E_k$, can be mathematically represented by $E_k = \frac{1}{2}mv^2$. Gravitational potential energy, $E_g$, can be mathematically represented by $E_g = mgh$. The amount of energy of an object is measured relative to a reference that is considered to be at a point of zero energy. The reference may be changed to help understand different situations. Only the change in the amount of energy can be measured absolutely. The conservation of energy and equations for kinetic and gravitational potential energy can be used to calculate values associated with energy (i.e., height, mass, speed) for situations involving energy transfer and transformation. Opportunities to quantify energy from data collected in experimental situations (e.g., a swinging pendulum, a car traveling down an incline) must be provided.
Cognitive Demand
Interpreting and Communicating Science Concepts (C)

Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.

Explanation of the Item
This one-point, machine-scored, constructed-response item requires the student to graph the initial and final potential and kinetic energies for a book released from rest that falls to the ground. Gravitational potential energy, \( E_g \), can be determined from the equation \( E_g = mgh \). Kinetic energy, \( E_k \), can be determined from the equation \( E_k = \frac{1}{2}mv^2 \). Energy can be transformed from one type of energy to another, but the total amount of energy must remain constant.

When the 2 kg book is held at rest 1 meter from the floor, it has 20 Joules of energy, as can be calculated by the equation \( E_g = mgh \) or \( E_g = (2 \text{ kg})(10 \text{ N/kg})(1 \text{ m}) = 20 \text{ J} \). Since it is at rest, there is no speed, and \( E_k = 0 \text{ J} \), according to the equation \( E_k = \frac{1}{2}mv^2 \) or \( E_k = \frac{1}{2}(1 \text{ kg})(0 \text{ m/s})^2 = 0 \text{ J} \).

The moment just before hitting the ground, the height is 0 meters and the gravitational potential energy, \( E_g \), is 0 J, according to the equation \( E_g = mgh \) or \( E_g = (2 \text{ kg})(10 \text{ N/kg})(0 \text{ m}) = 0 \text{ J} \). Since energy must be conserved and the total energy is initially equal to 20 J, the total energy just before hitting the ground is 20 J. Since the gravitational potential energy is 0 J, this means the kinetic energy, \( E_k \), must be 20 J.
Sample Response: 1 point

A student holds a 2 kg (kilogram) book at rest 1 m (meter) above the ground. He releases the book and it falls to the ground.

A. Create a bar graph of the gravitational potential energy relative to the ground (E_g) and kinetic energy (E_k) of the book before it is released (initial energy). Click on a line above each label in the graph to select the value.

B. Create a bar graph of the gravitational potential energy relative to the ground (E_g) and kinetic energy (E_k) of the book the moment just before it hits the ground (final energy). Click on a line above each label in the graph to select the value.

Notes on Scoring

This response earns full credit (1 point). The initial gravitational potential energy is correctly indicated as 20 J, and the final kinetic energy is correctly indicated as 20 J. The student has not selected any value for the initial kinetic energy and the final gravitational potential energy. Since bars exist that are close to zero, it is assumed that the intent was for these values to be 0 J.
Sample Response: 1 point

A student holds a 2 kg (kilogram) book at rest 1 m (meter) above the ground. He releases the book and it falls to the ground.

A. Create a bar graph of the gravitational potential energy relative to the ground (\(E_g\)) and kinetic energy (\(E_k\)) of the book before it is released (initial energy). Click on a line above each label in the graph to select the value.

B. Create a bar graph of the gravitational potential energy relative to the ground (\(E_g\)) and kinetic energy (\(E_k\)) of the book the moment just before it hits the ground (final energy). Click on a line above each label in the graph to select the value.

Notes on Scoring

This response earns full credit (1 point). The initial gravitational potential energy is correctly indicated as 20 J, and the initial kinetic energy is correctly indicated as 0 J. The final gravitational potential energy is correctly indicated as 0 J and the final kinetic energy is correctly indicated as 20 J.
Notes on Scoring

This response earns no credit (0 points). While the response correctly indicates the values of the initial kinetic energy, the final gravitational potential energy and the final kinetic energy, it incorrectly identifies the initial gravitational potential energy as 10 J rather than 20 J, as can be determined by the equation $E_g = mgh$ or $E_g = (2 \text{ kg})(10 \text{ N/kg})(1 \text{ m}) = 20 \text{ J}$. Furthermore, the graph does not show that energy is conserved. In order to receive full credit, all four values must be indicated correctly. No partial credit can be awarded.
Notes on Scoring

This response earns no credit (0 points). While this response shows a total amount of initial and final energy of 20 J, the type of energy is incorrect. Initially, the book is at rest, so its kinetic energy must be zero. Since it is held at a height above the ground, the 20 J are potential energy. Just before the book hits the ground, it is 0 meters above the ground, so its gravitational potential energy is 0 J. The book is moving at its maximum speed just before hitting the ground, so the kinetic energy must be 20 J. In order to receive full credit, all four values must be indicated correctly. No partial credit can be awarded.
Physical Science
Spring 2015 Item Release

Question 9

Question and Scoring Guidelines
Question 9

Ozone (O₃) forms from oxygen (O₂) in the upper atmosphere when it is bombarded by radiation. Which balanced equation illustrates this reaction?

A: \( O₂ → O₃ \)
B: \( 2O₂ → O₃ \)
C: \( 2O₂ → 2O₃ \)
D: \( 3O₂ → 2O₃ \)

Points Possible: 1
See Alignment for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. This equation shows two oxygen atoms on the reactants side, three on the products side and is not balanced.

Rationale for Option B: This is incorrect. This equation shows four oxygen atoms on the reactants side, three on the products side and is not balanced.

Rationale for Option C: This is incorrect. This equation shows four oxygen atoms on the reactants side, six on the products side and is not balanced.

Rationale for Option D: Key – This equation shows six oxygen atoms on the reactants side, six on the products side and is therefore balanced.
**Alignment**

**Topic**
Study of Matter

**Subtopic**
Reactions of Matter

**Content Elaboration**
In physical science, conservation of matter is expressed by writing balanced chemical equations. Reactants and products can be identified from an equation, and simple equations can be written and balanced given either the formulas of the reactants and products or a word description of the reaction.

**Cognitive Demand**
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students’ knowledge of science fact, information, concepts, tools, procedures and basic principles.

**Explanation of the Item**
This one-point, multiple-choice item requires the student to identify a balanced equation for the formation of ozone from oxygen. When a chemical reaction occurs, matter is always conserved. This means that there are the same type and number of atoms before and after the reaction. Balanced equations are ways to represent chemical reactions. A balanced equation will have the same type and number of atoms on each side. This can be accomplished by adding the appropriate coefficients. For the formation of ozone, the correctly balanced equation is:

\[ 3 \text{O}_2 \rightarrow 2 \text{O}_3 \]

This equation gives six oxygen atoms on both sides of the equation, making it balanced.
Ozone (O₃) forms from oxygen (O₂) in the upper atmosphere when it is bombarded by radiation. Which balanced equation illustrates this reaction?

A) O₂ → O₃
B) 2O₂ → O₃
C) 2O₂ → 2O₃
D) 3O₂ → 2O₃

Sample Response: 1 point
Physical Science
Spring 2015 Item Release

Question 10

Question and Scoring Guidelines
Actinium-225 has a half-life of 10 days. A scientist starts with a 160-gram sample.

Plot three points to show how much Actinium-225 will remain after 10 days, 20 days and 30 days.

Points Possible: 1
See Alignment for more detail.

Scoring Guidelines

For this item, a full-credit response includes:

• A point plotted at 80 grams at 10 days;
  AND
• A point plotted at 40 grams at 20 days;
  AND
• A point plotted at 20 grams at 30 days;
  AND
• A total of three points plotted in the graph space OR a total of four points plotted on the graph with the 4th point plotted at 160 grams at 0 days (1 point).
For any radioisotope, the half-life is unique and constant. Graphs can be constructed that show the amount of a radioisotope that remains as a function of time and can be interpreted to determine the value of the half-life. Half-life values are used in radioactive dating.

Cognitive Demand
Interpreting and Communicating Science Concepts (C)

Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.

Explanation of the Item
This one-point, machine-scored, constructed-response item requires the student to use half-life information for an isotope and plot the amount of the original isotope remaining over time. The half-life for a radioisotope is the time it takes for half of the sample to undergo radioactive decay. The question states that the half-life for Actinium-225 is 10 days. Since the initial amount of Actinium-225 present is 160 grams, it will take 10 days for half of this amount, 80 grams, to decay, leaving 80 grams of Actinium-225. During the second half-life (another 10 days, for a total of 20 days), half of the remaining 80 grams will decay, leaving 40 grams. After the third half-life (another 10 days, for a total of 30 days), half of the remaining 40 grams will decay, leaving 20 grams. A correct response should indicate points at (10 days, 80 grams), (20 days, 40 grams) and (30 days, 20 grams). All three points must be correctly plotted to receive credit. Credit is not awarded if the response contains any extra points. However, the students are not penalized if they place an additional point at (0 days, 160 grams).
Actinium-225 has a half-life of 10 days. A scientist starts with a 160-gram sample.

Plot three points to show how much Actinium-225 will remain after 10 days, 20 days and 30 days.

![Decay of Actinium-225](image)

**Notes on Scoring**

This response earns full credit (1 point). Three points are correctly plotted at (10 days, 80 grams), (20 days, 40 grams) and (30 days, 20 grams).
Sample Response: 1 point

Actinium-225 has a half-life of 10 days. A scientist starts with a 160-gram sample.

Plot three points to show how much Actinium-225 will remain after 10 days, 20 days and 30 days.

![Graph of Actinium-225 Decay]

Notes on Scoring

This response earns full credit (1 point). Three points are correctly plotted at (10 days, 80 grams), (20 days, 40 grams) and (30 days, 20 grams). There is a fourth point plotted, but it is at (0 days, 160 grams). While placing this point is not required for credit, students are not penalized for adding this point.
Sample Response: 0 points

Actinium-225 has a half-life of 10 days. A scientist starts with a 160-gram sample. Plot three points to show how much Actinium-225 will remain after 10 days, 20 days and 30 days.

Notes on Scoring

This response earns no credit (0 points). The three plotted points, (10 days, 40 grams), (20 days, 100 grams) and (30 days, 20 grams) do not represent the mass of Actinium-225 that remains at these times. The correct masses are 80 grams at 10 days, 40 grams at 20 days and 20 grams at 30 days.
Notes on Scoring

This response earns no credit (0 points). The three plotted points, (10 days, 40 grams), (17.5 days, 100 grams) and (27.5 days, 160 grams) do not represent the mass of Actinium-225 that remains at these times. The correct masses are 80 grams at 10 days, 40 grams at 20 days and 20 grams at 30 days.
Physical Science
Spring 2015 Item Release

Question 11

Question and Scoring Guidelines
Question 11

Which characteristic of metals gives them high conductivity?

A. Metal atoms retain energy.
B. Metal atoms are weakly bonded.
C. Metals resist temperature changes.
D. Metals have electrons that flow freely.

Points Possible: 1
See Alignment for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. Conductivity is dependent on the ability of electrons in the substance to move freely, not by metal’s ability to retain energy.

Rationale for Option B: This is incorrect. Conductivity depends on the ability of electrons to flow freely, not on how strongly the metal atoms are bonded together.

Rationale for Option C: This is incorrect. Temperature changes happen when thermal energy enters or leaves an object. Conductivity is related to the motion of electrons through an object.

Rationale for Option D: Key – Metals are able to conduct electricity because of the ability of the electrons to flow freely throughout the material.
Content Elaboration
In physical science, circuits are explained by the flow of electrons, and current, voltage and resistance are introduced conceptually. The differences between electrical conductors and insulators can be explained by how freely the electrons flow throughout the material due to how firmly electrons are held by the nucleus.

Cognitive Demand
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students' knowledge of science fact, information, concepts, tools, procedures and basic principles.

Explanation of the Item
This one-point, multiple-choice item requires the student to recall that metals are good conductors because their electrons flow freely throughout the material since the electrons are not as firmly held by the nucleus as with nonmetals.

Sample Response: 1 point

Which characteristic of metals gives them high conductivity?

A. Metal atoms retain energy.
B. Metal atoms are weakly bonded.
C. Metals resist temperature changes.
D. Metals have electrons that flow freely.
Physical Science
Spring 2015 Item Release

Question 12

Question and Scoring Guidelines
Question 12

Scoring Guidelines

For this item, a full-credit response includes:

- The “2 s” car placed at the “20 m” position or sign;

  AND

- The “6 s” car placed at the “60 m” position or sign (1 point).

There is no partial credit for this item.
Content Elaboration

Velocity is a vector property that represents the rate at which position changes. Average velocity can be calculated by dividing displacement (change in position) by the elapsed time (\(v_{\text{avg}} = (x_f - x_i)/(t_f - t_i)\)). Velocity may be positive or negative, depending upon the direction of motion, and is not always equal to the speed. Objects that move with constant velocity have the same displacement for each successive time interval. While speeding up or slowing down and/or changing direction, the velocity of an object changes continuously, from instant to instant.

Motion can be represented by position vs. time and velocity vs. time graphs. Specifics about the speed, direction and change in motion can be determined by interpreting such graphs. For physical science, graphs will be limited to positive x-values and will show only uniform motion involving segments of constant velocity or constant acceleration. Motion must be investigated by collecting and analyzing data in the laboratory. Technology can enhance motion exploration and investigation through video analysis, the use of motion detectors and graphing data for analysis.

Constant acceleration is represented by a straight line (not necessarily horizontal) on a velocity vs. time graph. Objects that have no acceleration (at rest or moving at constant velocity) will have a straight horizontal line for a velocity vs. time graph. Average acceleration can be determined from the slope of a velocity vs. time graph. The details about motion graphs should not be taught as rules to memorize but rather as generalizations that can be developed from interpreting the graphs.

Cognitive Demand

Interpreting and Communicating Science Concepts (C)

Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.
Explanation of the Item
This one-point, machine-scored, constructed-response item requires the student to interpret a speed vs. time graph of a car to determine the position of the car at different times. The speed vs. time graph shows a straight horizontal line at a speed of 10 meters/second. This means that the car is traveling at a constant speed of 10 meters/second. The car travels an additional 10 meters every second. This means that at two seconds, the position would be 20 meters and, at six seconds, the position would be 60 meters. A response must correctly show both positions in order to receive credit. No partial credit is awarded.
Physical Science
Spring 2015 Item Release

Question 12

Sample Responses
Sample Response: 1 point

The graph shows a car’s speed as it moves to the right along a 100-meter section of a race track.

**Speed vs. Time for a Moving Car**

A. Move the car labeled “2 s” to the position on the track of the car at 2 seconds.

B. Move the car labeled “6 s” to the position on the track of the car at 6 seconds.

---

**Notes on Scoring**

This response earns full credit (1 point). The positions are correctly shown as 20 meters at 2 seconds and 60 meters at 6 seconds.
Sample Response: 1 point

The graph shows a car’s speed as it moves to the right along a 100-meter section of a race track.

Notes on Scoring

This response earns full credit (1 point). The positions are correctly shown as 20 meters at 2 seconds and 60 meters at 6 seconds. Even though the 6-second marker is placed above the sign rather than on the track, the intent is clear and the response is awarded full credit.
Sample Response: 0 points

The graph shows a car's speed as it moves to the right along a 100-meter section of a race track.

**Speed vs. Time for a Moving Car**

A. Move the car labeled "2 s" to the position on the track of the car at 2 seconds.

B. Move the car labeled "6 s" to the position on the track of the car at 6 seconds.

---

**Notes on Scoring**

This response receives no credit (0 points). Although the 2-second marker is correctly placed at 20 meters, the 6-second marker is incorrectly placed at 100 meters rather than 60 meters. This would mean that the car is accelerating, and the graph clearly shows constant speed.
Sample Response: 0 points

Notes on Scoring

This response earns no credit (0 points). The placement of the markers at 80 meters for 2 seconds and 25 meters at 6 seconds is not consistent with the graph, which shows constant speed.
Physical Science
Spring 2015 Item Release

Question 13

Question and Scoring Guidelines
Question 13

A beaker of ice and water has a temperature of 0°C. A teacher heats the beaker of ice and water on a hot plate, adding thermal energy to the mixture. The temperature of the mixture does not change until all the ice melts.

What is the effect of the added thermal energy while the ice is melting?

A. The atoms in the molecules split.
B. The bonds between the molecules break.
C. The average size of the molecules increases.
D. The average kinetic energy of the molecules decreases.

Points Possible: 1
See Alignment for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. Splitting of atoms is a nuclear reaction. Adding thermal energy to the mixture produces an increase in the potential energy rather than a nuclear reaction.

Rationale for Option B: Key – The thermal energy is used to break bonds that hold molecules together in the rigid, solid state. The molecules are then free to move as a liquid.

Rationale for Option C: This is incorrect. The molecules remain the same size. The distance between them is decreased as ice melts.

Rationale for Option D: This is incorrect. Adding thermal energy to the mixture will increase the potential energy of the particles.
Phase changes can be represented by graphing the temperature of a sample vs. the time it has been heated. Investigations must include collecting data during heating, cooling and solid-liquid-solid phase changes. At times, the temperature will change steadily, indicating a change in the motion of the particles and the kinetic energy of the substance. However, during a phase change, the temperature of a substance does not change, indicating there is no change in kinetic energy. Since the substance continues to gain or lose energy during phase changes, these changes in energy are potential and indicate a change in the position of the particles. When heating a substance, a phase change will occur when the kinetic energy of the particles is great enough to overcome the attractive forces between the particles; the substance then melts or boils. Conversely, when cooling a substance, a phase change will occur when the kinetic energy of the particles is no longer great enough to overcome the attractive forces between the particles; the substance then condenses or freezes. Phase changes are examples of changes that can occur when energy is absorbed from the surroundings (endothermic) or released into the surroundings (exothermic).

Cognitive Demand
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students' knowledge of science fact, information, concepts, tools, procedures and basic principles.

Explanation of the Item
This one-point, multiple-choice item requires the student to identify the effect of adding thermal energy during melting. Temperature is an indication of the average kinetic energy of the particles of a substance. When thermal energy is added to the ice at 0°C, the temperature remains constant as the ice begins to melt. Since the temperature remains constant, it can be concluded that the kinetic energy of the particles also remains constant. Therefore, the energy that is added must increase the
potential energy of the substance. In fact, the energy goes into breaking the bonds between the water molecules that hold it in a rigid, solid structure. The added thermal energy goes into an increased potential energy due to the change in position of the particles.

Sample Response: 1 point

A beaker of ice and water has a temperature of 0°C. A teacher heats the beaker of ice and water on a hot plate, adding thermal energy to the mixture. The temperature of the mixture does not change until all the ice melts.

What is the effect of the added thermal energy while the ice is melting?

A. The atoms in the molecules split.
B. The bonds between the molecules break.
C. The average size of the molecules increases.
D. The average kinetic energy of the molecules decreases.
Physical Science
Spring 2015 Item Release

Question 14

Question and Scoring Guidelines
Question 14

An astronomer records and studies the absorption spectrum of a distant galaxy and compares the data with those of a nearby galaxy. The absorption spectra are shown.

Absorption Spectrum of a Nearby Galaxy

Absorption Spectrum of a Distant Galaxy

Which conclusion about the motion of the distant galaxy relative to the nearby galaxy is supported by these data?

A. The distant galaxy is moving toward Earth.
B. The distant galaxy is moving around Earth.
C. The distant galaxy is moving away from Earth.
D. The distant galaxy is moving parallel with Earth.

Points Possible: 1

See Alignment for more detail.
Scoring Guidelines

Rationale for Option A: This is incorrect. The galaxy is shifted toward the red (700 nm) end of the spectrum. A shift toward the blue (400 nm) end of the spectrum would be evidence that a galaxy is moving toward the point of observation.

Rationale for Option B: This is incorrect. The galaxy is shifted toward the red (700 nm) end of the spectrum. A galaxy orbiting the point of observation would have a red shift and a blue shift as it moved away from and then back toward the observation point.

Rationale for Option C: Key – The galaxy is shifted toward the red (700 nm) end of the spectrum. Red shift is evidence that a galaxy is moving away from the point of observation.

Rationale for Option D: This is incorrect. The galaxy is shifted toward the red (700 nm) end of the spectrum. A galaxy moving parallel with the point of observation would have no shift in the spectrum.

Alignment

Topic
The Universe

Subtopic
Galaxy Formation

Content Elaboration
Hubble’s law states that galaxies that are farther away have a greater red shift, so the speed at which a galaxy is moving away is proportional to its distance from the Earth. Red shift is a phenomenon due to Doppler shifting, so the shift of light from a galaxy to the red end of the spectrum indicates that the galaxy and the observer are moving farther away from one another.

Cognitive Demand
Interpreting and Communicating Science Concepts (C)

Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.
Explaination of the Item
This one-point, multiple-choice item requires the student to explain how evidence from stars produces information about the processes that cause changes in the scale of the universe by communicating how red shift helps provide information about the relative motion of celestial bodies.

Sample Response: 1 point

An astronomer records and studies the absorption spectrum of a distant galaxy and compares the data with those of a nearby galaxy. The absorption spectra are shown.

Which conclusion about the motion of the distant galaxy relative to the nearby galaxy is supported by these data?

1. The distant galaxy is moving toward Earth.
2. The distant galaxy is moving around Earth.
3. The distant galaxy is moving away from Earth.
4. The distant galaxy is moving parallel with Earth.
Physical Science
Spring 2015 Item Release

Question 15

Question and Scoring Guidelines
Question 15

Scoring Guidelines

For this item, a full-credit response includes:

- Only “Atom #2” and “Atom #4” in the “Isotopes” boxes;
  AND
- Only “Atom #1” and “Atom #3” in the “Ions” boxes (1 point).

Points Possible: 1
See Alignment for more detail.
Alignment

Topic
Study of Matter

Subtopic
Atoms

Content Elaboration
All atoms of a particular element have the same atomic number; an element may have different isotopes with different mass numbers. Atoms may gain or lose valence electrons to become anions or cations. Atomic number, mass number, charge and identity of the element can be determined from the numbers of protons, neutrons and electrons.

Cognitive Demand
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students' knowledge of science fact, information, concepts, tools, procedures and basic principles.

Explanation of the Item
This one-point, machine-scored, constructed-response item requires the student to identify ions and isotopes from the numbers of protons, neutrons and electrons of different atoms. Atoms are isotopes of each other when they have the same number of protons but different numbers of neutrons. Atom #2 and Atom #4 both have 7 protons, but Atom #2 has 7 neutrons, while Atom #4 has 8 neutrons. Since they have the same number of protons but different numbers of neutrons, Atom #2 and Atom #4 are isotopes of one another.

Ions are atoms that have either lost or gained an electron to form a charged particle. Protons are positively charged, and electrons are negatively charged. Atoms that have the same number of protons as electrons have a net charge of zero and are neutral. Positive ions have more protons than electrons. Negative ions have more electrons than protons. Atom #1 has 9 protons and 10 electrons, giving an overall charge of 1–, making it an ion. Atom #3 has 11 protons and 10 electrons, giving an overall charge of 1+, making it an ion as well.
Physical Science
Spring 2015 Item Release

Question 15

Sample Responses
Sample Response: 1 point

Notes on Scoring

This response earns full credit (1 point) for indicating that Atom #2 and Atom #4 are isotopes and that Atom #1 and Atom #3 are ions.
Notes on Scoring

This response earns no credit (0 points). Atom #1 and Atom #2 have different numbers of protons and cannot be isotopes of each other. While Atom #3 is an ion, Atom #4 has the same number of protons as electrons and is therefore neutral. Ions must have an overall net charge. No partial credit is given for this item.
Notes on Scoring

This response earns no credit (0 points). Atom #1 has 9 protons and Atom #3 has 11 protons. Since they have different numbers of protons, the atoms cannot be isotopes of each other. Both Atom #2 and Atom #4 have 7 protons and 7 electrons. Since they have the same number of protons as electrons, the atoms are both neutral with no charge. Ions always have a charge, so Atom #2 and Atom #4 cannot be ions.
Physical Science
Spring 2015 Item Release

Question 16

Question and Scoring Guidelines
Question 16

Which element has properties most similar to those of carbon (C)?

A. boron (B)
B. nitrogen (N)
C. phosphorus (P)
D. silicon (Si)

Points Possible: 1
See Alignment for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. Boron is in Group 13 on the periodic table while carbon is in Group 14. Elements within the same group have similar properties.

Rationale for Option B: This is incorrect. Nitrogen is in Group 15 on the periodic table while carbon is in Group 14. Elements within the same group have similar properties.

Rationale for Option C: This is incorrect. Phosphorus is in Group 15 on the periodic table while carbon is in Group 14. Elements within the same group have similar properties.

Rationale for Option D: Key – Both carbon and silicon are in Group 14 on the periodic table. Elements within the same group have similar properties.
Alignment

Topic
Study of Matter

Subtopic
Periodic Trends of the Elements

Content Elaboration
When elements are listed in order of increasing atomic number, the same sequence of properties appears over and over again; this is the periodic law. The periodic table is arranged so that elements with similar chemical and physical properties are in the same group or family. Metalloids are elements that have some properties of metals and some properties of nonmetals. Metals, nonmetals, metalloids, periods and groups or families (including the alkali metals, alkaline earth metals, halogens and noble gases) can be identified by their position on the periodic table. Elements in Groups 1, 2 and 17 have characteristic ionic charges that will be used to predict the formulas of compounds.

Cognitive Demand
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students' knowledge of science fact, information, concepts, tools, procedures and basic principles.

Explanation of the Item
This one-point, multiple-choice item requires the student to recognize that elements in the same group or family (vertical column) on the periodic table have similar properties. The item asks which element is similar to carbon, which is in Group 14. Boron is in Group 13, nitrogen and phosphorus are in Group 15, and silicon is in Group 14. Since carbon and silicon are in the same vertical column, they are in the same group or family and thus share similar properties.
Which element has properties most similar to those of carbon (C)?

A. boron (B)
B. nitrogen (N)
C. phosphorus (P)
D. silicon (Si)
Physical Science
Spring 2015 Item Release

Question 17

Question and Scoring Guidelines
Question 17

Some of the elements given bond ionically while others bond covalently. Given the name for each compound, determine the type and number of atoms needed to represent the composition of the compound.

A. Place the type and number of atoms into the chart to represent the composition of each ionic compound.

B. Place the type and number of atoms into the chart to represent the composition of each covalent compound.

- You may use each element more than once.
- You do not need to use all of the elements.

### Ionic Compounds

<table>
<thead>
<tr>
<th>Compound Name</th>
<th>Composing Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium oxide</td>
<td></td>
</tr>
<tr>
<td>Calcium fluoride</td>
<td></td>
</tr>
</tbody>
</table>

### Covalent Compounds

<table>
<thead>
<tr>
<th>Compound Name</th>
<th>Composing Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon monoxide</td>
<td></td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td></td>
</tr>
</tbody>
</table>

Scoring Guidelines

For this item, a full-credit response (2 points) includes:

- Only two “Na” and one “O” in the “Sodium oxide” box AND only one “Ca” and two “F” in the the “Calcium fluoride” box (1 point);

AND

- Only one “C” and one “O” in the “Carbon monoxide” box AND only one “S” and two “O” in the “Sulfur dioxide” box (1 point).

Points Possible: 2

See Alignment for more detail.
For this item, a partial-credit response (1 point) includes:

- Only two “Na” and one “O” in the “Sodium oxide” box AND only one “Ca” and two “F” in the “Calcium fluoride” box (1 point);

  OR

- Only one “C” and one “O” in the “Carbon monoxide” box AND only one “S” and two “O” in the “Sulfur dioxide” box (1 point).

**Alignment**

**Topic**
Study of Matter

**Subtopic**
Bonding and Compounds

**Content Elaboration**
Using the periodic table to determine ionic charge, formulas of ionic compounds containing elements from Groups 1, 2, 17, hydrogen and oxygen can be predicted. Given a chemical formula, a compound can be named using conventional systems that include Greek prefixes where appropriate. Prefixes will be limited to represent values from one to 10. Given the name of an ionic or covalent substance, formulas can be written.

**Cognitive Demand**
Interpreting and Communicating Science Concepts (C)

Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.

**Explanation of the Item**
This two-point, machine-scored, constructed-response item requires the student to determine the elemental ratios of atoms in different compounds, given their names. For ionic compounds, the elemental ratio can be determined from the ionic charges of the atoms, given their position on the periodic table. The first ionic compound is sodium oxide. Sodium is in Group 1 on the periodic table, which tends to form 1+ ions. “Oxide” refers to an ion of oxygen. Oxygen is in Group 16 on the periodic table, which
tends to form 2– ions. In order to give a neutral compound, two 1+ sodium ions, Na, are needed for every one 2– oxygen ion, O.

The second ionic compound is calcium fluoride. Calcium is in Group 2 on the periodic table, which tends to form 2+ ions. “Fluoride” refers to an ion of fluorine. Fluorine is in Group 17 on the periodic table, which tends to form 1– ions. In order to give a neutral compound, two 1– fluoride ions, F, are needed for every one 2+ calcium ion, Ca.

For covalent compounds, the elemental ratio can be determined from the Greek prefixes in the names. The first covalent compound is carbon monoxide. When there is no prefix for the first element, it can be assumed that there is only one of these atoms. Therefore, there will be only one carbon atom. The prefix “mono-” means 1, so there is only one oxygen atom. Carbon monoxide is made up of one carbon atom, C, and one oxygen atom, O.

The second covalent compound is sulfur dioxide. Since there is no prefix in front of “sulfur,” it can be assumed that there is only one. The prefix “di-” means “two,” so “dioxide” means that there are two oxygen atoms. Sulfur dioxide is made up of one sulfur atom, S, and two oxygen atoms, O.
Physical Science
Spring 2015 Item Release

Question 17

Sample Responses
Some of the elements given bond ionically while others bond covalently. Given the name for each compound, determine the type and number of atoms needed to represent the composition of the compound.

A. Place the type and number of atoms into the chart to represent the composition of each ionic compound.

<table>
<thead>
<tr>
<th>Compound Name</th>
<th>Composing Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium oxide</td>
<td>Na, Na, O</td>
</tr>
<tr>
<td>Calcium fluoride</td>
<td>Ca, F, F</td>
</tr>
</tbody>
</table>

B. Place the type and number of atoms into the chart to represent the composition of each covalent compound.

- You may use each element more than once.
- You do not need to use all of the elements.

<table>
<thead>
<tr>
<th>Compound Name</th>
<th>Composing Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon monoxide</td>
<td>C, O</td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>S, O, O</td>
</tr>
</tbody>
</table>

Notes on Scoring

This response earns full credit (2 points). Sodium oxide is shown as being made up of 2 sodiums, Na, and one oxygen, O. Calcium fluoride is shown as being made up of one calcium, Ca, and two fluorines, F. Carbon monoxide is shown as being made up of one carbon, C, and one oxygen, O. Sulfur dioxide is shown as being made up of one sulfur, S, and two oxygens, O.
Sample Response: 1 point

Notes on Scoring

This response earns partial credit (1 point). The response correctly gives the type and number of atoms for Part B, so the response earns 1 point for covalent compounds. However, sodium oxide contains two sodiums, Na, and one oxygen, O. Calcium fluoride contains one calcium, Ca, and two fluorines, F. Since the response does not indicate the correct ratios for the ionic compounds, no credit is awarded for Part A.
Notes on Scoring

This response earns partial credit (1 point). The response correctly shows sodium oxide consisting of two sodiums, Na, and one oxygen, O. The response also correctly shows calcium fluoride as containing one calcium, Ca, and two fluorines, F. However, the response does not show carbon monoxide consisting of one carbon, C, and one oxygen, O. It also does not show sulfur dioxide consisting of one sulfur, S, and two oxygens, O. Therefore, the point for indicating the ratio of atoms in covalent compounds cannot be awarded.
Some of the elements given bond ionically while others bond covalently. Given the name for each compound, determine the type and number of atoms needed to represent the composition of the compound.

A. Place the type and number of atoms into the chart to represent the composition of each ionic compound.

B. Place the type and number of atoms into the chart to represent the composition of each covalent compound.

- You may use each element more than once.
- You do not need to use all of the elements.

### Notes on Scoring

This response earns no credit (0 points). The response is incorrect for all four compounds. Sodium oxide is made up of two sodium atoms, Na, and one oxygen atom, O. Calcium fluoride is made up of one calcium atom, Ca, and two fluorine atoms, F. Carbon monoxide is made up of one carbon atom, C, and one oxygen atom, O. Sulfur dioxide is made up of one sulfur atom, S, and two oxygen atoms, O.
Notes on Scoring

This response earns no credit (0 points). The response is incorrect for all four compounds. Sodium oxide is made up of two sodium atoms, Na, and one oxygen atom, O. Calcium fluoride is made up of one calcium atom, Ca, and two fluorine atoms, F. Carbon monoxide is made up of one carbon atom, C, and one oxygen atom, O. Sulfur dioxide is made up of one sulfur atom, S, and two oxygen atoms, O.
Physical Science
Spring 2015 Item Release

Question 18

Question and Scoring Guidelines
Question 18

What is the primary force that holds neutrons and protons together in the nucleus of an atom?

- A) electrical force
- B) magnetic force
- C) gravitational force
- D) strong nuclear force

Points Possible: 1
See Alignment for more detail.

Scoring Guidelines

**Rationale for Option A:** This is incorrect. Electrical force acts against the force that binds nucleons together.

**Rationale for Option B:** This is incorrect. Magnetic force in atoms is not a binding force in the nucleus.

**Rationale for Option C:** This is incorrect. Gravitational force is many orders of magnitude weaker than the other attractive and repulsive forces in the nucleus.

**Rationale for Option D:** **Key** – The strong nuclear force is stronger than the electromagnetic force, holding the nucleus together.
While chemical changes involve changes in the electrons, nuclear reactions involve changes to the nucleus and involve much larger energies than chemical reactions. The strong nuclear force is the attractive force that binds protons and neutrons together in the nucleus. While the nuclear force is extremely weak at most distances, over the very short distances present in the nucleus, the force is greater than the repulsive electrical forces among protons. When the attractive nuclear forces and repulsive electrical forces in the nucleus are not balanced, the nucleus is unstable. Through radioactive decay, the unstable nucleus emits radiation in the form of very fast-moving particles and energy to produce a new nucleus, thus changing the identity of the element. Nuclei that undergo this process are said to be radioactive. Radioactive isotopes have several medical applications. The radiation they release can be used to kill undesired cells (e.g., cancer cells). Radioisotopes can be introduced into the body to show the flow of materials in biological processes.

Cognitive Demand
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students’ knowledge of science fact, information, concepts, tools, procedures and basic principles.

Explanation of the Item
This one-point, multiple-choice item requires the student to identify the strong nuclear force that holds nucleons together in the nucleus.
Sample Response: 1 point

What is the primary force that holds neutrons and protons together in the nucleus of an atom?

A  electrical force
B  magnetic force
C  gravitational force
D  strong nuclear force
Physical Science
Spring 2015 Item Release

Question 19

Question and Scoring Guidelines
Question 19

A scientist walks from her home to the post office to her lab as shown in the diagram.

Path of a Scientist

A. Place a number in the blank box to show the distance that she travels.
B. Use the Add Arrow button to show her displacement.

• Place only one number in the blank box.
• You do not need to use all the numbers.

Points Possible: 1
See Alignment for more detail.

Scoring Guidelines
For this item, a full-credit response includes:

• The “70” label and no other labels in the “Distance...” box;

AND

• A single arrow starting at “Home” and ending at “Lab” (1 point).
The motion of an object depends on the observer’s frame of reference and is described in terms of distance, position, displacement, speed, velocity, acceleration and time. Position, displacement, velocity and acceleration are all vector properties (magnitude and direction). All motion is relative to whatever frame of reference is chosen, for there is no motionless frame from which to judge all motion. The relative nature of motion is addressed conceptually, not mathematically. Non-inertial reference frames are excluded. Motion diagrams can be drawn and interpreted to represent the position and velocity of an object.

The displacement or change in position of an object is a vector quantity that can be calculated by subtracting the initial position from the final position \( \Delta x = x_f - x_i \). Displacement can be positive or negative depending upon the direction of motion. Displacement is not always equal to the distance traveled. Examples should be given where the distance is not the same as the displacement.

**Cognitive Demand**

**Recalling Accurate Science (R)**

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students' knowledge of science fact, information, concepts, tools, procedures and basic principles.

**Explanation of the Item**

This one-point, machine-scored, constructed-response item requires the student to indicate the distance traveled and the displacement for a scientist who walks a particular path. Distance is a scalar property and is independent of direction. To determine the distance, one must add up all the individual distances traveled, regardless of the direction. In this case, the scientist walks 40 meters from home to the post office, then 30 meters from the post office to the lab. Her distance traveled is the sum of these values, 40 m + 30 m = 70 m.
Displacement is a vector property that includes both magnitude and direction. Displacement depends only upon the initial and final positions, not on the path that is traveled. Displacement can be represented with an arrow that starts at the initial position and ends on the final position. In this case, an arrow should be drawn from the home to the lab, with the arrow pointing toward the lab.

This item is assessing whether the student understands the differences between distance and displacement, and it has a value of one point. Since both parts are necessary to demonstrate that the student understands the differences between distance and displacement, responses must have both parts correct to earn one point.
Physical Science
Spring 2015 Item Release

Question 19

Sample Responses
Sample Response: 1 point

Notes on Scoring

This response earns full credit (one point). It correctly gives a distance of 70 meters and indicates a displacement arrow going from “Home” to the “Lab,” pointing toward the “Lab.”
Notes on Scoring

This response earns no credit (0 points). While the response correctly indicates the displacement with an arrow starting at “Home” and pointing to the “Lab,” it incorrectly indicates a distance of 10 meters instead of 70 meters. In order to earn one point, both parts of the response must be correct.
Sample Response: 0 points

Notes on Scoring

This response earns no credit (0 points). The response incorrectly indicates a distance of 40 meters instead of 70 meters. It also incorrectly indicates the displacement with two arrows, one starting at “Home” and pointing toward the “Post Office” and the other starting at the “Post Office” and pointing toward the “Lab.” The correct displacement arrow starts at “Home” and points toward the “Lab.”