Item Position	Rationales	
1	Option B is correct	One molecule of acetic acid (CH_3COOH) contains 4 atoms of hydrogen.
	Option A is incorrect	There are three elements in the molecule, but there are not three atoms of hydrogen.
	Option C is incorrect	There are not five atoms of any of the elements in the molecule.
	Option D is incorrect	There are six letters written in the formula, but this does not represent the number of atoms of hydrogen.

Item Position	Rationales	
2	2 pts	White dwarfs: Sirius B Main sequence: Altair Giants: Aldebaran Supergiants: Betelgeuse
	1 pt	Half or more than half of the answer is correct.
	0 pt	Less than half of the answer is correct.

Item Position	Rationales	
3	Option A is correct	Reversible changes in the state of matter, such as melting, are physical changes.
	Option B is incorrect	The water can be frozen again and turned back into ice cubes. Because the change is reversible, it is a physical change, not a chemical change.
	Option C is incorrect	Melting is a physical change, but heat is transferred from the liquid to the ice cubes, not from the ice cubes to the liquid.
	Option D is incorrect	A new substance is not being formed. The water is simply changing from a solid to a liquid.

Item Position	Rationales	
4	Option D is correct	The sun is located on a spiral arm of the Milky Way about 28,000 light-years from the galactic center.
	Option A is incorrect	The sun does not have a rocky core. The sun's core is plasma.
	Option B is incorrect	The sun is a medium-sized star.
	Option C is incorrect	The sun is the closest star to Earth.

Item Position	Rationales	
5	Option D is correct	The combination with the greatest mass, Cart 3 and Cargo Y, will have the least acceleration. The combination with the least mass, Cart 1 and Cargo Z, will have the greatest acceleration.
	Option A is incorrect	Cart 1 is not the cart with the greatest mass, so this combination will not result in the least acceleration.
	Option B is incorrect	Cart 2 is not the cart with the greatest mass, so this combination will not result in the least acceleration.
	Option C is incorrect	Cargo Z is not the cart with the greatest mass, so this combination will not result in the least acceleration.

Item Position	Rationales	
6	Part A	
	Option A is correct	Continental plates move toward each other at convergent boundaries, resulting in mountain ranges.
	Option B is incorrect	Mid-ocean ridges can form at divergent plate boundaries between two oceanic plates.
	Option C is incorrect	Trenches are formed when an oceanic plate subducts beneath a continental plate.
	Option D is incorrect	Continental plates move apart at divergent boundaries, resulting in rift valleys.
	Part B	
	Option D is correct	When two continental plates move toward each other at convergent boundaries, the edges of the plates are folded and pushed upward, resulting in mountain ranges.
	Option A is incorrect	Continental plates are generally less dense than oceanic plates. Therefore, they do not get pulled underneath other plates.
	Option B is incorrect	At divergent boundaries, two plates pull away from each other.
	Option C is incorrect	An oceanic plate can slide beneath another plate at a convergent boundary, not at a divergent boundary.

Item Position	Rationales	
7	Option C is correct	This plot is not good for studying primary succession, because primary succession does not start with soil. Primary succession is a process where living organisms first colonize an area in which there was no life in that area before, such as on newly formed volcanic rock.
	Option A is incorrect	The plan will not be successful. Even though there is a water source, the plan will not be successful because the field is not appropriate for studying primary succession.
	Option B is incorrect	Using a smaller plot of land will not help the student's plan succeed. Succession is generally better to study in a large area.
	Option D is incorrect	The student removed all plants from the plot of land, so there should not be any grass in the field. Additionally, if there were grass, the student's plan could not be successful, because grass is not present at the beginning of primary succession.

Item Position	Rationales	
8	Option B is correct	Shrimp consume plankton and algae, so if there is an increase in the shrimp population, the algae and plankton populations will most likely decrease.
	Option A is incorrect	The algae population would most likely decrease since there would be an increase in shrimp consuming the algae (and plankton). The small fish population would most likely increase due to the increase in shrimp.
	Option C is incorrect	The small fish population would most likely increase, leading to an increase in the eel population.
	Option D is incorrect	The increase in shrimp would cause a decrease in plankton, and the eel population would most likely increase.

Item Position	Rationales	
9	Option B is correct	In this position, the South Pole is tilted toward the sun, which increases the amount of sunlight that the Southern Hemisphere receives. This indicates summer.
	Option A is incorrect	This position shows spring in the Southern Hemisphere.
	Option C is incorrect	This position shows fall in the Southern Hemisphere.
	Option D is incorrect	In this position, the South Pole is tilted away from the sun, which reduces the amount of sunlight that the Southern Hemisphere receives. This indicates winter.

Item Position	Rationales	
10	Option C is correct	Palladium is a metal with all these properties.
	Option A is incorrect	Arsenic is brittle, not ductile.
	Option B is incorrect	Neon is a gas at room temperature, not a solid.
	Option D is incorrect	Silicon is brittle, not ductile.

Item Position	Rationales	
11	Option A is correct	The moon is perpendicular to the sun, which causes a neap tide.
	Option B is incorrect	A spring tide is when the sun, the moon, and Earth are all in alignment, which is not shown in the diagram.
	Option C is incorrect	A neap tide results in the smallest difference between the high and low tide, not the largest difference.
	Option D is incorrect	A spring tide is when the sun, the moon, and Earth are all in alignment, which is not shown in the diagram.

Item Position	Rationales	
12	Option D is correct	Action and reaction forces act in opposite directions.
	Option A is incorrect	Action and reaction forces are equal in magnitude.
	Option B is incorrect	Action and reaction forces act in opposite directions.
	Option C is incorrect	Action and reaction forces are equal in magnitude.

Item Position	Rationales	
13	Option A is correct	The net force is 48.0 N – 41.0 N = 7.0 N. According to Newton's second law, acceleration = net force divided by mass; so 7.0 N/14.0 kg = 0.5 m/s^2
	Option B is incorrect	2.9 m/s^2 is not correct. The student likely calculated 41.0 N divided by 14.0 kg.
	Option C is incorrect	3.4 m/s^2 is not correct. The student likely calculated 48.0 N divided by 14.0 kg.
	Option D is incorrect	6.4 m/s^2 is not correct. The student likely calculated 48.0 N + 41.0 N divided by 14.0 kg.

Item Position	Rationales	
14	Option C is correct	Dark-colored fur would be a favorable genetic trait in an environment with less snow over time.
	Option A is incorrect	A decreasing owl population may or may not favor dark-colored fur in mice, depending on the environment.
	Option B is incorrect	An increasing owl population may or may not favor dark-colored fur in mice, depending on the environment.
	Option D is incorrect	Increased snowfall would favor light-colored fur in mice.

Item Position	Rationales	
15	Option B is correct	The force from the first student is 100kg * 1.5 m/s^2 = 150 N and the net force from both students is 100 kg * 2.5 m/s^2 = 250 N. Therefore, the force from Student 2 alone must be 250 N – 150 N = 100 N.
	Option A is incorrect	50 N is half the force applied by the second student.
	Option C is incorrect	150 N is the force applied by the first student.
	Option D is incorrect	250 N is the net force applied by both students.

Item Position	Rationales	
16	Option C is correct	By the law of conservation of mass, the total number of atoms in the reactants is equal to the total number of atoms in the products.
	Option A is incorrect	A molecule of liquid water has three atoms, while a molecule of oxygen gas has two atoms.
	Option B is incorrect	A hydrogen peroxide molecule has four atoms, while a molecule of oxygen gas has two atoms.
	Option D is incorrect	The two hydrogen peroxide molecules have a total of eight atoms, while each molecule of liquid water has three atoms.

Item Position	Rationales	
17	Option B is correct	A straight line with a positive slope on a distance-time graph indicates constant speed. A horizontal line indicates that the train has stopped moving.
	Option D is correct	A straight line with a negative slope on a distance-time graph indicates constant speed in the reverse direction.
	Option A is incorrect	A straight line with a positive slope on a distance-time graph indicates constant speed, not acceleration. A horizontal line indicates that the train has stopped moving, not that it is traveling at a constant speed.
	Option C is incorrect	A straight line with a negative slope on a distance-time graph indicates constant speed in the reverse direction, not increasing speed.
	Option E is incorrect	The maximum distance reached is 60 km at the peak, but then the train reverses direction and returns to its starting point, for a total round-trip distance of 120 km.

Item Position	Rationales	
18	Part A	
	Option C is correct	Sea ducks would most likely decrease, as their only food source is insects.
	Option A is incorrect	Bald eagles would most likely remain the same initially and then decrease in population. Bald eagles eat sea ducks; sea ducks eat insects.
	Option B is incorrect	Small fish would most likely remain the same, as they eat both insects and phytoplankton.
	Option D is incorrect	Phytoplankton would most likely increase, since there would be fewer insects eating the phytoplankton.
	Part B	
	Option D is correct	Sea ducks eat only insects, so the sea ducks would have less food available if the insect population decreased.
	Option A is incorrect	Although the predator populations would have multiple food options available, this does not explain why the sea ducks would decrease in number.
	Option B is incorrect	Although the decrease in the number of sea ducks would lead to an increase in phytoplankton, this does not explain why the sea ducks would decrease in number.
	Option C is incorrect	Although there would be fewer insects eating the zooplankton, this does not explain why the sea ducks would decrease in number.

Item Position	Rationales	
19	Option C is correct	Giants have a luminosity that is 10 to 100 times brighter than the sun, with surface temperatures ranging from 3,000 K to 6,000 K.
	Option A is incorrect	Based on the H-R diagram, main-sequence stars with surface temperatures of 3,500 K tend to be less luminous than the sun.
	Option B is incorrect	Based on the H-R diagram, supergiants with surface temperatures of 3,500 K tend to have a luminosity that is 10,000 times brighter than the sun.
	Option D is incorrect	Based on the H-R diagram, white dwarfs typically have surface temperatures greater than 6,000 K.

Item Position	Rationales	
20	Option D is correct	Mechanical energy moves the switch, which then causes electrical energy to be converted into light energy.
	Option A is incorrect	Mechanical energy is not converted into chemical energy in the body.
	Option B is incorrect	Light energy in the bulb is not converted into chemical energy.
	Option C is incorrect	Chemical energy is not directly converted into light energy.

Item Position	Rationales	
21	Option D is correct	Ammonia has 2 elements and 4 atoms. Sodium hydroxide has 3 elements and 3 atoms.
	Option A is incorrect	Sodium hydroxide has more elements than ammonia but not more atoms.
	Option B is incorrect	Ammonia has more atoms than sodium hydroxide but not more elements.
	Option C is incorrect	Ammonia has more atoms than sodium hydroxide, and sodium hydroxide has more elements than ammonia.

Item Position	Rationales	
22	2 pts	The student response states that there was no net force on the box (or that the net force was zero) before the rough surface and that the net force after entering the rough surface was 0.5 N, which decreased the box's velocity.
	1 pt	The student answers half of the questions correctly.
	0 pt	The response is incorrect or irrelevant.

Item Position	Rationales	
23	Option A is correct	This is the total distance divided by the total time: 240 km/4 h = 60 km/h.
	Option B is incorrect	This is the total distance traveled divided by the total time the car was moving: 240 km / 3 h = 80 km/h. This does not include the time the car was stopped.
	Option C is incorrect	This is the average of the two speeds during the intervals that the car was being driven: (100 km/h + 70 km/h)/2 = 85 km/h.
	Option D is incorrect	This is the average of the two distances traveled: (100 km + 140 km)/2 = 120 km.

Item Position	Rationales	
24	Option B is correct	Earth's orbit around the sun is one of the reasons for the different seasons experienced on Earth.
	Option A is incorrect	The movement of the sun on its axis is not a reason for the different seasons experienced on Earth.
	Option C is incorrect	The rotation of Earth causes day and night, not the change of seasons.
	Option D is incorrect	The moon's orbit around Earth is not a reason for the different seasons experienced on Earth.

Item Position	Rationales	
25	Option B is correct	The heat released from condensation fuels hurricanes.
	Option A is incorrect	Hurricanes originate in the tropics or sub-tropics.
	Option C is incorrect	Ocean currents affect the climate of the surrounding land, but they do not produce hurricanes.
	Option D is incorrect	Hurricanes do not form based on the convection process exhibited by different wind directions along the coast during the day and night.

Item Position	Rationales	
26	Option C is correct	The East Pacific Rise was formed at the divergent boundary between the Pacific and Nazca plates. New ocean crust is formed by magma as the plates move apart.
	Option A is incorrect	The East Pacific Rise was formed at the divergent boundary between the Pacific and Nazca plates. This describes the formation of mountains at a convergent boundary.
	Option B is incorrect	The East Pacific Rise was formed at the divergent boundary between the Pacific and Nazca plates. This describes subduction at a convergent boundary.
	Option D is incorrect	The East Pacific Rise was formed at the divergent boundary between the Pacific and Nazca plates. This describes the formation of faults at a transform boundary.

Item Position	Rationales	
27	2 pts	The mass of the ring will **decrease**. The mass of the solution will **increase**. The total mass of the ring and the solution will **remain the same**.
	1 pt	The student answers half or more than half of the responses correctly.
	0 pt	Less than half of the responses are correct.

Item Position	Rationales	
28	Option B is correct	The ocean is responsible for air temperature stability.
	Option A is incorrect	The ocean absorbs carbon dioxide.
	Option C is incorrect	The ocean does not play a role in supplying the atmosphere with nitrogen.
	Option D is incorrect	The ocean does not generate Earth’s magnetic field.

Item Position	Rationales	
29	2 pts	The student identifies one of the following as an example of a physical change: wax changing from solid to liquid or changing from liquid to solid. The student identifies one of the following as an example of a chemical change: the match igniting, the match burning in the air, the candle wick burning the candle wax. AND Reasoning for the physical change includes the fact that there is no change in the basic characteristics of the wax. Reasoning for the chemical change includes the fact that the changes cannot be reversed by physical means OR that the chemical properties are altered.
	1 pt	The student answers half of the questions correctly.
	0 pt	The response is incorrect or irrelevant.

Item Position	Rationales	
30	Option D is correct	Sexual reproduction introduces new gene combinations, resulting in greater diversity within the population.
	Option A is incorrect	Asexual reproduction results in offspring adapted to their environment.
	Option B is incorrect	Asexual reproduction results in genetically identical offspring that would have any genetic mutations that their parent had.
	Option C is incorrect	Asexual reproduction takes less time and energy than sexual reproduction. Sexual reproduction requires finding a mate.

Item Position	Rationales	
31	Option C is correct	The respiratory and muscular systems are involved in coughing.
	Option A is incorrect	Based on the description, the respiratory and muscular systems are involved in coughing. The circulatory system, which carries nutrients and oxygen to cells, and the integumentary system, which protects internal organs, are not directly involved in coughing.
	Option B is incorrect	Based on the description, the respiratory and muscular systems are involved in coughing. The circulatory system, which carries nutrients and oxygen to cells, is not directly involved in coughing.
	Option D is incorrect	Based on the description, the respiratory and muscular systems are involved in coughing. The integumentary system, which protects internal organs, is not directly involved in coughing.

Item Position	Rationales	
32	2 pts	The student selects: Carrots: Remain the same Grasses: Increase Rabbits: Increase Owls: Decrease
	1 pt	The student selects half, or more than half, of the responses correctly.
	0 pt	Less than half of the responses are correct.

Item Position	Rationales	
33	Option A is correct	Changes resulting in the loss of the greatest number of species will cause the most damage to an ecosystem's sustainability.
	Option B is incorrect	Loss of species is more damaging to an ecosystem's sustainability than loss of individuals.
	Option C is incorrect	The loss of one population will not have as large of an impact on an ecosystem's sustainability as the loss of four species.
	Option D is incorrect	Loss of species is more damaging to an ecosystem's sustainability than loss of individuals.

Item Position	Rationales	
34	Option B is correct	Plants growing in a forest after a wildfire are an example of secondary succession. Secondary succession describes the process of plants and animals re-colonizing an environment that has experienced a large disruption but still has soil.
	Option A is incorrect	Plants growing around a volcano after a recent eruption are an example of primary succession. Primary succession describes the process of soil development and stages of colonization by living things in an area that had no soil.
	Option C is incorrect	A landslide that exposes rock is an example of primary succession. Primary succession describes the process of soil development and stages of colonization by living things in an area that had no soil.
	Option D is incorrect	Plants and trees growing where a glacier has retreated are an example of primary succession. Primary succession describes the process of soil development and stages of colonization by living things in an area that had no soil.

Item Position	Rationales	
35	1 pt	The student entered "3" in the box. Zooplankton and krill receive energy from phytoplankton, and crabs receive energy from seaweed.
	0 pt	The response is incorrect.

Item Position	Rationales	
36	Option C is correct	Friction slows the rolling ball.
	Option A is incorrect	There is no force keeping the ball rolling, only a force slowing it down.
	Option B is incorrect	Gravity is a constant force.
	Option D is incorrect	Inertia cannot be greater than the applied force, because inertia does not actively apply a force; it is a measure of the ball's resistance to changes in motion.

Item Position	Rationales	
37	Option C is correct	Mid-ocean ridges such as the Mid-Atlantic Ridge form when plates move apart at divergent boundaries.
	Option A is incorrect	Plates move apart at divergent boundaries and result in the formation of ridges.
	Option B is incorrect	For one plate to move on top of another, the plates must be moving toward each other. The formation of the ridge indicates that the plates are moving away from each other.
	Option D is incorrect	Ridges form when plates move away from each other, not slide past each other.

Item Position	Rationales	
38	Option D is correct	Aluminum (Al) is in the formula for albite, $NaAlSi_3O_8$.
	Option A is incorrect	Astatine (At) is not in the formula for albite.
	Option B is incorrect	Sulfur (S) is not in the formula for albite.
	Option C is incorrect	Nitrogen (N) is not in the formula for albite.