PRACTICE EXAM 29: EARTH AND SPACE SCIENCES REGENTS SIMULATION (50 QUESTIONS)

1. The light from nearly all distant galaxies is shifted toward the red end of the spectrum, an effect known as redshift. What does this widespread redshift indicate?

A. Almost all distant galaxies are moving away from us, which is evidence that the universe is expanding

B. Almost all distant galaxies are moving toward us, which is evidence that the universe is collapsing inward

C. Almost all distant galaxies are made of red-hot gas that naturally gives off only red-colored light

D. Almost all distant galaxies are perfectly stationary, which proves the universe never changes in size at all

2. When a star many times more massive than the Sun runs out of fuel, what is the most likely way its life will end?

A. It gently cools and fades in place, gradually shrinking into a small, dim, slowly cooling white dwarf star

B. It explodes as a supernova, scattering its material into space and leaving a neutron star or black hole behind

C. It quietly splits into several smaller stars that drift apart and continue shining on their own for billions of years

D. It expands without any limit, growing endlessly larger until it eventually fills its entire host galaxy with light

3. The gold in jewelry and the iron in your blood are examples of elements heavier than helium. According to current scientific understanding, where were such heavy elements first created?

A. They formed during the first few minutes after the Big Bang, when the entire universe was extremely hot and dense

B. They are continuously produced today by ordinary chemical reactions occurring at Earth's surface and in its oceans

C. They were created in the cold, empty space between the galaxies, where stray particles slowly combine over time

D. They were forged inside stars and scattered into space when massive stars exploded as supernovae long ago

4. A dwarf planet orbits the Sun at an average distance of 36 AU. Using Kepler's Third Law ($T^2 = a^3$ in solar units), about how long does it take to complete one orbit?

A. About 36 years, because the orbital period in years is always equal to the average distance measured in AU

B. About 6 years, because the orbital period is found by taking the square root of the average distance in AU

C. About 216 years, because 36 cubed is 46,656, and the square root of 46,656 is about 216 years

D. About 72 years, because the orbital period is always equal to twice the value of the average distance in AU

5. In June, the Northern Hemisphere experiences summer while the Southern Hemisphere experiences winter at the same time. What causes the two hemispheres to have opposite seasons?

A. The Southern Hemisphere is much farther from the Sun than the Northern Hemisphere during the month of June

B. The Sun emits far more of its energy toward the Northern Hemisphere than toward the Southern Hemisphere in June

C. The Southern Hemisphere is mostly covered by ocean, which keeps it permanently colder than the Northern Hemisphere

D. In June, the Northern Hemisphere is tilted toward the Sun while the Southern Hemisphere is tilted away from it

6. About a week after a new moon, the Moon appears exactly half lit on its right side and is high in the southern sky at sunset. What phase is this?

A. A waning crescent, the thin phase the Moon passes through just before it returns to the new moon stage

B. A first quarter moon, the phase about a week after new moon, when the right half of the Moon appears illuminated

C. A full moon, the phase when the entire visible face of the Moon is illuminated and stays up throughout the night

D. A waning gibbous, the more-than-half phase the Moon passes through just after it reaches the full moon stage

7. Almost all of the planets spin and orbit the Sun in the same direction. Which idea best explains this shared direction of motion across the solar system?

A. The Sun's bright light physically pushes all of the planets so that they all move in one common direction

B. The planets were each captured separately from deep space and happened by pure chance to all move the same way

C. The entire solar system formed from a single spinning cloud, and the planets inherited that original spinning motion

D. Gravity from a passing star long ago tugged all of the planets until each one moved in the very same direction

8. A solar eclipse occurs when the Moon passes between the Sun and Earth and blocks the Sun's light from reaching part of Earth's surface. During which moon phase can a solar eclipse happen?

A. The new moon phase, when the Moon lies between the Earth and the Sun and can cast its shadow onto Earth

B. The full moon phase, when the Moon is on the far side of the Earth from the Sun and is fully illuminated

C. The first quarter phase, when only the right half of the Moon's visible disk appears lit in the evening sky

D. The waning gibbous phase, when more than half of the Moon is lit but the illuminated portion is shrinking

9. Most coastlines around the world experience two high tides and two low tides each day. What is the main cause of these regular daily tides?

A. The heating of the ocean by the Sun, which makes the seawater expand twice and contract twice each day

B. The Moon's gravity, which raises bulges of water on the near and far sides of Earth that the planet rotates through

C. Strong winds blowing across the ocean surface, which push the water toward and away from the shore twice daily

D. The rotation of the Earth alone, which sloshes the water from one side of each ocean basin to the other and back

10. The Sun has shone steadily for billions of years and will continue for billions more. What process generates the Sun's energy, and where does it occur?

A. The chemical burning of hydrogen gas, similar to a campfire, occurring throughout all of the Sun's outer layers

B. The radioactive decay of heavy elements such as uranium, occurring just beneath the visible surface of the Sun

C. Friction between the Sun's rapidly spinning layers, which generates heat continuously across the entire surface

D. The fusion of hydrogen into helium, occurring in the Sun's extremely hot, dense core where energy is released

11. At solar noon, sunlight reaching the ground in a tropical location strikes at a steep, nearly overhead angle, while sunlight at a far northern location strikes at a low, slanting angle. Why does the tropical location receive more concentrated solar energy?

A. The tropical location is physically much closer to the Sun than the far northern location is at solar noon

B. The Sun deliberately aims more of its radiation toward tropical locations than toward far northern locations

C. A steep, overhead beam concentrates energy on a smaller area, while a slanting beam spreads it over a larger area

D. The far northern location's atmosphere is much thinner, which allows nearly all of the sunlight to pass through it

12. In a sequence of undisturbed sedimentary rock layers, which layer was deposited first and is therefore the oldest?

A. The bottom layer, because in an undisturbed sequence the layers are deposited from the bottom upward over time

B. The top layer, because the highest layer in any sequence is always the first one that was deposited over time

C. The middle layer, because deposition always begins in the center of a sequence and then works outward in both directions

D. None of the layers, because the order in which sedimentary layers are deposited is completely random in every case

13. A radioactive isotope has a half-life of 4,000 years. A sample now contains one-quarter of its original amount of this isotope. How much time has passed?

A. About 4,000 years, because a single half-life reduces the isotope to one-quarter of its original amount remaining

B. About 8,000 years, because two half-lives are required to reduce the isotope to one-quarter of its original amount

C. About 12,000 years, because three half-lives are required to reduce the isotope to one-quarter of its original amount

D. About 16,000 years, because four half-lives are required to reduce the isotope to one-quarter of its original amount

14. Which organism would serve as the best index fossil for matching the ages of rock layers found in different places?

A. A slow-moving bottom-dwelling animal that lived for hundreds of millions of years within a single small region

B. A very large land animal whose heavy bones are easily preserved but that lived in just one isolated mountain range

C. A kind of single-celled life that has existed nearly unchanged from the earliest oceans all the way to the present day

D. A free-floating ocean organism that spread across the entire globe but lived during only a short span of geologic time

15. An igneous intrusion cuts across and bakes the edges of several layers of sedimentary rock in an outcrop. According to the principle of cross-cutting relationships, what can be concluded about the intrusion?

A. The intrusion and the sedimentary layers all formed at exactly the same time because they are touching each other

B. The intrusion is older than the sedimentary layers, which were later deposited on top of the already-cooled intrusion

C. The intrusion is younger than the sedimentary layers, because a feature that cuts across rocks must form after them

D. The relative ages cannot be compared without first determining the exact numerical age of every rock with isotopes

16. Several times in Earth's history, a large fraction of all living species died out within a relatively short span of geologic time. What are these events called?

A. Mass extinctions, intervals during which a large proportion of Earth's species disappeared across the globe in a short time

B. Unconformities, buried eroded surfaces that separate older rock below from much younger rock deposited above them

C. Index fossils, the preserved remains of organisms that are used to match the ages of rock layers around the world

D. Half-lives, the lengths of time that are required for half of the atoms of a radioactive isotope to decay away

17. Fossils of the same land-dwelling plants and reptiles, which could not have crossed a wide ocean, are found on continents that are now separated by thousands of kilometers of seawater. What does this best support?

A. The idea that each continent has always remained in its present position and has never moved at any point in time

B. The idea that the now-separated continents were once joined together and have since drifted apart over geologic time

C. The idea that these plants and reptiles independently evolved into identical forms on each separate continent by chance

D. The idea that ancient people carried these plants and reptiles by boat from one continent to another across the ocean

18. A rock layer is made of well-rounded, well-sorted sand grains arranged in large, sweeping cross-beds, and it contains no marine fossils at all. Which past environment is most consistent with this rock?

A. A deep, calm ocean basin far from shore, where only the very finest clay particles slowly settled to the bottom

B. A coral reef in a warm, shallow tropical sea that was teeming with shelled organisms and other marine life forms

C. A glacier that scraped up and dropped a chaotic, unsorted jumble of boulders, sand, and fine clay all mixed together

D. A desert environment where wind piled sand into large dunes, rounding and sorting the grains as they were carried

19. The Himalaya Mountains continue to rise today where the Indian Plate is pushing into the Eurasian Plate. What kind of plate boundary is responsible for building these mountains?

A. A divergent boundary, where two plates pull apart from each other and magma rises to form new crust between them

B. A transform boundary, where two plates grind horizontally past each other, producing earthquakes but no mountains

C. A convergent boundary, where two continental plates collide and crumple the crust upward into a high mountain range

D. A passive margin, where the edge of a continent lies quietly far from any active plate boundary or geologic activity

20. Earth's interior is divided into distinct layers. Which sequence correctly lists these layers from the surface inward to the center?

A. Mantle, then crust, then a solid outer core, and finally a liquid inner core at the very center of the planet

B. Crust, then mantle, then a liquid outer core, and finally a solid inner core at the very center of the planet

C. Crust, then a liquid mantle, then a gaseous outer core, and finally another layer of crust at the center

D. A liquid outer core, then the solid mantle, then the crust, and finally a gaseous inner core at the center

21. Deep within the Earth, an existing rock is subjected to intense heat and pressure, causing its minerals to recrystallize and align into bands, but the rock never melts. What type of rock forms?

A. A metamorphic rock, formed when an existing rock is changed by heat and pressure without melting into magma

B. An igneous rock, formed when molten magma or lava cools and hardens either deep underground or at the surface

C. A clastic sedimentary rock, formed when loose fragments of older rocks are compacted and cemented together

D. A chemical sedimentary rock, formed when dissolved minerals crystallize out of evaporating water over time

22. A geologist tries to scratch an unknown mineral with a steel knife blade. The blade scratches the mineral easily, leaving a groove. What does this result tell the geologist about the mineral?

A. The mineral has a metallic luster, since only metallic minerals can ever be scratched by a steel knife blade

B. The mineral must contain calcium carbonate, since that is the only material a steel knife is able to scratch

C. The mineral has perfect cleavage, since being scratched proves it must break along smooth, flat parallel planes

D. The mineral is softer than the steel blade, since a harder material can scratch a softer one but not the reverse

23. A dark volcanic rock has crystals so small that they cannot be seen even with a hand lens. What does this fine-grained texture reveal about how the rock formed?

A. The rock cooled extremely slowly deep underground over millions of years, allowing the crystals to grow very large

B. The rock formed from layers of sediment that were compacted and cemented together rather than from any molten material

C. The rock formed when lava cooled quickly at or near the surface, leaving little time for large crystals to grow

D. The rock was heated and squeezed until its minerals recrystallized into visible bands of different colored minerals

24. Warm, moist air rises and cools until the water vapor in it turns into tiny liquid droplets that form a cloud. What is the name of this process in which water vapor changes into liquid?

A. Evaporation, the process in which liquid water absorbs energy from its surroundings and changes into water vapor

B. Condensation, the process in which water vapor cools and changes into tiny liquid water droplets in the atmosphere

C. Precipitation, the process in which water falls from clouds back down to Earth's surface as rain, snow, sleet, or hail

D. Runoff, the process in which water flows across the surface of the land and collects together into streams and rivers

25. After a long, wet spring with heavy rainfall, the water level rises in many local wells across a region. What does this rise most directly indicate about the underground water?

A. The water table has risen, because the heavy rainfall recharged the groundwater stored beneath the surface

B. The bedrock beneath the wells has dissolved, which allowed extra water to collect inside the bottoms of the wells

C. The permeability of the underground rock has permanently increased as a direct result of all the heavy rainfall

D. The porosity of the soil has dropped all the way to zero, which forced the groundwater upward toward the surface

26. For millions of years, carbon was stored underground in coal, oil, and natural gas. How does burning these fossil fuels today change the carbon cycle?

A. It removes large amounts of carbon dioxide from the atmosphere and stores it underground, gradually cooling the planet

B. It has no measurable effect on the atmosphere, because the carbon released by burning these fuels is much too small to matter

C. It rapidly releases long-stored carbon into the air as carbon dioxide, adding it faster than natural processes remove it

D. It permanently turns atmospheric carbon dioxide into solid rock, locking the carbon safely away beneath the surface for good

27. As the climate warms, bright sea ice melts and exposes the darker ocean beneath it. The dark water absorbs more sunlight than the ice did, which causes even more warming and more melting. What kind of feedback is this?

A. A negative feedback, because the newly exposed ocean water cools the region and reverses the original warming trend

B. An external forcing, because the melting sea ice comes from a source that lies entirely outside the climate system

C. A neutral process, because the melting of bright ice has no measurable effect on how much sunlight the surface absorbs

D. A positive feedback, because the melting reduces the surface's reflectivity and amplifies the original warming further

28. In a cold mountain region, water seeps into cracks in the rock, freezes and expands overnight, and thaws during the day. After many such cycles, the rock breaks apart, but its mineral composition does not change. What process is this?

A. Chemical weathering, in which minerals in the rock react with water and air to form completely new substances over time

B. Frost wedging, a form of mechanical weathering in which freezing water expands inside cracks and physically breaks the rock

C. Oxidation, a form of chemical weathering in which minerals containing iron react with oxygen and develop a reddish rust

D. Deposition, in which loose sediment carried along by wind or by water is dropped and accumulates in a brand-new location

29. After a thick continental glacier melts away, geologists often find long parallel scratches and grooves carved into the exposed bedrock. What do these scratches reveal?

A. The direction in which the glacier was moving, since the rocks frozen into the ice scraped these grooves as it advanced

B. The depth of a former lake, since the grooves mark the highest level the lake water once reached across the landscape

C. The location of a former volcano, since lava flowing across the bedrock carved these parallel grooves as it cooled

D. The path of an ancient river, since fast-flowing river water cut these straight parallel grooves into the solid bedrock

30. A maritime tropical (mT) air mass forms over the warm waters of the Gulf of Mexico and then moves into the southeastern United States during summer. What weather would this air mass most likely bring?

A. Cold, dry conditions with clear skies and the sharpest drop in temperature seen anywhere during the whole season

B. Cool, dry conditions producing crisp, clear mornings that are followed by mild, comfortable, and sunny afternoons

C. Warm, humid conditions with high humidity and a strong chance of afternoon thunderstorms developing in the heat

D. Bitterly cold, snowy conditions typical of an air mass that formed over a frozen, snow-covered polar landscape

31. A fast-moving cold front pushes into a region of warm, humid air on a summer afternoon. What weather is most likely to occur along the front as it passes through?

A. A long, gentle stretch of light, steady drizzle that lasts for several days as the two air masses slowly mix together

B. A narrow band of heavy thunderstorms, followed by clearing skies and a shift to cooler, drier air behind the front

C. Several days of motionless fog and unchanging low gray clouds that simply hang over the same area without moving at all

D. Completely clear skies and steadily rising temperatures as the warm air smoothly slides in to replace the cooler air

32. On a calm, clear evening, patches of fog often appear near the ground a few hours after sunset as the air cools. What is the most direct cause of this fog?

A. The wind speed increases sharply after sunset, which mechanically pushes scattered fog together close to the ground

B. The air pressure rises steeply during the night, which physically squeezes liquid water droplets out of the dry air

C. The ground releases stored heat upward, which boils the moisture at the surface into a rising layer of thick steam

D. The air cools down to its dew point, so the water vapor in it condenses into the tiny droplets that make up the fog

33. Hurricanes form over tropical oceans during late summer and early fall. Which condition is essential for a hurricane to form and grow stronger?

A. Warm ocean water above about 26.5°C, which evaporates and supplies the heat and moisture that power the storm

B. Cold ocean water below about 15°C, which supplies the dense, sinking air that a developing hurricane needs to grow

C. Strong winds blowing in opposite directions at different heights, which help to organize and strengthen the storm's spin

D. A position located directly on the equator, where the rotational effects of the Earth on the wind are at their strongest

34. Sunlight warms Earth's surface, and the warmed surface then gives off energy as infrared (heat) radiation. What do greenhouse gases do with this outgoing infrared radiation?

A. They reflect the incoming sunlight back into space before it ever reaches and warms the surface of the Earth below

B. They allow all of the outgoing infrared radiation to escape directly into space, which cools the lower atmosphere quickly

C. They absorb much of the outgoing infrared radiation and re-radiate part of it back downward, warming the lower atmosphere

D. They convert the outgoing infrared radiation into visible light, which then passes easily out of the atmosphere into space

35. On a hot, sunny afternoon at the beach, a cool breeze blows from the ocean toward the land. What causes this daytime sea breeze?

A. The Moon's gravity drags the cool ocean air toward the shore during the warmest part of the afternoon each day

B. The ocean water heats up faster than the land, so the warm sea air rises and pulls the land air outward over the water

C. The salt contained in the sea air makes that air heavier, so it sinks and slides downhill toward the land in the afternoon

D. The land heats up faster than the water, so warm air rises over the land and cooler ocean air flows in to replace it

36. A scientist explains that one unusually cold and snowy winter does not by itself disprove long-term global warming. What is the best reasoning behind this statement?

A. Cold and snowy winters can no longer happen at all now that the planet's climate has clearly begun to warm up

B. Climate is the long-term average of weather over many years, so one cold winter is short-term weather, not a climate trend

C. A single winter's weather matters far more than many decades of collected data when scientists judge the global climate

D. A cold winter proves that human activities have no effect on the climate and that all temperature changes are purely random

37. Which of the following lists contains only renewable energy resources?

A. Solar energy, wind energy, and hydroelectric power, all of which are continuously replenished by natural processes

B. Coal, petroleum, and natural gas, which are fossil fuels that took many millions of years to form deep underground

C. Uranium, coal, and oil, all of which are mined or pumped from the ground and are used up once they are consumed

D. Gasoline, diesel fuel, and natural gas, all of which are produced by refining crude oil that is pumped from the ground

38. A power plant lowers its costs by dumping warm wastewater into a river, but the heated water kills fish that local people depend on for food and income. The harm done to those people is best described as which of the following?

A. A private benefit, since it is income that the power plant earns directly by selling the electricity that it produces

B. A renewable resource, since the local people are able to use the river over and over again without it ever running out

C. A negative externality, since it is a cost of the power plant's activity that falls on people outside the transaction

D. A government subsidy, since it is a direct cash payment that the local people receive from the government each year

39. A large, continuous forest is cut into many small, separated patches by new roads and housing developments. Even though much forest remains, the variety of species living there declines. Which driver of biodiversity loss does this illustrate?

A. Overharvesting, in which humans remove a species from the wild faster than the species is able to reproduce and recover

B. Climate change, in which steadily rising temperatures push organisms beyond the range of conditions they can tolerate

C. An invasive species, in which a non-native organism is introduced and outcompetes or preys upon the native organisms

D. Habitat fragmentation, in which dividing a habitat into small, isolated pieces limits the movement of populations and lowers diversity

40. A coastal salt marsh absorbs the energy of storm surges and filters pollutants out of the water flowing through it, protecting the communities behind it. These benefits are best classified as which type of ecosystem service?

A. A provisioning service, because the marsh is directly supplying people with food, lumber, fresh water, and other raw materials

B. A regulating service, because the marsh moderates natural hazards and improves water quality through natural processes

C. A cultural service, because the marsh provides people with recreation, natural beauty, and spiritual or artistic inspiration

D. A supporting service, because the marsh carries out basic processes such as nutrient cycling and the formation of new soil

41. Which of the following is a projected effect of continued global warming that is supported by strong scientific consensus?

A. Many regions will experience more frequent and more intense heat waves, droughts, and other extreme weather events

B. The world's glaciers and great ice sheets will steadily grow larger and thicker as global temperatures continue to rise

C. Average global surface temperatures will soon begin to fall steadily as greenhouse gas concentrations keep increasing

D. The oceans will gradually become more alkaline and basic as they absorb more carbon dioxide from the atmosphere above

42. Acid rain that damaged lakes and forests in the northeastern United States formed when pollutants released by burning fossil fuels reacted with water in the atmosphere. Which two pollutants were chiefly responsible?

A. Carbon dioxide and oxygen, which combined together in the atmosphere to form a strong acid that then fell as acid rain

B. Helium and argon, two inert gases released from power plants that reacted with rainwater and made it strongly acidic

C. Sulfur dioxide and nitrogen oxides, which reacted with water vapor in the atmosphere to form sulfuric and nitric acids

D. Water vapor and nitrogen gas, the two most common atmospheric gases, which combined together to acidify the falling rain

43. A coastal community notices that its fish catch is shrinking each year because too many fish are being taken. Which approach would best allow the fishery to recover and remain productive into the future?

A. Increasing the catch each year to make up for the shrinking numbers, before all of the fish in the region disappear for good

B. Removing all of the natural predators of the target fish so that a much greater number of the target fish survive each year

C. Ignoring the shrinking catch entirely and continuing to fish in exactly the same way the community has always fished before

D. Setting limits on the number of fish that may be caught so that the fish population can reproduce and recover over time

44. The human population grew very slowly for most of history and then increased rapidly over the past two centuries to about 8 billion people. Which development most directly contributed to this rapid growth?

A. Advances in agriculture, sanitation, and medicine, which increased the food supply and lowered the human death rate

B. A worldwide decrease in the amount of food available, which somehow forced families to have far fewer children over time

C. A dramatic cooling of the global climate, which made far more of the Earth's land surface suitable for human settlement

D. The sudden and complete elimination of every infectious disease from all of the human populations across the entire globe

45. A national government invests heavily in solar and wind power plants to replace coal-burning power plants, with the goal of lowering the country's greenhouse gas emissions. Which climate change strategy does this best represent?

A. Adaptation, because the government is adjusting the country's infrastructure to cope with climate impacts that are already arriving

B. Mitigation, because the government is reducing the greenhouse gas emissions that are the underlying cause of climate change

C. Geoengineering, because the government is deliberately altering the entire global climate system on a large planetary scale

D. Recovery, because the government is responding to a major climate disaster that has already struck and damaged the country

46. As the ocean absorbs more carbon dioxide from the atmosphere and becomes more acidic, which group of marine organisms is most directly threatened?

A. Fast-swimming open-ocean predator fish that rely mainly on their powerful muscles and gills to chase down their prey

B. Large marine mammals such as whales and dolphins, which must return to the surface regularly to breathe air from above

C. Shell- and skeleton-building organisms such as corals, oysters, and clams, which need carbonate minerals to form their shells

D. Floating mats of seaweed and kelp near the surface, which depend on receiving plenty of sunlight for their photosynthesis

47. Farming, permanent villages, and the first cities all developed during the Holocene Epoch, a span of roughly the last 11,000 years. Which characteristic of the Holocene best explains why these developments became possible?

A. The Holocene has had a relatively warm and stable climate, which made farming dependable and allowed people to settle in one place

B. The Holocene was an extremely cold ice age during which thick sheets of ice covered the majority of the planet's surface

C. During the Holocene, the level of oxygen in the atmosphere first rose high enough for human beings to breathe and survive

D. The Holocene had a chaotic, rapidly shifting climate that forced early humans to constantly move from one place to another

48. An engineering team designing a new electric bus is told it must carry at least 40 passengers (a requirement for success) and must cost no more than a set budget (a limit it cannot exceed). The passenger requirement and the budget limit are examples of, in order, which two things?

A. Two prototypes, since each one is an early working model that is built and tested before the final bus is constructed

B. Two externalities, since both are costs that fall on people who are not directly involved in building the new electric bus

C. Two feedback loops, since each one describes the way the new electric bus responds to changes in its surroundings over time

D. A criterion and a constraint, since one is a requirement the design must meet and the other is a fixed limit it cannot exceed

49. After building and testing a prototype of a new electric bus, an engineering team finds that it carries enough passengers but its battery runs out before the end of a full route. According to the engineering design process, what should the team do next?

A. Abandon the entire project, because any problem found during testing proves that the design can never be made to work at all

B. Use what they learned from testing to redesign the bus for longer battery life, and then test the improved version again

C. Put the prototype into service without any changes, because the very first version of any design is always the final design

D. Hide the battery problem from the public so that no one ever finds out the original prototype had a performance issue at all

50. Before a city replaces its diesel buses with electric ones, engineers build a computer model to predict how the change would affect the city's air quality and traffic. What is the greatest value of running such a model first?

A. The model guarantees one exact outcome that is certain to occur no matter what real conditions actually arise in the city later

B. The model removes any need for the city to ever collect real measurements of its air quality or traffic before or after the change

C. The model lets engineers explore the likely effects of the change and compare options before the city spends money to make it

D. The model proves with complete certainty that switching to electric buses will have absolutely no downside of any kind for the city

Practice Exam 29: Answer Key with Explanations

1. A — Widespread redshift shows that almost all distant galaxies are moving away from us, which is evidence that the universe is expanding (Hubble's Law). Light stretched toward red indicates recession. This expansion is a central pillar of Big Bang cosmology.
2. B — A star many times more massive than the Sun ends its life by exploding as a supernova, scattering its material and leaving behind a neutron star or black hole. Only low-mass stars fade quietly into white dwarfs. A star's mass determines its dramatic or gentle endpoint.
3. D — Heavy elements like gold and iron were forged inside stars and scattered into space when massive stars exploded as supernovae. The Big Bang produced only the lightest elements. This stellar origin is why such elements exist in planets and living things today.
4. C — Kepler's Third Law gives $T^2 = a^3$, so with a = 36, $a^3 = 46{,}656$ and T equals the square root of 46,656, about 216 years. The cube of the distance sets the square of the period. This relationship applies to any object orbiting the Sun.

5. D — The hemispheres have opposite seasons because in June the Northern Hemisphere is tilted toward the Sun while the Southern Hemisphere is tilted away. The orientation of the tilt, not distance or ocean cover, governs the seasons. Six months later the tilt orientation reverses, swapping the seasons.
6. B — A Moon half lit on its right side about a week after new moon, high in the sky at sunset, is the first quarter phase. The Moon is waxing, moving from new toward full, with the right half illuminated. Right-side illumination in the evening sky is the signature of first quarter.
7. C — The shared direction of planetary spin and orbit is explained by the whole solar system forming from a single spinning cloud, with the planets inheriting that rotational motion. The original spin set the common direction. This is a key prediction of the nebular hypothesis.
8. A — A solar eclipse can occur only at the new moon, when the Moon lies between Earth and the Sun and can cast its shadow onto Earth. Only then is the geometry right to block the Sun's light. A tilted lunar orbit is why eclipses do not happen at every new moon.
9. B — Two daily tides result from the Moon's gravity raising water bulges on the near and far sides of Earth, which the rotating planet carries each coastline through. The near bulge faces the Moon and the far bulge results from inertia. Rotating through both bulges produces two highs and two lows per day.
10. D — The Sun's energy comes from the fusion of hydrogen into helium in its extremely hot, dense core, where energy is released. Only the core has the conditions needed for fusion. This process, not chemical burning or decay, powers the Sun's long, steady shine.
11. C — A steep, overhead beam concentrates its energy on a smaller area, while a slanting beam spreads the same energy over a larger area, so the tropical location receives more concentrated sunlight. The angle of insolation controls this concentration. This effect explains why low latitudes are warmer.
12. A — By the principle of superposition, the bottom layer in an undisturbed sequence was deposited first and is the oldest. Layers accumulate from the bottom upward over time. This rule is the foundation of relative dating in horizontal strata.
13. B — One-quarter of the isotope remaining means two half-lives have passed, since $1 \rightarrow 1/2 \rightarrow 1/4$. Two half-lives × 4,000 years equals 8,000 years. Counting the number of halvings is the key to radiometric age problems.
14. D — The best index fossil comes from a free-floating ocean organism that spread across the globe but lived during only a short span of geologic time. Wide distribution allows correlation across regions, and brief existence pins the age precisely. Long-lived or narrowly distributed organisms make poor index fossils.
15. C — By cross-cutting relationships, an igneous intrusion that cuts across and bakes sedimentary layers must be younger than those layers, since they existed before it intruded. The baking, or contact metamorphism, confirms the magma came later. This establishes the intrusion's relative age.
16. A — Intervals in which a large proportion of Earth's species die out across the globe in a short time are called mass extinctions. They are defined by the scale and speed of species loss. Such events have repeatedly reshaped the history of life on Earth.
17. B — Identical land plants and reptiles, unable to cross a wide ocean, found on now-separated continents support the idea that those continents were once joined and have since drifted apart. The shared fossils make sense only if the landmasses were connected. This was key evidence for continental drift.

18. D — Well-rounded, well-sorted sand in large cross-beds with no marine fossils indicates a desert environment, where wind piled sand into dunes and rounded and sorted the grains. Wind transport produces this distinctive sorting and cross-bedding. The absence of marine fossils rules out an ocean setting.
19. C — The Himalayas formed at a convergent boundary where two continental plates collide and crumple the crust upward. Because both plates are buoyant continental crust, neither subducts easily, so the crust thickens and rises. Continental collision builds the world's highest mountain ranges.
20. B — From the surface inward, Earth's layers are the crust, the mantle, the liquid outer core, and the solid inner core. The outer core is liquid while the inner core is solid. This layered structure was deduced largely from the behavior of seismic waves.
21. A — Heat and pressure recrystallizing and banding a rock without melting it produces a metamorphic rock. Metamorphism alters existing rock in the solid state, developing new textures like foliation. Because there is no melting, it is metamorphic rather than igneous.
22. D — If a steel blade scratches the mineral, the mineral is softer than the steel, since a harder material can scratch a softer one but not the reverse. This is a basic hardness test. Hardness is determined by which materials a sample can and cannot scratch.
23. C — A fine-grained texture with crystals too small to see indicates the rock formed when lava cooled quickly at or near the surface, leaving little time for crystals to grow. Rapid cooling limits crystal size. Slow underground cooling, by contrast, produces large, visible crystals.
24. B — Water vapor cooling and changing into tiny liquid droplets that form a cloud is condensation. Rising moist air cools until its vapor condenses around particles. Condensation is the opposite of evaporation, which converts liquid water into vapor.
25. A — Rising well levels after heavy rain indicate that the water table has risen because the rainfall recharged the groundwater. The water table moves up and down with the balance of recharge and withdrawal. More rainfall means more replenishment, raising the level that supplies wells.
26. C — Burning fossil fuels rapidly releases long-stored carbon into the air as carbon dioxide, adding it faster than natural processes remove it. This releases carbon that was locked away for millions of years. The resulting buildup is the main driver of human-caused climate change.
27. D — Melting bright sea ice exposing dark ocean water that absorbs more sunlight, causing further warming and melting, is a positive feedback, because it amplifies the original warming. The change reinforces itself rather than reversing. This ice-albedo feedback accelerates Arctic warming.
28. B — Water freezing and expanding in cracks until the rock splits, with no change in composition, is frost wedging, a form of mechanical weathering. The rock breaks into smaller pieces physically. Repeated freeze-thaw cycles make this process especially active in cold climates.
29. A — Parallel scratches and grooves carved into bedrock reveal the direction the glacier was moving, since rocks frozen into the ice scraped these grooves as it advanced. These striations record the ice flow. They are a classic indicator of past glaciation.
30. C — A maritime tropical air mass from the warm Gulf of Mexico carries warm, humid air, bringing high humidity and a strong chance of afternoon thunderstorms. "Maritime" indicates moisture and "tropical" indicates warmth. This contrasts sharply with cold, dry continental polar air.
31. B — A fast-moving cold front forces warm, humid air upward steeply, producing a narrow band of heavy thunderstorms, followed by clearing skies and cooler, drier air. The steep frontal slope drives quick, vigorous uplift. This abrupt change is characteristic of cold front passage.

32. D — Fog forms when the air cools to its dew point, causing water vapor to condense into tiny droplets near the ground. Nighttime cooling after sunset lowers the temperature to saturation. The dew point is the temperature at which the air becomes saturated and condensation begins.
33. A — A hurricane needs warm ocean water above about 26.5°C, which evaporates and supplies the heat and moisture that power the storm. This is why hurricanes form over tropical seas and weaken over cold water or land. Strong wind shear and an equatorial position actually inhibit development.
34. C — Greenhouse gases absorb much of the outgoing infrared radiation from Earth's surface and re-radiate part of it back downward, warming the lower atmosphere. They act on outgoing heat rather than reflecting incoming sunlight. This absorption and re-emission is the essence of the greenhouse effect.
35. D — A daytime sea breeze forms because the land heats faster than the water, so warm air rises over the land and cooler ocean air flows in to replace it. The land-sea temperature difference drives the circulation. This onshore breeze reverses at night as the land cools faster.
36. B — Because climate is the long-term average of weather over many years, one cold winter is short-term weather, not a climate trend, and cannot by itself disprove global warming. Long-term data, not one season, reveals climate trends. Distinguishing weather from climate is key to interpreting them.
37. A — Solar, wind, and hydroelectric power are all renewable because they are continuously replenished by natural processes and not used up. The other lists include fossil fuels or uranium, which are finite. Continuous natural replenishment is what defines a renewable resource.
38. C — The harm done to local people who lose their fish to the power plant's heated wastewater is a negative externality, a cost of the plant's activity that falls on people outside the transaction. Externalities are real costs the producer does not pay. Including them is essential for honest cost-benefit analysis.
39. D — Cutting a continuous forest into small, isolated patches is habitat fragmentation, which limits the movement of populations and lowers diversity even when total forest area remains. Fragmentation restricts breeding, feeding, and migration. It is a major driver of species decline.
40. B — A salt marsh buffering storm surge and filtering pollutants provides a regulating service, the category covering processes that moderate hazards and improve environmental quality. Regulating services control flooding, water quality, and similar conditions. This illustrates the practical value of intact ecosystems.
41. A — Strong scientific consensus supports that continued warming will bring more frequent and intense heat waves, droughts, and other extreme weather. Rising temperatures shift conditions toward greater extremes. The other options contradict observed trends and ocean chemistry, which is becoming more acidic, not basic.
42. C — Acid rain forms mainly from sulfur dioxide and nitrogen oxides, which react with atmospheric water vapor to produce sulfuric and nitric acids. These gases come largely from burning fossil fuels. Reducing their emissions is how acid rain has been curbed.
43. D — Setting limits on the catch lets the fish population reproduce and recover, supporting a sustainable fishery. Harvesting within the population's reproductive capacity prevents collapse. Matching the catch to recovery rates is the core of sustainable fisheries management.
44. A — Rapid recent population growth was enabled mainly by advances in agriculture, sanitation, and medicine that increased the food supply and lowered the death rate. More people survived while food became more abundant. These improvements, not climate or eliminated disease, drove the surge.

45. B — Replacing coal plants with solar and wind to lower emissions is mitigation, because it reduces the greenhouse gases that cause climate change. Mitigation targets the underlying cause, while adaptation copes with impacts. Cutting emissions at the source is the defining feature of mitigation.
46. C — A more acidic ocean most directly threatens shell- and skeleton-building organisms such as corals, oysters, and clams, because acidification reduces the carbonate minerals they need. Without enough carbonate, they struggle to build their shells. This threat ripples through marine food webs.
47. A — The Holocene's relatively warm and stable climate made farming dependable and allowed people to settle in one place, supporting villages and the first cities. Predictable growing seasons were essential for agriculture. Climatic stability, not an ice age or oxygen changes, enabled civilization.
48. D — The minimum-passenger requirement is a criterion, defining what the design must achieve, while the budget limit is a constraint, a fixed restriction it cannot exceed. Criteria define success; constraints set boundaries. Distinguishing the two is fundamental to framing an engineering problem.
49. B — When a prototype reveals a shortfall, the engineering process calls for using the test results to redesign it and then test the improved version again. Iteration—testing, refining, and retesting—is central to good engineering. A flaw found in testing is information, not a reason to abandon the project.
50. C — The greatest value of the model is that it lets engineers explore the likely effects and compare options before the city spends money to make the change. Models allow ideas to be tested safely and cheaply in advance. They guide decisions while acknowledging uncertainty, and they support rather than replace real measurements.