Practice Exam 21: Earth and Space Sciences Regents Simulation (50 Questions)

1. Which observation is considered direct evidence that the universe began in an extremely hot, dense state and has cooled as it expanded?

A. The presence of spiral arms in many large galaxies throughout the observable universe

B. The detection of gravitational waves from pairs of black holes merging in distant galaxies

C. The classification of stars into a main sequence based on their color and luminosity values

D. The cosmic microwave background radiation detected uniformly across the entire sky everywhere

2. A star located in the lower-left region of a Hertzsprung-Russell diagram has which combination of properties?

A. High luminosity and low surface temperature, typical of a cool red supergiant star

B. Low luminosity and high surface temperature, typical of a small hot white dwarf star

C. High luminosity and high surface temperature, typical of a massive blue main sequence star

D. Low luminosity and low surface temperature, typical of a cool dim red main sequence star

3. Elements heavier than iron, such as gold and uranium, are thought to form primarily during which event?

A. The steady fusion of hydrogen into helium within the cores of ordinary main sequence stars

B. The cooling of plasma during the first few minutes following the Big Bang in the early universe

C. The explosive deaths of massive stars and the collisions of neutron stars releasing immense energy

D. The slow radioactive decay of lighter elements within the rocky interiors of terrestrial planets

4. A planet orbits its star at an average distance of 9 AU. Using Kepler's Third Law ($T^2 = a^3$ in solar units), what is the planet's approximate orbital period?

A. Approximately 27 Earth years are required for the planet to complete one full orbit of its star

B. Approximately 9 Earth years are required for the planet to complete one full orbit of its star

C. Approximately 3 Earth years are required for the planet to complete one full orbit of its star

D. Approximately 81 Earth years are required for the planet to complete one full orbit of its star

5. On the winter solstice in New York State, why are temperatures generally cold despite Earth being near its closest approach to the Sun?

A. The Sun emits significantly less total energy during the winter months of the calendar year

B. Earth's atmosphere is much thicker in winter, blocking most of the incoming solar radiation

C. The Northern Hemisphere is tilted away from the Sun, giving low Sun angles and short days

D. Earth's slightly greater winter distance from the Sun more than offsets the axial tilt effect

6. Why does a solar eclipse not occur at every new moon phase even though the Moon is between Earth and the Sun?

A. The Moon is too far from Earth during most new moons for its shadow to reach the surface

B. The Moon's orbit is tilted about 5 degrees, so its shadow usually misses Earth at new moon

C. The Sun's glare during the daytime simply hides the eclipse from observers on the ground

D. New moons happen only at night, when the Sun is below the horizon and cannot be eclipsed

7. Why are the inner planets rocky while the outer planets are largely composed of gas and ice?

A. Near the young Sun it was too hot for ices to condense, so only rock and metal formed there

B. The inner planets lost their original gases because they formed much later than the outer planets

C. The outer planets captured their gases from passing comets long after the planets had fully formed

D. The Sun's gravity pulled all the heavy rocky material outward toward the edge of the solar system

8. A coastal town experiences two high tides and two low tides during a single day. What is the primary cause of these regular tides?

A. The prevailing winds that push ocean water toward and away from the shoreline each day

B. Seasonal changes in the temperature of the ocean water near the surface along the coast

C. The rotation of Earth alone, which sloshes water back and forth within each ocean basin

D. The gravitational pull of the Moon, which raises bulges of water on opposite sides of Earth

9. The mass of a helium nucleus formed by fusion in the Sun is slightly less than the mass of the four hydrogen nuclei that formed it. What happened to the missing mass?

A. It was ejected from the Sun as part of the continuous stream of charged solar wind particles

B. It was converted into energy according to the relationship between mass and energy ($E = mc^2$)

C. It remained trapped inside the new helium nucleus as additional stored gravitational potential

D. It was lost as the helium nucleus captured extra electrons to balance its new electric charge

10. Throughout the year, equatorial regions receive more total solar energy per unit area than polar regions. What is the primary reason for this difference?

A. Near the equator sunlight strikes more directly, concentrating energy over a smaller surface area

B. The equator is significantly closer to the Sun than the poles because of Earth's spherical shape

C. The polar atmosphere is far thicker than the equatorial atmosphere and absorbs more sunlight

D. The Sun emits more radiation toward the equator than toward the polar regions of the planet

11. Stars appear to move in circular paths around Polaris over the course of a night, as seen from New York State. What actually causes this apparent motion?

A. The stars physically orbit Polaris, which sits at the gravitational center of our galaxy

B. The stars drift across the sky as they are carried along by the expansion of the universe

C. Earth rotates on its axis, making the sky appear to turn around the north celestial pole

D. The Sun's gravity bends the starlight, curving the paths the stars seem to trace each night

12. Sedimentary rock layers in a canyon wall are tilted at a steep angle. According to the principle of original horizontality, what is the best interpretation?

A. The layers were originally deposited at this steep angle along the sloping side of the canyon

B. The steep tilt proves the layers are igneous rather than sedimentary in their true origin

C. The layers must be read from top to bottom, since tilting reverses the normal age order

D. The layers were deposited horizontally and later tilted by Earth movements after deposition

13. An igneous rock contains a radioactive isotope with a half-life of 1.3 billion years. Analysis shows that one-quarter of the original isotope remains. Approximately how old is the rock?

A. About 2.6 billion years old, because two half-lives are needed to reduce the isotope to one-quarter

B. About 1.3 billion years old, because a single half-life reduces the isotope to one-quarter remaining

C. About 5.2 billion years old, because four half-lives are needed to reach one-quarter of the original

D. About 0.65 billion years old, because half of one half-life leaves one-quarter of the isotope behind

14. A fault cuts across several sedimentary rock layers in an outcrop. According to the principle of cross-cutting relationships, what can be concluded about the fault?

A. The fault and the layers it cuts through all formed at exactly the same moment in time

B. The fault is younger than all of the rock layers that it cuts across in the outcrop

C. The fault is older than the rock layers, which were deposited on top of it afterward

D. The age of the fault cannot be compared to the layers without radiometric dating first

15. A rock layer contains fossils of early flowering plants and dinosaurs but no fossils of modern grasses or large mammals. During which era was this rock most likely formed?

A. The Precambrian, when only simple single-celled organisms lived in the early oceans

B. The Paleozoic, when trilobites and early fish dominated the shallow marine environments

C. The Cenozoic, when modern mammals and flowering plants diversified across the continents

D. The Mesozoic, when dinosaurs were dominant and the first flowering plants appeared on land

16. A geologist finds horizontal sedimentary layers lying directly on top of an eroded surface of much older tilted layers. What does this unconformity represent?

A. A continuous, unbroken record of deposition with no missing time in the rock sequence

B. A single rapid flood event that deposited all the layers, both tilted and horizontal, at once

C. A gap in the rock record, where deposition, tilting, erosion, and renewed deposition occurred

D. A zone where molten rock intruded and then cooled between two existing sedimentary layers

17. Identical fossils of the freshwater reptile Mesosaurus are found in both South America and Africa, but nowhere else. How does this best support the theory of continental drift?

A. Mesosaurus could not have swum across a wide ocean, so the continents were once joined

B. Mesosaurus fossils were carried between the continents by ancient ocean currents over time

C. Mesosaurus evolved independently and identically on two separate, never-connected continents

D. Mesosaurus fossils prove the two continents are slowly moving closer together at present

18. A rock layer is composed of compressed plant material and forms a dark, carbon-rich coal seam. Which past environment is most consistent with this rock?

A. A deep, cold ocean floor where fine clay slowly settled far from any land or vegetation

B. A warm swamp or wetland where abundant plant matter accumulated and was later buried

C. A dry desert basin where windblown sand piled into large dunes over long time periods

D. A high mountain glacier that scraped and deposited unsorted rock fragments of many sizes

19. The San Andreas Fault in California is a boundary where the Pacific Plate and the North American Plate move horizontally past each other. What type of plate boundary is this?

A. A divergent boundary where the two plates pull apart and new crust forms between them

B. A convergent boundary where one plate is forced downward beneath the overriding plate

C. A transform boundary where the two plates slide past one another, producing earthquakes

D. A hot spot where a rising plume of magma melts through the middle of a tectonic plate

20. What is the primary driving force that moves Earth's tectonic plates across the surface over geologic time?

A. The gravitational pull of the Moon dragging the solid plates along beneath the oceans

B. The rotation of Earth on its axis flinging the plates outward toward the equatorial region

C. The pressure of wind and ocean currents pushing steadily against the edges of the continents

D. Convection currents in the mantle, where hot material rises and cooler material sinks slowly

21. Layers of sand are buried, compacted, and cemented together over millions of years. Which rock forms through this process?

A. Sandstone, a sedimentary rock formed when sand grains are compacted and cemented together

B. Gneiss, a metamorphic rock formed when existing rock is banded under intense heat and pressure

C. Granite, an igneous rock formed when molten magma cools slowly deep beneath Earth's surface

D. Pumice, a frothy volcanic rock formed when gas-rich lava cools very rapidly at the surface

22. A student tests an unknown mineral and finds it has a hardness of 3, breaks along three cleavage directions that are not at right angles, and fizzes when dilute acid is applied. Which mineral is this?

A. Quartz, which has a hardness of 7, no cleavage, conchoidal fracture, and a glassy luster

B. Halite, which has a hardness of 2.5, cubic cleavage at right angles, and a distinct salty taste

C. Calcite, which has a hardness of 3, three cleavage directions, and reacts with dilute acid

D. Feldspar, which has a hardness of 6, two cleavage directions, and does not react with acid

23. Two igneous rocks have the same chemical composition, but one has large visible crystals and the other has tiny crystals too small to see. What best explains this difference?

A. The two rocks formed from different parent magmas with completely different mineral contents

B. The coarse-grained rock cooled slowly underground; the fine-grained rock cooled quickly at the surface

C. The fine-grained rock is much older and its crystals have worn down over long periods of time

D. The coarse-grained rock formed in water while the fine-grained rock formed in dry desert air

24. As liquid water evaporates from the surface of a lake on a sunny day, what happens to energy in the surrounding environment?

A. Energy is released by the water, warming the air directly above the surface of the lake

B. Energy is created by the water molecules as they escape into the atmosphere as vapor

C. No net energy change occurs because evaporation is purely a change in physical location

D. Energy is absorbed from the surroundings, which has a cooling effect on the lake surface

25. During an extended drought, the water level in many local wells drops significantly. What does this most directly indicate about the groundwater system?

A. The permeability of the underground rock layers has permanently increased during the drought

B. The bedrock beneath the wells has dissolved, allowing the well water to drain away downward

C. The water table has fallen because recharge from precipitation has decreased during the drought

D. The porosity of the soil has dropped to zero, leaving no space for any groundwater to occupy

26. Which pair of processes moves carbon back and forth between the atmosphere and living things on short, seasonal timescales?

A. Photosynthesis removes carbon dioxide from the air, and respiration returns it to the air

B. Volcanic eruptions add carbon to the air, and rock weathering removes it over long ages

C. Fossil fuel burning adds carbon to the air, and ocean burial removes it deep in sediments

D. Radioactive decay produces carbon underground, and mountain uplift exposes it to the air

27. Some climate processes are negative feedbacks that tend to stabilize the system. Which of the following is an example of a negative (stabilizing) feedback?

A. Melting sea ice exposes dark ocean water, which absorbs more heat and melts still more ice

B. Warming increases plant growth, and the extra plants remove carbon dioxide, slowing warming

C. Thawing permafrost releases methane, a greenhouse gas, which traps heat and warms the air

D. Warmer air holds more water vapor, a greenhouse gas, which traps heat and warms the air further

28. In a warm, humid tropical climate, which type of weathering tends to dominate in breaking down exposed bedrock?

A. Frost wedging, because repeated freezing and thawing of water pries rock apart in cold cracks

B. Glacial abrasion, because thick moving ice sheets grind and scrape the underlying solid bedrock

C. Salt crystal growth, because evaporating seawater leaves salt that wedges apart desert rocks

D. Chemical weathering, because warmth and abundant water speed reactions that dissolve minerals

29. The Finger Lakes of central New York are long, narrow, deep lakes oriented north to south. What process is most responsible for carving these distinctive lake basins?

A. Continental glaciers that advanced southward, deepening existing river valleys into long troughs

B. A series of large rivers that meandered side to side, widening the valleys into broad lake basins

C. Tectonic faulting that dropped narrow blocks of crust downward to form parallel rift valleys

D. Volcanic activity that created long chains of craters which later filled with rainwater over time

30. During winter, a continental polar (cP) air mass moves south from central Canada into New York State. What weather does this air mass typically bring?

A. Warm, very humid air that produces afternoon thunderstorms and heavy tropical downpours

B. Mild, moist air off the ocean that produces long periods of drizzle and low gray clouds

C. Cold, dry air that often produces clear skies along with sharply colder temperatures

D. Hot, dry desert air that produces drought conditions and blowing dust across the region

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

A. A long, steady period of light rain and drizzle that lasts gently for two or three full days

B. A narrow line of heavy thunderstorms followed by clearing skies and cooler, drier air behind

C. Several days of unchanging fog and low clouds that remain stationary over the entire region

D. Clear skies and rising temperatures as warm air gradually replaces the cooler air at the surface

32. On a summer afternoon, the air temperature is 30°C and the dew point is 12°C. What does this large difference between the two temperatures indicate?

A. The relative humidity is fairly low, so the air must cool a great deal before clouds can form

B. The air is completely saturated, so fog and steady precipitation are occurring at the surface

C. The relative humidity is exactly 100 percent, meaning condensation is happening on all surfaces

D. The air holds no water vapor at all, which is typical of extremely dry polar winter conditions

33. Hurricanes weaken rapidly after they move over land. What is the primary reason for this weakening?

A. The increased friction with the land instantly cools the storm's core below the freezing point

B. The Coriolis effect disappears entirely once a hurricane crosses from the ocean onto the land

C. The land emits cold air upward that immediately replaces all of the storm's warm rising air

D. The storm is cut off from the warm ocean water that supplied the moisture and heat it needed

34. The natural greenhouse effect is essential for life on Earth. Which statement best explains why?

A. Without greenhouse gases, the atmosphere would contain too little oxygen to support animal life

B. Without greenhouse gases trapping heat, Earth's average surface temperature would be far below freezing

C. Without greenhouse gases, harmful ultraviolet radiation would reach and sterilize Earth's surface

D. Without greenhouse gases, the atmosphere would lose all of its pressure and escape into outer space

35. In the Northern Hemisphere, surface winds spiral inward and counterclockwise around a low-pressure center. Which factor produces this counterclockwise rotation?

A. The friction between the moving air and the rough surface of the land beneath the storm

B. The pull of ocean currents that drag the winds in a counterclockwise loop around the low

C. The Coriolis effect from Earth's rotation, which deflects the inflowing winds to the right

D. The heating of the air by the Sun, which always forces winds to turn toward the west

36. Direct measurements at Mauna Loa Observatory since 1958 show a steady year-over-year rise in atmospheric carbon dioxide, with small seasonal wiggles. What does the long-term upward trend most strongly indicate?

A. Atmospheric carbon dioxide has been increasing over time, largely due to human activities

B. Carbon dioxide levels are naturally stable and the apparent rise is only a measurement error

C. The seasonal wiggles prove that volcanoes are the dominant source of the added carbon dioxide

D. Carbon dioxide is decreasing overall once the seasonal plant cycles are correctly accounted for

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

A. Natural gas, solar, wind, and coal, which together can supply energy for many centuries ahead

B. Petroleum, nuclear, geothermal, and wind, which are all sustainable over human timescales

C. Coal, oil, natural gas, and uranium, which are all replenished steadily by natural earth processes

D. Solar, wind, geothermal, and hydroelectric, which are continuously replenished by natural processes

38. A city is deciding whether to approve a new highway. A complete cost-benefit analysis should include which of the following as a cost?

A. Only the direct price of the concrete, steel, and labor needed to physically build the highway

B. Only the toll revenue the city expects to collect from drivers using the new highway each year

C. The increased air pollution and noise affecting neighborhoods located near the planned highway

D. Only the reduction in travel time that commuters will enjoy once the new highway is completed

39. A coral reef that supported hundreds of fish species is converted into a barren zone after warming seawater causes the corals to bleach and die. Which driver of biodiversity loss does this scenario most directly illustrate?

A. Overharvesting, in which humans catch reef organisms faster than the populations can recover

B. Climate change, in which rising ocean temperatures push organisms beyond their tolerance limits

C. Invasive species, in which a non-native organism is introduced and outcompetes the native corals

D. Direct habitat clearing, in which the reef is physically removed to make space for development

40. A forest supplies timber, edible fruits, and medicinal plants that people harvest and use directly. Which category of ecosystem service does this represent?

A. A provisioning service, because the ecosystem directly supplies material goods that people use

B. A regulating service, because the ecosystem controls the climate, floods, and the spread of disease

C. A cultural service, because the ecosystem provides recreation, beauty, and spiritual enrichment

D. A supporting service, because the ecosystem carries out soil formation and the cycling of nutrients

41. Which projected effect of continued climate change is supported by strong scientific consensus?

A. The number of glaciers worldwide will increase as cooler air allows more snow to accumulate

B. Average global temperatures will stabilize and then decline steadily over the next century ahead

C. The oceans will become more basic as they absorb additional carbon dioxide from the atmosphere

D. Many regions will experience more frequent and intense heat waves as the planet continues warming

42. Lakes in the Adirondack region of New York were damaged in the late twentieth century when rain became unusually acidic. Which pollutants were the primary cause of this acid rain?

A. Carbon dioxide and water vapor released naturally from forests and wetlands across the region

B. Sulfur dioxide and nitrogen oxides released by burning coal and other fossil fuels upwind

C. Chlorofluorocarbons released from refrigerators and aerosol cans used in nearby communities

D. Fine dust and ash particles blown into the region from distant volcanic eruptions overseas

43. A farmer wants to keep cropland productive for future generations while reducing soil erosion. Which practice best supports this goal of sustainable agriculture?

A. Plowing all fields deeply after every harvest and leaving the bare soil exposed through winter

B. Planting the same single crop in the same field every year to maximize that crop's total yield

C. Rotating crops and planting cover crops to protect the soil and maintain its fertility over time

D. Removing all trees and hedgerows around the fields so that more land can be planted with crops

44. Roughly half of the world's habitable land is used for agriculture. Of that agricultural land, the large majority is used for which purpose?

A. Raising livestock and growing their feed, which uses far more land than crops grown for people to eat directly

B. Growing fruits and vegetables for direct human consumption, which uses most of the world's farmland

C. Producing fibers such as cotton and materials for clothing, which dominate global agricultural land use

D. Growing crops used only to manufacture biofuels, which occupy the majority of all agricultural land

45. A power company replaces a coal-burning plant with a wind farm to lower its carbon dioxide emissions. Which climate change strategy does this action best represent?

A. Adaptation, because the company is adjusting to climate impacts that are already taking place

B. Mitigation, because the company is reducing the greenhouse gas emissions that drive climate change

C. Geoengineering, because the company is deliberately altering the global climate on a planetary scale

D. Resilience, because the company is increasing its ability to recover quickly from future disasters

46. Ocean acidification is occurring as the ocean takes up increasing amounts of a gas from the atmosphere. Which gas is primarily responsible?

A. Methane, which bubbles up from the seafloor and dissolves into the deep ocean waters

B. Nitrogen, which makes up most of the atmosphere and steadily dissolves into seawater

C. Oxygen, which is consumed by marine animals and lowers the pH of the surrounding water

D. Carbon dioxide, which dissolves in seawater and forms a weak acid that lowers the ocean's pH

47. Why was the relatively stable climate of the last several thousand years important for the development of human civilization?

A. The stable climate caused a sudden burst of biological evolution that produced modern humans

B. The stable climate raised atmospheric oxygen to the level finally needed for human survival

C. The stable climate allowed dependable agriculture, which supported cities and growing populations

D. The stable climate ended all natural disasters, removing every threat early communities once faced

48. An engineering team is asked to reduce flooding in a neighborhood that floods during heavy storms. What should be the team's first step in the engineering design process?

A. Clearly define the problem, including the criteria a good solution must meet and the constraints

B. Immediately begin building the most expensive flood barrier available on the current market

C. Choose whichever solution looks the most impressive without studying the neighborhood at all

D. Survey residents about their favorite color so the barrier can be painted to match their homes

49. After building and testing a prototype flood barrier, an engineering team finds that water still seeps through at the joints. According to the engineering design process, what should the team do next?

A. Abandon the project entirely, since any failure during testing means the design can never work

B. Ship the prototype to the public unchanged, because the first design is always the final design

C. Hide the test results so that the public never learns the original prototype had any weaknesses

D. Use the test results to redesign the joints and then test the improved prototype once again

50. Scientists build a computer model to predict how a river's floodplain will respond to different amounts of rainfall. Which statement best describes how engineers should use this model?

A. Treat the model's output as an exact certainty that will happen regardless of any real conditions

B. Use the model to explore likely outcomes under different scenarios to help guide design decisions

C. Reject the model completely, because rivers are far too complex to study using any mathematics

D. Replace all field measurements of the river with the model, since real data is no longer needed

ANSWERS KEY EXPLANATION

1. D — The cosmic microwave background is the cooled, faint remnant heat left over from the universe's hot, dense early state, detectable evenly across the whole sky. Its uniform presence everywhere is direct evidence the universe expanded and cooled from a hotter beginning. This observation is one of the strongest pillars of Big Bang cosmology.
2. B — The lower-left of an H-R diagram means high surface temperature (left) but low luminosity (bottom), which describes a small, hot white dwarf. White dwarfs are dense stellar remnants that are hot but tiny, so they emit little total light. Position on the H-R diagram directly encodes a star's temperature and brightness.
3. C — Elements heavier than iron require energy input to form, so they are produced in the extreme conditions of supernova explosions and neutron star collisions rather than ordinary fusion. Normal stellar fusion stops at iron because building heavier nuclei consumes rather than releases energy. These cataclysmic events seed the galaxy with gold, uranium, and other heavy elements.
4. A — Kepler's Third Law gives $T^2 = a^3$, so with $a = 9$, $a^3 = 729$ and $T^2 = 729$, making $T = 27$ years. The orbital period grows much faster than distance because of the cube relationship. This law connects any planet's distance from the Sun to the time it takes to orbit.

5. C — Seasons are caused by axial tilt, not distance, so winter cold results from the Northern Hemisphere tilting away from the Sun, producing low Sun angles and short days. Earth is in fact slightly closer to the Sun during Northern Hemisphere winter, which shows distance is not the cause. The reduced angle and duration of insolation, not proximity, drives the cold.
6. B — The Moon's orbit is tilted roughly 5 degrees relative to Earth's orbital plane, so at most new moons its shadow passes above or below Earth and no eclipse occurs. Only when the new moon lines up near the intersection of the two planes does a solar eclipse happen. This orbital tilt is why eclipses are occasional rather than monthly.
7. A — Close to the young, hot Sun, volatile ices could not condense, so only rock and metal solidified, forming the inner rocky planets. Farther out where it was cold, ices and gases could accumulate, building the giant outer planets. This temperature gradient in the solar nebula explains the compositional divide.
8. D — Tides are caused primarily by the Moon's gravity, which raises a water bulge on the side facing the Moon and another on the opposite side. As Earth rotates through these two bulges, a coastline experiences two high and two low tides daily. The Moon's gravitational pull, not wind or temperature, drives this regular pattern.
9. B — In fusion, the small loss of mass when hydrogen nuclei combine into helium is converted into energy according to $E = mc^2$. Because the speed of light squared is enormous, even a tiny mass loss yields a vast amount of energy. This mass-to-energy conversion is the source of the Sun's power.
10. A — Near the equator, sunlight strikes the surface more directly, concentrating its energy over a smaller area, while at the poles the same light spreads over a larger area at a low angle. The angle of insolation, not distance to the Sun, controls the energy received per unit area. This is why equatorial regions are consistently warmer than polar ones.
11. C — The nightly circular motion of stars around Polaris is an apparent motion caused by Earth rotating on its axis, which makes the whole sky seem to turn. The stars themselves are essentially fixed in position over a single night. The north celestial pole near Polaris is simply the point Earth's axis points toward.
12. D — The principle of original horizontality states that sediments are deposited in flat, horizontal layers, so steeply tilted layers must have been moved after they formed. The tilt is evidence of later tectonic forces deforming the rock. This principle lets geologists recognize when crustal movement has occurred.
13. A — Each half-life halves the isotope, so one-quarter remaining means two half-lives have passed: $1 \rightarrow 1/2 \rightarrow 1/4$. Two half-lives × 1.3 billion years equals about 2.6 billion years. Counting the number of halvings is the key to radiometric age problems.
14. B — By the principle of cross-cutting relationships, a geologic feature that cuts across rock layers must be younger than the layers it disrupts. Since the fault cuts through the sedimentary layers, those layers had to exist first. This principle establishes relative ages between intrusions, faults, and the rocks they cut.
15. D — The presence of dinosaurs together with the first flowering plants, but no modern mammals or grasses, places the rock in the Mesozoic Era. Dinosaurs dominated the Mesozoic, and flowering plants first appeared during that era. Fossil succession lets geologists assign rocks to specific eras based on which organisms are present.
16. C — An angular unconformity, with horizontal layers resting on eroded tilted layers, records a sequence of deposition, tilting, erosion, and renewed deposition, and therefore a gap in the rock

record. The missing time corresponds to the erosion phase. Unconformities reveal that the geologic record is often incomplete.

17. A — Mesosaurus was a freshwater reptile incapable of crossing a wide salt-water ocean, so finding identical fossils in South America and Africa indicates the continents were once joined. This shared fossil distribution is best explained by the landmasses having been connected. It was a key line of evidence for continental drift.
18. B — Coal forms from large amounts of plant material that accumulated in warm, oxygen-poor swamps and wetlands and was later buried and compressed. Such environments allowed organic matter to build up faster than it decayed. The carbon-rich nature of coal reflects this swampy depositional origin.
19. C — At the San Andreas Fault, two plates slide horizontally past each other, which defines a transform boundary. The grinding motion builds and releases stress, producing frequent earthquakes. Transform boundaries create neither new crust nor subduction, distinguishing them from divergent and convergent types.
20. D — Mantle convection, in which hot material rises and cooler material sinks, is the primary engine driving plate motion over geologic time. These slow-moving currents drag and push the overlying plates. Heat from Earth's interior, not the Moon or rotation, powers this circulation.
21. A — Sandstone forms when layers of sand are buried, compacted, and cemented together, a clastic sedimentary process. The grains are bound by mineral cement over long periods without melting or recrystallization. This compaction-and-cementation pathway is characteristic of sedimentary rock formation.
22. C — A hardness of 3, three cleavage directions, and a reaction with dilute acid are the diagnostic properties of calcite. The acid fizz comes from calcium carbonate releasing carbon dioxide. These combined tests distinguish calcite from quartz, halite, and feldspar.
23. B — Identical composition but different crystal sizes is explained by cooling rate: slow cooling underground grows large crystals, while rapid cooling at the surface produces tiny ones. Cooling rate, not composition, controls grain size in igneous rocks. This is why intrusive rocks are coarse-grained and extrusive rocks are fine-grained.
24. D — Evaporation absorbs energy from the surroundings as liquid water gains the latent heat needed to become vapor, which cools the remaining surface. This is why evaporation has a cooling effect, such as sweat cooling skin. The energy is absorbed, not released, during this phase change.
25. C — Falling well levels during drought indicate that the water table has dropped because reduced precipitation has lessened the recharge of groundwater. The water table rises and falls with the balance between recharge and withdrawal. Less rainfall means less replenishment, lowering the level that supplies wells.
26. A — Photosynthesis pulls carbon dioxide out of the air to build plant tissue, and respiration returns carbon dioxide to the air, cycling carbon between the atmosphere and living things seasonally. These two processes operate quickly and account for the seasonal rise and fall of atmospheric carbon dioxide. The other listed processes act over far longer timescales.
27. B — Increased plant growth that removes carbon dioxide and thereby slows warming is a negative feedback, because it counteracts the original change and stabilizes the system. Negative feedbacks dampen a disturbance rather than amplify it. The other options describe positive feedbacks that reinforce warming.
28. D — In warm, humid climates, abundant heat and moisture accelerate the chemical reactions that dissolve and alter minerals, so chemical weathering dominates. Higher temperatures and water

availability speed these reactions. This is why tropical regions show deep chemical breakdown of bedrock rather than frost or salt weathering.

29. A — The Finger Lakes formed when southward-advancing continental glaciers deepened and widened existing north-south river valleys into long, narrow troughs that later filled with water. The ice carved the characteristic deep, elongated basins. Their orientation reflects the direction of glacial flow.
30. C — A continental polar air mass forms over cold, dry land in central Canada, so it brings cold, dry air that often produces clear skies and sharply lower temperatures. "Continental" indicates dryness and "polar" indicates cold. This contrasts sharply with warm, moist maritime tropical air masses.
31. B — A fast-moving cold front forces warm, humid air upward quickly, producing a narrow band of intense thunderstorms, followed by cooler, drier air and clearing skies behind it. The steep frontal slope drives rapid uplift and brief, violent weather. This sudden, sharp weather change is characteristic of cold front passage.
32. A — A large gap between air temperature (30°C) and dew point (12°C) means the air is far from saturation, so relative humidity is low and the air must cool substantially before clouds form. The dew point is the temperature at which saturation occurs. A wide spread indicates dry air, not saturated conditions.
33. D — Hurricanes are powered by heat and moisture from warm ocean water, so moving over land cuts off that energy supply and the storm weakens rapidly. Without the ocean's warm, moist air feeding the storm, it loses strength. This dependence on warm water explains why hurricanes fade quickly inland.
34. B — Without greenhouse gases trapping outgoing heat, Earth's average surface temperature would be well below freezing, far too cold for most life. The natural greenhouse effect keeps the planet warm enough to support liquid water and living organisms. This warming role is what makes the effect essential to life.
35. C — The counterclockwise inflow around a Northern Hemisphere low results from the Coriolis effect, which deflects moving air to the right, turning the inward-rushing winds into a counterclockwise spiral. Earth's rotation produces this deflection. The same effect produces clockwise rotation around lows in the Southern Hemisphere.
36. A — The steady long-term rise in the Mauna Loa carbon dioxide record shows that atmospheric carbon dioxide is increasing over time, largely from human activities such as burning fossil fuels. The small seasonal wiggles reflect plant growth cycles superimposed on the upward trend. This continuous record is direct evidence of human-driven increases.
37. D — Solar, wind, geothermal, and hydroelectric are all renewable because they are continuously replenished by natural processes and not depleted by use. The other lists each include fossil fuels or uranium, which are finite and nonrenewable. Renewability depends on whether a source is naturally restored on human timescales.
38. C — A complete cost-benefit analysis must include external costs such as the air pollution and noise imposed on nearby neighborhoods, not just direct construction expenses. These externalities are real costs borne by people affected by the project. Ignoring them would understate the true cost of the highway.
39. B — Warming seawater that bleaches and kills coral, collapsing the reef ecosystem, illustrates climate change driving biodiversity loss by pushing organisms beyond their temperature tolerance. Corals are highly sensitive to heat stress. This mechanism is distinct from overharvesting, invasive species, or direct physical removal.

40. A — A forest directly supplying timber, fruits, and medicines provides a provisioning service, the category covering material goods that people harvest and use. Provisioning services are the tangible products obtained from ecosystems. This differs from regulating, cultural, or supporting services.
41. D — Strong scientific consensus supports that continued warming will make heat waves more frequent and more intense in many regions. Rising average temperatures shift the distribution toward more extreme heat. The other options contradict observed trends and ocean chemistry, which is becoming more acidic, not basic.
42. B — Acid rain in the Adirondacks was caused mainly by sulfur dioxide and nitrogen oxides released from burning coal and other fossil fuels, which form acids when they react with water in the atmosphere. These pollutants traveled from upwind industrial sources. Reducing such emissions later helped lakes begin to recover.
43. C — Rotating crops and planting cover crops protect soil from erosion and maintain its fertility, supporting long-term agricultural sustainability. These practices keep the ground covered and replenish nutrients. They preserve the productive capacity of the land for future generations.
44. A — Of the world's agricultural land, the large majority is devoted to raising livestock and growing their feed, which requires far more land than crops grown for direct human consumption. Livestock production is highly land-intensive relative to the food energy it provides. This makes meat and dairy a dominant driver of agricultural land use.
45. B — Replacing a coal plant with a wind farm reduces greenhouse gas emissions, which is mitigation—addressing the cause of climate change. Mitigation lowers the emissions driving warming, while adaptation instead copes with impacts. Cutting emissions at the source is the defining feature of a mitigation strategy.
46. D — Ocean acidification is driven by the ocean absorbing carbon dioxide, which dissolves to form carbonic acid and lowers seawater pH. Rising atmospheric carbon dioxide increases the amount taken up by the ocean. This acid formation is what threatens shell-building marine organisms.
47. C — The stable climate of the last several thousand years allowed dependable agriculture, which produced reliable food surpluses that supported cities and growing populations. Predictable growing conditions made permanent settlement possible. Climatic stability, not changes in oxygen or evolution, was the enabling factor for civilization.
48. A — The first step in the engineering design process is to clearly define the problem, including the criteria a successful solution must meet and the constraints it must work within. A precise problem definition guides every later stage. Skipping this step risks building a solution that fails to address the actual need.
49. D — When testing reveals a flaw, the engineering process calls for using those results to redesign the weak point and then retest the improved prototype. Iteration—testing, refining, and retesting—is central to good engineering. Failure during testing is an expected source of information, not a reason to quit.
50. B — A model should be used to explore likely outcomes under different scenarios to inform design decisions, not treated as exact certainty or as a replacement for real data. Models project possibilities based on assumptions and help engineers plan. Their value lies in guiding decisions while acknowledging uncertainty.