

Practice Exam 54: Earth and Space Sciences Regents Simulation (50 Questions)

1. The light from a distant galaxy reaches Earth's telescopes today, but it left the galaxy millions of years ago. What does this fact reveal about looking out into space?

A. Light from distant objects in space arrives at the Earth's telescopes the instant the light is emitted from the source it came from

B. Light from distant objects in space has its colors completely changed during the trip, which makes it impossible to study the source at all

C. Light from distant objects in space is mostly absorbed by interstellar gas, so almost no light from beyond our galaxy ever reaches the Earth

D. Looking at light from very distant objects means we are seeing them as they were in the past, not as they are right now

2. Why is helium the second most abundant element in the universe, after hydrogen?

A. Helium is produced in great amounts by lightning storms in Earth's atmosphere, which then gradually leaks out and fills the rest of the universe

B. Hot, dense conditions in the first few minutes of the Big Bang produced large amounts of helium from hydrogen, leaving the universe rich in helium

C. Helium is forged exclusively in supernova explosions, which is why it is now the second most abundant element found throughout the universe today

D. Helium is the most stable atom that exists, so any heavier element will eventually break down into helium over time everywhere in the universe

3. A red giant is the swollen, late-life stage of a star like the Sun. What conditions inside an aging star cause it to expand into a red giant?

- A. The core runs out of hydrogen and contracts, while hydrogen fusion begins in a shell around it, causing the outer layers to puff outward and cool
- B. The core suddenly fills up with brand-new hydrogen that comes from outside the star, which makes the star expand outward to a giant size very quickly
- C. The star slowly collects gas and dust from interstellar space, gradually adding so much mass that the star grows much larger over many years
- D. The star's outer surface freezes solid into a thick crust, which then bulges outward and forces the star to expand into a red giant over time

4. Kepler's First Law describes the shape of planetary orbits. Which statement correctly captures this law?

- A. The planets orbit the Sun in perfect circles, with the Sun positioned exactly at the geometric center of every one of these circular orbits
- B. The planets orbit the Sun in straight lines and then suddenly turn around at the far end of each orbit before traveling back the way they came
- C. The planets orbit the Sun in ellipses, with the Sun located at one of the two foci of each elliptical orbit rather than at the center
- D. The planets orbit the Sun in irregularly shaped, constantly changing curves that never repeat the same path more than once in their entire history

5. A comet's orbital period is 64 years. Using Kepler's Third Law ($T^2 = a^3$ in solar units), what is its approximate average distance from the Sun?

- A. About 8 AU, because the average distance from the Sun is always found by taking the square root of the orbital period measured in years
- B. About 16 AU, because 64 squared is 4,096, and the cube root of 4,096 is 16 AU
- C. About 64 AU, because the average distance from the Sun is always equal to the orbital period itself when the period is measured in years
- D. About 4 AU, because the average distance is always found by dividing the orbital period by 16, regardless of the actual length of the orbit

6. During the December solstice, the Northern Hemisphere experiences its shortest day of the year. Where on Earth does the Sun reach its highest point in the sky at noon on this day?

A. The Tropic of Capricorn, located at about 23.5 degrees south latitude, where the Sun appears directly overhead at noon on the December solstice

B. The Tropic of Cancer, located at about 23.5 degrees north latitude, where the Sun appears directly overhead at noon on the December solstice

C. The South Pole, located at 90 degrees south latitude, where the Sun appears directly overhead at noon on the December solstice

D. The equator, located at 0 degrees latitude, where the Sun appears directly overhead at noon on the December solstice every single year

7. A waxing crescent Moon appears in the western sky just after sunset, with a thin sliver lit on its right side. About three to four nights later, what phase will the Moon be in?

A. The new moon, when the Moon lies between the Earth and the Sun and the side facing us is dark, so the Moon cannot be easily seen in the sky

B. The full moon, when the Earth lies between the Sun and the Moon and the entire side facing us is brightly lit throughout the entire evening

C. The first quarter, when exactly the right half of the Moon's visible disk appears illuminated in the early evening sky just after sunset

D. The waning gibbous, when more than half of the Moon is lit and the bright portion is gradually shrinking each night after the full moon

8. The terrestrial planets (Mercury, Venus, Earth, Mars) are smaller, rockier, and denser than the gas giants (Jupiter, Saturn, Uranus, Neptune). Which of the following best explains why the gas giants are so much larger than the terrestrial planets?

A. Gas giants formed first and had hundreds of millions of years more time than the terrestrial planets to collect their material from the disk

B. Gas giants were born from a different cloud of gas and dust entirely separate from the one that formed the inner terrestrial planets close to the Sun

C. Gas giants were small rocky planets that grew larger by colliding with one another over time, gradually merging into the giant planets we see now

D. Gas giants formed beyond the frost line where ice could remain solid, allowing them to gather thick layers of ice and gas in addition to rocky cores

9. A solar eclipse occurs when the Moon's shadow falls on Earth, but during many solar eclipses observers see only a thin ring of sunlight surrounding the Moon, called an annular eclipse, rather than a total blackout. Why does this happen?

A. The Sun deliberately changes its size during certain eclipses, leaving a thin ring visible around the Moon instead of being completely blocked out

B. The Moon's orbit is slightly elliptical, so during some eclipses the Moon is farther from Earth and appears too small to completely cover the Sun

C. Earth's atmosphere distorts the Moon's appearance during eclipses, which makes the Moon look smaller than the Sun's bright disk behind it

D. The Earth deliberately shrinks itself during certain solar eclipses, which makes the Moon appear too small to completely cover the Sun in the sky

10. Spring tides occur when the Sun, Earth, and Moon line up nearly in a straight line, so the Sun's and Moon's gravitational pulls add together to produce the largest tidal range. During which two Moon phases does this happen?

A. The new moon and full moon, because in both of these phases the Sun, Earth, and Moon are aligned in a nearly straight line at the same time

B. The first quarter and last quarter, because in both of these phases the Sun and Moon pull on Earth's water at right angles to each other

C. The waxing crescent and waning crescent, because in both of these phases only a thin sliver of the Moon's face appears to be illuminated

D. Only during eclipses, because tides depend entirely on the Sun and Moon being so closely aligned that one casts a shadow on the other

11. The Sun's surface temperature is about 5,800 K, while a small, cool red dwarf star may have a surface temperature of only about 3,500 K. Which colors of light dominate the radiation from each of these stars?

- A. The Sun shines mostly in red light because its temperature is lower, while the red dwarf shines mostly in blue light because its temperature is higher
- B. Both stars emit identical light, because the surface temperature of a star has no measurable effect on the colors of light it produces in space
- C. The Sun emits most of its energy as visible (yellow-white) light, while the cooler red dwarf emits more of its energy at longer, redder wavelengths
- D. The Sun emits only ultraviolet radiation, while the red dwarf emits only microwaves, with no overlap in the wavelengths of light they produce

12. A geologist studying a region of folded and faulted rock layers concludes that the folding occurred after the layers were originally deposited. Which principle of relative dating most directly supports this conclusion?

- A. Original horizontality, the principle that sedimentary layers are first deposited in flat, horizontal sheets and only later become folded or tilted
- B. Superposition, the principle that in an undisturbed sequence of sedimentary rocks, the lowest layer is the oldest and the highest layer is youngest
- C. Cross-cutting relationships, the principle that any geologic feature that cuts across other rocks must be younger than the rocks it cuts through
- D. Faunal succession, the principle that the fossil organisms found in rock layers appear and disappear in a definite, predictable order over time

13. A radioactive isotope has a half-life of 2,500 years. A sample now contains one-eighth of the original amount of this isotope. About how many years have passed since the sample formed?

- A. About 2,500 years, because reducing the isotope to one-eighth of its original amount requires only one half-life of the isotope's total lifetime
- B. About 5,000 years, because reducing the isotope to one-eighth of its original amount requires exactly two half-lives of the isotope's lifetime
- C. About 7,500 years, because three half-lives are needed to reduce the isotope to one-eighth of its original amount
- D. About 25,000 years, because eight half-lives are needed to reduce the isotope to one-eighth of its original amount of the isotope

14. Geologists use carbon-14 dating mainly to determine the ages of relatively young samples that contain organic material. Why is carbon-14 not useful for determining the ages of rocks that are tens of millions of years old?

A. Carbon-14 is not found in any organic material on Earth, so it cannot be used to date the age of even the very youngest of any organic samples

B. Carbon-14 has a relatively short half-life of about 5,700 years, so after roughly 50,000 years almost no carbon-14 remains to be measured at all

C. Carbon-14 has a half-life of billions of years, so its amount does not change measurably over the lifetime of the entire Earth, making it useless

D. Carbon-14 is too dangerous to handle in the laboratory at all, so scientists never use it to determine the age of any sample at any time

15. Two layers of sandstone are separated by a flat surface that shows clear signs of erosion. What does this type of unconformity tell a geologist about the time period the surface represents?

A. It represents a gap in the rock record, during which earlier rocks were eroded away and no new sediment was deposited for a long period of time

B. It represents an unusually rapid period of sediment deposition, during which both layers of sandstone were deposited almost at the same instant

C. It represents a brief moment during which the layers were melted by heat and then re-solidified, leaving a smooth flat surface between them

D. It represents a span of time during which the two sandstone layers were both being continuously deposited together at exactly the same rate

16. Identical fossils of a freshwater reptile, Mesosaurus, are found in rocks from both South America and Africa. The reptile could not have crossed a wide ocean. What does this finding support?

A. The two continents were once located at completely different latitudes and have since drifted closer together to share many fossil species

B. The two continents have always been in their present positions, and identical reptiles independently evolved on each continent at exactly the same time

C. The two continents have no real geologic relationship at all, and the matching fossils are just an unusual coincidence with no broader significance

D. The two continents were once joined together as part of a single landmass, allowing the same freshwater reptile to live across the entire region

17. Mass extinctions are intervals during which a large fraction of Earth's species die out worldwide within a relatively short span of geologic time. Which of the following is a hypothesized cause of past mass extinctions?

A. The slow, steady cooling of the Sun over billions of years, which has steadily reduced the amount of sunlight reaching Earth and gradually triggered extinctions

B. The discovery of new species of animals by paleontologists in modern times, which is itself the main reason that any species ever goes extinct on Earth

C. Large asteroid impacts and massive volcanic eruptions that rapidly altered the climate, ocean chemistry, and ecosystems on a global scale

D. The migration of animals across continents, which by itself has been shown to cause the global extinction of many other species over short periods

18. A layer of well-sorted, well-rounded sand shows large, sweeping cross-beds and contains no marine fossils at all. Which past environment most likely produced this rock layer?

A. A deep ocean basin, where only fine clay particles slowly settled out over many millions of years to produce thick, evenly layered deposits

B. A windswept desert, where wind sorted the sand grains by size and piled them into large dunes whose internal structure was preserved

C. A slow-moving river delta, where heavy debris was dropped quickly into a calm bay and buried under thick layers of unsorted material

D. A glacial environment, where unsorted rock and gravel were dumped together in chaotic piles as the moving ice sheet finally melted away

19. Scientists organize Earth's 4.6-billion-year history into a sequence of eons, eras, periods, and epochs of varying lengths. Which of the following is the major reason that the boundaries between these divisions are placed where they are?

- A. The boundaries are placed at completely arbitrary numerical points so that every single division ends up containing exactly the same length of time
- B. The boundaries are placed wherever paleontologists happen to be working at the moment, so they reflect modern research locations more than past events
- C. The boundaries simply repeat the divisions of the modern calendar year on a much longer time scale, with no relationship at all to Earth's history
- D. The boundaries mark major changes in Earth's life, climate, or geology preserved in the rock record, such as mass extinctions and major shifts

20. Earth's lithosphere is divided into a number of large rigid plates that move slowly over the planet's surface. Which of the following best describes what drives the motion of these plates?

- A. Convection in the hot, partly molten mantle below the plates, which slowly transfers heat from the interior outward and drags the plates along
- B. The Moon's gravitational pull on Earth's solid rock, which directly drags the lithospheric plates back and forth across the surface of the planet
- C. Strong winds in the upper atmosphere, which physically push the lithospheric plates across the surface of the Earth from above the ground
- D. The rotation of the Earth on its axis, which centrifugally flings the plates outward and causes them to move steadily across the surface

21. Two oceanic plates pull apart, allowing magma to rise up between them and create new oceanic crust. Where on Earth does this process most commonly occur?

- A. At mid-ocean ridges, long mountain chains running along the seafloor where seafloor spreading produces new oceanic crust
- B. At deep oceanic trenches near the coasts of continents, where one plate is forced down into the mantle beneath another tectonic plate
- C. At transform fault zones such as the San Andreas, where two plates slide past one another horizontally instead of pulling apart from each other
- D. At hotspots far from any plate boundary, where rising plumes of mantle magma punch through the middle of a single tectonic plate to form volcanoes

22. A sample of mineral has a glassy luster, breaks along curved surfaces called conchoidal fracture, and cannot be scratched by a steel knife. Of the following, which mineral is the sample most likely to be?

A. Talc, an extremely soft mineral that is easily scratched by a fingernail and is the softest mineral commonly used on the Mohs hardness scale

B. Calcite, a mineral that reacts with dilute acid, has three directions of cleavage at oblique angles, and is softer than a steel knife blade

C. Quartz, a mineral with glassy luster and conchoidal fracture that cannot be scratched by a steel knife because its hardness is greater than the knife

D. Halite, a soft mineral with three directions of cleavage at right angles, a salty taste, and a hardness far below that of any steel knife blade

23. Three classes of rock—igneous, sedimentary, and metamorphic—can be transformed into one another over geologic time through processes such as melting, weathering, and heat and pressure. What is this set of transformations called?

A. The water cycle, the continuous movement of water between the atmosphere, oceans, land, and living things by processes such as evaporation

B. The rock cycle, the set of natural processes through which rocks are continuously transformed among the igneous, sedimentary, and metamorphic classes

C. The carbon cycle, the continuous movement of carbon among living organisms, the atmosphere, the oceans, and rocks through a variety of processes

D. The nitrogen cycle, the continuous movement of nitrogen among the atmosphere, soil, plants, animals, and decomposers through a series of processes

24. Streams and rivers carry sediment from higher elevations to lower areas, where they deposit it. Which factor most directly determines the size of the sediment that a stream can carry?

A. The temperature of the surrounding air on the day that the stream is observed flowing, because warm days always allow streams to carry larger pieces

B. The color of the bedrock found in the surrounding region, because lighter-colored bedrock allows streams to carry much larger pieces of sediment

C. The number of fish swimming in the stream at any given time, because more fish always increase the size of sediment a stream is able to carry

D. The speed of the flowing water, because faster water has more energy and can carry larger and heavier particles than slower water can

25. A confined aquifer is a layer of permeable rock that holds water and is sandwiched between two layers of impermeable rock. Why might a well drilled into a confined aquifer produce water that rises in the well casing without being pumped?

A. The water in a confined aquifer is being constantly heated from below, so the steam that is produced pushes the water in the well upward to the surface

B. The wind blowing across the top of the well casing creates a strong suction that lifts the water from the aquifer upward to the well's surface

C. Pressure in the confined aquifer is high enough that, when the well penetrates the upper impermeable layer, water rises in the well casing on its own

D. Confined aquifers are warmer than the rocks above them, so heat in the well causes the water inside to rise on its own without any kind of pump

26. Energy in Earth's atmosphere is moved around through three main mechanisms: radiation, conduction, and convection. Which of these mechanisms is responsible for the rising of warm air and the sinking of cool air in the atmosphere?

A. Convection, in which warmer, less dense air rises while cooler, denser air sinks, creating a circulation that transfers heat through the atmosphere

B. Conduction, in which heat is transferred only by direct contact between particles touching one another, with no actual bulk movement of any air at all

C. Radiation, in which heat is transferred only as electromagnetic waves through the vacuum of empty space, with no bulk movement of any air at all

D. Friction, in which heat is transferred when two surfaces rub against one another, which is the main way that heat moves throughout the atmosphere

27. Soils form slowly over time as rocks weather and as organic material accumulates from dead plants and other organisms. Which of the following is a major factor controlling the formation of soil in a region?

- A. The width of the local roads passing through the region, because wider roads always permit soil to form much more quickly than narrow roads
- B. The number of buildings constructed in the region, because more buildings always cause the soil in the area to form much more quickly over time
- C. The brightness of the local streetlights at night in the region, because brighter lights always cause soil to form more quickly in the surrounding area
- D. The climate of the region, because temperature and rainfall control how quickly rocks weather and how rapidly organic matter builds up in the soil

28. A glacier flowing down a mountain valley carries large boulders and finer rock pieces of all sizes within and beneath its ice. As the glacier slowly melts, it drops this debris in a chaotic, unsorted pile. What is this deposit called?

- A. A moraine, a ridge or pile of unsorted rock and sediment dropped along the sides or end of a glacier as the ice melts
- B. A delta, a fan-shaped deposit of well-sorted sediment that builds up where a river slows down and enters a standing body of water
- C. A sand dune, a mound of well-sorted, fine grains of sand piled up by the wind in dry regions where vegetation is sparse or completely absent
- D. A floodplain, a flat, low-lying area next to a river that is covered by fine sediment whenever the river overflows its banks during a major flood

29. A river makes a tight bend, called a meander. As the river flows around the bend, it tends to erode the outer edge of the bend and deposit sediment along the inner edge of the bend. Why does this happen?

- A. The river deliberately chooses to wear away the outside of every bend, because rivers always prefer to make their channels much wider than they are deep
- B. The Moon's gravitational pull is much stronger on the outer edge of every meander, which causes the river to erode much more strongly on that side
- C. Water flows faster on the outside of the bend and slower on the inside, so the faster water erodes the outer bank and the slower water deposits sediment
- D. The river bed is always made of much softer rock on the outside of every meander, which causes erosion to act much more strongly on that side

30. A barometer measures the pressure of the atmosphere at a particular location. Which of the following statements correctly relates atmospheric pressure to weather conditions?

- A. Low-pressure systems are usually associated with clear skies and fair weather, while high-pressure systems are usually associated with stormy weather
- B. Pressure has no measurable effect on the weather, since the atmosphere is so vast that small changes in pressure are never able to influence weather
- C. Both high-pressure and low-pressure systems always produce the same kind of weather, because the air pressure has no effect on cloud formation
- D. Low-pressure systems are often associated with rising air, clouds, and precipitation, while high-pressure systems are often associated with fair weather

31. The jet stream is a fast-flowing river of air high in the troposphere, found at mid-latitudes. Which of the following is the main role of the jet stream in determining weather patterns?

- A. The jet stream determines the chemical composition of the air, which directly causes thunderstorms to form near the equator and not in the mid-latitudes
- B. The jet stream steers weather systems such as low- and high-pressure areas across the surface of the Earth, helping to set the path that storms take
- C. The jet stream blocks the Sun's radiation from reaching the surface of the Earth, which is the main control on whether or not storms are able to form
- D. The jet stream serves only as a path for airplanes to fly along, with no measurable effect on the weather felt by people living below it on the ground

32. Lightning that strikes the ground during a thunderstorm releases a tremendous amount of energy in an extremely short time. Why does thunder always follow a flash of lightning, often several seconds later?

- A. Thunder is caused by air rushing into the gap left after a lightning bolt passes, and only loud sounds can ever be produced this way each time lightning flashes
- B. Thunder is the sound made by the lightning bolt itself slowly heating the air far below the cloud, so it always arrives many seconds after the flash of light
- C. Thunder is caused by an enormous magnetic disturbance in the air that travels slowly through the surrounding sky after every single lightning strike of any size

D. Thunder is caused by the rapid heating and expansion of the air along the lightning's path, and sound travels much slower than light through the air

33. Hurricanes weaken rapidly once they make landfall. Which factor is the main reason for this rapid weakening of a hurricane after it comes ashore?

A. The hurricane loses its supply of warm ocean water, which had been providing the heat and moisture needed to power the storm out at sea

B. The Coriolis effect immediately stops acting on the storm the instant the hurricane crosses the coastline, which immediately disorganizes it

C. The pressure in the eye of the storm immediately becomes equal to the pressure of the surrounding air, which prevents any further rotation from developing

D. The hurricane is repelled by the magnetic field of the Earth when it gets close to land, which slows its winds and quickly disorganizes it

34. Earth's climate has changed many times over its long history, including past ice ages and warm periods. Which of the following is considered a major natural cause of long-term climate change over geologic time?

A. The rapid construction of cities and roads, which is one of the major natural causes of long-term climate change that has been at work for billions of years

B. The discovery of new species of animals by paleontologists in modern times, which is one of the major natural causes of long-term climate change worldwide

C. Variations in Earth's orbit and axial tilt, called Milankovitch cycles, which change the amount and distribution of sunlight reaching Earth over long times

D. The shining of starlight from outside our own solar system, which is one of the major natural causes of long-term climate change occurring on Earth

35. Scientists from many different fields agree that human activities are now the main driver of current global warming. Which of the following is the most important human activity contributing to this warming?

- A. The construction of new roads and houses, which has been shown to be the single largest source of greenhouse gas emissions in the modern world
- B. The hunting and fishing of wild animals, which has been shown to be the single largest source of greenhouse gas emissions in the modern world
- C. The cultivation of crops in fields, which has been shown to be the single largest source of greenhouse gas emissions in the modern world
- D. The burning of fossil fuels, which releases large amounts of carbon dioxide and other greenhouse gases into the atmosphere over time

36. A scientist explains that "no single weather event can be definitively attributed to climate change." Which of the following best explains why this is the case?

- A. Climate change has absolutely no effect on the weather at all, so no weather event in any region can ever be linked back to climate change of any kind
- B. Climate change shifts the long-term odds of certain kinds of weather, but any individual event is also influenced by many short-term factors that vary
- C. Climate change affects only the temperature and never affects precipitation, so no precipitation event in any region can ever be linked to climate change
- D. Climate change occurs only in the polar regions of Earth, so weather in mid-latitudes or the tropics is completely unaffected by climate change at all

37. Which of the following statements correctly compares renewable and nonrenewable energy resources?

- A. Renewable resources are continuously replenished on human timescales, while nonrenewable resources are used up far faster than natural processes can replace them
- B. Renewable resources are always more expensive than nonrenewable resources, while nonrenewable resources are always cheaper than any renewable energy source
- C. Renewable resources produce no usable energy at all, while nonrenewable resources are the only resources on Earth that can be used to generate any energy
- D. Renewable resources are always located deep underground, while nonrenewable resources are always located only on the surface of the Earth above the ground

38. Mining for coal, metals, and other minerals often produces piles of waste rock and uncovers chemicals that can leak into nearby streams and groundwater. Which of the following is a direct environmental consequence of mining if it is not carefully managed?

- A. Streams in the area suddenly become much cleaner, as mining always physically removes all contaminants from water that was already in the region
- B. The local climate immediately becomes much cooler, as mining always physically lowers the temperature of the region where the mining is taking place
- C. Local water quality may be degraded by acid mine drainage and toxic runoff, and habitats may be destroyed by the removal of soil and vegetation
- D. The local population of fish always grows much larger, because mining always adds many new young fish to streams in the area where the mining is happening

39. A region restricts new development in floodplains, the low-lying areas next to rivers that periodically flood. Which of the following statements correctly describes why this is considered a sound land-use decision?

- A. Floodplains are physically incapable of ever flooding, regardless of how much rain falls or how high the river rises in the surrounding area
- B. New development in floodplains is the only way to prevent rivers from ever overflowing their banks, so restricting development always causes more floods to happen
- C. Floodplains have no relationship at all to any flooding from any nearby river, so restricting development in them is unrelated to any flood damage
- D. Floodplains are areas naturally prone to flooding, so restricting development there reduces future property damage and protects natural flood storage

40. A natural meadow is full of many different species of plants, insects, birds, and small mammals living together and interacting with one another. The variety of life present in this meadow is best described by which of the following terms?

- A. Carrying capacity, the largest population of a single species that an environment can support indefinitely with its available natural resources
- B. Biodiversity, the variety of life found in an area, including the different species, the variation within each species, and the different ecosystems

C. Productivity, a measure of how rapidly the plants in an ecosystem produce new biomass through photosynthesis over a particular period of time

D. Trophic level, the position that an organism occupies in a food chain based on what it eats and what eats it in turn within an ecosystem

41. A coastal community is restoring a damaged salt marsh by planting native marsh grasses and removing invasive species. Which of the following is the best example of an ecosystem service this restored marsh will provide to people?

A. It will permanently and instantly stop all sea-level rise from happening anywhere along the entire global coastline by removing carbon from seawater

B. It will guarantee that no hurricane will ever be able to make landfall along this stretch of coastline again, no matter how strong the hurricane is

C. It will help buffer the coast from storm surge and erosion while filtering pollutants from the water that flows through the salt marsh ecosystem

D. It will produce an unlimited supply of fresh drinking water for the coastal community by removing all of the dissolved salt from the seawater nearby

42. Soil that has lost its fertility through repeated heavy farming can sometimes be partially restored by changing the practices used on the land. Which of the following practices most directly helps restore the fertility of farm soil?

A. Planting cover crops and legumes between cash crops, which adds organic matter and nitrogen back to the soil and helps to maintain its fertility over time

B. Plowing the same field straight up and down the slope over many seasons, which always increases the soil's fertility and prevents any future erosion

C. Spreading large amounts of plastic and other waste over the field, which always increases the soil's fertility and improves its ability to grow crops

D. Removing every tree, shrub, and hedgerow from around the field, which always increases the soil's fertility by giving the field full exposure to sunlight

43. A country decides to require that all new houses meet strict energy-efficiency standards for insulation, windows, and heating systems. Which of the following best describes the rationale for this policy from an environmental perspective?

- A. Energy-efficient houses cost more to build, so the policy is intended only to make construction companies and contractors much wealthier than they are
- B. Energy-efficient houses use exactly the same amount of energy as other houses, so the policy has no measurable environmental effect of any kind at all
- C. Energy-efficient houses produce no waste of any kind, so the policy is designed mainly to eliminate household garbage and not to reduce emissions
- D. Energy-efficient houses use less energy to heat and cool, reducing demand for fossil fuels and the greenhouse gas emissions that come from burning them

44. Many countries have signed international agreements aimed at reducing greenhouse gas emissions and limiting climate change. Which of the following best describes why international cooperation is needed to address climate change?

- A. Climate change occurs only in countries that emit greenhouse gases themselves, so countries that do not emit any gases are not affected by climate change at all
- B. Climate change is purely a local problem affecting only individual cities, so international cooperation has nothing to do with addressing climate change at all
- C. The atmosphere is shared globally, so greenhouse gases released in one country affect the climate everywhere, requiring countries to work together
- D. Climate change is completely impossible to address through any kind of human action, so international cooperation cannot help to address climate change at all

45. Which of the following best describes a feedback loop in Earth's climate system?

- A. A feedback loop is a one-time event that occurs only once in Earth's history and has no continuing influence on the climate after the original event happens
- B. A feedback loop is a process in which a change in one part of the climate system causes further changes that either amplify or counteract the original change
- C. A feedback loop is a measurement instrument used to record the average temperature of the Earth's surface, with no actual influence on the climate
- D. A feedback loop is a treaty signed by countries that agree to take certain actions related to the climate, with no physical basis in the climate system

46. A city promotes the use of buses, trains, bicycles, and walking instead of personal cars. Which of the following is a likely environmental benefit of this kind of policy?

A. Lower greenhouse gas emissions and reduced air pollution per person, since shared transit and active travel use less fuel per person than driving alone

B. A complete and immediate end to all global climate change, since shifting a single city's transportation patterns is enough to permanently solve climate change

C. A sharp increase in the total amount of fuel burned in the city, since buses and trains always burn far more fuel per person than personal cars do

D. A complete elimination of every air pollutant from every part of the world, since the choices made in a single city always affect the entire global atmosphere

47. A community wants to manage a local forest so that it continues to provide timber, recreation, and wildlife habitat for future generations. Which of the following best describes this approach?

A. Maximum extraction, an approach that focuses entirely on harvesting as much timber as possible in the short term without regard for future generations

B. Land abandonment, an approach in which the community simply leaves the forest alone and refuses to use it in any way for any human purposes

C. Resource depletion, an approach that focuses on using up the resources in the forest as quickly as possible before any other community can use them

D. Sustainable management, an approach that uses the forest in ways that maintain its long-term productivity, ecological health, and recreational value

48. When defining a problem at the start of the engineering design process, an engineering team needs to identify the criteria and constraints. Which of the following correctly describes these two terms?

A. Criteria are the requirements a design must meet to be considered successful, while constraints are the fixed limits within which the design must operate

B. Criteria are the limits within which a design must operate, while constraints are the requirements that a design must meet to be considered successful

C. Criteria and constraints both refer to fixed physical limits on a design, with no relationship at all to the requirements for the design to be successful

D. Criteria and constraints both refer to the goals of a design, with no relationship at all to the physical limits that govern how the design will work

49. Before a city builds a new flood-control levee along a river, engineers run a computer simulation of how high the river might rise during severe storms. Which of the following best describes the role of this simulation in the engineering design process?

A. The simulation is meant to replace any actual measurements of the river itself, since computer simulations are always more accurate than any real-world data

B. The simulation helps engineers explore how the design might perform under various conditions, supporting better decisions before the costly levee is built

C. The simulation guarantees with complete certainty that the finished levee will perform exactly as predicted under every possible condition that may ever occur

D. The simulation has no real value at all, since computer simulations cannot provide any useful information about how a real flood-control levee will perform

50. Science and engineering are closely related, but they differ in their primary goals. Which of the following statements best describes how they differ?

A. Science and engineering have exactly the same goal, which is to design new useful technologies, and they differ only in the equipment that they happen to use

B. Science and engineering have exactly the same goal, which is to explain natural phenomena, and they differ only in the equipment that they happen to use

C. Science aims to design new useful technologies, while engineering aims to explain natural phenomena, which is the only difference between the two fields

D. Science aims to explain natural phenomena and understand how the world works, while engineering aims to apply that knowledge to design solutions to problems

Practice Exam 54: Answer Key with Explanations

1. D — Light from very distant objects took millions of years to reach us, so we see them as they were in the past rather than as they are now. Light's finite speed turns distance into a window onto earlier times. This is why astronomy is in part the study of cosmic history.
2. B — Helium is the second most abundant element because the hot, dense conditions in the first few minutes of the Big Bang fused hydrogen into large amounts of helium before the universe cooled too much for fusion to continue. This Big Bang nucleosynthesis set the early elemental mix. Later stars added only modestly to the helium total.
3. A — A star like the Sun becomes a red giant when its core runs out of hydrogen and contracts, while hydrogen fusion ignites in a shell around the core. The shell's heat puffs the outer layers outward, and they cool and redden as they expand. This stage marks the star's late life.
4. C — Kepler's First Law states that the planets orbit the Sun in ellipses, with the Sun at one of the two foci of each elliptical orbit. Orbits are not perfect circles, and the Sun is not at the center. This shape governs how distance and speed change along an orbit.
5. B — Kepler's Third Law gives $T^2 = a^3$, so with $T = 64$, T^2 equals 4,096 and a is the cube root of 4,096, which is 16 AU. The square of the period sets the cube of the distance. This relationship applies to any object orbiting the Sun.
6. A — On the December solstice the Sun appears directly overhead at noon along the Tropic of Capricorn, about 23.5° south latitude. The Southern Hemisphere is then tilted most toward the Sun, while the Northern Hemisphere has its shortest day. This solstice marks the start of Southern Hemisphere summer.
7. C — A waxing crescent grows into a first quarter Moon about three to four nights later, with exactly the right half of the visible disk illuminated. "Waxing" means the lit fraction is increasing. The next stages would be waxing gibbous and then full moon.
8. D — The gas giants formed beyond the frost line, where temperatures were low enough for ice to remain solid, allowing them to gather thick layers of ice and gas around rocky cores. The inner regions were too hot for these volatiles to condense. This temperature divide explains the size contrast.
9. B — An annular eclipse occurs because the Moon's orbit is slightly elliptical, so during some eclipses the Moon is farther from Earth and appears too small to fully cover the Sun. A ring of sunlight remains visible around the Moon. Lunar distance determines whether an eclipse is total or annular.
10. A — Spring tides occur at the new and full moons, when the Sun, Earth, and Moon are aligned in a nearly straight line and the Sun's and Moon's pulls combine. This alignment produces the largest tidal range. At the quarter phases, by contrast, the pulls partly cancel and tides are weaker.
11. C — A hotter star emits its peak energy at shorter wavelengths, so the Sun radiates most strongly in visible yellow-white light, while a cooler red dwarf emits more energy at longer, redder wavelengths. This is Wien's displacement law in practice. Temperature shapes the color of a star.
12. A — Original horizontality states that sedimentary layers are first deposited in flat, horizontal sheets, so layers that are now folded must have been deformed after deposition. The original flat layering is the starting assumption. The folding records crustal movement that came later.
13. C — One-eighth remaining means three half-lives have passed, since $1 \rightarrow 1/2 \rightarrow 1/4 \rightarrow 1/8$. Three half-lives \times 2,500 years equals 7,500 years. Counting halvings is the key to radiometric age problems.

14. B — Carbon-14 has a short half-life of about 5,700 years, so after roughly 50,000 years the remaining amount is too small to measure reliably. That makes it useless for samples millions of years old. Other isotopes with longer half-lives are used for older rocks.
15. A — An eroded surface between rock layers is an unconformity that represents a gap in the rock record, during which earlier rocks were eroded and no new sediment was deposited. Time is missing from the sequence. Recognizing unconformities is essential for reconstructing geologic history.
16. D — Identical fossils of a freshwater reptile on two continents that cannot be crossed by such an animal support the idea that the continents were once joined as a single landmass. Shared fossils across an ocean make sense only if the lands were connected. This was key evidence for continental drift.
17. C — Hypothesized causes of past mass extinctions include large asteroid impacts and massive volcanic eruptions that rapidly altered the climate, ocean chemistry, and ecosystems on a global scale. Sudden, severe environmental changes outpace many species' ability to adapt. The end-Cretaceous event is a famous example.
18. B — Well-sorted, well-rounded sand with large, sweeping cross-beds and no marine fossils indicates a windswept desert, where wind sorted and rounded the grains and piled them into dunes. Wind transport produces this distinctive sorting and cross-bedding. The absence of marine fossils rules out an ocean.
19. D — Boundaries on the geologic time scale are placed where the rock record shows major changes in life, climate, or geology, such as mass extinctions and major environmental shifts. The divisions are tied to real events, not arbitrary numbers. This makes the time scale a record of Earth's history.
20. A — Plate motion is driven mainly by convection in the hot, partly molten mantle below, which transfers heat from the interior outward and drags the plates along. Mantle convection is the engine of plate tectonics. The Moon's pull, winds, and rotation do not drive the plates.
21. A — Two oceanic plates pulling apart create new crust at mid-ocean ridges, long mountain chains running along the seafloor where seafloor spreading occurs. Magma rises into the gap and solidifies as new oceanic crust. Trenches, transform faults, and hotspots are different settings.
22. C — A mineral with glassy luster, conchoidal fracture, and hardness greater than steel matches quartz. Quartz has a Mohs hardness of 7, above steel's ~5.5. These properties together are diagnostic for quartz.
23. B — The rock cycle is the set of natural processes through which rocks are continuously transformed among the igneous, sedimentary, and metamorphic classes. Melting, weathering, and heat and pressure drive the transformations. It links all three rock types over geologic time.
24. D — A stream's ability to carry sediment depends mainly on the speed of the flowing water, because faster water has more energy and can move larger, heavier particles. Slower water drops the larger particles first. This is why fast mountain streams carry boulders and slow lowland rivers carry mud.
25. C — Water in a confined aquifer is under pressure between two impermeable layers, so when a well penetrates the upper layer the pressure pushes the water upward in the well casing on its own. Such artesian wells need no pump to bring water to the surface. The pressure, not heat or wind, drives the rise.
26. A — Convection moves heat in the atmosphere as warmer, less dense air rises while cooler, denser air sinks, creating a circulation that transfers heat through the air. Conduction and radiation transfer heat by other mechanisms. Convection is responsible for many large-scale weather patterns.

27. D — Climate is a major factor in soil formation because temperature and rainfall control how quickly rocks weather and how rapidly organic matter accumulates in the soil. Warm, wet climates speed both processes, while cold or dry climates slow them. This is why soils vary so much between regions.
28. A — A chaotic, unsorted pile of rock and sediment dropped by a melting glacier along its sides or end is called a moraine. The ice carries debris of all sizes and drops it together without sorting. Moraines are classic landforms left behind by past glaciation.
29. C — Water flows faster on the outside of a meander and slower on the inside, so the faster water erodes the outer bank and the slower water deposits sediment on the inside. This pattern gradually shifts the meander across its floodplain. Speed differences across the bend drive the asymmetry.
30. D — Low-pressure systems are associated with rising air, which cools and produces clouds and precipitation, while high-pressure systems involve sinking air and bring fair weather. The motion of the air, not pressure itself, is what shapes the weather. This is why falling pressure often signals an approaching storm.
31. B — The jet stream steers weather systems such as low- and high-pressure areas across Earth's surface, helping set the path that storms take across the mid-latitudes. Forecasters track the jet's position to anticipate weather changes. Its meanders bring warm or cold air south or north.
32. D — Thunder is caused by the rapid heating and expansion of air along the lightning's path, and because sound travels far slower than light, the boom arrives seconds after the flash. Counting the delay gives a rough distance to the strike. Light and sound speeds explain the timing.
33. A — A hurricane weakens over land because it loses its supply of warm ocean water, which had provided the heat and moisture powering the storm. Without that energy source, the storm rapidly decays. This is why hurricanes intensify over warm seas and weaken once ashore.
34. C — Variations in Earth's orbit and axial tilt, known as Milankovitch cycles, change the amount and distribution of sunlight reaching Earth over tens of thousands of years and are a major natural cause of long-term climate change. These slow cycles helped pace past ice ages. They operate on geologic, not human, timescales.
35. D — The most important human contribution to current global warming is the burning of fossil fuels, which releases large amounts of carbon dioxide and other greenhouse gases into the atmosphere. CO₂ from coal, oil, and gas dominates human emissions. Cutting these emissions is central to climate action.
36. B — No single weather event can be definitively attributed to climate change because climate change shifts the long-term odds of certain kinds of weather, while any individual event is also shaped by many short-term factors. Climate sets probabilities; weather plays them out. This is why scientists speak in terms of changing risk.
37. A — Renewable resources are continuously replenished on human timescales, while nonrenewable resources are used up far faster than natural processes can replace them. This rate of replenishment is the defining difference. Cost and location vary independently.
38. C — Poorly managed mining can degrade local water quality through acid mine drainage and toxic runoff, and habitats can be destroyed by removing soil and vegetation. Both water and ecosystems are vulnerable. Careful planning and reclamation reduce these impacts.
39. D — Restricting development on floodplains is sound because floodplains are naturally prone to flooding, so limiting building there reduces future property damage and preserves natural flood storage. The river's floodwaters need somewhere to go. Land-use planning that respects this is a long-term cost saver.

40. B — The variety of life found in an area, including different species, variation within species, and different ecosystems, is biodiversity. It is a key measure of ecological richness. High biodiversity often supports more resilient and productive ecosystems.
41. C — A restored salt marsh helps buffer the coast from storm surge and erosion while filtering pollutants from the water flowing through it. These are recognized ecosystem services. Marshes do not abolish sea-level rise, prevent every hurricane, or produce fresh water.
42. A — Planting cover crops and legumes between cash crops adds organic matter and nitrogen back to the soil, helping restore fertility over time. Legumes fix nitrogen, and cover crops protect and enrich the soil. These practices are central to sustainable farming.
43. D — Energy-efficient houses use less energy to heat and cool, which reduces demand for fossil fuels and the greenhouse gas emissions that come from burning them. Lower energy use also lowers utility costs for occupants. Efficiency standards are a key climate policy tool.
44. C — International cooperation on climate is needed because the atmosphere is shared globally, so greenhouse gases released in one country affect the climate everywhere. No single nation can solve the problem alone. Coordinated action allows fairer and more effective emissions cuts.
45. B — A feedback loop in the climate system is a process in which a change in one part of the system causes further changes that either amplify (positive feedback) or counteract (negative feedback) the original change. Feedbacks can speed or slow climate change. Identifying them is essential to understanding climate sensitivity.
46. A — Promoting transit, biking, and walking lowers greenhouse gas emissions and air pollution per person, because shared transit and active travel use less fuel per person than driving alone. Cleaner air and lower emissions are direct benefits. Transportation choices are a major lever for sustainability.
47. D — Managing a forest to provide timber, recreation, and habitat for future generations is sustainable management, an approach that maintains long-term productivity, ecological health, and social value. It balances current use with future availability. This contrasts with maximum extraction and abandonment.
48. A — Criteria are the requirements a design must meet to be considered successful, while constraints are the fixed limits within which the design must operate. Criteria define success; constraints set boundaries. Distinguishing them is fundamental to framing an engineering problem.
49. B — A computer simulation helps engineers explore how the design might perform under various conditions, supporting better decisions before the costly levee is built. Simulations make it possible to test scenarios safely and cheaply. They inform, but do not replace, real measurements.
50. D — Science aims to explain natural phenomena and understand how the world works, while engineering aims to apply that knowledge to design solutions to problems. Science explains; engineering applies. The two fields are linked but pursue different ends.