

PRACTICE EXAM 22: EARTH AND SPACE SCIENCES REGENTS SIMULATION (50 QUESTIONS)

1. The observed abundance of light elements in the universe is approximately 75% hydrogen and 25% helium by mass. This ratio is best explained by which idea?
 - A. Nuclear reactions in the first few minutes after the Big Bang produced this hydrogen-to-helium ratio
 - B. Ongoing fusion inside present-day stars steadily maintains this fixed ratio throughout the universe
 - C. Hydrogen and helium were delivered to galaxies in equal amounts by streams of passing comets
 - D. Radioactive decay of heavier elements inside planets continuously generates hydrogen and helium gas

2. Our Sun is currently a middle-aged main sequence star. What is the most likely sequence of stages in its future evolution?
 - A. The Sun will explode as a supernova and then collapse directly into a dense black hole
 - B. The Sun will cool steadily in place and slowly fade into a cold dark cloud of dust and gas
 - C. The Sun will expand into a red giant, then shed its outer layers and become a white dwarf
 - D. The Sun will split into two smaller stars that will orbit each other as a binary star system

3. How are the heavier elements that were forged inside a massive star ultimately spread through space to become part of new stars and planets?
 - A. They gradually leak outward through the star's surface as a slow steady stream over billions of years
 - B. They are carried away one at a time by individual photons of light leaving the surface of the star
 - C. They remain locked inside the original star forever and can never become part of any new objects

D. They are blasted into space when the massive star ends its life in a violent supernova explosion

4. A planet has an orbital period of 5 Earth years. Using Kepler's Third Law ($T^2 = a^3$ in solar units), what is the planet's approximate average distance from the Sun?

A. About 1.7 AU, since the average distance equals the orbital period divided by three exactly

B. About 2.9 AU, since the cube root of 25 gives the average distance in astronomical units

C. About 5.0 AU, since the average distance always equals the orbital period in astronomical units

D. About 12.5 AU, since the average distance equals the orbital period multiplied by two and a half

5. On the spring equinox, an observer in New York State notices that day and night are each approximately 12 hours long. What is the primary reason for this equal division?

A. Earth is at its closest point to the Sun, which evens out the hours of daylight and darkness

B. The Sun temporarily stops emitting radiation toward the Southern Hemisphere on that single day

C. Earth's axis briefly points directly at the Sun, distributing daylight equally over the whole planet

D. Earth's tilted axis points neither toward nor away from the Sun, so sunlight is shared equally

6. Three days after a full moon, an observer in New York looks at the Moon. What phase will the Moon most likely be in, and how will it appear?

A. A waxing crescent, appearing as a thin sliver lit on the right and setting just after the Sun

B. A first quarter moon, appearing exactly half lit on the right side and high in the evening sky

C. A waning gibbous, appearing more than half lit but shrinking, and rising later in the evening

D. A new moon, appearing completely dark and rising and setting together with the Sun each day

7. Nearly all the planets orbit the Sun in the same direction and roughly the same plane. Which idea best accounts for this orderly arrangement?

A. The planets were captured one by one over time from random directions in interstellar space

- B. The planets all formed together from a single flattened, rotating disk of gas and dust around the Sun
 - C. The Sun's magnetic field forces every planet into the same orbital plane after each one forms
 - D. Collisions between fully formed planets eventually aligned all of their orbits into one shared plane
8. During a total solar eclipse, only observers within a narrow path on Earth's surface see totality, while a much wider region sees only a partial eclipse. What explains this narrow path of totality?
- A. The Moon's dark inner shadow, the umbra, is small and sweeps across only a narrow strip of Earth
 - B. The Sun shrinks dramatically in size during the eclipse, shading only a thin band of the planet
 - C. Earth's atmosphere blocks the eclipse everywhere except along one narrow cloud-free corridor
 - D. Only people standing exactly on the equator are ever able to view the total phase of any eclipse
9. A harbor records its greatest tidal range—the largest difference between high and low water—around the times of new and full moon. What causes this maximum tidal range?
- A. The Moon is at its closest approach to Earth on exactly those two days of every single month
 - B. Strong onshore winds always blow toward the coast during new moon and full moon periods
 - C. The Sun and Moon are aligned, so their gravitational pulls combine to produce larger tides
 - D. Earth spins faster during new and full moons, throwing more water against the coastlines
10. Where in the Sun is the energy that eventually reaches Earth as sunlight originally produced?
- A. In the outermost layer called the corona, where charged particles escape as the solar wind
 - B. On the visible surface called the photosphere, where dark sunspots form and disappear over time
 - C. In the chromosphere, the thin reddish layer that becomes briefly visible during a solar eclipse
 - D. In the extremely hot, dense core, where hydrogen nuclei fuse into helium and release energy
11. At solar noon in New York State, a vertical flagpole casts a shorter shadow in late June than it does in late December. What does the shorter June shadow indicate?

- A. The Sun is closer to Earth in June, so its light reaches the flagpole from a steeper direction
- B. The Sun's noon altitude is higher in June, so sunlight strikes from a more nearly overhead angle
- C. The flagpole physically expands in the summer heat, which changes the length of its cast shadow
- D. The atmosphere bends the summer sunlight downward, eliminating most of the flagpole's shadow

12. In a sequence of undisturbed sedimentary rock, layer X lies above layer Y, and layer Y lies above layer Z. Which statement about the relative ages is correct?

- A. Layer Z is the oldest and layer X is the youngest, because lower undisturbed layers form first
- B. Layer X is the oldest and layer Z is the youngest, because upper layers always form first
- C. All three layers are exactly the same age, because they belong to one continuous rock sequence
- D. The relative ages cannot be determined from position alone without radiometric dating of each layer

13. A sample of organic material from an archaeological site contains one-eighth of its original carbon-14, which has a half-life of about 5,700 years. Approximately how old is the sample?

- A. About 5,700 years old, because one half-life reduces carbon-14 to one-eighth of the original amount
- B. About 11,400 years old, because two half-lives reduce carbon-14 to one-eighth of the original amount
- C. About 17,100 years old, because three half-lives reduce carbon-14 to one-eighth of the original amount
- D. About 45,600 years old, because eight half-lives reduce carbon-14 to one-eighth of the original amount

14. Two widely separated rock outcrops each contain the same species of an extinct, short-lived marine organism. What can a geologist reasonably conclude?

- A. The two outcrops were both formed in a deep ocean basin far from any nearby coastline
- B. The organism must still be alive somewhere today since its fossils are so widely distributed
- C. The two outcrops are made of exactly the same type of rock with identical mineral content
- D. The two rock layers formed during the same span of geologic time and can be correlated in age

15. The fossil record shows that life forms have changed in a definite, irreversible order through geologic time. How is this principle of fossil succession used by geologists?

- A. To measure the exact numerical age of a rock in years directly from the fossils it contains
- B. To determine the relative age of rock layers based on which fossil organisms they contain
- C. To predict which new species of organisms will evolve in Earth's ecosystems in the future
- D. To prove that all rock layers around the world were deposited during one single time period

16. A mass extinction is best defined by which of the following?

- A. A relatively short interval in which a large fraction of Earth's species die out across the globe
- B. The gradual disappearance of a single species from one local area over many millions of years
- C. A steady increase in the total number of species living on Earth during a warm climate period
- D. The seasonal migration of large numbers of animals from one continent to another each year

17. The seafloor on either side of a mid-ocean ridge shows a symmetrical pattern of magnetic stripes recording reversals of Earth's magnetic field. How does this pattern support seafloor spreading?

- A. It shows that the seafloor is the oldest rock on Earth and has never moved since it first formed
- B. It shows that Earth's magnetic field has remained perfectly constant throughout all of geologic time
- C. It shows that the continents, not the seafloor, are the parts of the crust that actually move over time
- D. It shows that new crust forms at the ridge and records the field as it spreads outward symmetrically

18. A deposit consists of unsorted material ranging from fine clay to large boulders all mixed together, with scratched and grooved rock surfaces nearby. Which past environment does this best indicate?

- A. A calm deep lake where only the very finest sediment slowly settled to the bottom over time
- B. A fast-flowing river that sorted its sediment neatly by size as the current carried particles along
- C. A glacial environment where moving ice carried and dropped a chaotic, unsorted mix of debris

D. A windswept desert where blowing sand was sorted into well-rounded grains of uniform size

19. The Himalaya Mountains are still rising today where the Indian Plate pushes into the Eurasian Plate. What type of plate boundary produced these mountains?

A. A convergent boundary where two continental plates collide and crumple the crust upward

B. A divergent boundary where two plates separate and magma rises to fill the gap between them

C. A transform boundary where two plates slide past each other without creating any new crust

D. A passive margin where the edge of a continent sits quietly far from any active plate boundary

20. Which statement correctly describes the general structure of Earth's interior from the surface to the center?

A. A liquid crust, a solid mantle, a liquid inner core, and a solid outer core at the very center

B. A thin solid crust, a thick mostly solid mantle, a liquid outer core, and a solid inner core

C. A gaseous crust, a liquid mantle, a gaseous outer core, and a small liquid core at the center

D. A uniform solid composition with the same density and material from the surface to the center

21. Molten rock cools and solidifies deep underground, producing a coarse-grained rock with large interlocking crystals. Which rock type and origin does this describe?

A. A sedimentary rock formed by the compaction and cementation of small sediment grains over time

B. A metamorphic rock formed when an existing rock is altered by intense heat and pressure underground

C. An extrusive igneous rock formed when lava erupted onto the surface and cooled very rapidly there

D. An intrusive igneous rock formed when magma cooled slowly below the surface, growing large crystals

22. A mineral can scratch glass but is itself scratched by a steel file. On the Mohs hardness scale, which range best describes this mineral's hardness?

A. A hardness near 2, since the mineral is soft enough to be scratched easily by a human fingernail

- B. A hardness of 10, since only a diamond can scratch glass and resist scratching by all other materials
 - C. A hardness between about 5.5 and 6.5, since it is harder than glass but softer than a steel file
 - D. A hardness of exactly 3, since minerals in this range can be scratched by an ordinary copper penny
23. A geologist examines an igneous rock that is dark in color and rich in iron and magnesium minerals. Which rock is this most likely to be?
- A. Basalt, a dark, dense igneous rock rich in iron and magnesium that commonly forms ocean crust
 - B. Granite, a light-colored igneous rock rich in quartz and feldspar that commonly forms continental crust
 - C. Limestone, a light sedimentary rock made of calcium carbonate that often contains marine fossils
 - D. Quartzite, a hard metamorphic rock that forms when quartz sandstone recrystallizes under pressure
24. Which process in the water cycle returns water vapor to the atmosphere directly from the leaves of plants?
- A. Infiltration, in which water soaks downward through the soil and into the groundwater below
 - B. Transpiration, in which plants release water vapor into the air through tiny pores in their leaves
 - C. Precipitation, in which water falls from clouds back to the surface as rain, snow, sleet, or hail
 - D. Runoff, in which water flows across the land surface and collects into streams and rivers downhill
25. A clay-rich layer has a high porosity, meaning it contains a large volume of pore space, yet water moves through it extremely slowly. Which statement best explains this?
- A. The clay layer must actually have very low porosity, since high porosity always allows fast water flow
 - B. The clay layer is too deep underground for any water to be able to enter its pore spaces at all
 - C. The pore spaces in clay are tiny and poorly connected, giving the layer low permeability despite high porosity
 - D. The clay chemically destroys any water that enters it, which is why no water can pass through the layer
26. Over millions of years, where is the largest amount of Earth's carbon stored?

- A. In the atmosphere as carbon dioxide gas, which makes up the majority of all carbon on the planet
- B. In the bodies of living plants and animals, which together hold most of Earth's total carbon supply
- C. In the surface waters of lakes and rivers, which contain the bulk of the planet's stored carbon
- D. In rocks such as limestone and in fossil fuels, which hold by far the largest reservoir of carbon

27. When snow and ice cover the ground, they reflect much of the incoming sunlight. As the climate warms and this bright cover melts, the exposed darker ground absorbs more sunlight and warms further. This is an example of which kind of feedback?

- A. A negative feedback that pushes the climate system back toward its original temperature
- B. A positive feedback in which melting reduces reflectivity and amplifies the original warming
- C. A neutral process that has no measurable effect on the temperature of the surrounding region
- D. An external forcing that originates entirely outside of Earth's climate system altogether

28. In a mountain region with many cycles of freezing and thawing, water repeatedly seeps into cracks in the rock, freezes, and expands. Over time the rock breaks apart. What is this process called?

- A. Frost wedging, a form of mechanical weathering in which freezing water pries rock apart at cracks
- B. Oxidation, a form of chemical weathering in which minerals react with oxygen and rust over time
- C. Carbonation, a form of chemical weathering in which acidic water dissolves rocks such as limestone
- D. Deposition, in which sediment that has been carried by water or wind is dropped in a new location

29. A river slows as it enters a calm lake, dropping its sediment to build a flat, fan-shaped landform at the river's mouth. What is this landform called?

- A. A moraine, formed from the unsorted rock debris that is pushed and dropped by a moving glacier
- B. A sand dune, formed where wind piles loose sand into mounds that slowly migrate across the land
- C. A delta, formed where a river deposits its sediment as it slows upon entering a lake or the sea
- D. A canyon, formed where a fast-flowing river cuts deeply downward through layers of solid bedrock

30. A maritime polar (mP) air mass forms over the cold North Atlantic Ocean and moves onto the New England coast. What weather characteristics would this air mass most likely bring?

- A. Hot and very dry conditions that bring drought and clear sunny skies for many days in a row
- B. Cool and moist conditions that often bring clouds, fog, and steady precipitation to the region
- C. Cold and bone-dry conditions that bring crystal-clear skies and the coldest air of the season
- D. Warm and humid tropical conditions that bring frequent thunderstorms and very high humidity

31. A boundary between two air masses shows little movement for several days, bringing prolonged cloudy, rainy weather to the same area. What type of front is this?

- A. A cold front, which moves quickly and brings a brief, intense band of storms before clearing
- B. A warm front, which advances steadily and brings a period of light rain followed by warmer air
- C. An occluded front, in which a fast cold front overtakes and lifts a warm front off the ground
- D. A stationary front, where two air masses meet but neither advances, prolonging the wet weather

32. On a clear evening, the air temperature drops during the night while the actual amount of water vapor in the air stays the same. What happens to the relative humidity as the air cools?

- A. The relative humidity rises, because cooler air can hold less water vapor before reaching saturation
- B. The relative humidity falls, because cooler air is able to hold much more water vapor than warm air
- C. The relative humidity stays exactly the same, since the amount of water vapor has not changed at all
- D. The relative humidity instantly drops to zero, because cold air can never contain any water vapor

33. At the very center of a hurricane is a region of calm, clear skies and light winds called the eye. Which statement about the eye is correct?

- A. The eye is the most destructive part of the storm, with the strongest winds found anywhere in it
- B. The eye is a band of intense thunderstorms that produces the heaviest rainfall of the entire storm
- C. The eye is a calm center of sinking air, surrounded by the eyewall where the strongest winds occur

D. The eye is a cold pocket of polar air that has been pulled into the warm center of the hurricane

34. Burning fossil fuels has increased the concentration of which gas, the main human-produced contributor to the enhanced greenhouse effect?

- A. Oxygen, which is added to the atmosphere whenever coal, oil, and natural gas are burned for energy
- B. Carbon dioxide, which is released when fossil fuels are burned and which traps outgoing heat energy
- C. Nitrogen, which is the most abundant atmospheric gas and the strongest absorber of infrared radiation
- D. Helium, which escapes from underground fossil fuel deposits and accumulates in the upper atmosphere

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

- A. The land heats faster than the water, so warm air rises over land and cooler ocean air flows in to replace it
- B. The ocean water heats much faster than the land, forcing warm sea air to rush inland across the beach
- C. The Moon's gravity drags the surface air from the ocean toward the shoreline during the afternoon hours
- D. The salt in the ocean air makes it heavier, so it always sinks and slides downhill away from the water

36. What is the key difference between weather and climate?

- A. Weather refers only to temperature, while climate refers only to the amount of rainfall in a region
- B. Weather describes conditions over many decades, while climate describes conditions on a single day
- C. Weather and climate are simply two different words that mean exactly the same thing in science
- D. Weather is the short-term state of the atmosphere, while climate is the long-term average over many years

37. Which of the following energy resources is nonrenewable?

- A. Wind energy, which is captured by turbines and is continuously replenished by the movement of air
- B. Coal, which forms from buried plant material over millions of years and cannot be quickly replaced
- C. Solar energy, which arrives from the Sun and is available again each day without being used up
- D. Hydroelectric energy, which is generated by flowing water that is continually renewed by the water cycle

38. A company can dispose of its waste cheaply by dumping it, but this pollutes a public lake used by a nearby town. In economic terms, the pollution damage borne by the town is best described as which of the following?

- A. A private benefit that the company earns directly from selling its manufactured products to consumers
- B. A government subsidy paid to the town to compensate it for living near the company's facility
- C. A negative externality, a cost of the company's activity that falls on people outside the transaction
- D. A renewable resource that the town can continue to use freely without any reduction in its value

39. A large continuous forest is divided into many small, isolated patches by new roads and housing developments. Even though much forest remains, biodiversity declines. Which driver of biodiversity loss does this best illustrate?

- A. Habitat fragmentation, in which dividing a habitat isolates populations and limits their movement
- B. Overharvesting, in which organisms are removed from the environment faster than they can reproduce
- C. Ocean acidification, in which seawater becomes more acidic and harms shell-building marine organisms
- D. The introduction of an invasive predator that has no natural controls in the local ecosystem at all

40. A coastal mangrove forest absorbs the energy of storm surges and protects inland communities from flooding during hurricanes. Which category of ecosystem service does this protection represent?

- A. A provisioning service, because the mangroves directly supply food, lumber, and other raw materials
- B. A cultural service, because the mangroves offer recreation, beauty, and inspiration to local people
- C. A supporting service, because the mangroves carry out nutrient cycling and the formation of new soil

D. A regulating service, because the mangroves moderate natural hazards and reduce flooding from storms

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

- A. The total volume of ice stored in glaciers and ice sheets will grow steadily over the coming century
- B. Average global surface temperatures will cool noticeably as greenhouse gas concentrations keep rising
- C. Sea levels will continue to rise as ocean water warms and expands and as land-based ice melts
- D. The oceans will gradually become more alkaline as they take up more carbon dioxide from the air

42. The Montreal Protocol, an international agreement, has helped the stratospheric ozone layer begin to recover. This recovery was achieved primarily by phasing out which substances?

- A. Carbon dioxide emissions produced by burning coal, oil, and natural gas in power plants worldwide
- B. Chlorofluorocarbons (CFCs) once used in refrigerators, air conditioners, and aerosol spray cans
- C. Sulfur dioxide emissions produced by coal-fired power plants and large industrial smokestacks
- D. Nitrogen-based fertilizers spread across farm fields that then ran off into rivers and the ocean

43. A desert city relies on a groundwater aquifer that is being pumped faster than rainfall can refill it. Which approach best promotes the long-term sustainability of this water supply?

- A. Reducing water use and limiting pumping so that withdrawals do not exceed the aquifer's recharge rate
- B. Pumping the aquifer as fast as possible now so the city can grow quickly before the water runs out
- C. Ignoring the recharge rate entirely and basing all pumping decisions only on current water demand
- D. Draining the aquifer completely and then searching for an entirely new water source somewhere else

44. The human population grew slowly for most of history but rose extremely rapidly over the past two centuries, reaching about 8 billion people. Which development most directly enabled this rapid population growth?

- A. A sudden worldwide decrease in the average number of children born to each family over that time
- B. A dramatic cooling of the global climate that made far more of Earth's land suitable for farming
- C. The complete elimination of all infectious diseases from every human population around the world
- D. Advances in agriculture, sanitation, and medicine that increased food supplies and lowered death rates

45. A national government invests heavily in planting forests and capturing carbon to lower the amount of carbon dioxide in the atmosphere. Which type of climate change strategy is this?

- A. Adaptation, because the government is adjusting to climate impacts that are already taking place now
- B. Mitigation, because the government is reducing the greenhouse gases that cause climate change
- C. Disaster recovery, because the government is responding to a climate emergency that has already struck
- D. Forecasting, because the government is predicting future climate conditions rather than acting on them

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

- A. Fast-swimming open-ocean fish that rely mainly on their muscles and gills to survive and hunt
- B. Large marine mammals such as whales and seals that surface regularly to breathe air from above
- C. Shell- and skeleton-building organisms such as corals, clams, and oysters that need carbonate minerals
- D. Floating seaweeds and kelp that grow near the surface and rely on sunlight for photosynthesis daily

47. Scientists note that human civilization developed during an unusually stable warm period following the last ice age. Why was this stability significant for human societies?

- A. The steady climate made farming reliable, allowing food surpluses that supported towns and cities
- B. The steady climate caused the rapid biological evolution that first produced the modern human species
- C. The steady climate finally raised atmospheric oxygen to a level high enough for humans to breathe
- D. The steady climate permanently ended all droughts, floods, and storms that early farmers had to face

48. An engineering team is told that a new bridge must safely carry a specified load and must be completed for no more than a fixed budget. The required load and the budget limit are best described as which of the following?

- A. Externalities, because they are costs imposed on people who are not involved in the bridge project
- B. Prototypes, because they are early working models built to test how the final bridge will perform
- C. Feedback loops, because they describe how the bridge responds to changes in its surroundings over time
- D. Criteria and constraints, because they define what the design must achieve and the limits it must respect

49. A design team must choose between a flood wall that is cheap but blocks the community's view of the river and a raised levee that preserves the view but costs much more. This decision best illustrates which engineering idea?

- A. The idea that the most technologically advanced option should always be chosen over simpler ones
- B. The idea that engineers should ignore community preferences and focus only on the lowest price
- C. The idea that engineering design involves trade-offs, balancing competing criteria that often conflict
- D. The idea that the cheapest available option is always the best choice regardless of any drawbacks

50. A team of scientists uses a computer model to test how different amounts of greenhouse gas emissions might affect global temperature by the year 2100. How should the results of such a model best be understood?

- A. As exact predictions of the future that are guaranteed to occur no matter what people choose to do
- B. As projections of likely outcomes under different assumptions, useful for guiding planning and policy
- C. As meaningless numbers, because the climate is far too complicated to study with any computer model
- D. As a complete replacement for real-world observations, which are no longer needed once a model exists

ANSWERS KEYS WITH EXPLANATIONS

1. A — The roughly 75% hydrogen and 25% helium composition of the universe was set by nuclear reactions in the first few minutes after the Big Bang, a process called Big Bang nucleosynthesis. Conditions were briefly hot and dense enough to fuse some hydrogen into helium before expansion cooled things too much. This predicted ratio closely matches what is observed, supporting Big Bang theory.
2. C — A star like the Sun will exhaust its core hydrogen, swell into a red giant, then shed its outer layers and leave behind a hot, dense white dwarf. Only much more massive stars explode as supernovae and form neutron stars or black holes. A star's mass determines its evolutionary endpoint.
3. D — A massive star disperses the heavy elements it forged when it dies in a supernova, an enormous explosion that scatters its enriched material into space. That debris later becomes part of new stars, planets, and ultimately living things. Supernovae are the primary mechanism that seeds galaxies with heavy elements.
4. B — Kepler's Third Law gives $a^3 = T^2$, so with $T = 5$, $T^2 = 25$ and a equals the cube root of 25, about 2.9 AU. The cube-root relationship means distance grows more slowly than period. This law links any planet's orbital period to its average distance from the Sun.
5. D — At an equinox, Earth's tilted axis points neither toward nor away from the Sun, so both hemispheres receive equal illumination and day and night are about 12 hours each. The tilt, not distance, governs the distribution of daylight. Equinoxes mark the transition between the seasons.
6. C — Three days after full moon, the illuminated fraction is shrinking but still more than half lit, which is the waning gibbous phase, and it rises progressively later each evening. "Waning" means decreasing illumination as the Moon heads toward last quarter. Tracking the lit fraction and rise time identifies the phase.
7. B — The planets share a common orbital direction and plane because they all condensed from a single flattened, rotating disk of gas and dust surrounding the young Sun. The disk's spin was inherited by the planets that formed within it. This shared geometry is a central prediction of the nebular hypothesis.
8. A — The Moon's umbra, its small dark inner shadow, reaches only a narrow strip of Earth, so only observers along that path see totality. Surrounding regions fall within the broader penumbra and see only a partial eclipse. The small size of the umbra is why total eclipses are visible from such limited areas.
9. C — The largest tidal range, the spring tide, occurs at new and full moon when the Sun and Moon are aligned and their gravitational pulls add together. This combined pull produces higher highs and lower lows. Tidal range therefore depends on the changing alignment of the Sun, Moon, and Earth.
10. D — Sunlight originates in the Sun's extremely hot, dense core, where hydrogen nuclei fuse into helium and release energy. The energy then slowly works its way outward to the surface before radiating into space. The core is the only region with conditions extreme enough to sustain fusion.
11. B — A shorter noon shadow in June means the Sun's noon altitude is higher, so sunlight strikes from a more nearly overhead angle. The higher Sun angle in summer produces both shorter shadows and more concentrated heating. Shadow length is a direct indicator of the Sun's altitude.
12. A — By the principle of superposition, in undisturbed layers the lowest forms first and is oldest, so layer Z is oldest and layer X, on top, is youngest. Sediments accumulate from the bottom upward over time. This is the basic rule for relative dating of horizontal strata.

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 5,700 years equals about 17,100 years. Counting halvings is the key to solving radiocarbon age problems.
14. D — The same short-lived, widespread fossil species in two separate outcrops means the layers formed during the same span of geologic time and can be correlated. Such organisms make excellent index fossils precisely because of their brief existence and wide range. Correlation lets geologists match rock ages across distant locations.
15. B — Fossil succession is used to determine the relative ages of rock layers based on which fossil organisms they contain, because life forms appear in a known, irreversible order. It establishes which layers are older or younger, not their exact numerical age. This ordering is the foundation of the geologic time scale.
16. A — A mass extinction is a relatively short interval in which a large fraction of Earth's species die out across the globe. It is distinguished by the scale and speed of species loss worldwide. Such events have repeatedly reshaped the history of life on Earth.
17. D — The symmetrical magnetic stripes show that new crust forms continuously at the ridge and records the field's polarity as it spreads outward in both directions. The matching pattern on either side is direct evidence of seafloor spreading. It also documents that Earth's magnetic field has reversed many times.
18. C — Unsorted material spanning clay to boulders, together with scratched and grooved bedrock, is the signature of a glacial environment, where moving ice carries and dumps a chaotic mix of debris. Ice transports particles of all sizes without sorting them. Striations on rock surfaces record the passage of the glacier.
19. A — The Himalayas formed at a convergent boundary where two continental plates collide, crumpling and thrusting the crust upward into mountains. Because both plates are buoyant continental crust, neither subducts easily, so the crust thickens and rises. Continental collision builds the world's highest mountain ranges.
20. B — Earth's interior consists of a thin solid crust, a thick mostly solid mantle, a liquid outer core, and a solid inner core. The outer core is liquid, which is why S-waves cannot pass through it. This layered structure was deduced largely from the behavior of seismic waves.
21. D — Slow cooling of magma deep underground produces an intrusive igneous rock with large, interlocking crystals, because the minerals have time to grow. Coarse grain size is the signature of slow, deep cooling. Rapid surface cooling instead yields fine-grained extrusive rock.
22. C — A mineral that scratches glass (hardness about 5.5) but is scratched by a steel file (about 6.5) falls between roughly 5.5 and 6.5 on the Mohs scale. Hardness is determined by which materials a mineral can and cannot scratch. This comparative scratch testing is a standard field identification method.
23. A — A dark, dense igneous rock rich in iron and magnesium is basalt, which commonly makes up oceanic crust. Its dark color reflects its high content of iron- and magnesium-bearing minerals. Basalt contrasts with light-colored, silica-rich granite of the continents.
24. B — Transpiration is the process by which plants release water vapor into the atmosphere through tiny pores in their leaves. It moves water from the soil, up through the plant, and into the air. Transpiration is a major pathway returning water to the atmosphere in the water cycle.
25. C — Clay can have high porosity yet low permeability because its pore spaces are extremely small and poorly connected, so water moves through very slowly. Porosity measures how much space exists; permeability measures how easily water flows through it. These two properties are distinct and do not always go together.

26. D — Over geologic timescales, the largest carbon reservoir is in rocks such as limestone, along with fossil fuels, which together dwarf the carbon held in the atmosphere or living things. Carbonate rock stores immense quantities of carbon for millions of years. This rock reservoir anchors the long-term carbon cycle.
27. B — Melting bright snow and ice exposes darker ground that absorbs more sunlight and warms further, melting still more ice, which is a positive feedback that amplifies the original warming. The change reinforces rather than dampens itself. This ice-albedo feedback is a key amplifier in the climate system.
28. A — Frost wedging is mechanical weathering in which water seeps into cracks, freezes, expands, and pries the rock apart over repeated freeze-thaw cycles. The expansion of freezing water exerts strong outward pressure. This process is especially active in cold mountain climates.
29. C — A delta is the flat, fan-shaped landform built where a river slows on entering a lake or sea and drops its sediment. The loss of velocity reduces the river's ability to carry its load, so deposition occurs at the mouth. Deltas are classic features of river deposition.
30. B — A maritime polar air mass forms over cold ocean water, so it is cool and moist, often bringing clouds, fog, and steady precipitation. "Maritime" indicates moisture and "polar" indicates cool temperatures. This contrasts with cold, dry continental polar air.
31. D — A stationary front occurs where two air masses meet but neither advances, so the boundary lingers and produces prolonged cloudy, rainy weather over the same area. The lack of movement is what extends the unsettled conditions. This distinguishes it from fast-moving cold or warm fronts.
32. A — As air cools while its water vapor content stays fixed, the relative humidity rises because cooler air can hold less vapor before reaching saturation. Relative humidity compares actual vapor to the maximum the air can hold at that temperature. This is why dew and fog often form on cool nights.
33. C — The eye is a calm center of sinking air with clear skies, surrounded by the eyewall, where the storm's strongest winds and heaviest rain occur. The contrast between the calm eye and the violent eyewall is characteristic of hurricanes. Sinking air in the eye suppresses cloud formation there.
34. B — Burning fossil fuels releases carbon dioxide, the main human-produced greenhouse gas, which absorbs and re-emits outgoing infrared heat. Its rising concentration enhances the greenhouse effect and warms the planet. Reducing carbon dioxide emissions is central to limiting climate change.
35. A — A sea breeze forms because land heats faster than water, so warm air rises over the land and cooler, denser ocean air flows in to replace it. The temperature difference between land and sea drives the circulation. This daytime onshore breeze reverses at night as the land cools faster.
36. D — Weather is the short-term, day-to-day state of the atmosphere, while climate is the long-term average of weather over many years. Climate describes the typical conditions of a region; weather describes what is happening at a given moment. Distinguishing the two is essential to understanding climate change.
37. B — Coal is nonrenewable because it forms from buried plant material over millions of years and cannot be replaced on human timescales. The other options—wind, solar, and hydroelectric—are continuously replenished by natural processes. Formation time is what separates renewable from nonrenewable resources.
38. C — The pollution damage borne by the town is a negative externality, a cost of the company's activity that falls on people outside the transaction. Externalities are real costs not reflected in the polluter's own expenses. Accounting for them is essential to honest cost-benefit analysis.

39. A — Dividing a continuous forest into small, isolated patches is habitat fragmentation, which isolates populations and limits their movement, lowering biodiversity even when total forest area remains. Fragmentation restricts breeding, feeding, and migration. It is a major and often underappreciated driver of species decline.
40. D — Mangroves buffering storm surge and reducing flooding provide a regulating service, the category covering ecosystems that moderate natural hazards and conditions. Regulating services control processes like flooding, climate, and disease. This protective function illustrates the practical value of intact ecosystems.
41. C — Strong scientific consensus supports continued sea level rise as warming ocean water expands and land-based ice melts. Both thermal expansion and ice loss add water to the oceans. The other options contradict observed trends and ocean chemistry, which is becoming more acidic rather than alkaline.
42. B — The Montreal Protocol aided ozone recovery primarily by phasing out chlorofluorocarbons (CFCs), which released ozone-destroying chlorine in the stratosphere. Eliminating CFCs allowed the ozone layer to begin healing. It is widely regarded as a successful model of international environmental action.
43. A — Sustainability requires that withdrawals not exceed the aquifer's recharge rate, so reducing water use and limiting pumping protects the supply for the long term. Pumping faster than recharge steadily depletes the resource. Matching use to recharge is the core principle of sustainable groundwater management.
44. D — Rapid recent population growth was enabled mainly by advances in agriculture, sanitation, and medicine that boosted food supplies and lowered death rates. More people survived to adulthood while food became more abundant. These improvements, not climate or eliminated disease, drove the population surge.
45. B — Planting forests and capturing carbon to lower atmospheric carbon dioxide is mitigation, because it reduces the greenhouse gases that cause climate change. Mitigation targets the underlying cause, while adaptation copes with impacts. Reducing emissions or removing carbon are defining mitigation actions.
46. C — A more acidic ocean most directly harms shell- and skeleton-building organisms such as corals, clams, and oysters, because acidification reduces the carbonate minerals they need. Without enough carbonate, these organisms struggle to build and maintain their structures. This threat ripples through entire marine food webs.
47. A — The stable post-ice-age climate made farming reliable, producing food surpluses that allowed towns and cities to develop. Predictable growing seasons were essential to settled agriculture. Climatic stability, not evolution or oxygen levels, enabled the rise of human civilization.
48. D — The required load and the budget limit are criteria and constraints: criteria define what the design must achieve, and constraints define the limits it must respect. Together they frame the engineering problem. Clearly stating them guides the design toward an acceptable solution.
49. C — Choosing between a cheap wall that blocks the view and a costlier levee that preserves it illustrates trade-offs, the balancing of competing criteria that often conflict. No single option maximizes every goal, so engineers weigh priorities. Recognizing trade-offs is central to real-world design decisions.
50. B — Climate model results should be understood as projections of likely outcomes under different assumptions, useful for guiding planning and policy rather than as exact predictions. Models explore possibilities based on chosen scenarios. They inform decisions while acknowledging uncertainty, and they complement rather than replace observations.

