PRACTICE EXAM 23: EARTH AND SPACE SCIENCES REGENTS SIMULATION (50 QUESTIONS)

1. Astronomers find that almost every distant galaxy is moving away from us, and the farther a galaxy is, the faster it recedes. What does this relationship most strongly support?

A. The Milky Way galaxy sits at the exact center of a stationary, unchanging universe

B. The other galaxies are being pulled toward a single massive object at the edge of space

C. The universe as a whole is expanding, with space itself stretching between the galaxies

D. The light from distant galaxies is being bent by dust clouds scattered throughout space

2. On a Hertzsprung-Russell diagram, most stars, including the Sun, fall along a broad diagonal band. What does a star's position on this band represent?

A. The total number of planets that orbit the star at various distances within its system

B. The chemical makeup of the star, which differs completely from one band star to the next

C. The age of the star measured in billions of years since it first began to form from gas

D. The relationship between a star's surface temperature and its luminosity while fusing hydrogen

3. Astronomers say that humans are "made of star stuff." What does this statement mean in terms of the origin of the atoms in our bodies?

A. Human atoms are continuously created by sunlight striking and reacting with Earth's surface

B. Many atoms in our bodies were forged by nuclear fusion inside stars that lived and died long ago

C. Human atoms were all manufactured during the first three minutes following the Big Bang event

D. Human atoms are slowly produced by radioactive decay occurring deep within Earth's hot interior

4. A dwarf planet orbits the Sun with an orbital period of 1,000 Earth years. Using Kepler's Third Law ($T^2 = a^3$ in solar units), what is its approximate average distance from the Sun?

A. About 100 AU, since the cube root of one million (1,000 squared) gives the distance in AU

B. About 10 AU, since the average distance equals the square root of the orbital period in years

C. About 1,000 AU, since the average distance always equals the orbital period in Earth years

D. About 31 AU, since the average distance equals the cube root of the orbital period in years

5. When it is summer in the Northern Hemisphere, it is winter in the Southern Hemisphere. What best explains why the two hemispheres experience opposite seasons at the same time?

A. The Southern Hemisphere is significantly farther from the Sun than the Northern Hemisphere is

B. As Earth orbits with its tilted axis, the hemisphere tilted toward the Sun has summer while the other has winter

C. The Sun emits more energy toward the Northern Hemisphere during half of every calendar year

D. The Southern Hemisphere contains more ocean, which keeps it permanently colder than the north

6. Observers on Earth always see the same side of the Moon, never the far side. What causes this to happen?

A. The Moon does not rotate on its axis at all, so the same side constantly faces toward Earth

B. The Moon spins so rapidly that both of its sides blur together into one face as seen from Earth

C. Earth's shadow permanently hides the far side of the Moon from the view of every observer

D. The Moon rotates once on its axis in exactly the same time it takes to orbit Earth once

7. The asteroid belt lies between Mars and Jupiter and contains many small rocky bodies that never formed into a planet. Which explanation best accounts for this?

A. Jupiter's strong gravity stirred up the region, preventing the small bodies from combining into one planet

B. A large planet that once existed there was shattered into pieces by a collision with a passing comet

C. The Sun's heat in that zone was so intense that any forming planet was completely vaporized away

D. The bodies in the belt were captured from interstellar space long after the planets had all formed

8. A solar eclipse occurs at new moon and a lunar eclipse occurs at full moon, yet eclipses do not happen every month. What is the main reason eclipses are relatively rare?

A. The Sun is only occasionally bright enough to cast a shadow that can reach all the way to Earth

B. Earth's rotation must slow down briefly for an eclipse to occur, which happens only a few times a year

C. The Moon's orbit is tilted relative to Earth's orbit, so the three bodies rarely line up exactly enough

D. Eclipses can occur only during the summer months when the Sun is highest in the daytime sky

9. Why do most coastlines experience two high tides and two low tides during each day rather than just one of each?

A. The Sun and the Moon each independently create exactly one separate high tide every single day

B. Ocean water heats and expands once and then cools and contracts once during each daily cycle

C. Earth's rotation reverses direction twice per day, sending water toward and then away from shore

D. Tidal bulges form on both the near and far sides of Earth, and rotation carries a coast through both

10. The Sun has been shining steadily for about 4.6 billion years. What allows the Sun to release energy at such a high rate for so long?

A. The Sun slowly burns hydrogen gas in chemical combustion reactions similar to a wood fire

B. Nuclear fusion in the core converts a tiny fraction of mass into a very large amount of energy

C. The Sun absorbs energy from surrounding stars and re-emits it outward across the solar system

D. Friction between the Sun's rotating layers continuously generates heat throughout its interior

11. In New York State, the total amount of solar energy received at the surface on a clear day is greatest in June and least in December. Which combination of factors best explains this difference?

A. In June the Sun reaches a higher angle and stays above the horizon longer than it does in December

B. In June Earth is much closer to the Sun, while in December Earth is much farther from the Sun

C. In June the Sun emits far more total radiation than it does during the month of December

D. In June the atmosphere is thinner, so almost no sunlight is absorbed before reaching the ground

12. A geologist finds that a layer of igneous rock cuts across several sedimentary layers and even bakes the rock along its edges. What does this indicate about the igneous rock's age?

A. The igneous rock is the same age as the sedimentary layers because they are touching each other

B. The igneous rock is older than all the sedimentary layers it cuts through and bakes along the edges

C. The igneous rock is younger than the sedimentary layers, since it intruded and altered them later

D. The relative age of the igneous rock cannot be determined from cross-cutting evidence alone

13. A radioactive isotope has a half-life of 700 million years. A mineral sample currently contains one-half of its original amount of this isotope. Approximately how old is the mineral?

A. About 350 million years old, because half of one half-life leaves one-half of the isotope remaining

B. About 700 million years old, because exactly one half-life reduces the isotope to one-half its amount

C. About 1.4 billion years old, because two half-lives are required to leave one-half of the isotope

D. About 2.1 billion years old, because three half-lives are required to leave one-half of the isotope

14. Which combination of characteristics makes an organism a good index fossil for dating rock layers?

A. The organism lived for a very long span of time and was found in only one small geographic area

B. The organism was very large in size and lived deep in the ocean where it was rarely preserved

C. The organism is still living today and is found across many different continents around the world

D. The organism was geographically widespread but existed for only a short, well-defined span of time

15. Which of the following lists the major divisions of geologic time in the correct order from oldest to youngest?

A. Precambrian, Paleozoic, Mesozoic, Cenozoic, progressing from the most ancient to the most recent

B. Cenozoic, Mesozoic, Paleozoic, Precambrian, progressing from the most ancient to the most recent

C. Paleozoic, Precambrian, Cenozoic, Mesozoic, progressing from the most ancient to the most recent

D. Mesozoic, Cenozoic, Precambrian, Paleozoic, progressing from the most ancient to the most recent

16. After a major mass extinction, the fossil record often shows a burst of new species appearing over the following millions of years. Why does this commonly happen?

A. The surviving species immediately stop evolving, leaving the ecosystems frozen and unchanged

B. The mass extinction permanently removes all life, so entirely new life must begin again from nothing

C. The loss of many species opens up ecological niches, allowing surviving groups to diversify into them

D. New species are carried to Earth from space to replace those that were lost in the extinction event

17. Alfred Wegener proposed that the continents were once joined into a single supercontinent. Which of the following did he use as evidence for this idea?

A. Identical satellite photographs of the continents taken from orbit high above the Earth's surface

B. Direct measurements showing the continents physically moving several meters apart each year

C. Records of identical earthquakes striking the same locations on different continents simultaneously

D. Matching rock types, mountain ranges, and fossils found on the facing coasts of separate continents

18. A thick layer of limestone contains abundant fossils of corals, shelled marine creatures, and other sea organisms. Which past environment is most consistent with this rock?

A. A dry, windswept desert where sand dunes slowly migrated across the land over long periods of time

B. A warm, shallow sea where marine organisms thrived and their carbonate remains accumulated on the bottom

C. A cold mountain glacier that scraped up and deposited a chaotic, unsorted mix of rock fragments

D. A swift river channel that tumbled and rounded pebbles before depositing them downstream over time

19. In East Africa, a long valley is forming where the continent is slowly splitting apart, with frequent earthquakes and volcanoes along its length. What type of plate boundary is forming here?

A. A divergent boundary, where the plates are pulling apart and the crust stretches and breaks

B. A convergent boundary, where one plate is sliding down beneath another into the deep mantle

C. A transform boundary, where two plates grind horizontally past each other along a fault line

D. A collision boundary, where two thick continental plates are crumpling upward into a mountain range

20. What is the primary source of the internal heat that drives mantle convection and powers Earth's plate tectonics?

A. Heat that flows into Earth's interior from the Sun and slowly works its way down to the mantle

B. Heat generated by the constant friction of ocean waves and tides acting on the planet's surface

C. Heat from the decay of radioactive elements within Earth, plus heat left over from its formation

D. Heat produced by lightning strikes that travel from the atmosphere deep into the solid ground

21. Shale, a fine-grained sedimentary rock, is subjected to increasing heat and pressure deep underground. As metamorphism intensifies, which sequence of rocks does the shale most likely become?

A. Shale changes into limestone, then into sandstone, and finally into loose gravel near the surface

B. Shale changes into slate, then into schist, and finally into gneiss as metamorphism increases

C. Shale changes into basalt, then into granite, and finally into obsidian as heat keeps rising

D. Shale changes into coal, then into oil, and finally into natural gas deep within the crust

22. A student rubs an unknown metallic-looking mineral across an unglazed porcelain plate and observes the color of the powder left behind. Which property is the student testing?

A. Cleavage, the tendency of a mineral to break along smooth flat planes in specific directions

B. Hardness, the resistance of a mineral to being scratched by another material or object

C. Density, the amount of mass contained within a given unit of volume of the mineral sample

D. Streak, the color of a mineral's powder, which is often more reliable than its surface color

23. A volcanic rock contains a few large crystals scattered within a fine-grained background of tiny crystals. What does this two-sized texture indicate about the rock's cooling history?

A. The rock cooled at a single constant rate, producing crystals that are all the same uniform size

B. The rock never fully cooled and remains partly molten beneath the surface even at the present day

C. The magma cooled slowly underground at first, forming large crystals, then erupted and cooled quickly

D. The rock formed entirely from sediment that was compacted and cemented rather than from any melt

24. What is the primary source of energy that drives the continuous movement of water through the water cycle?

A. The Sun, whose energy evaporates surface water and powers the circulation of the atmosphere

B. The gravitational pull of the Moon, which lifts water vapor upward into the cooler atmosphere

C. Heat from Earth's hot interior, which boils surface water and sends it rising into the sky as vapor

D. The rotation of Earth on its axis, which flings ocean water upward into the surrounding atmosphere

25. A town draws its drinking water from an underground aquifer. Which action would most effectively help recharge the aquifer and keep it from being depleted?

A. Paving over large areas of land with concrete and asphalt so that rainfall runs off more quickly

B. Drawing water from the aquifer at a faster rate during dry years to make up for the lack of rain

C. Lining all the local streams and rivers with concrete so that the water flows away more rapidly

D. Preserving open ground and wetlands that allow rainfall to soak into the soil and refill the aquifer

26. Burning coal, oil, and natural gas releases carbon that had been stored underground for millions of years. How does this human activity affect the carbon cycle?

A. It removes carbon dioxide from the atmosphere, gradually cooling the planet's surface over time

B. It rapidly adds carbon dioxide to the atmosphere, raising its concentration faster than natural removal

C. It has no measurable effect on atmospheric carbon dioxide because the amounts involved are too small

D. It converts atmospheric carbon dioxide into solid rock, locking the carbon away permanently underground

27. As the planet warms, frozen ground called permafrost begins to thaw, releasing methane, a powerful greenhouse gas, into the atmosphere. The added methane traps more heat, causing further thawing. This cycle is an example of which kind of feedback?

A. A negative feedback, because the released methane eventually cools the atmosphere back down again

B. An external forcing, because the methane originates from a source outside the climate system entirely

C. A positive feedback, because the released methane amplifies the warming that caused the thawing

D. A neutral feedback, because methane has no real effect on the temperature of the atmosphere at all

28. Iron-rich rocks exposed at the surface in a humid climate gradually develop a reddish-brown crust as the iron reacts with oxygen and water. What weathering process is responsible?

A. Oxidation, a form of chemical weathering in which minerals combine with oxygen to form new compounds

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

C. Abrasion, a form of mechanical weathering in which wind-blown sand grinds against and wears down the rock

D. Exfoliation, a form of mechanical weathering in which curved sheets of rock peel away from the surface

29. A river flows swiftly down a steep mountain slope and then reaches a broad, nearly flat plain. Where along this path is the river most likely to deposit the sediment it is carrying?

A. On the steep mountain slope, where the fast-moving water drops its heaviest sediment first of all

B. At the very source of the river high in the mountains, before the water has gained any real speed

C. Evenly along the entire length of the river, since deposition does not depend on the water's speed

D. On the broad flat plain, where the river slows down and can no longer carry its load of sediment

30. A continental tropical (cT) air mass forms over the hot, dry deserts of the southwestern United States in summer. What weather characteristics would this air mass bring to areas it moves into?

A. Cold and snowy conditions with strong winds and the lowest temperatures of the entire winter season

B. Hot and very dry conditions with clear skies and little chance of rain across the affected region

C. Cool and damp conditions with persistent fog, low clouds, and frequent light drizzle for many days

D. Mild and humid conditions off the ocean bringing steady rainfall and overcast skies to the region

31. As a cold front passes a weather station, observers typically record a sharp drop in temperature, a shift in wind direction, and a rise in air pressure. Why does the air pressure rise after the front passes?

A. Cold, dense air moves in behind the front, and denser air exerts greater pressure at the surface

B. Warm, light air moves in behind the front, and lighter air always exerts greater surface pressure

C. The front removes all the air from the region, leaving a vacuum that raises the measured pressure

D. The front heats the ground rapidly, which causes the surface air pressure to climb very quickly

32. On a humid summer day, water droplets form on the outside of a cold glass of iced tea. What does this observation demonstrate about the surrounding air?

A. The air contains no water vapor, and the droplets are leaking outward through the glass itself

B. The cold glass is chemically producing new water by reacting with the gases in the warm air

C. The air was cooled below its dew point at the glass surface, causing water vapor to condense

D. The relative humidity of the surrounding air must be exactly zero percent for this to occur

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

A. Cold ocean water below about 20°C, which supplies the dense air that hurricanes require to grow

B. Strong winds blowing in opposite directions at different heights, which help organize the storm's spin

C. A location directly on the equator, where the Earth's rotational effects on wind are the strongest

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

34. Earth's surface absorbs sunlight and then radiates energy back toward space as infrared radiation. How do greenhouse gases in the atmosphere affect this outgoing infrared energy?

A. They absorb much of the outgoing infrared energy and radiate part of it back toward the surface

B. They reflect the outgoing infrared energy straight back down without absorbing any of it at all

C. They speed up the escape of infrared energy into space, cooling the surface more rapidly than before

D. They convert the outgoing infrared energy into visible light that then escapes harmlessly into space

35. Warm air rises near the equator and sinks near 30° latitude, creating large loops of circulating air in the atmosphere. These large-scale loops are best described as which of the following?

A. Tidal currents, in which the Moon's gravity drives the regular rise and fall of the atmosphere

B. Ocean gyres, in which surface seawater circulates in great loops around entire ocean basins

C. Convection cells, in which uneven heating drives rising and sinking air in repeating loops

D. Magnetic field lines, in which charged particles spiral along the planet's magnetic field

36. Scientists drill deep into ancient ice sheets and analyze the tiny air bubbles trapped within the layers of ice. What can these trapped air bubbles reveal?

A. The exact daily weather conditions, including cloud cover and wind, on each day of the distant past

B. The composition of the ancient atmosphere, including past levels of greenhouse gases like carbon dioxide

C. The precise locations of all the volcanoes that were erupting anywhere on Earth at that time

D. The total number of living organisms that existed in the oceans during each year of the past

37. Which of the following energy sources is considered renewable?

A. Natural gas, a fossil fuel pumped from underground deposits that took millions of years to form

B. Coal, a fossil fuel mined from the ground that releases stored energy when it is burned for power

C. Uranium, a metal mined from the ground and used as fuel in nuclear fission power reactors

D. Geothermal energy, which taps the continuous heat flowing from within the Earth's hot interior

38. A city plants thousands of trees along its streets. Besides shade, the trees absorb air pollution and reduce flooding, benefits that extend to people throughout the city. In economic terms, these additional benefits are best described as which of the following?

A. Positive externalities, because they are benefits of the tree planting that extend to people beyond those who paid for it

B. Private costs, because they are expenses paid only by the individuals who planted the trees themselves

C. Nonrenewable resources, because the benefits are used up completely the moment the trees are planted

D. Government subsidies, because they are direct cash payments made by the city to each of its residents

39. A species of ocean fish is caught in such large numbers each year that its population drops sharply and struggles to recover. Which driver of biodiversity loss does this best illustrate?

A. Habitat fragmentation, in which a continuous habitat is divided into small, isolated pieces over time

B. Climate change, in which shifting temperatures push organisms beyond the limits they can tolerate

C. Overharvesting, in which humans remove organisms from the wild faster than they can reproduce

D. Pollution, in which harmful substances released into the environment poison or sicken living organisms

40. A national park draws millions of visitors each year who hike its trails, photograph its scenery, and find inspiration in its natural beauty. Which category of ecosystem service does the park primarily provide to these visitors?

A. A provisioning service, because the park directly supplies food, timber, fresh water, and raw materials

B. A cultural service, because the park provides recreation, beauty, and inspiration that enrich people's lives

C. A regulating service, because the park controls floods, filters the air, and moderates the local climate

D. A supporting service, because the park carries out nutrient cycling and the formation of fertile new soil

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

A. Glaciers and ice sheets worldwide will grow larger as the planet's average temperature keeps rising

B. The global average temperature will hold perfectly steady despite rising greenhouse gas concentrations

C. Ocean water will steadily become more basic and alkaline as it absorbs more carbon dioxide from the air

D. Many regions will face more frequent and severe droughts, heat waves, and other weather extremes

42. Acid rain, formed when certain pollutants mix with water in the atmosphere, damaged many lakes and forests in the northeastern United States. What was one major effect of acid rain on affected lakes?

A. The water became too acidic for many fish and other organisms to survive, reducing the lakes' biodiversity

B. The water became far warmer than normal, causing the lakes to evaporate completely during the summer

C. The water turned permanently salty, transforming the freshwater lakes into bodies of salt water instead

D. The water became so clean and pure that all aquatic life in the affected lakes thrived and multiplied

43. A community wants to reduce the amount of waste it sends to its landfill while also conserving raw materials. Which practice would most directly help achieve both of these goals?

A. Burning all of the community's waste in the open air so that nothing is ever sent to the landfill

B. Recycling materials such as metal, glass, and paper so they can be made into new products again

C. Burying all waste, including recyclable materials, as deeply as possible beneath the landfill surface

D. Shipping all of the community's waste to a different region so it becomes another community's problem

44. Agriculture is the single largest human use of fresh water worldwide. Most of this agricultural water is used for which purpose?

A. Cleaning and processing harvested crops in factories before they are shipped to grocery stores

B. Providing drinking water for the farm workers and livestock that live and work on the farms

C. Irrigating crops, supplying the water that growing plants need in regions without enough rainfall

D. Generating hydroelectric power at dams built on the rivers that flow through agricultural regions

45. A coastal town builds higher seawalls, elevates its buildings, and restores protective wetlands to cope with rising seas and stronger storms. Which climate change strategy does this best represent?

A. Adaptation, because the town is adjusting to climate impacts that are already beginning to occur

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

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

D. Reversal, because the town's actions will permanently stop the sea level from rising any further

46. The ocean has absorbed a large portion of the carbon dioxide that humans have added to the atmosphere. What effect has this absorption had on the ocean?

A. It has made the ocean significantly warmer but has had no effect at all on the ocean's chemistry

B. It has made the ocean steadily more alkaline, raising its pH well above its natural historic level

C. It has caused the ocean to release all of its dissolved oxygen, suffocating most marine animals

D. It has made the ocean more acidic, lowering its pH and harming shell-building marine organisms

47. The current geologic epoch, the Holocene, has had a relatively stable and mild climate for roughly the last 11,000 years. Why is this stability considered important for human history?

A. The stable climate caused the rapid evolution of entirely new human species during this short epoch

B. The stable climate allowed the development of agriculture, which made permanent settlements and cities possible

C. The stable climate finally produced the oxygen-rich atmosphere that humans first needed to breathe

D. The stable climate permanently removed all natural hazards, leaving early humans with no dangers to face

48. Before designing a solution to reduce a city's air pollution, an engineering team carefully identifies the pollution sources, sets goals for how much pollution to cut, and lists the budget and legal limits they must work within. What stage of the engineering design process is this?

A. Building a prototype, the stage in which a working physical model of the final solution is constructed

B. Testing and evaluating, the stage in which a finished solution is measured against real-world performance

C. Defining the problem, the stage in which the criteria for success and the constraints are clearly established

D. Communicating results, the stage in which the completed design is presented and explained to the public

49. After testing a prototype water filter, an engineering team finds it removes most contaminants but clogs too quickly to be practical. According to the engineering design process, what should the team do next?

A. Use what they learned from the test to redesign the filter and then test the improved version again

B. Stop all work permanently, since a prototype that clogs proves the entire project can never succeed

C. Sell the clogging filter to the public unchanged, because the first prototype is always the final product

D. Ignore the clogging problem entirely and simply declare the original prototype a complete success

50. Engineers use a computer model to simulate how a proposed dam would affect the flow of a river downstream under different rainfall conditions. What is the greatest value of using such a model before building the dam?

A. The model guarantees one exact outcome that will occur no matter what conditions actually arise later

B. The model removes any need to ever collect real measurements from the river before or after construction

C. The model proves that the dam will have no effect at all on the river or the communities downstream

D. The model lets engineers explore likely outcomes and test ideas safely before committing to construction

ANSWERS KEYS WITH EXPLANATIONS

1. C — The relationship in which more distant galaxies recede faster (Hubble's Law) shows that the universe as a whole is expanding, with space itself stretching between galaxies. Because all galaxies move apart, none occupies a special center. This expansion is a foundational piece of evidence for the Big Bang.
2. D — The main sequence band plots the relationship between a star's surface temperature and its luminosity during the long phase when it fuses hydrogen into helium in its core. A star's position along the band reflects these linked properties, not its age or planet count. Most stars, including the Sun, spend the bulk of their lives here.
3. B — "Made of star stuff" means that many atoms in our bodies, such as carbon and oxygen, were forged by nuclear fusion inside earlier stars that later died and scattered this material. Only the lightest elements came from the Big Bang itself. New stars and planets, including life, formed from this enriched debris.
4. A — Kepler's Third Law gives $a^3 = T^2$, so with T = 1,000, T^2 = 1,000,000 and a equals the cube root of one million, which is 100 AU. The cube-root relationship keeps the distance far smaller than the period. This law applies to any object orbiting the Sun.
5. B — Opposite seasons occur because Earth's axis stays tilted as it orbits, so the hemisphere tilted toward the Sun has summer while the other, tilted away, has winter. The tilt, not distance, drives the seasons. Six months later the orientation reverses, swapping the seasons between hemispheres.
6. D — We always see the same face of the Moon because it rotates once on its axis in exactly the time it takes to orbit Earth once, a state called synchronous rotation. This matched timing keeps one side perpetually facing us. The Moon does rotate; it simply does so in step with its orbit.
7. A — Jupiter's powerful gravity repeatedly disturbed the region between Mars and Jupiter, preventing the small bodies there from accreting into a single planet. The gravitational tugging kept the material broken into countless asteroids. This is why a belt of debris exists rather than a planet.

8. C — Eclipses are rare because the Moon's orbit is tilted relative to Earth's orbit, so at most new and full moons the alignment is slightly off and shadows miss their target. Only when the bodies line up near the orbital crossing points does an eclipse occur. This orbital tilt is why eclipses happen only a few times a year.
9. D — Two daily high tides occur because tidal bulges form on both the near and far sides of Earth, and the planet's rotation carries each coastline through both bulges. The near bulge faces the Moon while the far bulge results from inertia. Rotating through two bulges produces two highs and two lows per day.
10. B — The Sun sustains its output through nuclear fusion, which converts a tiny fraction of mass into an enormous amount of energy via $E = mc^2$. Fusion releases far more energy than any chemical reaction, which is why the Sun has lasted billions of years. This process powers the Sun's long, steady shine.
11. A — June receives the most solar energy because the Sun reaches a higher noon angle and stays above the horizon longer than in December. Higher angle concentrates the energy, and longer days extend the heating. Earth is actually slightly farther from the Sun in June, confirming that angle and day length, not distance, drive the difference.
12. C — By cross-cutting relationships, an igneous intrusion that cuts through and bakes surrounding sedimentary layers must be younger than those layers, since they had to exist before it intruded. The baking, or contact metamorphism, confirms the magma came later. This principle establishes the intrusion's relative age.
13. B — One-half of the isotope remaining means exactly one half-life has elapsed, so the mineral is about 700 million years old. By definition, a single half-life reduces an isotope to half its original amount. Counting half-lives is the key to radiometric age problems.
14. D — A good index fossil comes from an organism that was geographically widespread but lived for only a short, well-defined span of time. Wide distribution allows correlation across regions, and brief existence pins the age precisely. These two traits together make a fossil useful for dating rock layers.
15. A — The correct order from oldest to youngest is Precambrian, Paleozoic, Mesozoic, Cenozoic. This sequence reflects the progression of life and events recorded in the rock record. Knowing this order is essential for placing fossils and events on the geologic time scale.
16. C — After a mass extinction, the loss of many species frees up ecological niches, and the surviving groups diversify to fill them, producing a burst of new species. This process is called adaptive radiation. It explains why major extinctions are often followed by rapid evolutionary change.
17. D — Wegener supported continental drift with matching rock types, mountain ranges, and fossils found on the facing coasts of separate continents. These features align when the continents are reassembled, implying they were once joined. He lacked a mechanism, but this evidence later helped build plate tectonic theory.
18. B — Limestone full of coral and shelled marine fossils points to a warm, shallow sea where such organisms thrived and their carbonate remains built up on the seafloor. The fossils confirm marine conditions, and limestone forms from carbonate accumulation. This environment is inconsistent with desert, glacial, or river settings.
19. A — The East African Rift is a divergent boundary forming where a continent is pulling apart, stretching and breaking the crust and producing earthquakes and volcanoes. Continental rifting can eventually split a landmass and open a new ocean. The pulling-apart motion defines the divergent boundary.

20. C — Earth's internal heat comes mainly from the decay of radioactive elements plus residual heat left over from the planet's formation. This heat drives mantle convection, which in turn moves the plates. Solar energy does not penetrate to the mantle, so the Sun is not the source.
21. B — Increasing metamorphism transforms shale into slate, then schist, and finally gneiss as heat and pressure rise. Each step recrystallizes the rock further and develops coarser foliation. This progression is a classic example of how metamorphic grade increases with depth and intensity.
22. D — Rubbing a mineral on an unglazed porcelain plate tests its streak, the color of its powder, which is often more reliable for identification than surface color. Streak removes surface tarnish and weathering effects. It is especially useful for distinguishing metallic-looking minerals.
23. C — A texture with large crystals embedded in a fine-grained background indicates two cooling stages: slow cooling underground grew the large crystals, then eruption and rapid surface cooling formed the fine matrix. This porphyritic texture records a changing cooling history. Crystal size directly reflects cooling rate.
24. A — The Sun is the primary energy source driving the water cycle, evaporating surface water and powering the atmospheric circulation that moves moisture. Solar energy lifts water into the air, where it later condenses and falls. Without the Sun's energy input, the cycle would stop.
25. D — Preserving open ground and wetlands lets rainfall soak into the soil and recharge the aquifer, replenishing the groundwater supply. Infiltration depends on permeable, uncovered surfaces. Paving or channeling water away reduces recharge and accelerates depletion.
26. B — Burning fossil fuels rapidly adds carbon dioxide to the atmosphere, releasing carbon that was locked away for millions of years faster than natural processes can remove it. This raises atmospheric carbon dioxide concentrations. The imbalance is the main driver of human-caused climate change.
27. C — Thawing permafrost releasing methane that traps more heat and causes further thawing is a positive feedback, because it amplifies the warming that triggered it. The cycle reinforces itself rather than dampening. This permafrost-methane feedback is a serious concern for accelerating climate change.
28. A — The reddish-brown crust forming as iron reacts with oxygen and water is oxidation, a form of chemical weathering that creates new compounds such as iron oxides. Chemical weathering alters the rock's mineral composition rather than just breaking it physically. Warm, humid conditions speed this reaction.
29. D — A river deposits most of its sediment on the broad flat plain, where it slows and loses the energy needed to carry its load. Sediment-carrying capacity depends on velocity, so the drop in speed forces deposition. Fast-moving stretches transport sediment; slow stretches drop it.
30. B — A continental tropical air mass forms over hot, dry desert land, so it brings hot, very dry conditions with clear skies and little rain. "Continental" indicates dryness and "tropical" indicates heat. This contrasts with moist maritime air masses.
31. A — Air pressure rises after a cold front passes because cold, dense air moves in behind it, and denser air exerts greater pressure at the surface. The denser cold air sinks and presses down more strongly. This pressure rise is a reliable indicator that a cold front has moved through.
32. C — Droplets forming on a cold glass show that the surrounding air was cooled below its dew point at the glass surface, causing water vapor to condense into liquid. The dew point is the temperature at which air becomes saturated. The water comes from vapor already in the air, not from the glass.
33. D — Hurricanes require warm ocean water above about 26.5°C, which supplies the heat and moisture that power the storm. Warm water fuels the rising, moisture-laden air that drives a

hurricane's circulation. This is why hurricanes form over tropical oceans and weaken over cooler water or land.

34. A — Greenhouse gases absorb much of the outgoing infrared energy radiated by Earth's surface and re-radiate part of it back downward, warming the surface and lower atmosphere. They act on outgoing longwave radiation rather than reflecting it. This absorption and re-emission is the heart of the greenhouse effect.
35. C — The large loops of rising and sinking air created by uneven heating are convection cells, such as the Hadley cells between the equator and 30° latitude. Warm air rises where heating is strong and sinks where it cools. These cells are fundamental to global atmospheric circulation.
36. B — Air bubbles trapped in ancient ice preserve samples of the past atmosphere, including former levels of greenhouse gases like carbon dioxide. Analyzing them lets scientists reconstruct atmospheric composition over hundreds of thousands of years. Ice cores are a key tool for studying long-term climate change.
37. D — Geothermal energy is renewable because it taps the continuous heat flowing from Earth's hot interior, a supply that is not used up on human timescales. The other options—natural gas, coal, and uranium—are finite resources extracted from the ground. Continuous natural replenishment is what defines a renewable source.
38. A — The widespread benefits of the trees, such as cleaner air and reduced flooding for people who did not pay for them, are positive externalities. Externalities are effects of an action that fall on third parties outside the transaction. Recognizing positive externalities helps justify public investment in projects like tree planting.
39. C — Catching a fish species faster than it can reproduce, causing its population to crash, illustrates overharvesting. Removing organisms beyond the population's capacity to recover drives the decline. This differs from habitat loss, climate change, or pollution as a biodiversity threat.
40. B — A park valued for recreation, scenery, and inspiration provides a cultural ecosystem service, the category covering nonmaterial benefits people gain from nature. Cultural services include aesthetic, spiritual, and recreational value. These benefits enrich human well-being without supplying physical goods.
41. D — Strong scientific consensus supports that continued warming will bring more frequent and severe droughts, heat waves, and other weather extremes. Rising temperatures shift weather patterns toward greater extremes. The other options contradict observed trends and ocean chemistry, which is becoming more acidic, not basic.
42. A — A major effect of acid rain was that lake water became too acidic for many fish and other organisms to survive, reducing biodiversity. The lowered pH stressed or killed sensitive species and disrupted food webs. Emission controls later allowed many affected lakes to begin recovering.
43. B — Recycling materials such as metal, glass, and paper reduces landfill waste while conserving raw materials, since recovered materials are remade into new products. It addresses both goals at once by keeping resources in use. This is a core practice of sustainable waste management.
44. C — Most agricultural water is used for irrigating crops, supplying the water plants need where rainfall is insufficient. Irrigation accounts for the vast majority of agriculture's heavy water demand. This makes farming the largest human use of fresh water worldwide.
45. A — Building seawalls, elevating buildings, and restoring wetlands to cope with impacts already occurring is adaptation, since the town is adjusting to climate change rather than reducing its causes. Adaptation manages consequences; mitigation would cut emissions. These protective measures fit the definition of adaptation.

46. D — Absorbing carbon dioxide has made the ocean more acidic, lowering its pH and harming shell-building organisms that depend on carbonate minerals. The dissolved gas forms a weak acid that reduces carbonate availability. This ocean acidification is a direct chemical consequence of rising atmospheric carbon dioxide.
47. B — The stable Holocene climate allowed the development of agriculture, which produced food surpluses that made permanent settlements and cities possible. Reliable growing conditions were essential for settled farming. Climatic stability, not evolution or oxygen changes, enabled the rise of civilization.
48. C — Identifying pollution sources, setting goals, and listing budget and legal limits is the defining-the-problem stage, in which criteria for success and constraints are established. A clear problem definition guides every later step of the design process. Skipping it risks building a solution that fails to meet the real need.
49. A — When a prototype underperforms, the engineering process calls for using the test results to redesign it and then test the improved version again. Iteration—testing, refining, and retesting—is central to good engineering. A failed test is a source of information, not a reason to abandon the project.
50. D — The greatest value of the model is that it lets engineers explore likely outcomes and test ideas safely before committing to building the dam. Models reveal potential consequences and reduce costly real-world mistakes. They guide decisions while acknowledging uncertainty, and they support rather than replace real measurements.