# PRACTICE EXAM 53: EARTH AND SPACE SCIENCES REGENTS SIMULATION (50 QUESTIONS)

1. Edwin Hubble observed that distant galaxies are moving away from us, and that more distant galaxies recede faster than closer ones. What does this discovery support?

A. The universe is expanding, with space itself stretching and carrying galaxies farther apart over time

B. The universe is contracting, with all of the galaxies moving inward toward a common center point in the middle

C. The universe is completely static and unchanging, with no galaxies actually moving at all relative to one another

D. The universe is rotating, with all of the galaxies spinning together in a great circle around a single fixed axis

2. Inside a low-mass star like the Sun, what is the dominant nuclear process producing energy throughout most of its lifetime?

A. The fusion of carbon into oxygen, which is the most common reaction taking place in the core of any low-mass star

B. The fission of heavy elements like uranium splitting apart, the same kind of reaction used in nuclear power plants on Earth

C. The fusion of hydrogen nuclei into helium, with a small amount of mass converted into a large amount of energy

D. The slow chemical burning of methane and other fuels, similar to the way a candle burns by combining fuel with oxygen

3. Why is the night sky relatively dark, and what does this tell us about the universe?

A. The Sun's light blocks out all of the other stars at night, so no light from the rest of the universe ever reaches the Earth at all

B. The universe is not infinite and unchanging; it has a finite age and has been expanding, so light from many distant regions has not yet reached us

C. All of the other stars in the universe burned out long ago, and only our Sun and a few neighboring stars are still shining today

D. The atmosphere of the Earth completely absorbs all of the light coming from outside our own solar system, leaving the night sky perfectly dark

4. A planet orbits the Sun at an average distance of 100 AU. Using Kepler's Third Law ($T^2 = a^3$ in solar units), about how long is its orbital period?

A. About 100 years, because the orbital period in years is always equal to the average distance from the Sun measured in AU

B. About 10 years, because the orbital period is found by simply taking the square root of the average distance from the Sun in AU

C. About 10,000 years, because the orbital period in years is always equal to the square of the average distance from the Sun in AU

D. About 1,000 years, because 100 cubed is 1,000,000, and the square root of 1,000,000 is exactly 1,000 years

5. Near the June solstice, a city in the Northern Hemisphere has a longer day than a city in the Southern Hemisphere at the same latitude south. What causes this difference in daylight hours?

A. The Northern Hemisphere is much closer to the Sun in June than the Southern Hemisphere is, which gives it longer summer days

B. Earth's axis is tilted, so in June the Northern Hemisphere leans toward the Sun, giving it longer days while the Southern Hemisphere has shorter days

C. The Moon blocks part of the Sun's light from reaching the Southern Hemisphere during June, which makes its days noticeably shorter

D. The Sun deliberately sends more of its energy to the Northern Hemisphere during the month of June than it sends to the Southern Hemisphere

6. A waxing gibbous Moon, more than half lit and with the bright portion still growing each night, is followed about a week later by which phase?

A. The new moon, when the Moon lies between the Earth and the Sun with its lit side facing away and is therefore invisible to observers

B. The waning crescent, the thin sliver phase the Moon passes through just before returning to the new moon at the end of its monthly cycle

C. The last quarter, the phase in which exactly the left half of the Moon's visible disk is illuminated in the early morning hours before dawn

D. The first quarter, the phase in which exactly the right half of the Moon's visible disk is illuminated and observed in the early evening sky

7. During the formation of the solar system, a collapsing cloud of gas and dust began to spin faster as it shrank. Why did the cloud spin faster as it collapsed?

A. As the cloud's size decreased, it had to spin faster to conserve its angular momentum, the same way a spinning skater speeds up when arms pull in

B. The Sun's strong gravitational pull at the center deliberately spun the cloud up faster and faster until the planets eventually began to form within it

C. Friction with the surrounding empty space pushed the cloud and caused it to begin spinning faster the smaller and more compact it became

D. Strong magnetic forces from a nearby star reached across the cloud and twisted it into a faster and faster spin as it slowly grew smaller

8. Lunar eclipses are visible from anywhere on the night side of Earth, while solar eclipses can be seen only from a narrow path on Earth's surface. What is the main reason for this difference?

A. Lunar eclipses last only a very brief moment, while solar eclipses last for many hours and so can sweep across the whole planet

B. The Sun deliberately aims its eclipse shadow at one narrow region of Earth, while the Earth's shadow during a lunar eclipse is spread evenly

C. Lunar eclipses happen only at midnight in every time zone, while solar eclipses happen only at noon, which limits where each can be seen

D. Earth's shadow on the Moon is much larger than the Moon's tiny shadow on Earth, so a lunar eclipse covers the whole nightside while a solar eclipse covers only a small path

9. Tidal forces from the Moon and the Sun are responsible for ocean tides on Earth. Which of the two bodies exerts the larger tidal influence on Earth's oceans, and why?

A. The Sun, because it is far more massive than the Moon, and only mass matters when determining how strongly tides are produced on Earth's oceans

B. The Moon, because tidal force depends very strongly on distance, and the Moon's much closer distance more than compensates for its smaller mass

C. The Sun, because it is far brighter than the Moon, and the brightness of an object is what determines its strength of pull on the ocean's water

D. The Moon, because it is much more massive than the Sun, and the body with the greater mass always exerts the greater pull on Earth's water

10. Inside the Sun, energy produced by fusion in the core takes hundreds of thousands of years to reach the surface, even though light itself moves extremely fast. Why does the energy take so long to escape?

A. The energy travels at far less than the speed of light inside the Sun, because light slows down to a crawl when it passes through any kind of gas

B. The energy waits for tens of thousands of years in the core, simply pausing before it begins to make its journey toward the surface of the Sun

C. The energy is absorbed and re-emitted countless times by particles in the Sun's dense interior, making its journey to the surface a long random walk

D. The energy moves only when the Sun rotates, so it can only travel outward when the surface happens to be turning, which slows its journey

11. Which of the following best describes why the equator receives more energy from the Sun each year than the polar regions do?

A. The equator is much closer to the Sun than the poles, because the Earth bulges outward strongly enough at its middle to make a real distance difference

B. Sunlight strikes the equator more directly than the poles, so a given amount of solar energy is concentrated on a smaller area near the equator

C. The Sun deliberately sends more of its energy to the equator than to the poles, focusing its beams onto the warmer regions of the planet's surface

D. The equator turns more quickly than the poles do, which somehow draws more energy out of the Sun and toward the equator throughout the year

12. A geologist examines a layer of sandstone containing many flat-lying clamshells. Below it lies an older layer of mudstone, and above it sits a younger layer of limestone with corals. Which principle of relative dating allows the geologist to say which layer is oldest?

A. Cross-cutting relationships, the principle that any feature cutting across other rocks must be younger than the rocks it cuts through

B. Original horizontality, the principle that sedimentary layers are first laid down in flat horizontal sheets before any later tilting

C. Faunal succession, the principle that fossil organisms appear and disappear in the rock record in a definite and predictable order

D. Superposition, the principle that in an undisturbed sequence of sedimentary rocks the lowest layer is the oldest

13. A radioactive isotope has a half-life of 1,000 years. A sample now contains one-sixteenth of the original amount of this isotope. About how much time has passed?

A. About 1,000 years, because reaching one-sixteenth of the original amount requires only a single half-life of the radioactive isotope

B. About 2,000 years, because reaching one-sixteenth of the original amount requires exactly two half-lives of the radioactive isotope

C. About 4,000 years, because four half-lives are needed to reduce the isotope to one-sixteenth of its original amount

D. About 16,000 years, because sixteen half-lives are needed to reduce the isotope to one-sixteenth of its original amount

14. A scientist uses the principle of faunal succession to match the ages of rock layers found on different continents. What does this principle state?

A. Fossil organisms appear and disappear in the rock record in a definite and predictable order, so layers containing the same fossils are likely the same age

B. The same kinds of fossils can be found in every rock layer of every age, so fossils cannot be used to compare the ages of any rock layers at all

C. Each species lives forever and is found in every single rock layer formed since the Earth itself was born, so fossils cannot reveal a layer's age

D. Fossils show only the color of a rock layer and reveal nothing at all about when the layer formed or which other layers might be the same age

15. A volcanic ash bed deposited from a single eruption is found in rock layers in widely separated regions. Why is such an ash bed especially useful for matching rock layers in different locations?

A. Volcanic ash always settles only in the bottom of deep oceans, so the same ash bed can never be found in two different regions at once

B. Volcanic ash gradually changes its composition over thousands of years, so a thicker bed of ash must always be much older than a thinner bed

C. Volcanic ash beds are exactly the same in every eruption everywhere, so they cannot actually be used to distinguish one eruption from another

D. A single eruption spreads ash widely in a very short time, so the same ash bed found in different places represents the same instant in geologic time

16. Which of the following pieces of evidence supports the theory of biological evolution as a major force in Earth's history?

A. The same species of every organism has been found completely unchanged in every rock layer ever examined from the entire history of the Earth

B. Fossils in successive rock layers show a clear progression of life forms, with simpler organisms in older layers and more complex ones in younger layers

C. No fossils have ever been discovered anywhere in the world that show any sign whatsoever of change in any form of life over geologic time

D. Every single fossil that has ever been discovered belongs to an organism that is still alive today, with no known extinct organisms in the fossil record

17. Mid-ocean ridges show alternating bands of normal and reversed magnetism in the rock, mirrored on both sides of the ridge. What does this magnetic pattern provide evidence for?

A. Seafloor spreading, because new crust forms at the ridge and records the magnetic field as it cools, then is carried outward on both sides as new crust forms

B. Continental collision, because the alternating magnetic bands form only when two continents push directly into each other and crumple the seafloor together

C. Asteroid impact, because the bands are formed only when large asteroids strike the seafloor and leave behind alternating bands of magnetic crater material

D. Glacial erosion, because the moving ice sheets scrape patterns into the seafloor that just happen to record alternating magnetic field directions

18. A geologist studying ancient rocks finds layers containing droplets of evaporated salts, mud cracks, and ripple marks. Which past environment is most consistent with these features?

A. A deep open ocean basin, where only fine clay slowly settled to the bottom in a thick, smooth, evenly layered deposit far from any land

B. A glacial valley, where a thick slow-moving sheet of ice scraped and rounded the bedrock and left behind unsorted piles of rock and gravel

C. A shallow body of water that periodically dried out, where salts crystallized, mud cracks formed, and ripples were preserved in the soft sediment

D. A deep underground cave system, where slow-dripping mineral-rich water built up smooth, layered formations on the walls and the cave's floor

19. Tall volcanic mountains in the Andes of South America are aligned parallel to the coast, with a deep ocean trench just offshore. What plate boundary process produced these features?

A. Two continental plates colliding head-on, which slowly crumpled the crust upward into a high mountain range with no associated volcanoes at all

B. Two plates sliding horizontally past each other along a long fault, which produces only earthquakes but never any volcanoes or any deep ocean trench

C. Two plates pulling apart at a divergent boundary, which forms a long ridge of new volcanic rock down the middle of the seafloor between them

D. An oceanic plate subducting beneath a continental plate, which forms the deep ocean trench and feeds the chain of inland volcanoes

20. Earth's outer core is liquid metal, mostly iron and nickel, and Earth has a strong magnetic field. What is the connection between these two facts?

A. Movement of the liquid metal in the outer core generates electric currents that produce Earth's magnetic field, an effect called the geodynamo

B. The outer core is solid, not liquid, and the magnetic field comes from giant permanent magnets that are buried very deep within the Earth's mantle

C. Earth's magnetic field is produced by lightning strikes occurring on the surface and has nothing whatsoever to do with the conditions of Earth's outer core

D. The outer core is filled with cold gas rather than liquid metal, and its slow flow produces Earth's magnetic field through ordinary chemical reactions

21. A rock contains rounded pebbles of many different minerals, all cemented together. Which type of rock and process best describes this sample?

A. An intrusive igneous rock formed deep underground from slowly cooling magma, which grew very large interlocking crystals over many years

B. An extrusive igneous rock formed at the surface from rapidly cooling lava, which left only tiny crystals or a glassy texture in the rock

C. A metamorphic rock formed when intense heat and pressure recrystallized an existing rock and developed wavy bands of aligned minerals

D. A sedimentary rock called conglomerate, formed when rounded gravel was deposited, buried, and cemented together over time

22. A mineral has a metallic luster, leaves a black streak, and contains a high percentage of iron. Which property describes the way it reflects light?

A. Cleavage, the tendency of a mineral to break along smooth flat planes determined by the orderly arrangement of its atoms inside its crystal

B. Luster, the way that the surface of a mineral reflects light, described by terms such as metallic, glassy, pearly, silky, waxy, or dull

C. Hardness, a measure of how strongly a mineral resists being scratched by another material whose hardness is already known and standardized

D. Density, a measure of how much mass a mineral packs into a given volume, often used to compare the heaviness of different minerals of similar size

23. Why are obsidian and granite, both igneous rocks of similar overall composition, so different in appearance?

A. Obsidian cooled so quickly at the surface that no crystals formed, producing a glassy texture, while granite cooled slowly underground and grew large crystals

B. Obsidian formed deep underground while granite formed at the surface, which is why obsidian has large crystals and granite has none at all

C. Obsidian is a sedimentary rock made of compacted volcanic ash, while granite is a metamorphic rock made of recrystallized minerals deep underground

D. Obsidian and granite have completely different chemical compositions, with obsidian containing only iron and granite containing only carbon

24. Plants take up water from the soil through their roots and release water vapor into the atmosphere through their leaves. What is this process called?

A. Condensation, the process in which water vapor in the air cools and changes back into liquid droplets that gather together to form clouds

B. Infiltration, the process in which water at the surface soaks downward through the soil and rock and eventually joins the underground water supply

C. Transpiration, the process in which plants release water vapor into the atmosphere through small openings on their leaves and stems

D. Precipitation, the process in which water droplets in a cloud grow heavy enough to fall back to the surface as rain, snow, sleet, or hail

25. Two rock samples are tested as potential aquifer material. Rock A is mostly clay with small, poorly connected pores. Rock B is sandstone with large, well-connected pores. Which makes the better aquifer, and why?

A. Rock A, because clay always holds far more water than sandstone, which makes it the better choice for any aquifer regardless of how well water flows

B. Rock A, because clay's small pores hold water tightly and prevent it from escaping, which is exactly what is needed in a high-yielding aquifer

C. Rock B, because sandstone has no pores at all, and only rocks with no pores can store enough groundwater to supply a well of any kind

D. Rock B, because its large, well-connected pores give sandstone high permeability, allowing groundwater to flow easily toward a well

26. Which of the following is a major natural source of carbon dioxide entering the atmosphere?

A. Photosynthesis by green plants, which takes carbon dioxide out of the air and uses it to build sugars, adding large amounts of $CO_2$ to the atmosphere

B. Respiration by living organisms, which breaks down sugars for energy and releases carbon dioxide back into the surrounding air

C. The dissolving of carbon dioxide gas into the surface waters of the oceans, which steadily adds large amounts of $CO_2$ to the atmosphere above

D. The freezing of polar ice during the winter, which directly releases enormous amounts of carbon dioxide into the surrounding atmosphere

27. A large area of bare soil is left exposed on a steep hillside after the vegetation is removed. How does the loss of vegetation most directly affect the soil during a heavy rainstorm?

A. The rate of soil erosion increases sharply, because plant roots no longer hold the soil in place and bare soil washes away readily in the rain

B. The rate of soil erosion drops to almost zero, because bare soil is somehow far more resistant to the impact of falling raindrops than soil that is covered by plants

C. The soil becomes far more fertile, because removing the plants gives the soil more access to sunlight, which then dramatically improves the soil's quality

D. The soil's mineral content sharply increases, because the absence of plants causes the soil's atoms to spontaneously rearrange into many new useful minerals

28. A region experiences a long period of much-below-average precipitation, leading to dry soils, low river flows, and water shortages. What is this condition called?

A. A flood, an unusually large amount of water in rivers or on land surfaces, often caused by heavy rainfall or rapid snowmelt over a region

B. A blizzard, a severe winter storm that produces extremely heavy snowfall along with very strong sustained winds across a wide affected area

C. A hurricane, a powerful spinning tropical storm with very strong winds and torrential rainfall that develops over warm tropical ocean water

D. A drought, a prolonged period of below-average precipitation that leads to dry soils, reduced stream flow, and shortages of water

29. Mineral resources such as iron, copper, and aluminum are concentrated in certain locations on Earth's surface. Which of the following geologic processes plays a major role in concentrating these mineral resources?

A. Glaciation, the slow movement of ice sheets across the land, which carves out broad U-shaped valleys but does not concentrate any minerals into ore deposits

B. The shining of starlight from beyond our own solar system, which directly causes specific minerals to gather together into rich ore deposits underground

C. Hydrothermal activity, in which hot, mineral-rich fluids circulate through cracks in rock and deposit metals as they cool, forming concentrated ore deposits

D. Lightning strikes on the open ocean surface, which directly cause specific minerals to gather together into rich underground ore deposits across continents

30. A cold front moves into an area and warm, humid air is forced upward steeply along the front, producing tall cumulonimbus clouds and a narrow band of thunderstorms. Why does the air rise so steeply along a cold front?

A. Cold air is much less dense than warm air, so it floats up over the warm air ahead of it, forcing the warm air to gently slide down beneath it

B. The cold air is denser than the warm air, so it wedges underneath and lifts the warm air sharply upward, producing fast, vigorous uplift

C. Cold fronts produce no lifting of any kind, because cold and warm air mix freely without any rising motion at all wherever they happen to meet

D. The cold air pulls the warm air downward toward the ground, which somehow generates tall thunderclouds and a narrow band of intense storms

31. A weather map shows a region of much higher pressure than the air surrounding it. What kind of weather is most commonly associated with high-pressure systems?

A. Clear skies and generally fair weather, because air sinks in a high-pressure region, which suppresses cloud formation and discourages precipitation

B. Heavy rain and frequent thunderstorms, because air rises strongly in a high-pressure region, leading to widespread cloud formation and steady precipitation

C. Snowstorms and blizzards, regardless of the season, because high-pressure systems always produce extremely cold air and abundant heavy snow

D. Strong tornadoes and hurricanes, because high-pressure systems always rotate violently and produce the most destructive of all severe weather events

32. Coastal cities in mid-latitudes often have milder summers and milder winters than inland cities at the same latitude. What is the main reason for this difference?

A. Coastal cities are always located at much higher elevations than nearby inland cities, and higher-elevation locations have milder summer and winter weather

B. The Sun directs more of its energy at coastal cities than at inland cities, which makes coastal weather both warmer in winter and cooler in summer

C. The ocean has a high specific heat and warms and cools slowly, so coastal areas experience smaller swings between summer and winter than inland areas

D. Coastal cities have no industry or buildings, while inland cities are entirely built up, which is the only reason coastal climates seem milder than inland climates

33. Tornadoes are most likely to form in association with which of the following weather features?

A. The calm center of a hurricane, where light winds and clear skies make tornado formation particularly likely during the slow passage of the eye

B. A stationary front that has not moved for several days, where steady gentle drizzle creates the strong rotation needed to produce tornadoes

C. A clear, sunny afternoon with high pressure and very light winds, the typical conditions under which most tornadoes are observed to form

D. Severe thunderstorms called supercells, where strong wind shear and rotating updrafts create the conditions needed to spin up a tornado

34. The ozone layer in the upper atmosphere protects life on Earth's surface from harmful radiation. What does the ozone layer protect against?

A. Most of the visible sunlight from the Sun, which would otherwise damage the eyes and skin of every animal living on the surface of the Earth

B. Most of the Sun's ultraviolet radiation, which damages DNA and would otherwise greatly increase the rate of skin cancer and harm many ecosystems

C. All of the heat coming from the Sun, which would otherwise cause the surface of the Earth to boil away every ocean and every lake on the planet

D. All of the cosmic rays coming in from deep space, which would otherwise penetrate deep into the ground and rapidly destroy every rock layer below

35. Which of the following is strong scientific evidence that Earth's climate has been warming over the last century or so?

A. Many independent records, including temperature, glacier mass, sea-ice extent, and sea level, all show consistent trends over many decades of careful observation

B. The temperature in one city happened to rise by a few degrees over a single weekend, which is by itself definitive proof that the global climate is warming

C. A single very warm summer in one country, by itself, completely settles the question of whether the entire global climate is warming over recent decades

D. The fact that some people personally feel that recent winters seem milder than the winters they remember from their own childhoods many decades ago

36. Climate models project that continued increases in greenhouse gas emissions will lead to which of the following changes in Earth's climate over the coming decades?

A. Lower average global temperatures, because additional greenhouse gases in the atmosphere will somehow begin to cool the surface of the planet

B. No measurable change in the climate, because the atmosphere is so vast that human emissions cannot possibly have any effect on Earth's overall climate

C. Sharply colder oceans, because additional greenhouse gases in the atmosphere will draw heat out of the ocean and quickly release it into outer space

D. Continued warming of the surface, rising sea levels, and more frequent or intense extreme weather events such as heat waves, droughts, and heavy rains

37. Which of the following is the best example of a nonrenewable resource?

A. Solar energy from the Sun, which arrives continuously at the Earth's surface and is replenished much faster than people on Earth can possibly use it up

B. Moving air, captured by wind turbines, which is continuously renewed by the Sun's uneven heating of the atmosphere as it shines down on the Earth

C. Petroleum, formed from buried organic matter over hundreds of millions of years, which is extracted today far faster than natural processes can replace it

D. Flowing water, used in hydroelectric dams, which is continuously renewed by the natural water cycle as precipitation falls and refills rivers and lakes

38. A community decides to require water-efficient appliances in all new homes and buildings. This policy is best described as which of the following approaches to managing natural resources?

A. Resource exhaustion, the deliberate practice of using a resource as quickly as possible until it is completely gone and no more remains anywhere

B. Resource conservation, the deliberate practice of using a resource more carefully and efficiently to make the available supply last longer

C. Resource extraction, the act of physically removing a resource from beneath the ground, with no relationship at all to how that resource is later used

D. Resource discovery, the act of finding entirely new resources, with no relationship at all to the careful use of resources that are already known

39. A pristine coastal estuary is filled in and converted into a parking lot. Which of the following is the most direct environmental consequence of this change?

A. Loss of habitat for the fish, shellfish, and birds that depend on the estuary, and a reduction in the natural flood and pollution protection it provided

B. A sudden long-term increase in the local fish population, because removing the estuary makes nearby waters far more suitable for many kinds of fish

C. An immediate large-scale recovery of the rainforest plants that originally grew where the estuary once was, before the area was ever converted into a wetland

D. A complete and instant reversal of global climate change, because filling in a single estuary on its own is enough to permanently halt all global warming

40. Pollinators such as bees move pollen between flowering plants, supporting the reproduction of many crops and wild plants. The pollination service that bees and other pollinators provide is best classified as which type of ecosystem service?

A. A provisioning service, because the bees are supplying people with material goods such as food, fresh water, timber, and other useful raw materials

B. A cultural service, because the bees are providing people with recreation, natural beauty, and a source of spiritual or artistic inspiration from nature

C. A simple inconvenience, because pollination by bees does not actually benefit any plants or any people in any measurable way that ecologists can detect

D. A regulating service, because pollination is a natural process that supports the reproduction of plants and is essential for many human food crops

41. A farmer notices that the topsoil in one of his fields has become much thinner over several years of plowing on a slope. Which practice would most directly reduce further soil erosion on this hillside?

A. Plowing the field straight up and down the slope, because furrows running directly downhill drain rainwater off the field as quickly as humanly possible

B. Removing every tree, shrub, and hedgerow from the hillside, because vegetation around a field always accelerates the rate of soil erosion across that field

C. Setting the field on fire after each harvest, because the heat permanently bonds the soil to the bedrock and makes the soil entirely immune to erosion

D. Planting cover crops and using contour plowing along the slope, because both practices help anchor the soil and reduce the speed of runoff

42. A coastal city, expecting more frequent storm flooding due to a warming climate, raises its main roads, strengthens its sea wall, and protects its wetlands. This combination of actions is best classified as which type of climate response?

A. Mitigation, because the city is reducing the greenhouse gas emissions that are the underlying cause of the warming and the rising sea level

B. Adaptation, because the city is adjusting its infrastructure to better cope with climate impacts that are already starting to occur in the region

C. Restoration, because the city is rebuilding ecosystems that have already been damaged or destroyed by previous human activity along the coast

D. Acidification, because the city is taking steps to reduce the rising acidity of the nearby ocean by removing carbon dioxide from the seawater

43. Acid rain falls into a lake and lowers its pH, harming the fish and other aquatic life that live there. Which type of pollutant emission is most responsible for producing acid rain?

A. Excess nitrogen-based fertilizer washing off farm fields into rivers, which is the main source of acid rain falling on lakes and forests

B. Carbon dioxide released by the respiration of animals and the decay of plants, which is the main source of acid rain falling on lakes

C. Sulfur dioxide and nitrogen oxides from burning fossil fuels, which react with water vapor in the atmosphere to form sulfuric and nitric acid

D. Plastic waste that breaks down into tiny particles in landfills and along beaches, which is the main source of acid rain falling on lakes

44. Which of the following statements correctly describes the difference between weather and climate?

A. Weather is the short-term atmospheric conditions of a place, while climate is the long-term average of weather over many years

B. Weather is the long-term average of conditions over many years, while climate is just the short-term conditions of the atmosphere on any given day

C. Weather and climate mean exactly the same thing, since both simply describe whether or not it is raining and how warm or cold it is feeling

D. Weather refers only to temperature, while climate refers only to precipitation, and the two cannot be measured together in the same region

45. As the human population grew over the past two centuries, demand for fresh water also increased sharply. Which of the following is a direct consequence of growing human water demand in many regions of the world?

A. The total amount of water in Earth's oceans has fallen sharply, because human water use has noticeably lowered the global level of the seas

B. The Earth has run out of water entirely, because all of the planet's water has already been pumped out of the ground and used up by people

C. The atmosphere has lost most of its water vapor, because human activity directly removes water vapor from the air at a very rapid rate

D. Many aquifers have been drawn down faster than they can recharge, lowering water tables and raising concerns about long-term water supply

46. A power company replaces its oldest coal-burning power plants with new wind and solar farms. Which environmental benefit most directly results from this change?

A. The local rivers in the region are suddenly able to support far more fish, because wind and solar farms physically add fresh new fish to rivers near the plants

B. The number of earthquakes worldwide drops sharply each year, because switching from coal power to wind and solar power directly reduces seismic activity

C. The amount of carbon dioxide and other air pollutants released into the atmosphere from the company's power plants is significantly reduced

D. The total amount of solar energy reaching the Earth from the Sun is sharply increased each year, because the new solar farms physically increase the Sun's output

47. Which of the following best illustrates the concept of sustainability in the use of a natural resource?

A. Harvesting fish from a lake at or below the rate at which the population can naturally reproduce, so the fishery can continue to support catches in the future

B. Catching every fish in a lake as quickly as possible to maximize income for the current year, before any competitor can possibly reach the same fish first

C. Stocking the lake with so many fish that the existing food supply is overwhelmed, and then continuing to add more fish year after year regardless of conditions

D. Banning all fishing in the lake forever, even when the fish population is healthy and could easily support a carefully managed and regulated annual catch

48. An engineering team designing a new water filter for use in remote villages must balance cost, ease of repair, and water output. These three factors are all examples of which of the following?

A. Failures, situations in which a design does not work as intended and must be either abandoned or completely redesigned from the start before being used

B. Criteria, the requirements a design must meet, against which competing designs can be evaluated and compared throughout the engineering design process

C. Prototypes, the early working models of a design that are built and then tested before the final version of the product is constructed and put into use

D. Externalities, the costs or benefits of a design that fall on people other than the original designers and that are usually left out of any analysis at all

49. An engineering team is testing a new bridge design. Which step of the engineering design process would the team perform next, after they have built a small-scale prototype?

A. Skip all testing and immediately build the full-sized version of the bridge, since a small-scale prototype already proves that the final design will work perfectly

B. Throw away the prototype and start the entire design process over from scratch, since a prototype no longer has any useful role to play in the design process

C. Sell the small-scale prototype to the public for use as a real working bridge, since prototypes are always able to safely support real traffic in everyday use

D. Test the prototype against the criteria and constraints, identify any problems, and then use the results to refine and improve the design before retesting

50. Which of the following best describes the relationship between scientific knowledge and engineering design?

A. Engineering design is based entirely on guesswork and pure intuition, and it never makes any use whatsoever of any scientific knowledge or scientific principles

B. Scientific knowledge can only be discovered through engineering design, and no real science can ever exist without first carrying out a major engineering project

C. Engineers apply scientific knowledge about the natural world to design technologies that solve practical problems within the limits set by the laws of nature

D. Science and engineering have absolutely no connection to each other, since each one develops in complete isolation from the other in every situation

## Practice Exam 53: Answer Key with Explanations

1. A — Hubble's observation that more distant galaxies recede faster supports an expanding universe, in which space itself stretches and carries galaxies farther apart. Greater distance means more intervening space to stretch, producing greater recession speed. This expansion is a central pillar of Big Bang cosmology.
2. C — The Sun, a low-mass star, is powered mainly by fusing hydrogen nuclei into helium in its core, converting a small amount of mass into a large amount of energy. This is the dominant reaction throughout the main-sequence lifetime. Fission and chemical burning do not power stars.
3. B — The dark night sky is explained by the universe having a finite age and expanding, so light from many distant regions has not yet reached us and what does arrive is stretched and dimmed. An infinite, static universe would make the sky bright everywhere. This puzzle is known as Olbers' paradox.
4. D — Kepler's Third Law gives $T^2 = a^3$, so with a = 100, $a^3$ equals 1,000,000 and T is the square root of 1,000,000, exactly 1,000 years. The cube of the distance sets the square of the period. This relationship applies to any object orbiting the Sun.
5. B — Earth's axis is tilted, so in June the Northern Hemisphere leans toward the Sun and has longer days, while the Southern Hemisphere leans away and has shorter days. The orientation of the tilt, not distance to the Sun, controls day length. Six months later the situation reverses.
6. C — A waxing gibbous Moon is followed about a week later by the last quarter, when the Moon's left half is illuminated. The full moon falls between them, after which the lit fraction begins to shrink. The lunar cycle proceeds new → first quarter → full → last quarter → new.

7. A — A collapsing cloud spins faster as it shrinks because angular momentum is conserved; with less radius, the rotation must speed up to keep the total constant. This is the same effect that speeds up a spinning skater pulling in their arms. It is why the early solar nebula flattened into a disk.
8. D — Earth's shadow on the Moon is much larger than the Moon's tiny shadow on Earth, so a lunar eclipse darkens the whole Moon and is visible from anywhere on the night side, while a solar eclipse covers only a narrow path. Shadow size, set by the geometry, makes the difference. This is why solar eclipses are far rarer for any one location.
9. B — The Moon exerts the larger tidal influence because tidal force falls off sharply with distance, and the Moon's much closer distance more than makes up for its smaller mass. Tides depend on the gradient of gravity across Earth, not on the total pull. This is why the Moon's tide is roughly twice the Sun's.
10. C — Energy from fusion in the Sun's core takes a long time to reach the surface because it is absorbed and re-emitted countless times by particles in the dense interior, making the journey a slow random walk. The photons take a tortuous path rather than a direct one. Once at the surface, light reaches Earth in about eight minutes.
11. B — The equator receives more annual solar energy because sunlight strikes it more directly, concentrating energy on a smaller area, while polar rays are spread over a larger area. The angle of insolation controls this concentration. This effect, not distance to the Sun, drives the equator-pole temperature contrast.
12. D — Superposition states that in an undisturbed sequence of sedimentary rocks the lowest layer was deposited first and is therefore the oldest. The mudstone below the sandstone is the oldest of the three. This rule is the foundation of relative dating in horizontal strata.
13. C — One-sixteenth remaining means four half-lives have passed, since $1 \rightarrow 1/2 \rightarrow 1/4 \rightarrow 1/8 \rightarrow 1/16$. Four half-lives × 1,000 years equals 4,000 years. Counting halvings is the key to radiometric age problems.
14. A — Faunal succession states that fossil organisms appear and disappear in the rock record in a definite, predictable order, so layers containing the same fossils are likely the same age. This lets geologists correlate strata across continents. It is a foundation of biostratigraphy.
15. D — A single eruption spreads ash widely in a very short time, so the same ash bed found in different places represents the same instant in geologic time. This makes it an excellent time marker. Volcanic ash beds are powerful tools for correlating distant rock sequences.
16. B — Fossils in successive rock layers showing a progression from simpler organisms in older layers to more complex ones in younger layers supports biological evolution over geologic time. This orderly change in life is documented worldwide. It is one of the strongest lines of evidence for evolution.
17. A — Mirror-image bands of normal and reversed magnetism on both sides of mid-ocean ridges support seafloor spreading: new crust forms at the ridge, records the magnetic field as it cools, and is carried outward as still more crust forms behind it. The symmetry records the spreading process. This was key evidence for plate tectonics.
18. C — Evaporite salts, mud cracks, and ripple marks together indicate a shallow body of water that periodically dried out, exposing soft sediment to the air. Salts crystallized as water evaporated, mud cracked on drying, and ripples were preserved. These features are signatures of an arid, shallow setting.
19. D — A coastal volcanic mountain chain paired with a deep offshore trench, as in the Andes, forms where an oceanic plate subducts beneath a continental plate. The descending plate creates the

trench, and melting above it feeds the inland volcanoes. This ocean-continent convergence built the Andes.

20. A — Movement of liquid metal in Earth's outer core generates electric currents that produce the planet's magnetic field, an effect called the geodynamo. The flowing conductive metal acts like a self-sustaining electromagnet. This mechanism explains why Earth has a strong, lasting magnetic field.
21. D — A rock made of rounded pebbles of many minerals cemented together is conglomerate, a sedimentary rock formed when rounded gravel is deposited, buried, and cemented. The rounded shapes record transport by water before deposition. Cementation, not crystallization or melting, binds the grains.
22. B — The way a mineral's surface reflects light is called luster, described by terms such as metallic, glassy, pearly, silky, waxy, or dull. Luster is a key diagnostic property in mineral identification. It is distinct from cleavage, hardness, and density.
23. A — Obsidian cooled so quickly at the surface that no crystals formed, producing a glassy texture, while granite cooled slowly underground and grew large interlocking crystals. Cooling rate controls crystal size in igneous rocks. Their compositions can be similar, but their textures differ because of where they cooled.
24. C — Plants releasing water vapor into the atmosphere through small openings in their leaves is transpiration. The water travels from roots through stems to leaves and escapes as vapor. Transpiration is an important pathway returning water to the atmosphere in the water cycle.
25. D — Sandstone with large, well-connected pores has high permeability, allowing groundwater to flow easily toward a well, which is what makes a good aquifer. Permeability, not just storage, governs how readily water moves. Clay holds water but flows poorly because its pores are small and disconnected.
26. B — Respiration by living organisms releases carbon dioxide into the air as cells break down sugars for energy. It is a major natural pathway returning carbon to the atmosphere. Photosynthesis, by contrast, removes carbon dioxide rather than adding it.
27. A — Removing vegetation increases erosion sharply because plant roots no longer hold the soil in place and bare soil washes away readily under heavy rainfall. Roots bind soil and leaves slow raindrops. Vegetation is one of the strongest natural protections against erosion.
28. D — A prolonged period of below-average precipitation that leads to dry soils, reduced stream flow, and water shortages is a drought. Droughts develop slowly as deficits in rainfall accumulate. They differ sharply from floods, blizzards, and hurricanes in cause and time scale.
29. C — Hydrothermal activity, in which hot mineral-rich fluids circulate through cracks in rock and deposit metals as they cool, concentrates many ore deposits. The cooling fluids drop their dissolved metals along the fractures. This is a major process behind copper, gold, and silver ores.
30. B — Cold air is denser than warm air, so along a cold front it wedges underneath and lifts the warm air sharply upward. This fast, vigorous uplift cools the rising air quickly and condenses it into tall cumulonimbus clouds and thunderstorms. The steep frontal slope drives the intensity.
31. A — High-pressure systems bring clear skies and generally fair weather because air sinks within them, which suppresses cloud formation and discourages precipitation. Sinking air warms and dries as it descends. Low-pressure systems, by contrast, bring rising air and storms.
32. C — Coastal cities have milder summers and winters because the ocean has a high specific heat and warms and cools slowly, moderating nearby air temperatures. The slow ocean response damps seasonal swings. Inland areas, lacking this buffer, experience larger extremes.

33. D — Tornadoes form most often in severe thunderstorms called supercells, where strong wind shear and rotating updrafts create the rotation needed to spin up a tornado. The shear tilts horizontal rotation into the vertical. Calm centers, stationary fronts, and clear afternoons do not provide these conditions.
34. B — The ozone layer protects life by absorbing most of the Sun's ultraviolet radiation, which damages DNA and would otherwise greatly increase skin cancer and harm ecosystems. UV is the specific danger ozone screens out. Visible light, heat, and cosmic rays are not its main targets.
35. A — Strong evidence of warming comes from many independent records—temperature, glacier mass, sea-ice extent, and sea level—all showing consistent trends over decades. The agreement across independent measurements is what makes the conclusion robust. Single events or personal impressions do not establish climate trends.
36. D — Climate models project continued surface warming, rising sea levels, and more frequent or intense extreme weather such as heat waves, droughts, and heavy rains. These trends follow from added greenhouse gases. The other options contradict the physics of the climate system.
37. C — Petroleum forms from buried organic matter over hundreds of millions of years and is extracted today far faster than natural processes can replace it, making it nonrenewable. Renewables like solar, wind, and flowing water are replenished on human timescales. Replenishment rate defines the distinction.
38. B — Requiring water-efficient appliances is resource conservation, the deliberate practice of using a resource more carefully and efficiently to make the available supply last longer. It addresses demand rather than supply. Conservation contrasts with exhaustion, extraction, and discovery.
39. A — Filling in an estuary directly removes habitat for the fish, shellfish, and birds that depend on it and eliminates the natural flood and pollution protection it provided. Estuaries serve as nurseries and natural buffers. Losing them carries both ecological and human costs.
40. D — Pollination by bees is a regulating service, a natural process that supports the reproduction of plants and is essential for many human food crops. Regulating services control or moderate ecological processes. This illustrates how wild ecosystems underpin agriculture.
41. D — Planting cover crops and using contour plowing along the slope reduce erosion because both practices help anchor the soil with roots and slow runoff across the hillside. Together they protect the topsoil from being washed away. These are core practices of sustainable agriculture.
42. B — Raising roads, strengthening sea walls, and protecting wetlands to cope with storm flooding is adaptation, because the city is adjusting infrastructure to climate impacts that are already occurring. Adaptation manages effects, while mitigation cuts the emissions causing them. Coping with unavoidable impacts is the defining feature of adaptation.
43. C — Acid rain forms mainly from sulfur dioxide and nitrogen oxides released by burning fossil fuels, which react with water vapor in the atmosphere to form sulfuric and nitric acids. These acids then fall in precipitation, lowering the pH of lakes. Cutting these emissions has reduced acid rain.
44. A — Weather is the short-term atmospheric conditions of a place, while climate is the long-term average of weather over many years. The two differ in time scale, not in what they measure. Distinguishing them is essential for interpreting climate trends.
45. D — Growing demand for fresh water has caused many aquifers to be drawn down faster than they recharge, lowering water tables and raising concerns about long-term supply. Overpumping outpaces natural replenishment. This is a major sustainability challenge in many regions.
46. C — Replacing coal plants with wind and solar farms directly reduces the carbon dioxide and other air pollutants released into the atmosphere from those plants. Wind and solar generate electricity without burning fuel. This is a key strategy for cutting emissions.

47. A — Harvesting fish at or below the rate at which the population can naturally reproduce allows the fishery to continue supporting catches in the future, which is the essence of sustainability. Matching the catch to the recovery rate prevents collapse. Sustainability balances current use with long-term availability.
48. B — Cost, ease of repair, and water output are criteria, the requirements a design must meet, against which competing designs can be evaluated and compared. Criteria define success in engineering design. They differ from constraints, which set fixed limits.
49. D — After building a prototype, the engineering team tests it against the criteria and constraints, identifies any problems, and uses the results to refine and improve the design before retesting. Iteration—testing, refining, and retesting—is central to good engineering. Skipping testing or abandoning the prototype would defeat its purpose.
50. C — Engineers apply scientific knowledge about the natural world to design technologies that solve practical problems within the limits set by the laws of nature. Science explains; engineering applies that understanding to human needs. The two are linked but pursue different ends.