

PRACTICE EXAM 28: EARTH AND SPACE SCIENCES REGENTS SIMULATION (50 QUESTIONS)

1. Two key observations support the Big Bang theory: the cosmic microwave background and the motion of galaxies. What does the motion of distant galaxies show?

- A. Distant galaxies are all moving steadily toward the Milky Way, showing the universe is collapsing inward
- B. Distant galaxies are moving away from us, with farther galaxies receding faster, showing the universe is expanding
- C. Distant galaxies remain perfectly fixed in place, showing the universe has stayed the same size forever
- D. Distant galaxies orbit the Milky Way in regular circles, showing our galaxy is the center of the universe

2. The Sun has been steadily fusing hydrogen into helium for billions of years and will continue to do so for billions more. What stage of its life is the Sun in right now?

- A. The red giant stage, in which the Sun has expanded enormously and is fusing helium in its outer layers
- B. The white dwarf stage, in which the Sun has collapsed into a small, dense, slowly cooling stellar remnant
- C. The main sequence stage, the long, stable phase during which a star fuses hydrogen into helium in its core
- D. The supernova stage, in which the Sun is exploding violently and scattering its material outward into space

3. The two lightest elements, hydrogen and helium, are by far the most abundant in the universe. Where did most of this hydrogen and helium originally form?

- A. In the first few minutes after the Big Bang, when the young, hot universe produced these light elements
- B. Inside the cores of stars, which fuse heavier elements back down into hydrogen and helium over time
- C. On the surfaces of rocky planets, where chemical reactions slowly build up hydrogen and helium gas
- D. In the empty space between galaxies, where scattered particles randomly combine into light gases

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), what is the planet's approximate orbital period?

- A. About 100 years, because the orbital period in years is always equal to the average distance in AU
- B. About 10 years, because the orbital period equals the square root of the average distance in astronomical units
- C. About 300 years, because the orbital period equals the average distance multiplied by three each time
- D. About 1,000 years, because 100 cubed is one million, and the square root of one million is 1,000 years

5. On the spring and fall equinoxes, locations all over the Earth experience roughly equal hours of daylight and darkness. Why does this happen on these two days?

- A. On the equinoxes, Earth's tilted axis points neither toward nor away from the Sun, so sunlight is shared equally between the hemispheres
- B. On the equinoxes, the Earth stops rotating for a full day, which makes the daylight and darkness last for equal lengths of time
- C. On the equinoxes, Earth is at its closest point to the Sun, which evens out the hours of daylight all over the planet
- D. On the equinoxes, the Sun temporarily emits its light in only one direction, splitting day and night into equal halves

6. A few days before a new moon, an observer sees only a thin sliver of the Moon lit on its left side, rising in the east just before dawn. What phase is the Moon in?

- A. A waxing crescent, the thin phase just after the new moon, when a sliver on the right side is illuminated
- B. A first quarter moon, when exactly the right half of the Moon's disk appears lit during the early evening

- C. A waning crescent, the thin phase just before the new moon, when only a sliver on the left side is lit
- D. A full moon, when the entire visible disk of the Moon is fully illuminated and is visible throughout the night

7. The planets of the solar system all orbit the Sun within nearly the same flat plane, rather than at random angles. Which idea best explains this arrangement?

- A. The Sun's magnetic field bends each planet's orbit until it lies in the same flat plane as the others
- B. The planets were captured one at a time from random directions and happened by chance to end up coplanar
- C. Collisions between the fully formed planets gradually flattened all of their orbits into a single plane
- D. The planets formed together from a single flat, spinning disk of gas and dust surrounding the young Sun

8. During a lunar eclipse, Earth's shadow falls across the Moon. For Earth's shadow to reach the Moon, the Moon must be on the side of Earth opposite the Sun. During which phase does this occur?

- A. The new moon, when the Moon lies directly between the Earth and the Sun and its dark side faces us
- B. The full moon, when the Moon is opposite the Sun and can pass into the shadow cast by the Earth
- C. The first quarter, when the Moon appears half illuminated and is highest in the sky in the early evening
- D. The waxing crescent, when only a thin sliver of the Moon's surface is illuminated just after the new moon

9. At certain points in the lunar cycle, the difference between high and low tide is smaller than usual because the Sun's and Moon's gravitational pulls partly cancel. During which phases do these neap tides occur?

- A. The new moon and full moon, when the Sun and Moon are lined up and their pulls add together fully
- B. The waxing and waning gibbous phases, when more than half of the Moon's visible face is illuminated
- C. The first quarter and last quarter, when the Sun and Moon pull on Earth's water at right angles to each other

D. Only during eclipses, when the shadow of one body falls directly across the surface of the other body

10. The Sun produces energy by fusing hydrogen into helium. In this reaction, the helium produced has slightly less mass than the hydrogen that went in. What becomes of the missing mass?

A. It is converted into energy, following the relationship between mass and energy described by $E = mc^2$

B. It is permanently lost from the universe, since mass that disappears during fusion can never be accounted for

C. It is stored inside the helium nucleus as extra particles that are added to balance the nucleus's charge

D. It escapes the Sun as a stream of solid dust grains that drift outward through the solar system over time

11. The polar regions of Earth are much colder year-round than the regions near the equator. Which statement best explains this difference in temperature?

A. The poles are much farther from the Sun than the equator because of the way the Earth spins on its axis

B. The Sun deliberately sends more of its radiation toward the equator and far less toward the polar regions

C. The thick layers of ice at the poles generate cold air that spreads outward and chills the entire region

D. Sunlight strikes the poles at a low, slanting angle, spreading its energy thinly over a large surface area

12. According to the principle of superposition, in a sequence of undisturbed sedimentary rock layers, where are the youngest rocks found?

A. At the bottom of the sequence, because the deepest layers are always the most recently deposited ones

B. At the top of the sequence, because each new layer is deposited on top of the layers that came before it

C. Scattered randomly throughout the sequence, because the order of deposition follows no consistent rule

D. Only at the very center of the sequence, because deposition always begins in the middle and works outward

13. A radioactive isotope has a half-life of 6,000 years. A sample now contains one-half of its original amount of the isotope. How much time has passed since the sample formed?

- A. About 6,000 years, because a single half-life is the time required to reduce the isotope to half its original amount
- B. About 12,000 years, because two half-lives are required to reduce the isotope to half of its original amount
- C. About 18,000 years, because three half-lives are required to reduce the isotope to half of its original amount
- D. About 3,000 years, because half of a single half-life is enough to reduce the isotope to half of its amount

14. The same species of an extinct, short-lived organism is found in rock layers on two different continents. What does this allow geologists to conclude about the two rock layers?

- A. The two layers must be made of exactly the same kind of rock and contain identical minerals throughout
- B. The organism must still be alive today, which proves that both of the rock layers formed very recently
- C. The two layers formed during the same span of geologic time and can therefore be matched in age
- D. The continent containing the thicker layer must be far older than the continent with the thinner layer

15. A geologist finds a buried, eroded surface in a cliff that separates older tilted rock below from younger horizontal rock above. What does this feature, called an unconformity, represent?

- A. A time of continuous, unbroken deposition during which sediment piled up steadily with no interruption
- B. A boundary where two rock layers of exactly the same age formed side by side under identical conditions
- C. A place where hot molten rock pushed up between two layers and then cooled into solid rock over time
- D. A gap in the rock record, representing time during which rock was eroded away or was never deposited at all

16. A thin worldwide layer of rock dated to about 66 million years ago is rich in iridium and contains shocked quartz. This layer is strong evidence for which event?

- A. A long, slow cooling of the global climate that gradually lowered sea levels across tens of millions of years

B. A massive asteroid impact, which scattered iridium around the world and helped trigger a major mass extinction

C. A series of routine volcanic eruptions that slowly built up thick layers of lava across all of the continents

D. A reversal of the Earth's magnetic field, which is permanently recorded in the rocks of the ocean floor

17. Alfred Wegener pointed to several lines of evidence to support his idea that the continents were once joined. Which of the following is one of those lines of evidence?

A. Matching fossils, rock layers, and mountain ranges found on the facing coasts of widely separated continents

B. Photographs taken from space that directly show the continents physically sliding across the ocean floor

C. Written records left by ancient civilizations describing the continents moving apart over recorded history

D. Identical modern cities and roads built in the same patterns on the coastlines of two distant continents

18. A rock is made of extremely fine clay particles that settled slowly and hardened into thin, flat layers, with no ripple marks or coarse grains. Which past environment does this best indicate?

A. A swift, rocky mountain stream that tumbled and rounded coarse gravel before depositing it downstream

B. A dry desert basin where strong winds piled large amounts of well-sorted sand into tall, sweeping dunes

C. A deep, calm body of water where only the finest particles slowly settled out far from any nearby shore

D. A glacier that bulldozed and dropped a chaotic, unsorted jumble of boulders, sand, and clay all together

19. Along the San Andreas Fault in California, two tectonic plates slide horizontally past one another, producing frequent earthquakes but no volcanoes. What type of plate boundary is this?

A. A convergent boundary, where one plate is forced downward beneath another plate into the deep mantle below

B. A transform boundary, where two plates grind horizontally past each other, building up stress that is released as quakes

C. A divergent boundary, where two plates pull apart from each other and rising magma forms new crust between them

D. A hot spot, where a plume of rising magma melts through the middle of a tectonic plate far from its edges

20. What is the underlying source of energy that powers the convection currents in Earth's mantle and drives the movement of tectonic plates?

A. Energy from the Sun, which heats the surface and slowly works its way downward into the deep mantle below

B. Energy from the gravitational pull of the Moon, which stirs the mantle as the Moon orbits around the Earth

C. Energy from ocean waves and tides, which transmit their motion downward through the crust into the mantle

D. Heat left over from Earth's formation combined with heat released by the decay of radioactive elements inside Earth

21. A river carries tiny grains of sand and mud and deposits them in layers on the ocean floor, where they are buried, compacted, and cemented together over millions of years. What type of rock forms through this process?

A. A sedimentary rock, formed when loose particles are deposited in layers and then compacted and cemented together

B. An igneous rock, formed when molten magma or lava cools and hardens either underground or at the surface

C. A metamorphic rock, formed when an existing rock is changed by intense heat and pressure without melting

D. A volcanic glass, formed when lava is cooled so suddenly that no mineral crystals have time to grow at all

22. When struck, a sample of the mineral mica splits easily into thin, flat, parallel sheets along smooth surfaces. Which physical property of the mineral does this behavior demonstrate?

- A. Streak, which is the color of the powder a mineral leaves behind when it is rubbed across a rough tile
- B. Hardness, which is the resistance of a mineral to being scratched by another, harder material or object
- C. Cleavage, which is the tendency of a mineral to break along smooth, flat planes in one or more directions
- D. Luster, which describes the way that the surface of a mineral reflects light, such as metallic or glassy

23. Two igneous rocks formed from magma of identical chemical composition. One has large crystals, and the other has tiny crystals. What is the most likely reason for the difference in their crystal sizes?

- A. The rock with large crystals is much older than the rock with tiny crystals, which formed only recently
- B. The large crystals grew during slow cooling underground, while the tiny crystals formed during fast cooling at the surface
- C. The two rocks were squeezed under different pressures, which is the only factor that controls crystal size
- D. The rock with large crystals formed underwater, while the rock with tiny crystals formed in dry desert air

24. As water evaporates from a warm lake on a sunny day, the liquid water changes into water vapor. What must happen for this change of state to occur?

- A. The water molecules must release energy into their surroundings, which causes the lake to warm up further
- B. The lake must first freeze solid, since water can only turn into vapor after it has passed through the ice phase
- C. The dissolved minerals in the lake water must chemically break down to supply the vapor with its energy
- D. The water molecules must absorb energy from the surroundings, which is supplied mainly by the Sun's warmth

25. A community is drilling a well and wants to reach a layer that can both store a large amount of groundwater and let it flow easily into the well. Which material would make the best aquifer?

- A. A thick layer of well-sorted sand and gravel, which has both high porosity for storing water and high permeability for flow
- B. A layer of solid, unfractured granite, which has very little pore space and does not allow water to flow through it
- C. A dense layer of clay, which can hold a lot of water in its pores but allows that water to flow only extremely slowly
- D. A sheet of solid bedrock with no cracks at all, which prevents water from both entering and moving through it

26. Coal, oil, and natural gas hold carbon that was removed from the atmosphere by living things and buried underground over millions of years. How does burning these fuels affect the carbon cycle today?

- A. It permanently removes carbon dioxide from the air and stores it underground, gradually cooling the planet over time
- B. It returns long-buried carbon to the atmosphere as carbon dioxide, adding it faster than natural processes remove it
- C. It has no measurable effect on the atmosphere, because the carbon released by burning these fuels is far too small
- D. It converts carbon dioxide in the air into solid rock, locking the carbon away beneath the surface for good

27. As the climate warms, frozen ground called permafrost begins to thaw and release methane, a powerful greenhouse gas. This methane traps more heat, which causes still more permafrost to thaw. What type of feedback is this?

- A. A negative feedback, because the released methane gradually cools the atmosphere and reverses the warming
- B. An external forcing, because the methane originates from a source that lies completely outside the climate system
- C. A positive feedback, because the released methane amplifies the warming that caused the permafrost to thaw
- D. A neutral process, because methane released into the atmosphere has no measurable effect on the temperature

28. Slightly acidic rainwater seeps into cracks in a thick limestone formation over thousands of years, slowly dissolving the rock and forming caves and sinkholes. What type of weathering causes this?

- A. Frost wedging, in which water freezing within the cracks expands and physically pries the limestone apart into pieces
- B. Abrasion, in which sand carried by the wind or by flowing water grinds against the limestone and wears it down
- C. Exfoliation, in which curved sheets of rock peel away from the surface of the limestone as overlying pressure is released
- D. Chemical weathering, in which slightly acidic water reacts with and dissolves the soluble limestone over long periods

29. As a glacier melts and retreats, it drops a ridge of unsorted rock debris of all sizes that it had been pushing ahead of and carrying within it. What is this landform called?

- A. A moraine, a ridge of unsorted rock material that a glacier deposits as it melts and retreats from an area
- B. A delta, a fan-shaped deposit of sediment that a river drops as it slows upon entering a lake or the ocean
- C. A sand dune, a mound of well-sorted sand that wind piles up and slowly moves across a dry landscape over time
- D. A canyon, a deep, narrow valley that a fast-flowing river cuts downward through layers of solid bedrock over time

30. In the middle of winter, a continental polar (cP) air mass forms over the snow-covered interior of Canada and then sweeps southward into the United States. What weather does this air mass bring?

- A. Warm, humid air that produces high humidity and a strong chance of heavy thunderstorms across the region
- B. Cold, dry air that often brings clear skies along with a sharp drop in temperature across the affected region
- C. Cool, moist ocean air that brings long periods of gray skies, fog, and steady light drizzle to the region
- D. Hot, dry desert air that brings extended drought conditions and clouds of blowing dust to the affected area

31. A warm front moves into a region as a mass of warm air gradually slides up and over a retreating mass of cooler air. What weather typically accompanies the passage of a warm front?

- A. A sudden, violent squall line of thunderstorms followed within minutes by a sharp drop into cold, dry air
- B. Several days of unchanging fog and motionless low clouds that hang over the same area without moving at all
- C. A long period of light to moderate steady rain or drizzle, followed by warmer, more humid air once it passes
- D. Completely clear skies and steady high pressure with no clouds and no precipitation of any kind whatsoever

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

- A. It rises, because cooler air can hold less water vapor, so the air moves closer to its saturation point
- B. It falls, because cooler air is able to hold much more water vapor than warm air can hold at any time
- C. It stays exactly the same, since the actual amount of water vapor in the air has not changed at all
- D. It drops immediately to zero, because cold air at night is never able to contain any water vapor at all

33. Hurricanes form over warm tropical oceans in late summer and weaken rapidly after moving over land. What is the main reason a hurricane weakens once it is over land?

- A. The increased friction with the land instantly freezes the storm's warm, moist core below the freezing point
- B. The Coriolis effect that organizes the storm completely disappears the moment the hurricane crosses onto land
- C. The cooler land surface emits cold air upward that immediately replaces all of the storm's rising warm air
- D. The storm is cut off from the warm ocean water that supplied the heat and moisture needed to power the storm

34. Earth's surface absorbs incoming sunlight and then radiates energy upward as infrared (heat) radiation. How do greenhouse gases such as carbon dioxide affect this outgoing infrared radiation?

- A. They allow all of the outgoing infrared radiation to escape directly into space, so they cool the lower atmosphere
- B. They absorb much of the outgoing infrared radiation and re-radiate part of it back downward, warming the lower atmosphere
- C. They convert the outgoing infrared radiation into visible light that then passes easily out of the atmosphere into space
- D. They reflect the incoming sunlight back into space before it can reach and warm the surface of the Earth at all

35. Global winds, such as the trade winds, do not travel in straight north-south lines but instead curve as they move across the Earth's surface. What is responsible for this curving of global wind patterns?

- A. The gravitational pull of the Moon, which drags the moving air sideways as the Moon travels around the Earth
- B. Ocean currents, which physically push the overlying winds into curved paths as they flow across the planet
- C. The Coriolis effect, produced by the rotation of the Earth, which deflects moving air to one side as it travels
- D. The Earth's magnetic field, which steers the moving air the same way that it steers the needle of a compass

36. A scientist explains that a single unusually hot summer is not by itself proof of long-term climate change. What is the best reasoning behind this statement?

- A. Climate is the long-term average of weather over many years, so a single hot summer is short-term weather, not a climate trend
- B. Climate change has actually stopped, which is the real reason a single hot summer cannot prove anything about it
- C. A single summer's weather is far more important than decades of data when scientists judge the global climate

D. Hot summers prove that human activities have no effect on climate and that all temperature changes are purely random

37. Which of the following energy resources is renewable, meaning it is naturally replenished and will not run out on human timescales?

A. Coal, a fossil fuel that is mined from underground and that took many millions of years to form from buried plants

B. Petroleum, a fossil fuel that is pumped from underground reservoirs and refined into gasoline and other products

C. Uranium, a heavy metal that is mined from the ground and used as the fuel inside nuclear fission power reactors

D. Solar energy, which arrives continuously from the Sun and is replenished every single day without ever running out

38. A factory keeps its costs low by releasing pollution into the air, but people living nearby suffer more breathing problems and higher medical bills as a result. The residents' medical costs are best described as which of the following?

A. A private profit, since they are money that the factory earns directly by selling the products that it manufactures

B. A renewable resource, since the residents can keep using the air around them again and again without it running out

C. A negative externality, since they are a cost of the factory's activity that falls on people outside the transaction

D. A government subsidy, since they are a direct payment the residents receive from the government every single year

39. A non-native fish is released into a lake, where it has no natural predators. It multiplies rapidly and eats the eggs of native fish until several native species vanish from the lake. Which driver of biodiversity loss does this illustrate?

- A. Overharvesting, in which humans remove a species from the wild faster than it is able to reproduce and recover
- B. An invasive species, in which an introduced organism spreads unchecked and outcompetes or preys on the native species
- C. Habitat fragmentation, in which a once-continuous habitat is broken apart into small, isolated, disconnected pieces
- D. Climate change, in which rising temperatures push native organisms beyond the range of conditions they can tolerate

40. A forest provides people with lumber for building, wild berries and nuts for food, and plants used to make medicines. These direct material goods that people harvest from the forest are best classified as which type of ecosystem service?

- A. A provisioning service, because the ecosystem directly supplies material goods such as food, lumber, and medicines to people
- B. A regulating service, because the ecosystem controls flooding, filters the air, and helps to moderate the local climate
- C. A cultural service, because the ecosystem provides recreation, natural beauty, and spiritual inspiration to the people who visit
- D. A supporting service, because the ecosystem carries out nutrient cycling and the formation of fertile new soil over time

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

- A. The world's glaciers and ice sheets will steadily grow larger as global temperatures continue to rise each year
- B. Average global surface temperatures will soon begin to fall as greenhouse gas concentrations keep on increasing
- C. Global sea levels will continue to rise as ocean water warms and expands and as land-based ice continues to melt
- D. The oceans will steadily become more alkaline and basic as they take in more carbon dioxide from the atmosphere

42. The protective ozone layer high in the atmosphere over Antarctica thinned dramatically during the late twentieth century. Which human-made chemicals were primarily responsible for this thinning?

- A. Carbon dioxide molecules released into the atmosphere by burning coal, oil, and natural gas in power plants worldwide
- B. Sulfur dioxide gas released from the tall smokestacks of coal-burning power plants and large industrial factories
- C. Nitrogen-based fertilizers spread across farm fields that then washed off into nearby rivers, lakes, and the ocean
- D. Chlorofluorocarbons (CFCs), chemicals once widely used in refrigerators, air conditioners, and aerosol spray cans

43. A farmer wants to keep a field productive for many years while preventing the topsoil from being washed or blown away. Which practice would best help achieve this goal?

- A. Plowing the field deeply after every harvest and leaving the bare soil completely exposed throughout the winter
- B. Rotating crops and planting cover crops between growing seasons to protect the soil and maintain its fertility
- C. Planting the exact same single crop in the field every year and removing all other vegetation from around it
- D. Clearing away all the trees, shrubs, and hedgerows surrounding the field so that even more of it can be planted

44. Although the Earth has an enormous amount of water, only a tiny fraction is fresh water that is readily available for people to use. Why is most of Earth's water not usable as fresh drinking water?

- A. Most of Earth's water is salt water in the oceans, and most of the fresh water is locked up in ice or buried deep underground
- B. Most of Earth's water has been permanently used up and destroyed by human activities over the past several centuries
- C. Nearly all of Earth's water is stored inside the bodies of the living plants and animals found across the planet

D. The majority of Earth's water exists only as invisible vapor floating high above the surface in the upper atmosphere

45. A city, expecting more frequent flooding from heavier rainstorms, upgrades its storm drains, builds flood barriers, and elevates vulnerable buildings. Which climate change strategy does this best represent?

A. Mitigation, because the city is reducing the greenhouse gas emissions that are the underlying root cause of climate change

B. Geoengineering, because the city is deliberately altering the entire global climate system on a large planetary scale

C. Adaptation, because the city is adjusting its infrastructure to cope with climate impacts that are already beginning to occur

D. Prevention, because these actions will permanently stop the rainstorms and flooding from ever affecting the city again

46. Ocean acidification, which threatens corals and shellfish, occurs as the ocean takes in increasing amounts of a particular gas from the atmosphere. Which gas is mainly responsible?

A. Nitrogen, which makes up most of the atmosphere and slowly dissolves into the surface waters of the ocean over time

B. Oxygen, which is consumed by marine animals as they breathe and which steadily lowers the pH of the surrounding water

C. Methane, which bubbles up from the seafloor and dissolves into the deep, cold waters far below the ocean's surface

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

47. The Holocene Epoch, spanning roughly the last 11,000 years, has had an unusually steady climate compared with the rapid temperature swings of the ice ages before it. Why has this steadiness been important for humans?

A. The steady climate caused entirely new species of humans to evolve very rapidly during this short geologic epoch

- B. The steady climate made farming dependable, which allowed people to settle permanently in one place and build cities
- C. The steady climate finally raised the level of oxygen in the atmosphere high enough for humans to breathe and survive
- D. The steady climate permanently eliminated every drought, flood, and storm, leaving early farmers with no risks to face

48. A team of engineers is asked to design a system to reduce traffic accidents at a dangerous intersection. What should the team do first in the engineering design process?

- A. Clearly define the problem, including the goals a successful solution must achieve and the limits the design must work within
- B. Immediately begin building the most expensive traffic-control system available without studying the intersection first at all
- C. Choose whichever solution looks the most modern and impressive, regardless of whether it actually fits the intersection
- D. Survey local drivers only about which color they would prefer the new traffic signs and signals to be painted in the end

49. After building and testing a prototype of a new traffic signal, an engineering team finds that it reduces accidents but causes long traffic backups during rush hour. According to the engineering design process, what should the team do next?

- A. Abandon the entire project, because any problem that appears during testing proves the design can never be made to work
- B. Install the prototype permanently without any changes, because the very first version of any design is always the final one
- C. Hide the backup problem from the public so that no one ever finds out the original prototype had a performance issue
- D. Use what they learned from testing to redesign the signal to reduce backups, and then test the improved version again

50. Before redesigning a busy intersection, engineers build a computer model that simulates how traffic would flow under several different designs. What is the greatest value of using such a model first?

- A. The model guarantees one exact traffic outcome that is certain to happen no matter what conditions actually arise later
- B. The model removes any need to ever collect real traffic measurements at the intersection before or after the redesign
- C. The model lets engineers compare the likely results of different designs before spending money to rebuild the intersection
- D. The model proves with complete certainty that every design tested will reduce accidents to exactly zero at the intersection

Practice Exam 28: Answer Key with Explanations

1. B — Distant galaxies are observed moving away from us, with farther ones receding faster (Hubble's Law), which shows the universe is expanding. Redshift in their light reveals this outward motion. Together with the cosmic microwave background, galactic recession is a central pillar of Big Bang theory.
2. C — The Sun is in the main sequence stage, the long, stable phase during which a star fuses hydrogen into helium in its core. Stars spend most of their lives here, and the Sun is roughly midway through this phase. Red giant, white dwarf, and supernova stages come later or apply to other stars.
3. A — Most hydrogen and helium formed in the first few minutes after the Big Bang, when the hot young universe produced these light elements. This early nucleosynthesis set their high abundance. Stars fuse hydrogen into heavier elements, they do not create it, so the light elements trace back to the Big Bang.
4. D — Kepler's Third Law gives $T^2 = a^3$, so with $a = 100$, $a^3 = 1,000,000$ and T equals the square root of one million, which is 1,000 years. The cube of the distance sets the square of the period. This relationship applies to any object orbiting the Sun.
5. A — On the equinoxes, Earth's tilted axis points neither toward nor away from the Sun, so both hemispheres receive equal illumination and day and night are about equal everywhere. The orientation of the tilt, not distance or a halted rotation, produces this balance. Equinoxes mark the transitions between seasons.
6. C — A thin sliver lit on the left side, rising just before dawn a few days before new moon, is the waning crescent. "Waning" means the illuminated portion is shrinking toward new moon. Left-side illumination and a pre-dawn rise identify this late phase for Northern Hemisphere observers.
7. D — The planets orbit in nearly the same plane because they formed together from a single flat, spinning disk of gas and dust around the young Sun. The disk's shape was imprinted on the planets' orbits. This coplanar arrangement is a key prediction of the nebular hypothesis.

8. B — Lunar eclipses occur at the full moon, when the Moon is opposite the Sun and can pass into Earth's shadow. Only then is the geometry right for Earth's shadow to fall on the Moon. A tilted lunar orbit is why this does not happen every full moon.
9. C — Neap tides, the smallest tidal ranges, occur at first and last quarter, when the Sun and Moon pull at right angles and their effects partly cancel. The misaligned pulls weaken the tidal bulges. This contrasts with the larger spring tides at new and full moon.
10. A — The mass lost when hydrogen fuses into helium is converted into energy according to $E = mc^2$. Because the speed of light squared is enormous, a tiny mass loss yields vast energy. This mass-to-energy conversion is the source of the Sun's power.
11. D — The poles are colder because sunlight strikes them at a low, slanting angle, spreading its energy thinly over a large surface area. Near the equator the same light arrives more directly and is concentrated. The angle of insolation, not distance to the Sun, controls this difference.
12. B — By the principle of superposition, the youngest rocks in an undisturbed sequence are at the top, because each new layer is deposited on top of older ones. Sediments accumulate from the bottom upward over time. This rule is the foundation of relative dating.
13. A — One-half of the isotope remaining means exactly one half-life has passed, so the sample is about 6,000 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. C — The same short-lived, widespread fossil species in layers on two continents means both layers formed during the same span of geologic time and can be matched in age. Such organisms make excellent index fossils. This allows correlation of rocks across great distances.
15. D — An unconformity represents a gap in the rock record, a span of time when rock was eroded away or never deposited. The eroded surface separates older rock below from younger rock above. Unconformities show that the geologic record is often incomplete.
16. B — The worldwide iridium layer and shocked quartz point to a massive asteroid impact, which scattered iridium globally and helped trigger a major mass extinction. Iridium is rare in Earth's crust but common in asteroids, and shocked quartz forms under impact pressures. This links the impact to the end-Cretaceous extinction.
17. A — Wegener supported continental drift with matching fossils, rock layers, and mountain ranges found on the facing coasts of separate continents. These features align when the continents are reassembled, implying they were once joined. This evidence later helped build plate tectonic theory.
18. C — Extremely fine clay settling slowly into thin, flat layers with no ripple marks or coarse grains indicates a deep, calm body of water far from shore. Only still water allows the finest particles to accumulate undisturbed. Energetic river, desert, or glacial settings would leave coarser, different deposits.
19. B — At the San Andreas Fault, two plates slide horizontally past each other, which defines a transform boundary. The grinding motion builds and releases stress as earthquakes but produces no volcanoes. Transform boundaries neither create nor destroy crust.
20. D — Mantle convection is powered by heat left over from Earth's formation combined with heat from the decay of radioactive elements inside Earth. This internal heat drives the circulation that moves the plates. Solar energy does not reach the mantle, so the Sun is not the source.
21. A — Loose sand and mud deposited in layers and then buried, compacted, and cemented form a sedimentary rock. This process, called lithification, turns sediment into solid rock. Clastic sedimentary rocks like sandstone and shale form this way.

22. C — Mica splitting into thin, flat, parallel sheets demonstrates cleavage, the tendency to break along smooth planes. The single perfect cleavage direction is what allows mica to peel into sheets. Cleavage is a diagnostic physical property used to identify minerals.
23. B — Identical composition but different crystal sizes is explained by cooling rate: large crystals grew during slow underground cooling, while tiny crystals formed during fast cooling at the surface. Cooling rate, not age or pressure, controls grain size in igneous rocks. This is why intrusive rocks are coarse and extrusive rocks are fine-grained.
24. D — For water to evaporate, its molecules must absorb energy from the surroundings, supplied mainly by the Sun's warmth, to break free into vapor. This energy input drives the phase change from liquid to gas. Because evaporation absorbs heat, it has a cooling effect on the surface.
25. A — Well-sorted sand and gravel makes the best aquifer because it has both high porosity, to store water, and high permeability, to let water flow easily to a well. Storage and flow are both needed for a productive aquifer. Granite and clay each lack one of these properties.
26. B — Burning fossil fuels returns long-buried carbon to the atmosphere as carbon dioxide, adding it faster than natural processes can remove it. This releases carbon that was locked away for millions of years. The resulting buildup is the main driver of human-caused climate change.
27. C — Thawing permafrost releasing methane that traps more heat and causes still more thawing is a positive feedback, because it amplifies the warming that triggered it. The cycle reinforces itself rather than counteracting the change. This feedback is a serious concern for accelerating climate change.
28. D — Acidic water dissolving limestone to form caves and sinkholes is chemical weathering, because the rock is chemically dissolved rather than merely broken apart. The reaction removes rock by reacting with it. This process creates the karst landscapes typical of limestone regions.
29. A — A ridge of unsorted rock debris dropped by a glacier as it melts and retreats is a moraine. The ice carries and deposits material of all sizes without sorting it. Moraines are characteristic depositional features of glaciers.
30. B — A continental polar air mass forms over cold, snow-covered land, so it brings cold, dry air that often produces clear skies and a sharp drop in temperature. "Continental" indicates dryness and "polar" indicates cold. This contrasts with warm, moist maritime air masses.
31. C — A warm front, with warm air sliding gently up over retreating cool air, typically brings a long period of light to moderate steady rain or drizzle, followed by warmer, more humid air. The gentle frontal slope produces widespread, prolonged precipitation. This differs from the abrupt storms of a cold front.
32. A — As air cools while its water vapor content stays fixed, the relative humidity rises because cooler air can hold less vapor, moving it closer to saturation. Relative humidity compares actual vapor to the maximum the air can hold. This is why dew and fog often form on cool nights.
33. D — A hurricane weakens over land because it is cut off from the warm ocean water that supplied the heat and moisture powering it. Without that energy source, the storm loses strength. This dependence on warm water explains why hurricanes fade quickly inland.
34. B — Greenhouse gases absorb much of the outgoing infrared radiation from Earth's surface and re-radiate part of it back downward, warming the lower atmosphere. They act on outgoing heat rather than reflecting incoming sunlight. This absorption and re-emission is the essence of the greenhouse effect.
35. C — The Coriolis effect, produced by Earth's rotation, deflects moving air to one side, causing global winds like the trade winds to curve. Without rotation the winds would travel straight between pressure zones. This deflection shapes the major global wind belts.

36. A — Because climate is the long-term average of weather over many years, a single hot summer is short-term weather, not a climate trend, and cannot by itself prove climate change. Long-term data, not one season, reveals climate trends. Distinguishing weather from climate is key to interpreting them correctly.
37. D — Solar energy is renewable because it arrives continuously from the Sun and is replenished every day without running out. The other options—coal, petroleum, and uranium—are finite resources extracted from the ground. Continuous natural replenishment is what defines a renewable resource.
38. C — The residents' medical costs from the factory's pollution are a negative externality, a cost of the factory's activity that falls on people outside the transaction. Externalities are real costs the polluter does not pay. Including them is essential for honest cost-benefit analysis.
39. B — A non-native fish that spreads unchecked and preys on native species until they vanish illustrates an invasive species. Free of natural predators, it outcompetes or consumes the natives. This differs from overharvesting, habitat loss, or climate change as a biodiversity threat.
40. A — A forest directly supplying lumber, food, and medicines provides a provisioning service, the category covering material goods people harvest. Provisioning services are the tangible products obtained from ecosystems. This differs from regulating, cultural, or supporting services.
41. C — Strong scientific consensus supports continued sea level rise as ocean water warms and expands and land-based ice melts. Both thermal expansion and ice loss add water to the oceans. The other options contradict observed trends and ocean chemistry, which is becoming more acidic, not basic.
42. D — Ozone thinning over Antarctica was caused mainly by chlorofluorocarbons (CFCs), once used in refrigerators, air conditioners, and aerosols. CFCs release chlorine that destroys ozone in the stratosphere. Phasing them out under the Montreal Protocol allowed the ozone layer to begin recovering.
43. B — Rotating crops and planting cover crops protect the soil from erosion and maintain its fertility, keeping the field productive for years. These practices keep the ground covered and replenish nutrients. They preserve the land's long-term productivity, supporting sustainable agriculture.
44. A — Most of Earth's water is salt water in the oceans, and most fresh water is locked in ice or deep underground, leaving little readily available for use. Only a tiny fraction is accessible fresh water. This scarcity makes water conservation important.
45. C — Upgrading drains, building barriers, and elevating buildings to cope with flooding already beginning to occur is adaptation, since the city is adjusting to climate impacts rather than reducing their cause. Adaptation manages consequences; mitigation would cut emissions. These protective measures fit the definition of adaptation.
46. D — Ocean acidification is driven by the ocean absorbing carbon dioxide, which dissolves to form a weak acid that lowers seawater pH. Rising atmospheric carbon dioxide increases the amount taken up. This acid formation is what threatens shell-building corals and shellfish.
47. B — The steady Holocene climate made farming dependable, allowing people to settle permanently in one place and build cities. Predictable growing seasons were essential for agriculture and settlement. Climatic stability, not evolution or oxygen changes, enabled the rise of civilization.
48. A — The first step in the engineering design process is clearly defining the problem, including the goals a successful solution must achieve and the limits the design must work within. A precise definition guides every later stage. Skipping it risks building a solution that fails to address the real need.

49. D — When a prototype reveals a new problem, 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 flaw found in testing is information, not a reason to abandon the project.
50. C — The greatest value of the model is that it lets engineers compare the likely results of different designs before spending money to rebuild the intersection. Models allow ideas to be tested safely and cheaply in advance. They guide decisions while acknowledging uncertainty, and they support rather than replace real measurements.