

Weatherforge — Activity Book

A Spark & Anvil activity book — puzzles, questions, and fun from Weatherforge.

Write in the book, circle your answers, and check the Answer Key at the back.

1. Atmosphere Basics

Circle the correct answer

1. What is the name of the layer of the atmosphere closest to Earth's surface?
(A) Mesosphere (B) Stratosphere (C) Troposphere (D) Thermosphere
2. Which layer of the atmosphere contains the ozone layer that protects us from ultraviolet radiation?
(A) Troposphere (B) Exosphere (C) Stratosphere (D) Mesosphere
3. As you travel upward through the troposphere, what happens to the temperature?
(A) It stays exactly the same (B) It increases steadily (C) It decreases — the air gets colder (D) It first increases then drops sharply
4. A weather balloon launched from the ground rises through increasingly cold air, then suddenly enters a zone where temperature begins to increase. Which boundary has the balloon just crossed?
(A) The mesopause, entering the thermosphere (B) The exobase, entering outer space (C) The stratopause, entering the mesosphere (D) The tropopause, entering the stratosphere
5. Why do scientists consider the troposphere the most important layer for understanding daily weather patterns?
(A) It contains nearly all the atmosphere's water vapor and is where air mixing creates weather systems (B) It is the thickest layer of the atmosphere (C) It has the highest temperatures of any layer (D) It is the only layer where oxygen exists
6. What gas makes up the largest percentage of Earth's atmosphere?
(A) Water vapor (B) Oxygen (C) Carbon dioxide (D) Nitrogen

Write the answer

7. Why is carbon dioxide important in the atmosphere even though it makes up less than one percent of the air?

Answer: _____

8. If you could remove all the water vapor from a sample of air, how would the percentages of nitrogen and oxygen change?

Answer: _____

9. Earth's atmosphere is about 21 percent oxygen, but Mars has an atmosphere with less than 0.2 percent oxygen. What does this difference suggest about the possibility of breathing on Mars?

Answer: _____

10. A classmate claims that since we only use oxygen when we breathe, nitrogen in the atmosphere serves no useful purpose. Evaluate this claim using what you know about the atmosphere.

Answer: _____

Match each question to its answer

1. What instrument is used to measure atmospheric air pressure? →

2. Why does air pressure decrease as you go higher in altitude? →

3. A weather forecaster reports that air pressure is falling rapidly. What type of weather would you expect to follow? →

4. Two cities are at the same altitude, but City A has a barometric reading of 1025 millibars while City B reads 1005 millibars. In which direction will wind tend to blow between them, and why? →

5. Evaluate whether this statement is accurate: 'If the barometer reading is high, the weather will definitely be good for the entire day.' →

(A) There is less air above you pressing down, so the weight of the air column is reduced

(B) Stormy or rainy weather is likely approaching

(C) The statement is oversimplified — high pressure usually brings fair weather, but conditions can change, and local factors also influence weather

(D) Barometer

(E) Wind will blow from City A to City B because air moves from high pressure to low pressure

2. Water Cycle and Precipitation

Circle the correct answer

11. What is the process called when liquid water changes into water vapor?

(A) Evaporation (B) Precipitation (C) Freezing (D) Condensation

12. Why does a wet towel dry faster when hung in the sun than when left in a cool, shady closet?

(A) Closets trap water inside the towel permanently (B) Sunlight provides heat energy that speeds up evaporation of the water from the towel (C) The sun's light bleaches the water away from the fabric (D) Sunlight causes the towel fibers to squeeze out the water

13. A farmer wants to reduce water loss from a small irrigation pond. Based on what you know about evaporation, which strategy would help the most?

(A) Shading the pond to reduce the amount of heat energy reaching the water surface (B) Digging the pond deeper in the center only (C) Painting the bottom of the pond white (D) Adding salt to the water to make it heavier

14. Two identical bowls of water are placed outside on the same sunny day. One is wide and shallow, the other is narrow and deep. After four hours, which bowl will have lost more water to evaporation, and why?

(A) The wide, shallow bowl because it has a larger surface area exposed to the air (B) Both lose the same amount because they started with equal volumes (C) The narrow, deep bowl because deeper water evaporates faster (D) The narrow, deep bowl because the water is under more pressure

15. A student claims that evaporation only happens when water boils at 100 degrees Celsius. Is this claim correct? Explain your reasoning.

(A) No, evaporation occurs at any temperature whenever water molecules at the surface gain enough energy to escape into the air (B) No, evaporation only occurs below freezing temperatures (C) Yes, evaporation and boiling are exactly the same process at the same temperature (D) Yes, water must reach boiling point before any molecules can become gas

16. What is the process called when water vapor cools and changes back into tiny liquid water droplets?

(A) Evaporation (B) Precipitation (C) Transpiration (D) Condensation

Write the answer

17. Why do clouds form when warm, moist air rises high into the atmosphere?

Answer: _____

18. What are condensation nuclei, and why are they important for cloud formation?

Answer: _____

19. You breathe out on a cold winter morning and see a small cloud of mist. What process is occurring?

Answer: _____

20. On a humid summer morning, dew covers the grass but the nearby paved sidewalk is dry. What explains this difference?

Answer: _____

Match each question to its answer

1. What are the four main types of precipitation that fall from clouds? →
2. What is sleet? →
3. How does hail form differently from sleet? →
4. The temperature at cloud level is minus 10 degrees Celsius, and the temperature all the way down to the ground is below freezing. What type of precipitation would you expect? →
5. During a winter storm, a city receives snow in the northern suburbs but freezing rain in the southern part of town. What atmospheric conditions could explain this difference across such a short distance? →

(A) Snow, because the ice crystals forming in the cloud never pass through warm air and remain frozen all the way to the ground

(B) A thin warm air layer aloft extends over the southern area but not the north, melting snow into rain that refreezes on contact with cold surfaces

(C) Rain, snow, sleet, and hail

(D) Hail forms inside thunderstorm clouds when ice pellets are carried up and down by strong updrafts, growing larger with each cycle

(E) Raindrops that freeze into small ice pellets as they fall through a layer of cold air near the ground

3. Clouds and Sky Observation

Circle the correct answer

21. What do cumulus clouds look like?

(A) Puffy, white, flat-bottomed clouds that resemble cotton balls or cauliflower (B) Dark, funnel-shaped clouds reaching the ground (C) Flat, gray sheets covering the entire sky (D) Thin, wispy streaks high in the sky

22. Why do cumulus clouds have flat bottoms but puffy, rounded tops?

(A) The flat bottom forms at the consistent altitude where rising air cools enough for condensation, while the puffy top grows as warm air continues rising and expanding

(B) The flat bottom is where rain collects before falling, as this is what research and standard practice suggests (C) Wind shears the bottom flat while the top is protected, which is the most common explanation for this phenomenon (D) The sun heats the top into a round shape but the bottom stays flat from gravity, and this has been

consistently demonstrated in practice

23. You are planning an outdoor picnic and see small, scattered cumulus clouds in the morning sky with plenty of blue sky between them. What weather can you most likely expect for the next few hours?

(A) An immediate thunderstorm because all cumulus clouds produce lightning (B) Heavy snowfall within the hour (C) A tornado because cumulus clouds always become severe storms (D) Fair, pleasant weather because small cumulus clouds on a sunny day usually indicate stable atmospheric conditions

24. Throughout the day, you notice cumulus clouds growing taller and darker. By afternoon they tower high into the sky. What pattern of change is occurring, and what might happen next?

(A) The cumulus clouds are developing into cumulonimbus through increasing atmospheric instability, and thunderstorms are likely approaching (B) The darkening means the clouds are filling with smoke from forest fires (C) The clouds are healthy and growing taller means better weather is coming (D) The clouds are shrinking because the sun is drying them out

25. A friend says that all cumulus clouds eventually turn into thunderstorms. Based on what you know about cloud development, evaluate whether this claim is accurate.

(A) This is inaccurate because most cumulus clouds remain small fair-weather clouds that dissipate without producing storms; only a small fraction develop into cumulonimbus under specific unstable conditions (B) The claim is correct because cumulus and cumulonimbus are the exact same type of cloud (C) The claim is wrong because cumulus clouds can never become thunderstorms under any conditions (D) The claim is correct because every cumulus cloud will produce thunder if given enough time

26. What do stratus clouds look like?

(A) Flat, gray, sheet-like clouds that cover the sky in a uniform layer like a blanket (B) Small, round puffs arranged in rows like fish scales (C) Tall, puffy towers reaching high into the atmosphere (D) Thin, wispy curls made of ice crystals

Write the answer

27. Why do stratus clouds usually produce only light drizzle or mist instead of heavy rain?

Answer: _____

28. What is the difference between stratus clouds and fog?

Answer: _____

29. You wake up to find the sky completely covered with a low, gray stratus cloud layer. What type of weather should you dress for?

Answer: _____

30. A coastal city experiences stratus clouds and fog nearly every summer morning, but they usually clear by noon. An inland city 50 miles away rarely gets this morning fog. What geographic factor explains this pattern?

Answer: _____

Match each question to its answer

1. What are cirrus clouds made of, and what do they look like? →
2. At approximately what altitude do cirrus clouds typically form? →
3. Why do cirrus clouds often appear stretched or streaked across the sky rather than forming puffy shapes like cumulus clouds? →
4. You see increasing numbers of cirrus clouds spreading across a previously clear sky. Based on weather patterns, what change might this indicate for the coming day or two? →
5. On a cold winter night, the sky is clear and full of stars. The next night, a thin layer of cirrus clouds covers the sky. Which night is likely to feel colder at ground level, and why? →

(A) A warm front or weather system may be approaching, as increasing cirrus clouds often arrive ahead of frontal systems

(B) Thin, wispy streaks made of ice crystals, found high in the atmosphere

(C) The clear night feels colder because without clouds, heat from the ground escapes freely into space; cirrus clouds act as a thin blanket trapping some heat

(D) Above 20,000 feet in the upper atmosphere

(E) Strong upper-level winds spread the ice crystals into long streaks and wispy trails

4. Severe Weather

Circle the correct answer

31. What three ingredients are needed for a thunderstorm to form?

(A) Moisture, an unstable atmosphere with warm air rising, and a lifting mechanism such as a front or daytime heating (B) Fog, high altitude, and ocean currents, which is why this approach is recommended by experts (C) Snow, high pressure, and calm winds, and this is the standard approach used in most cases (D) Dry air, cold temperatures, and clear skies, as this directly follows from the underlying principles

32. Why does lightning occur during a thunderstorm?

(A) The sun heats the cloud until it catches fire and sparks (B) Wind rubs against the outside of the cloud creating static electricity (C) Collisions between ice particles and water droplets inside the cloud create a buildup of electrical charge that is released as a lightning bolt (D) Raindrops move so fast they create friction with the air and ignite

33. Why does thunder follow lightning after a noticeable delay?

(A) Thunder is produced by a different cloud than the one that makes lightning (B) Sound only travels during nighttime when it is quieter (C) The lightning must cool down before the thunder can be released (D) Light travels much faster than sound, so you see the lightning flash almost instantly but the thunder sound takes time to travel to your ears

34. You see a lightning flash and count 10 seconds before hearing thunder.

Approximately how far away is the lightning?

(A) The lightning is directly overhead, and this has been consistently demonstrated in practice (B) About 2 miles away, since sound travels roughly 1 mile every 5 seconds (C) About 10 miles away, and this is the standard approach used in most cases (D) About 50 miles away, and this is the standard approach used in most cases

35. A region experiences thunderstorms almost every afternoon during summer but rarely during winter. What atmospheric conditions change between seasons to explain this pattern?

(A) Lightning cannot occur when temperatures are below 50 degrees Fahrenheit (B) Thunder only works in warm air because cold air absorbs all sound (C) The sun is farther away in winter so it cannot heat clouds enough (D) Summer provides stronger surface heating, more moisture from evaporation, and greater atmospheric instability, all of which fuel thunderstorm development

36. What is a tornado?

(A) A large ocean wave caused by an earthquake (B) A violently rotating column of air extending from a thunderstorm cloud to the ground (C) A tropical storm with sustained winds over 74 mph (D) A type of thunderstorm that produces only heavy rain

Write the answer

37. How does wind shear contribute to tornado formation?

Answer: _____

38. A tornado warning has been issued for your area. You are at home in a two-story house with a basement. Where should you go for the safest shelter?

Answer: _____

39. Tornadoes occur far more frequently in the central United States (Tornado Alley) than in other parts of the country. What geographic and atmospheric conditions make this region especially vulnerable?

Answer: _____

40. Some people claim that hiding under a highway overpass is a safe place during a tornado. Based on your knowledge of tornado winds, evaluate whether this is good advice.

Answer: _____

Match each question to its answer

1. What is the minimum sustained wind speed required for a tropical storm to be classified as a hurricane? →

2. After a hurricane passes, residents in the eye's path report calm, clear skies lasting about 30 minutes before violent winds returned from the opposite direction. A neighbor concludes the storm is over during the calm period. Evaluate whether it is safe to go outside during this calm. →

3. Why do hurricanes weaken rapidly after making landfall? →

4. A Category 3 hurricane is forecast to strike a coastal city in 24 hours. Emergency managers order a mandatory evacuation. Why is evacuating early so important, even though the storm is still a day away? →

5. Hurricane A forms over very warm ocean water of 84 degrees Fahrenheit with low wind shear, while Hurricane B forms over cooler 78-degree water with moderate wind shear. Based on these conditions, which hurricane is more likely to become a major hurricane, and why? →

(A) They lose their warm ocean water energy source and encounter increased friction from the rough land surface

(B) It is extremely dangerous because the calm is only the eye passing over, and the eyewall with the storm's strongest winds will return from the opposite direction shortly

(C) Hurricane A is more likely to intensify because warmer water provides more energy and low wind shear allows the storm structure to remain organized

(D) Roads become gridlocked as millions try to leave at once, and conditions deteriorate before the storm center arrives, making late evacuation impossible

(E) 74 miles per hour

5. Weather Instruments

Circle the correct answer

41. What does a thermometer measure?

(A) Wind speed and direction (B) Atmospheric pressure changes (C) Temperature of the air or other substances (D) Amount of rainfall over time

42. Which liquid was traditionally used inside glass thermometers before being largely replaced for safety reasons?

(A) Rubbing alcohol (B) Water (C) Vegetable oil (D) Mercury

43. Why are weather thermometers placed inside white, louvered shelters called Stevenson screens?

(A) To prevent animals from damaging the equipment (B) To measure air temperature while shielding the thermometer from direct sunlight and rain (C) To make the thermometer easier to see from far away (D) To keep the thermometer warm during cold weather

44. How does a liquid-in-glass thermometer work to show temperature changes?

(A) A tiny computer inside the glass measures molecular vibrations (B) Magnets inside the thermometer push the liquid to different positions (C) The liquid expands when heated and contracts when cooled, moving up or down a calibrated scale (D) The glass changes color based on the surrounding temperature

45. A student reads a thermometer and records 72 degrees Fahrenheit. If they need to report the temperature in Celsius for a science project, approximately what value should they record?

(A) About 40 degrees Celsius (B) About 72 degrees Celsius (C) About 22 degrees Celsius (D) About 0 degrees Celsius

46. What weather variable does a barometer measure?

(A) Wind speed (B) Atmospheric pressure (C) Relative humidity (D) Air temperature

Write the answer

47. Why does a falling barometer reading often indicate that stormy weather is approaching?

Answer: _____

48. A sailor notices the barometer has dropped sharply from 1013 millibars to 990 millibars over six hours. What action should the sailor most likely take?

Answer: _____

49. Two cities are 200 miles apart. City A has a barometric pressure of 1020 mb and City B has 1000 mb. What can you infer about the wind conditions between these two cities?

Answer: _____

50. A weather station records steady barometric pressure of 1025 mb for three consecutive days. What type of weather pattern does this most likely indicate?

Answer: _____

Match each question to its answer

1. What does an anemometer measure? →
2. How does a wind vane differ from an anemometer in what it measures? →
3. A weather report states winds are 'from the southwest at 25 mph.' If you are facing north, which direction is the wind blowing toward you from? →
4. A student builds a simple cup anemometer for a science project. During testing, the cups complete 20 full rotations in one minute. If each rotation equals 1 mph of wind speed, what is the measured wind speed? →
5. A local weather station reports wind from the north at 15 mph, but a student's homemade anemometer at the same location reads 22 mph. What is the most likely explanation for this difference? →

- (A) A wind vane shows wind direction while an anemometer shows wind speed
 - (B) Wind speed
 - (C) From your lower left, behind and to the left
 - (D) 20 miles per hour
 - (E) The student's anemometer may not be properly calibrated against a standard reference instrument
-

6. Climate Zones

Circle the correct answer

51. Where are tropical climate zones generally located on Earth?

- (A) Exclusively in the Southern Hemisphere (B) Along the Prime Meridian at all latitudes (C) Near the equator, between the Tropic of Cancer and the Tropic of Capricorn (D) Only at the North and South Poles

52. Why do tropical rainforest regions receive heavy rainfall almost daily?

- (A) Tropical regions are closer to the ocean than any other climate zone (B) The trees in rainforests create their own rain through photosynthesis (C) Intense solar heating causes strong evaporation and convection, creating tall cumulonimbus clouds that produce heavy afternoon rain (D) Wind patterns push all of Earth's moisture to the equator

53. What is the main difference between a tropical wet climate and a tropical wet-and-dry (savanna) climate?

(A) Tropical wet climates have rain year-round while savanna climates have distinct wet and dry seasons (B) Tropical wet climates are hotter than savanna climates (C) Savanna climates never experience any rainfall (D) Tropical wet climates have more animals than savanna climates

54. A farmer in a tropical savanna region needs to plan crop planting. During which season should they plant crops that require consistent moisture?

(A) In the middle of the dry season to take advantage of abundant groundwater (B) During the dry season when there is no rain to damage seedlings (C) Crops should be planted at the exact same time regardless of season (D) At the beginning of the wet season so crops can grow during the months of reliable rainfall

55. A city located at 5 degrees North latitude has an average monthly temperature that never drops below 24°C and receives over 200 cm of annual rainfall. Which tropical climate subtype does this city most likely have?

(A) Tropical wet-and-dry (savanna) climate (B) Arid desert climate (C) Tropical monsoon climate (D) Tropical wet (rainforest) climate

56. What is the defining characteristic of temperate climate zones?

(A) They are located only on islands in the middle of oceans (B) They have no rainfall at any time of year (C) They experience extreme cold temperatures year-round (D) They have moderate temperatures with distinct warm and cool seasons

Write the answer

57. Why do temperate regions experience four distinct seasons while tropical regions do not?

Answer: _____

58. A student is comparing climate data for London, England and Moscow, Russia — both temperate cities. London has milder winters despite being at a similar latitude. What geographic factor most likely explains this?

Answer: _____

59. Mediterranean climates have dry, hot summers and mild, wet winters — the opposite of most temperate climates. What causes this reversed precipitation pattern?

Answer: _____

60. Continental temperate climates (like central United States) have much larger temperature ranges between summer and winter than maritime temperate climates (like coastal France). Explain the physical reason for this difference.

Answer: _____

Match each question to its answer

1. What is the primary reason polar regions are extremely cold throughout the year?
→
 2. Why does temperature decrease as elevation increases in highland climates, even at tropical latitudes? →
 3. Mount Kilimanjaro in Tanzania is located near the equator but has glaciers at its summit. Using the lapse rate of approximately 6.5°C per 1,000 meters, estimate the temperature at the 5,895-meter summit if the base temperature is 25°C . →
 4. Some scientists argue that highland climates should not be classified as a single climate type because conditions change dramatically with elevation. Evaluate this argument. →
 5. Polar ice sheets reflect about 80-90% of incoming sunlight back to space (high albedo). If global warming causes ice to melt and expose darker ocean or rock, what effect would this have on temperatures? →
 - (A) Approximately -13°C
 - (B) Temperatures would rise further because darker surfaces absorb more solar energy, creating a positive feedback loop
 - (C) Sunlight strikes polar regions at a very low angle, spreading the same energy over a larger area
 - (D) The argument is valid because a single mountain can contain multiple climate zones from tropical base to polar summit, making one label misleading
 - (E) As air rises to higher elevations, it expands and cools because atmospheric pressure decreases with altitude
-

7. Weather Maps and Forecasting

Circle the correct answer

61. What is an air mass?
(A) A large body of air with relatively uniform temperature and moisture characteristics (B) A single cloud that moves across the sky (C) A measurement of wind speed at high altitudes (D) The total weight of air above a specific location
62. What is a cold front?
(A) The point where cold air stops moving and becomes stationary (B) A region where temperatures drop below freezing for the first time in a season (C) A boundary where two warm air masses collide (D) The leading edge of an advancing cold air mass that pushes under and replaces warmer air
63. Why does a warm front typically produce a longer period of lighter, steadier

precipitation compared to a cold front?

(A) Cold fronts move too slowly to produce any rain at all (B) Warm fronts always carry more moisture than cold fronts (C) Warm air rides gradually up and over the retreating cold air, creating widespread gentle lifting and broad cloud cover (D) Warm front precipitation is heavier but appears lighter because it is warmer

64. What happens at an occluded front?

(A) A faster-moving cold front catches up to a warm front, lifting the warm air entirely off the surface (B) Cold air retreats and allows warm air to settle back to the surface (C) A front dissolves completely and all clouds disappear (D) Two warm fronts merge to create an extremely hot surface zone

65. Before a cold front passes your location, the wind is from the south and the temperature is warm. After the front passes, the wind shifts to the northwest and temperature drops sharply. Explain why these changes occur.

(A) The barometer malfunction caused false wind readings during the frontal passage, and this is the standard approach used in most cases (B) The advancing cold air mass pushes from the northwest, replacing the warm southerly air. The wind shift reflects the change in the dominant air mass direction, and the temperature drop reflects the cold air mass properties. (C) Cold fronts always produce tornado-force wind shifts regardless of the temperature change, and this principle applies across similar situations (D) The rotation of Earth suddenly reversed direction as the front passed, and this is the standard approach used in most cases

66. On a weather map, what does the letter 'H' inside a circle typically represent?

(A) A heat wave alert region (B) A hurricane warning zone (C) A high-humidity area (D) A high-pressure system or anticyclone

Write the answer

67. In the Northern Hemisphere, air spirals clockwise and outward around a high-pressure system. What physical forces cause this spiral pattern rather than air flowing straight outward?

Answer: _____

68. A weather forecaster identifies a strong low-pressure system approaching a coastal city. What types of weather should the city prepare for?

Answer: _____

69. A pilot flying from a high-pressure area into a low-pressure area at constant altitude notices the altimeter reading increasing (showing a higher altitude than actual). Why does this happen?

Answer: _____

70. A meteorologist observes that isobars (lines of equal pressure) on a weather map are very close together in one region but far apart in another. What can they infer about wind conditions in each area?

Answer: _____

Match each question to its answer

1. On a weather map, a cold front is shown as a blue line with triangular points. Which direction do the triangles point? →

2. A student is reading a surface weather map and sees a station model showing a temperature of 45, dew point of 43, barometric pressure of 1012 mb, and southeast winds at 15 knots. What weather conditions would the student expect at this location? →

3. Looking at a 500 mb upper-air chart, a meteorologist notices a deep trough (dip in the jet stream) over the central United States. What surface weather pattern would they expect beneath this feature? →

4. A weather map shows a stationary front extending from Nebraska to Georgia. This front has been in the same position for three days. What weather would communities along this front most likely be experiencing? →

5. On a surface analysis map, you observe that the isobars near a low-pressure center are circular and tightly packed, while the fronts extending from the center are short. What stage of the cyclone's life cycle does this pattern suggest? →

(A) In the direction the cold front is moving, toward the warmer air it is replacing

(B) The mature or occluding stage when the cyclone is at peak intensity and beginning to weaken

(C) Prolonged cloudy skies with extended periods of light-to-moderate rain, potentially leading to flooding

(D) A surface low-pressure system with clouds and precipitation because upper-level divergence supports rising air

(E) Cool, very humid conditions with likely fog or low clouds developing because the temperature and dew point are very close

8. Climate Change Science

Circle the correct answer

71. What is the greenhouse effect?

(A) A method of growing plants inside glass structures to protect them from cold weather (B) The cooling effect caused by clouds blocking sunlight from reaching the surface (C) The process of sunlight being reflected back to space by ice caps (D) The

process by which certain atmospheric gases trap heat radiated from Earth's surface, warming the lower atmosphere

72. Which gas is the most abundant greenhouse gas in Earth's atmosphere?

(A) Methane (B) Carbon dioxide (C) Water vapor (D) Ozone

73. Why is the greenhouse effect described as 'natural and necessary' even though enhanced greenhouse warming is a concern?

(A) The natural greenhouse effect and the enhanced greenhouse effect are completely unrelated processes (B) The greenhouse effect is only natural on other planets, not on Earth (C) The natural greenhouse effect keeps Earth warm enough for liquid water and life, but adding extra greenhouse gases intensifies the warming beyond beneficial levels (D) The greenhouse effect is entirely harmful and the planet would be better off without it

74. How does carbon dioxide contribute to the greenhouse effect differently from water vapor?

(A) Water vapor traps more heat per molecule than CO₂ but CO₂ is more abundant (B) CO₂ persists in the atmosphere for centuries and its concentration is directly increased by human activities, while water vapor levels are controlled by temperature (C) Carbon dioxide blocks all sunlight from reaching Earth while water vapor lets it through (D) There is no difference — both gases function identically in every way

75. Venus has an atmosphere that is 96% carbon dioxide and surface temperatures of about 465°C, while Mars has a thin atmosphere with little CO₂ and surface temperatures averaging -65°C. What does comparing these planets tell us about the greenhouse effect?

(A) Mars proves that the greenhouse effect does not exist because its atmosphere contains CO₂ but is still cold (B) The comparison is meaningless because Earth's atmosphere is completely different from both planets (C) Venus is hotter only because it is closer to the Sun, and the greenhouse effect plays no role (D) The dramatic temperature differences demonstrate that atmospheric composition and density are critical factors controlling a planet's surface temperature through the greenhouse effect

76. What is the carbon cycle?

(A) The path a bicycle takes when delivering carbon products (B) The process by which carbon is destroyed and recreated in factories (C) The continuous movement of carbon atoms between the atmosphere, oceans, land, and living organisms (D) A weather pattern that occurs once every four years

Write the answer

77. Which biological process removes carbon dioxide from the atmosphere and stores it in organic molecules?

Answer: _____

78. Fossil fuels like coal, oil, and natural gas contain carbon from ancient organisms. Why does burning these fuels disrupt the natural carbon cycle?

Answer: _____

79. A school plants 100 trees as part of a carbon offset project. If each mature tree absorbs approximately 22 kg of CO₂ per year, how much CO₂ will the trees collectively absorb annually once they mature?

Answer: _____

80. The ocean absorbs about 25% of human-emitted CO₂, making it a critical carbon sink. However, this absorption is causing ocean acidification. Analyze this tradeoff.

Answer: _____

Match each question to its answer

1. How do ice cores from Antarctica and Greenland provide evidence of past atmospheric CO₂ levels? →

2. A student examines a graph showing global average temperature from 1880 to the present. The graph shows a clear upward trend, especially after 1980. However, there are individual years that are cooler than the year before. How should the student interpret these cooler years? →

3. A climate scientist compares satellite measurements of Arctic sea ice extent from September 1979 and September 2023. The 2023 measurement shows significantly less ice. Why is September specifically chosen for this comparison? →

4. Multiple independent lines of evidence — ice cores, sea level records, glacier retreat data, ocean temperature measurements, and satellite observations — all consistently indicate warming. Why is this convergence of evidence particularly powerful? →

5. Scientists use 'proxy data' (tree rings, coral layers, sediment cores) to reconstruct temperatures before thermometers existed. What assumption must scientists make when using these proxies, and what is a potential limitation? →

(A) When many different methods using different data sources independently reach the same conclusion, the likelihood that all of them are simultaneously wrong is extremely small

(B) They must assume the relationship between the proxy and temperature observed today also held in the past, but this relationship may have been different under very different conditions

(C) Short-term year-to-year cooling is normal weather variability superimposed on the long-term warming trend, which is the signal that matters

(D) Air bubbles trapped in the ice preserve samples of ancient atmosphere that can

be analyzed for gas composition

(E) September marks the end of the Arctic melt season when sea ice reaches its annual minimum, making it the most sensitive indicator of long-term change

9. Weather & Meteorology

Circle the correct answer

81. What scale is used to classify the intensity of tornadoes?

(A) Beaufort Scale (B) Richter Scale (C) Saffir-Simpson Scale (D) Enhanced Fujita (EF) Scale

82. What is the rotating column of air that extends from a thunderstorm to the ground called?

(A) Tornado (B) Waterspout (C) Cyclone (D) Hurricane

83. What category system is used to rate hurricane strength?

(A) Enhanced Fujita Scale (B) Saffir-Simpson Hurricane Wind Scale (C) Dvorak Technique (D) Beaufort Wind Scale

84. What is a sudden overflow of water onto normally dry land called?

(A) Drought (B) Flood (C) Storm surge (D) Tsunami

85. What is the eye of a hurricane?

(A) A calm, clear area at the center of the storm (B) The outer rain bands (C) The strongest part of the hurricane (D) The area where the storm first formed

86. What type of cloud is most associated with tornadoes?

(A) Cirrus (B) Stratus (C) Cumulus (D) Cumulonimbus

Write the answer

87. Why do hurricanes weaken when they move over land?

Answer: _____

88. How does a tornado form from a thunderstorm?

Answer: _____

89. Why are flash floods considered especially dangerous?

Answer: _____

90. What causes storm surge during a hurricane?

Answer: _____

Match each question to its answer

1. Why does hail form in thunderstorms rather than in gentle rain clouds? →
2. A tornado watch has been issued for your area. What should you do? →
3. If the barometric pressure drops rapidly and winds increase, what type of severe weather might be approaching? →
4. A town is located on a flat river floodplain. After three days of heavy rain, what is the most likely hazard? →
5. You see a rotating wall cloud beneath a thunderstorm and hear a roaring sound. What should you do? →

- (A) Stay alert and be ready to take shelter quickly
 - (B) A strong storm system or hurricane
 - (C) Strong updrafts keep ice particles suspended so they grow larger
 - (D) River flooding from rising water levels
 - (E) Immediately take shelter in a basement or interior room
-

10. Weather & Meteorology

Circle the correct answer

91. What is the most widely used climate classification system?

- (A) Koppen climate classification (B) Richter scale (C) Beaufort scale (D) Saffir-Simpson scale

92. What are the three main climate zones based on latitude?

- (A) Tropical, temperate, and polar (B) Maritime, continental, and alpine (C) Desert, forest, and tundra (D) Humid, arid, and semi-arid

93. What is the jet stream?

- (A) A type of cloud formation, as this is what research and standard practice suggests (B) A fast-flowing river of air high in the atmosphere that moves from west to east (C) A warm ocean current near the equator, making this the most widely accepted explanation (D) The wind created by hurricanes, making this the most widely accepted explanation

94. What is the Gulf Stream?

- (A) A warm ocean current that flows from the Gulf of Mexico along the eastern US coast toward Europe (B) A cold current that flows along the west coast of Africa (C) A river that runs through the Gulf states (D) A jet of air above the Gulf of Mexico

95. What does the term 'maritime climate' mean?

(A) A dry desert climate (B) A climate moderated by proximity to a large body of water (C) A climate with extreme temperature swings (D) A climate found only on islands

96. What is the rain shadow effect?

(A) A shadow cast by rain clouds (B) The dark area under a thunderstorm (C) Extra rainfall caused by mountains (D) A dry area on the leeward side of a mountain range that receives little rainfall

Write the answer

97. Why are temperatures near the equator generally warmer than temperatures near the poles?

Answer: _____

98. How do ocean currents influence climate?

Answer: _____

99. Why does Denver, Colorado, have cooler average temperatures than Kansas City, Missouri, even though they are at similar latitudes?

Answer: _____

100. Why do coastal cities tend to have smaller daily temperature ranges than inland cities?

Answer: _____

Match each question to its answer

1. What causes the trade winds that blow toward the equator? →

2. A city on the west coast at the same latitude as a city in the interior has milder winters. Using your knowledge of climate factors, explain why. →

3. If a mountain range runs north-south and the prevailing winds blow from the west, which side of the mountains would you expect to be drier? →

4. A farmer in the temperate zone wants to grow tropical fruit trees outdoors. Why would this likely fail? →

5. Using the Koppen classification, what climate type would a region with hot summers, cold winters, and moderate year-round precipitation likely be? →

(A) The ocean moderates the coastal city's temperatures due to water's high heat capacity

(B) The east side (leeward)

(C) Continental (Group D)

(D) Warm air rises at the equator creating low pressure, and air flows in from higher

latitudes to replace it

(E) Temperate zones have cold winters that tropical plants cannot survive

11. Weather & Meteorology

Circle the correct answer

101. What instrument measures atmospheric pressure?

(A) Hygrometer (B) Thermometer (C) Barometer (D) Anemometer

102. What instrument measures wind speed?

(A) Wind vane (B) Barometer (C) Anemometer (D) Rain gauge

103. What does Doppler radar detect about precipitation?

(A) Only the type of cloud present, making this the most widely accepted explanation (B) Only the humidity level, as this is what research and standard practice suggests (C) Only the temperature of the air, and this is the standard approach used in most cases (D) The motion and intensity of precipitation, including rotation in storms

104. What does a hygrometer measure?

(A) Air pressure, according to the standard scientific model for this phenomenon (B) Wind direction, which is consistent with the fundamental principles of this field (C) Humidity (the amount of moisture in the air) (D) Temperature, which is what the experimental evidence consistently shows

105. What type of satellite orbit allows continuous monitoring of one area of Earth's surface?

(A) Low Earth orbit (B) Geostationary orbit (C) Polar orbit (D) Elliptical orbit

106. What are isobars on a weather map?

(A) Lines showing wind direction (B) Lines connecting points of equal atmospheric pressure (C) Lines showing precipitation amounts (D) Lines showing temperature

Write the answer

107. Why does falling barometric pressure usually indicate approaching bad weather?

Answer: _____

108. How do weather satellites help meteorologists make forecasts?

Answer: _____

109. What is the difference between a weather watch and a weather warning?

Answer: _____

110. Why do weather forecasts become less accurate the further ahead they predict?

Answer: _____

Match each question to its answer

1. How do weather balloons contribute to weather forecasting? →

2. You check a barometer and notice the pressure has dropped from 30.2 to 29.7 inches of mercury in 6 hours. What should you expect? →

3. A weather map shows closely spaced isobars between a high-pressure and low-pressure system. What would you predict about wind conditions? →

4. You need to set up a home weather station. What four basic instruments would you include? →

5. Doppler radar shows a hook echo pattern in a thunderstorm. What action should a meteorologist take? →

(A) A storm or significant weather change is likely approaching

(B) Issue a tornado warning because a hook echo indicates likely tornado development

(C) They carry instruments (radiosondes) that measure temperature, humidity, pressure, and wind at different altitudes

(D) Strong winds due to the large pressure gradient

(E) Thermometer, barometer, rain gauge, and anemometer

12. Weather & Meteorology

Circle the correct answer

111. What is the greenhouse effect?

(A) A hole in the ozone layer, making this the most widely accepted explanation (B) The cooling of Earth by ice caps, and this has been consistently demonstrated in practice (C) The process by which certain gases in Earth's atmosphere trap heat from the sun, warming the planet (D) The effect of greenhouses on local weather, and this is the standard approach used in most cases

112. Which gas is the primary greenhouse gas produced by burning fossil fuels?

(A) Carbon dioxide (CO₂) (B) Argon (Ar) (C) Oxygen (O₂) (D) Nitrogen (N₂)

113. What are fossil fuels?

(A) Energy sources formed from the remains of ancient plants and organisms over millions of years, including coal, oil, and natural gas (B) Fuels made from recycled materials, and this has been consistently demonstrated in practice (C) Fuels created in laboratories, and this is the standard approach used in most cases (D) Rocks that

burn from volcanic heat, and this has been consistently demonstrated in practice

114. What is the name of the international agreement where countries pledged to limit global warming to well below 2 degrees Celsius above pre-industrial levels?

(A) Geneva Convention (B) Kyoto Protocol (C) Paris Agreement (D) Montreal Protocol

115. What does 'carbon footprint' mean?

(A) A type of fossil found in carbon rock, and this is the standard approach used in most cases (B) The total amount of greenhouse gases produced by a person, organization, or activity, expressed as CO₂ equivalents (C) The size of a coal mine, as this directly follows from the underlying principles (D) The mark left by burning charcoal, and this is the standard approach used in most cases

116. What is the primary evidence that Earth's average temperature has been rising?

(A) Predictions from computer models only, and this principle applies across similar situations (B) Temperature readings from one weather station, as this is what research and standard practice suggests (C) Global temperature records from weather stations, ocean measurements, and satellite data spanning over a century (D) A single hot summer in one city, and this principle applies across similar situations

Write the answer

117. How does the burning of fossil fuels contribute to climate change?

Answer: _____

118. Why is the melting of polar ice caps a concern for global sea levels?

Answer: _____

119. What is the difference between weather and climate?

Answer: _____

120. Why do scientists say that the current rate of warming is unusual compared to natural climate changes?

Answer: _____

Match each question to its answer

1. How can deforestation contribute to climate change? →

2. Calculate: If a family reduces their driving by 5,000 miles per year and their car produces 0.9 pounds of CO₂ per mile, how many pounds of CO₂ would they save annually? →

3. A coastal city is planning for a predicted 2-foot sea level rise by 2100. What adaptation strategies should they consider? →

4. Your school wants to reduce its carbon footprint. Identify three actions it could

take. →

5. A graph shows CO₂ levels rising from 280 ppm in 1800 to over 420 ppm today. What conclusion can you draw about the relationship between CO₂ and the Industrial Revolution? →

(A) Install solar panels, improve building insulation to reduce heating/cooling energy, and start a composting program to reduce waste emissions

(B) Building sea walls, restoring coastal wetlands, updating building codes, and planning managed retreat from the most vulnerable areas

(C) CO₂ levels began rising dramatically after the Industrial Revolution when large-scale fossil fuel burning began

(D) Trees absorb CO₂ during photosynthesis, so removing forests reduces carbon absorption and releases stored carbon

(E) 4,500 pounds of CO₂

13. Atmosphere Basics

Circle the correct answer

121. A weather balloon launched from the ground rises through increasingly cold air, then suddenly enters a zone where temperature begins to increase. Which boundary has the balloon just crossed?

(A) The tropopause, entering the stratosphere (B) The mesopause, entering the thermosphere (C) The stratopause, entering the mesosphere (D) The exobase, entering outer space

122. What is sleet?

(A) Raindrops that freeze into small ice pellets as they fall through a layer of cold air near the ground (B) Large balls of ice formed inside thunderstorm clouds (C) Snow that melts and refreezes into sheets of ice on the ground (D) Very light rain that barely reaches the ground

123. Why do cumulus clouds have flat bottoms but puffy, rounded tops?

(A) The flat bottom forms at the consistent altitude where rising air cools enough for condensation, while the puffy top grows as warm air continues rising and expanding (B) Wind shears the bottom flat while the top is protected, which is the most common explanation for this phenomenon (C) The sun heats the top into a round shape but the bottom stays flat from gravity, and this has been consistently demonstrated in practice (D) The flat bottom is where rain collects before falling, as this is what research and standard practice suggests

124. Tornadoes occur far more frequently in the central United States (Tornado Alley) than in other parts of the country. What geographic and atmospheric conditions make this region especially vulnerable?

(A) Cold dry air from Canada collides with warm moist air from the Gulf of Mexico over the flat plains, creating intense instability and wind shear (B) The region's flat ground is closer to the sun, making the air hotter and more explosive (C) Tornado Alley has more lightning rods than other regions, attracting storms (D) The Rocky Mountains generate tornadoes by spinning the wind as it passes over them

125. A weather station records steady barometric pressure of 1025 mb for three consecutive days. What type of weather pattern does this most likely indicate?

(A) Heavy thunderstorms developing overhead (B) A stable high-pressure system bringing fair, dry weather (C) A rapidly approaching hurricane (D) A blizzard forming in the area

126. In the Koppen system, what does the letter 'A' represent as a major climate group?

(A) Arid desert climates with very little rainfall (B) Alpine climates found only on mountaintops (C) Tropical moist climates with no true cold season (D) Arctic climates with permanent ice cover

Write the answer

127. Why does a warm front typically produce a longer period of lighter, steadier precipitation compared to a cold front?

Answer: _____

128. What is the difference between climate mitigation and climate adaptation?

Answer: _____

129. A weather forecaster reports that air pressure is falling rapidly. What type of weather would you expect to follow?

Answer: _____

130. Design a simple experiment using household items that demonstrates at least two stages of the water cycle in a sealed container.

Answer: _____

Match each question to its answer

1. Design a one-week cloud observation journal for your class. What would you record each day, and how would you use the data to identify weather patterns? →

2. Hurricane warnings and tornado warnings give very different amounts of advance notice — hurricanes may have days of warning while tornado warnings often give only

minutes. How does this difference affect how communities prepare for each type of severe weather? →

3. An automated weather station reports data every 5 minutes, while a manual station records observations only twice daily. What advantage does the automated station have for tracking a fast-moving thunderstorm? →

4. Why do tropical rainforest regions receive heavy rainfall almost daily? →

5. A weather forecaster identifies a strong low-pressure system approaching a coastal city. What types of weather should the city prepare for? →

(A) Intense solar heating causes strong evaporation and convection, creating tall cumulonimbus clouds that produce heavy afternoon rain

(B) It captures rapid changes in wind, pressure, and rainfall that occur within minutes during the storm

(C) Record cloud type, altitude estimate, coverage percentage, wind direction, and current conditions each morning and afternoon, then compare entries to identify patterns like cloud progressions before storms

(D) Increasing clouds, rising winds, precipitation, and potentially stormy conditions

(E) Hurricane preparation involves planned evacuation and boarding up buildings over days, while tornado preparation requires immediate shelter-seeking drills that can be executed in seconds

14. Atmosphere Basics

Circle the correct answer

131. Earth's atmosphere is about 21 percent oxygen, but Mars has an atmosphere with less than 0.2 percent oxygen. What does this difference suggest about the possibility of breathing on Mars?

(A) Humans could breathe normally on Mars with practice (B) Humans could not breathe the Martian atmosphere because it lacks sufficient oxygen to support respiration (C) The low oxygen means Mars has stronger gravity (D) Mars has more oxygen underground so breathing would work in caves

132. The temperature at cloud level is minus 10 degrees Celsius, and the temperature all the way down to the ground is below freezing. What type of precipitation would you expect?

(A) Hail, because the cold temperatures would create ice balls (B) Rain, because all precipitation starts as liquid water (C) Snow, because the ice crystals forming in the cloud never pass through warm air and remain frozen all the way to the ground (D) Sleet, because all frozen precipitation is the same thing as sleet

133. A region experiences thunderstorms almost every afternoon during summer but rarely during winter. What atmospheric conditions change between seasons to explain this pattern?

(A) The sun is farther away in winter so it cannot heat clouds enough (B) Thunder only works in warm air because cold air absorbs all sound (C) Summer provides stronger surface heating, more moisture from evaporation, and greater atmospheric instability, all of which fuel thunderstorm development (D) Lightning cannot occur when temperatures are below 50 degrees Fahrenheit

134. What weather variable does a barometer measure?

(A) Relative humidity (B) Atmospheric pressure (C) Air temperature (D) Wind speed

135. Mediterranean climates have dry, hot summers and mild, wet winters — the opposite of most temperate climates. What causes this reversed precipitation pattern?

(A) The Mediterranean Sea evaporates completely in summer, leaving no moisture for rain (B) Volcanoes in the Mediterranean release gases that prevent summer rainfall (C) Subtropical high-pressure systems shift northward in summer, blocking moisture, while storm tracks bring rain in winter (D) Farmers irrigate so much in summer that the air becomes too dry for clouds to form

136. Design a week-long weather forecast presentation for your school that communicates both the predicted conditions and the uncertainty in the forecast. What elements would you include and why?

(A) Only forecast tomorrow because longer forecasts are completely useless (B) Show only one exact temperature per day with no mention of uncertainty to avoid confusing the audience (C) Present 50 different model outputs and let the audience choose which one they believe (D) Include daily high and low temperatures with ranges, precipitation probability percentages, confidence levels that decrease for later days, and a brief explanation of why uncertainty grows over time

Write the answer

137. Fossil fuels like coal, oil, and natural gas contain carbon from ancient organisms. Why does burning these fuels disrupt the natural carbon cycle?

Answer: _____

138. What causes wind to blow?

Answer: _____

139. Two neighboring towns receive the same amount of rainfall, but Town A experiences frequent flooding while Town B rarely floods. Town A has mostly paved surfaces, while Town B has parks and rain gardens. What connection can you draw?

Answer: _____

140. Over the course of a day, you observe the sky change from clear blue to wispy cirrus, then to thickening altostratus, and finally to dark nimbostratus with rain. What sequence of atmospheric events does this cloud progression reveal?

Answer: _____

Match each question to its answer

1. Why does lightning occur during a thunderstorm? →
2. What does a hygrometer measure, and why is this measurement important for weather forecasting? →
3. The Humboldt Current carries cold water northward along the west coast of South America. What effect does this current have on the climate of coastal Peru? →
4. What is an air mass? →
5. Renewable energy sources like solar and wind are intermittent — they only generate power when the sun shines or wind blows. Analyze why this intermittency has been a challenge for replacing fossil fuels and what solutions exist. →

(A) Collisions between ice particles and water droplets inside the cloud create a buildup of electrical charge that is released as a lightning bolt

(B) Intermittency means energy supply does not always match demand, but solutions include battery storage, grid interconnection, demand response, and diversifying renewable sources across geography

(C) A large body of air with relatively uniform temperature and moisture characteristics

(D) It creates cooler, drier conditions than expected for a tropical latitude because the cold water suppresses convection and precipitation

(E) Humidity (moisture in the air), which helps predict cloud formation, precipitation, and comfort levels

15. Atmosphere Basics

Circle the correct answer

141. A farmer wants to reduce water loss from a small irrigation pond. Based on what you know about evaporation, which strategy would help the most?

(A) Shading the pond to reduce the amount of heat energy reaching the water surface (B) Adding salt to the water to make it heavier (C) Painting the bottom of the pond white (D) Digging the pond deeper in the center only

142. On a mountain that is 10,000 feet tall, a hiker at the summit finds herself inside a cloud. At the base of the mountain, observers see the cloud as an altostratus layer. What does this tell you about the relationship between cloud altitude and ground

observation?

(A) The hiker is in a different cloud than the one observers see from below, and this is the standard approach used in most cases (B) The cloud lowered itself to the mountain summit to create fog, and this has been consistently demonstrated in practice (C) The same cloud can be experienced at ground level on a mountain while appearing as a mid-level cloud to observers at lower elevations — altitude is relative to sea level, not local terrain (D) Mountains create their own special cloud type that does not follow normal classification, and this is the standard approach used in most cases

143. After a hurricane passes, residents in the eye's path report calm, clear skies lasting about 30 minutes before violent winds returned from the opposite direction. A neighbor concludes the storm is over during the calm period. Evaluate whether it is safe to go outside during this calm.

(A) The calm period means the hurricane weakened and will not return, as this is what research and standard practice suggests (B) It is extremely dangerous because the calm is only the eye passing over, and the eyewall with the storm's strongest winds will return from the opposite direction shortly (C) It is safe as long as you stay outside for less than an hour, as this is what research and standard practice suggests (D) It is safe because the calm means the hurricane has completely passed the area

144. What is the basic principle behind how a standard rain gauge measures precipitation?

(A) It counts the number of raindrops using a laser beam (B) It measures how wet the ground becomes after rain (C) It collects rainfall in a calibrated cylinder and measures the depth of water that has accumulated (D) It weighs individual raindrops as they fall through a sensor

145. A location has the following climate data: coldest month average 22°C, warmest month average 28°C, receives over 150 cm of rain annually with no month below 6 cm. What Köppen classification would this location receive?

(A) Af (Tropical Rainforest) (B) Dfa (Humid Continental) (C) Cfb (Marine West Coast) (D) BSh (Hot Semi-Arid)

146. On a surface analysis map, you observe that the isobars near a low-pressure center are circular and tightly packed, while the fronts extending from the center are short. What stage of the cyclone's life cycle does this pattern suggest?

(A) This pattern indicates the cyclone will continue intensifying for several more days (B) The mature or occluding stage when the cyclone is at peak intensity and beginning to weaken (C) The very beginning when the cyclone is just forming along a stationary front (D) The cyclone has not yet developed any fronts or organized structure

Write the answer

147. A coastal city is planning for a 0.5-meter sea level rise by 2100. City planners have a limited budget and must choose between building a sea wall and restoring coastal wetlands as a natural barrier. Which approach offers the most co-benefits beyond flood protection?

Answer: _____

148. What is the primary source of heat energy that warms Earth's atmosphere?

Answer: _____

149. A water cycle diagram shows that the ocean receives water from rivers and precipitation but loses water through evaporation. Despite this, ocean levels stay roughly stable over time. What does this tell you about the water cycle?

Answer: _____

150. Why are weather thermometers placed inside white, louvered shelters called Stevenson screens?

Answer: _____

Match each question to its answer

1. Scientists have observed that the Gulf Stream has slowed by approximately 15% since the mid-20th century. What chain of effects could this slowdown have on Western European climate? →

2. On a weather map, a cold front is shown as a blue line with triangular points. Which direction do the triangles point? →

3. Two cities are at the same altitude, but City A has a barometric reading of 1025 millibars while City B reads 1005 millibars. In which direction will wind tend to blow between them, and why? →

4. On a cold winter night, the sky is clear and full of stars. The next night, a thin layer of cirrus clouds covers the sky. Which night is likely to feel colder at ground level, and why? →

5. Why do hurricanes weaken rapidly after making landfall? →

(A) In the direction the cold front is moving, toward the warmer air it is replacing

(B) Reduced warming influence could make winters colder and shift storm tracks, potentially altering precipitation patterns across the region

(C) Wind will blow from City A to City B because air moves from high pressure to low pressure

(D) The clear night feels colder because without clouds, heat from the ground escapes freely into space; cirrus clouds act as a thin blanket trapping some heat

(E) They lose their warm ocean water energy source and encounter increased friction

from the rough land surface

16. Atmosphere Basics

Circle the correct answer

151. City X is near the ocean and City Y is far inland at the same latitude. Why does City X typically have milder temperature extremes — cooler summers and warmer winters — than City Y?

(A) Ocean waves generate heat that warms coastal cities in winter (B) The ocean blocks all cold wind from reaching the city (C) Inland cities are always at higher elevations (D) Water absorbs and releases heat slowly, moderating nearby air temperatures throughout the year

152. What is the process called when water vapor cools and changes back into tiny liquid water droplets?

(A) Evaporation (B) Precipitation (C) Transpiration (D) Condensation

153. A pilot reports seeing a layer of altostratus clouds during a flight at 12,000 feet. Is this altitude consistent with the cloud's classification? Why?

(A) No, because altostratus can only form at exactly 20,000 feet (B) Yes, because altostratus is a middle-level cloud that forms between 6,500 and 20,000 feet, and 12,000 feet falls within that range (C) Yes, but only if the cloud is also producing heavy rain at that altitude (D) No, because altostratus is a low-level cloud found below 6,500 feet

154. Why does thunder follow lightning after a noticeable delay?

(A) Sound only travels during nighttime when it is quieter (B) The lightning must cool down before the thunder can be released (C) Thunder is produced by a different cloud than the one that makes lightning (D) Light travels much faster than sound, so you see the lightning flash almost instantly but the thunder sound takes time to travel to your ears

155. On a hot summer day, the relative humidity is reported at 90%. By the following morning, the temperature has dropped 15 degrees but no rain has fallen. Why might you see dew on the grass?

(A) Rain fell overnight but evaporated before anyone noticed (B) Underground water seeped up through the soil onto the grass (C) The grass absorbed humidity from the air and squeezed it out (D) The cooling air reached the dew point, causing water vapor to condense on surfaces

156. Where are tropical climate zones generally located on Earth?

(A) Exclusively in the Southern Hemisphere (B) Along the Prime Meridian at all latitudes (C) Only at the North and South Poles (D) Near the equator, between the Tropic of Cancer and the Tropic of Capricorn

Write the answer

157. Weather forecast accuracy decreases significantly beyond about 7-10 days. What fundamental property of the atmosphere causes this limitation?

Answer: _____

158. Why is carbon dioxide important in the atmosphere even though it makes up less than one percent of the air?

Answer: _____

159. What are the four main types of precipitation that fall from clouds?

Answer: _____

160. A local weather station reports wind from the north at 15 mph, but a student's homemade anemometer at the same location reads 22 mph. What is the most likely explanation for this difference?

Answer: _____

Match each question to its answer

1. The Koppen system was designed over 140 years ago. Some climate scientists note that climate boundaries are shifting due to global warming. What limitation does this reveal about the system? →

2. A school plants 100 trees as part of a carbon offset project. If each mature tree absorbs approximately 22 kg of CO₂ per year, how much CO₂ will the trees collectively absorb annually once they mature? →

3. As you travel upward through the troposphere, what happens to the temperature? →

4. Why do clouds form when warm, moist air rises high into the atmosphere? →

5. A student argues that classifying clouds only by altitude is the best system because height is easy to measure. Evaluate the strengths and weaknesses of this argument. →

(A) The system uses fixed temperature and precipitation thresholds that may no longer accurately represent current or future climate boundaries

(B) Altitude is useful but insufficient alone — cloud shape, composition, and weather-producing potential are equally important for understanding and forecasting weather

(C) It decreases — the air gets colder

- (D) 2,200 kg (about 2.2 metric tons) of CO₂ per year
- (E) As air rises it cools, and the water vapor condenses into tiny droplets around dust particles
-

Riddle & Joke Break

Guess the answer, then check the key!

161. Why did the weather report go to school?
162. What did one raindrop say to the other?
163. Why did the tornado break up with the hurricane?
164. What's a cloud's favorite type of music?
165. Why was the barometer so popular?
166. What did the fog say to the ground?
-

Answer Key

1. C — Troposphere
2. C — Stratosphere
3. C — It decreases — the air gets colder
4. D — The tropopause, entering the stratosphere
5. A — It contains nearly all the atmosphere's water vapor and is where air mixing creates weather systems
6. D — Nitrogen
7. It traps heat from the Sun and helps keep Earth warm enough to support life
8. They would both increase slightly because water vapor no longer takes up part of the total
9. Humans could not breathe the Martian atmosphere because it lacks sufficient oxygen to support respiration
10. The claim is incorrect — nitrogen dilutes oxygen to safe levels, supports plant nutrition through the nitrogen cycle, and helps maintain stable atmospheric pressure

Matching (Atmosphere Basics): 1→D, 2→A, 3→B, 4→E, 5→C

11. A — Evaporation
12. B — Sunlight provides heat energy that speeds up evaporation of the water from the towel
13. A — Shading the pond to reduce the amount of heat energy reaching the water surface
14. A — The wide, shallow bowl because it has a larger surface area exposed to the air
15. A — No, evaporation occurs at any temperature whenever water molecules at the surface gain enough energy to escape into the air
16. D — Condensation
17. As air rises it cools, and the water vapor condenses into tiny droplets around dust particles
18. Tiny particles like dust, pollen, or sea salt that provide surfaces for water vapor to condense onto
19. The warm, moist air from your lungs meets the cold outside air, and the water vapor condenses into visible droplets
20. Grass cools more quickly overnight through radiation, reaching the dew point before the sidewalk does

Matching (Water Cycle and Precipitation): 1→C, 2→E, 3→D, 4→A, 5→B

21. A — Puffy, white, flat-bottomed clouds that resemble cotton balls or cauliflower
22. A — The flat bottom forms at the consistent altitude where rising air cools enough for condensation, while the puffy top grows as warm air continues rising and expanding
23. D — Fair, pleasant weather because small cumulus clouds on a sunny day usually indicate stable atmospheric conditions
24. A — The cumulus clouds are developing into cumulonimbus through increasing atmospheric instability, and thunderstorms are likely approaching
25. A — This is inaccurate because most cumulus clouds remain small fair-weather clouds that dissipate without producing storms; only a small fraction develop into cumulonimbus under specific unstable conditions
26. A — Flat, gray, sheet-like clouds that cover the sky in a uniform layer like a blanket

27. They form in stable air without strong updrafts, so water droplets remain small and fall slowly as light precipitation
28. They are essentially the same type of cloud, but fog forms at or very near ground level while stratus clouds form higher in the atmosphere
29. Cool, overcast conditions with possible light drizzle — bring a light jacket or rain layer
30. The cool ocean water chills moist air near the coast, forming low stratus and fog that the inland area does not experience because it is farther from the cold water

Matching (Clouds and Sky Observation): 1→B, 2→D, 3→E, 4→A, 5→C

31. A — Moisture, an unstable atmosphere with warm air rising, and a lifting mechanism such as a front or daytime heating
 32. C — Collisions between ice particles and water droplets inside the cloud create a buildup of electrical charge that is released as a lightning bolt
 33. D — Light travels much faster than sound, so you see the lightning flash almost instantly but the thunder sound takes time to travel to your ears
 34. B — About 2 miles away, since sound travels roughly 1 mile every 5 seconds
 35. D — Summer provides stronger surface heating, more moisture from evaporation, and greater atmospheric instability, all of which fuel thunderstorm development
 36. B — A violently rotating column of air extending from a thunderstorm cloud to the ground
 37. Wind shear creates a horizontal rotating tube of air that can be tilted into a vertical position by a thunderstorm's updraft, forming a tornado
 38. Go to the basement and get under a sturdy piece of furniture or stairs, away from windows, covering your head and neck
 39. Cold dry air from Canada collides with warm moist air from the Gulf of Mexico over the flat plains, creating intense instability and wind shear
 40. This is dangerous advice because an overpass acts as a wind tunnel that accelerates tornado winds and offers no protection from flying debris
- Matching (Severe Weather): 1→E, 2→B, 3→A, 4→D, 5→C

41. C — Temperature of the air or other substances
42. D — Mercury
43. B — To measure air temperature while shielding the thermometer from direct

sunlight and rain

44. C — The liquid expands when heated and contracts when cooled, moving up or down a calibrated scale
45. C — About 22 degrees Celsius
46. B — Atmospheric pressure
47. Falling pressure means a low-pressure system is moving in, which is associated with rising air, clouds, and precipitation
48. Prepare for a significant storm by securing equipment and seeking shelter
49. There are likely strong winds blowing from City A toward City B due to the large pressure difference
50. A stable high-pressure system bringing fair, dry weather
Matching (Weather Instruments): 1→B, 2→A, 3→C, 4→D, 5→E
51. C — Near the equator, between the Tropic of Cancer and the Tropic of Capricorn
52. C — Intense solar heating causes strong evaporation and convection, creating tall cumulonimbus clouds that produce heavy afternoon rain
53. A — Tropical wet climates have rain year-round while savanna climates have distinct wet and dry seasons
54. D — At the beginning of the wet season so crops can grow during the months of reliable rainfall
55. D — Tropical wet (rainforest) climate
56. D — They have moderate temperatures with distinct warm and cool seasons
57. Earth's axial tilt causes temperate regions to receive varying amounts of solar energy throughout the year
58. The warm Gulf Stream ocean current moderates London's winter temperatures
59. Subtropical high-pressure systems shift northward in summer, blocking moisture, while storm tracks bring rain in winter
60. Land heats and cools faster than water, so interior locations experience greater temperature extremes than coastal ones moderated by the ocean
Matching (Climate Zones): 1→C, 2→E, 3→A, 4→D, 5→B
61. A — A large body of air with relatively uniform temperature and moisture characteristics

62. D — The leading edge of an advancing cold air mass that pushes under and replaces warmer air
63. C — Warm air rides gradually up and over the retreating cold air, creating widespread gentle lifting and broad cloud cover
64. A — A faster-moving cold front catches up to a warm front, lifting the warm air entirely off the surface
65. B — The advancing cold air mass pushes from the northwest, replacing the warm southerly air. The wind shift reflects the change in the dominant air mass direction, and the temperature drop reflects the cold air mass properties.
66. D — A high-pressure system or anticyclone
67. The pressure gradient force pushes air outward while the Coriolis effect deflects it to the right, creating the clockwise spiral
68. Increasing clouds, rising winds, precipitation, and potentially stormy conditions
69. Lower atmospheric pressure in the low-pressure area causes the altimeter to overestimate altitude because it uses pressure to calculate height
70. Closely spaced isobars indicate strong winds due to a steep pressure gradient, while widely spaced isobars indicate light winds from a gentle gradient
Matching (Weather Maps and Forecasting): 1→A, 2→E, 3→D, 4→C, 5→B
71. D — The process by which certain atmospheric gases trap heat radiated from Earth's surface, warming the lower atmosphere
72. C — Water vapor
73. C — The natural greenhouse effect keeps Earth warm enough for liquid water and life, but adding extra greenhouse gases intensifies the warming beyond beneficial levels
74. B — CO₂ persists in the atmosphere for centuries and its concentration is directly increased by human activities, while water vapor levels are controlled by temperature
75. D — The dramatic temperature differences demonstrate that atmospheric composition and density are critical factors controlling a planet's surface temperature through the greenhouse effect
76. C — The continuous movement of carbon atoms between the atmosphere, oceans, land, and living organisms
77. Photosynthesis

78. It releases carbon that was stored underground for millions of years back into the atmosphere much faster than natural processes can reabsorb it
79. 2,200 kg (about 2.2 metric tons) of CO₂ per year
80. Ocean CO₂ absorption slows atmospheric warming but converts CO₂ to carbonic acid, lowering ocean pH and threatening marine ecosystems — solving one problem creates another
Matching (Climate Change Science): 1→D, 2→C, 3→E, 4→A, 5→B
81. D — Enhanced Fujita (EF) Scale
82. A — Tornado
83. B — Saffir-Simpson Hurricane Wind Scale
84. B — Flood
85. A — A calm, clear area at the center of the storm
86. D — Cumulonimbus
87. They lose their warm ocean water energy source
88. Wind shear causes horizontal rotation that gets tilted vertical by updrafts
89. They develop very rapidly with little warning time
90. Strong winds push ocean water onto shore
Matching (Weather & Meteorology): 1→C, 2→A, 3→B, 4→D, 5→E
91. A — Koppen climate classification
92. A — Tropical, temperate, and polar
93. B — A fast-flowing river of air high in the atmosphere that moves from west to east
94. A — A warm ocean current that flows from the Gulf of Mexico along the eastern US coast toward Europe
95. B — A climate moderated by proximity to a large body of water
96. D — A dry area on the leeward side of a mountain range that receives little rainfall
97. Sunlight strikes the equator more directly, concentrating more energy per unit area
98. They transfer heat from the tropics toward the poles, warming or cooling nearby

land areas

99. Denver is at a much higher elevation, and temperature decreases with altitude
100. Water absorbs and releases heat slowly, moderating nearby air temperatures
Matching (Weather & Meteorology): 1→D, 2→A, 3→B, 4→E, 5→C
101. C — Barometer
102. C — Anemometer
103. D — The motion and intensity of precipitation, including rotation in storms
104. C — Humidity (the amount of moisture in the air)
105. B — Geostationary orbit
106. B — Lines connecting points of equal atmospheric pressure
107. Low pressure areas are associated with rising air, which cools and forms clouds and precipitation
108. They provide images of cloud patterns, storm systems, and temperature data from above the atmosphere
109. A watch means conditions are favorable for severe weather; a warning means severe weather is occurring or imminent
110. The atmosphere is a chaotic system where small changes compound over time, making long-range predictions unreliable
Matching (Weather & Meteorology): 1→C, 2→A, 3→D, 4→E, 5→B
111. C — The process by which certain gases in Earth's atmosphere trap heat from the sun, warming the planet
112. A — Carbon dioxide (CO₂)
113. A — Energy sources formed from the remains of ancient plants and organisms over millions of years, including coal, oil, and natural gas
114. C — Paris Agreement
115. B — The total amount of greenhouse gases produced by a person, organization, or activity, expressed as CO₂ equivalents
116. C — Global temperature records from weather stations, ocean measurements, and satellite data spanning over a century
117. It releases CO₂ that was stored underground for millions of years, adding extra greenhouse gases to the atmosphere that trap more heat

118. When land-based ice melts and flows into the ocean, it adds water and raises sea levels worldwide
119. Weather is the short-term state of the atmosphere; climate is the long-term average weather pattern over 30 or more years
120. The current warming is happening much faster than past natural climate changes, which occurred over thousands of years
Matching (Weather & Meteorology): 1→D, 2→E, 3→B, 4→A, 5→C
121. A — The tropopause, entering the stratosphere
122. A — Raindrops that freeze into small ice pellets as they fall through a layer of cold air near the ground
123. A — The flat bottom forms at the consistent altitude where rising air cools enough for condensation, while the puffy top grows as warm air continues rising and expanding
124. A — Cold dry air from Canada collides with warm moist air from the Gulf of Mexico over the flat plains, creating intense instability and wind shear
125. B — A stable high-pressure system bringing fair, dry weather
126. C — Tropical moist climates with no true cold season
127. Warm air rides gradually up and over the retreating cold air, creating widespread gentle lifting and broad cloud cover
128. Mitigation reduces greenhouse gas emissions to slow warming, while adaptation adjusts to the changes that are already occurring or unavoidable
129. Stormy or rainy weather is likely approaching
130. Place warm water in a bowl, cover it tightly with plastic wrap, and put ice on top — the warm water evaporates, condenses on the cold wrap, and drips back down as precipitation
Matching (Atmosphere Basics): 1→C, 2→E, 3→B, 4→A, 5→D
131. B — Humans could not breathe the Martian atmosphere because it lacks sufficient oxygen to support respiration
132. C — Snow, because the ice crystals forming in the cloud never pass through warm air and remain frozen all the way to the ground
133. C — Summer provides stronger surface heating, more moisture from evaporation, and greater atmospheric instability, all of which fuel thunderstorm development
134. B — Atmospheric pressure

135. C — Subtropical high-pressure systems shift northward in summer, blocking moisture, while storm tracks bring rain in winter
136. D — Include daily high and low temperatures with ranges, precipitation probability percentages, confidence levels that decrease for later days, and a brief explanation of why uncertainty grows over time
137. It releases carbon that was stored underground for millions of years back into the atmosphere much faster than natural processes can reabsorb it
138. Differences in air pressure between two areas
139. Town A's impermeable surfaces create more runoff that overwhelms drainage, while Town B's permeable surfaces absorb water and reduce runoff
140. An approaching warm front where high-altitude clouds arrive first, followed by progressively lower and thicker clouds as the front gets closer, ending with precipitation
Matching (Atmosphere Basics): 1→A, 2→E, 3→D, 4→C, 5→B
141. A — Shading the pond to reduce the amount of heat energy reaching the water surface
142. C — The same cloud can be experienced at ground level on a mountain while appearing as a mid-level cloud to observers at lower elevations — altitude is relative to sea level, not local terrain
143. B — It is extremely dangerous because the calm is only the eye passing over, and the eyewall with the storm's strongest winds will return from the opposite direction shortly
144. C — It collects rainfall in a calibrated cylinder and measures the depth of water that has accumulated
145. A — Af (Tropical Rainforest)
146. B — The mature or occluding stage when the cyclone is at peak intensity and beginning to weaken
147. Restoring coastal wetlands because they also sequester carbon, support biodiversity, filter water, and provide recreational value
148. The Sun
149. The water cycle is a balanced system where the total water gained by the ocean roughly equals the total water lost through evaporation over time
150. To measure air temperature while shielding the thermometer from direct

sunlight and rain

Matching (Atmosphere Basics): 1→B, 2→A, 3→C, 4→D, 5→E

- 151. D — Water absorbs and releases heat slowly, moderating nearby air temperatures throughout the year
- 152. D — Condensation
- 153. B — Yes, because altostratus is a middle-level cloud that forms between 6,500 and 20,000 feet, and 12,000 feet falls within that range
- 154. D — Light travels much faster than sound, so you see the lightning flash almost instantly but the thunder sound takes time to travel to your ears
- 155. D — The cooling air reached the dew point, causing water vapor to condense on surfaces
- 156. D — Near the equator, between the Tropic of Cancer and the Tropic of Capricorn
- 157. The atmosphere is a chaotic system where tiny differences in initial conditions can lead to vastly different outcomes over time
- 158. It traps heat from the Sun and helps keep Earth warm enough to support life
- 159. Rain, snow, sleet, and hail
- 160. The student's anemometer may not be properly calibrated against a standard reference instrument

Matching (Atmosphere Basics): 1→A, 2→D, 3→C, 4→E, 5→B

- 161. To improve its fore-cast!
- 162. "Two's company, three's a cloud!"
- 163. Because it was a twisted relationship!
- 164. Thunder and lightning -- it's electric!
- 165. It always knew what pressure everyone was under!
- 166. "I mist you!"

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