

## Groundwater Study Guide

### Modified True/False

Indicate whether the sentence or statement is true or false. If false, change the identified word or phrase to make the sentence or statement true.

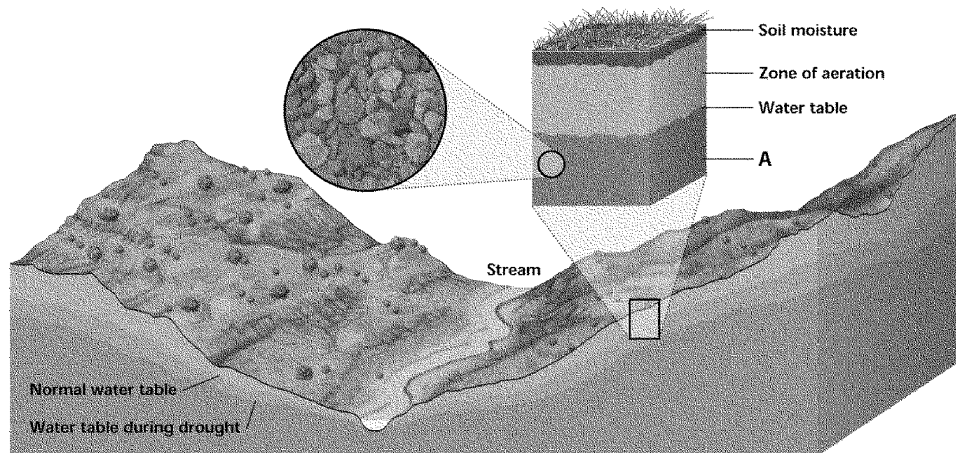
- \_\_\_\_ 1. Aquifers are barriers to groundwater flow. \_\_\_\_\_
- \_\_\_\_ 2. Limestone consists mostly of calcium carbonate, which dissolves readily in water.  
\_\_\_\_\_
- \_\_\_\_ 3. When a zone of saturation overlies an aquiclude and separates it from the water table below, it forms a(n) perched water table. \_\_\_\_\_
- \_\_\_\_ 4. The most easily polluted groundwater reservoirs are water table confined aquifers.  
\_\_\_\_\_
- \_\_\_\_ 5. Only a small portion of precipitation becomes groundwater and is returned directly to the oceans through streams and rivers. \_\_\_\_\_
- \_\_\_\_ 6. The depth of the water table in stream valleys is close to Earth's surface.  
\_\_\_\_\_
- \_\_\_\_ 7. The flow velocity of groundwater depends on the height of the water table.  
\_\_\_\_\_
- \_\_\_\_ 8. Groundwater is slightly acidic and evaporates limestone. \_\_\_\_\_
- \_\_\_\_ 9. The combination of water (H<sub>2</sub>O) and carbon dioxide (CO<sub>2</sub>) produces hydrogen (H).  
\_\_\_\_\_
- \_\_\_\_ 10. Common sources of groundwater pollution include sewage and harmful chemicals.  
\_\_\_\_\_

### Multiple Choice

Identify the letter of the choice that best completes the statement or answers the question.

- \_\_\_\_ 11. Much of the water that falls on the ground as precipitation \_\_\_\_\_.
  - a. enters the ground through the process of infiltration
  - b. evaporates back into the atmosphere
  - c. becomes runoff and finds its way back to the ocean
  - d. forms small pools

\_\_\_ 12. In the diagram below, the area labeled A is called the \_\_\_.



- a. zone of infiltration                      c. zone of saturation  
 b. recharge zone                            d. zone of permeability
- \_\_\_ 13. What is responsible for the production of most ions in groundwater?  
 a. precipitation of calcium carbonate  
 b. groundwater surges  
 c. dissolution of carbonic acid and calcium carbonate  
 d. geysers reacting with carbonic acid
- \_\_\_ 14. What two materials are necessary for the formation of most caves?  
 a. water and carbon dioxide              c. soft water and travertine  
 b. carbonic acid and groundwater        d. acidic groundwater and limestone

### Completion

Complete each sentence or statement.

15. Through the process of \_\_\_\_\_, most precipitation that falls on land becomes groundwater.
16. The percentage of pore space, or \_\_\_\_\_, of sand is about 30 percent.
17. The \_\_\_\_\_ is an area below Earth's surface that is completely saturated with water.
18. The upper boundary of the zone of saturation is the \_\_\_\_\_.
19. Materials, such as sand, with large, connected pores have a high \_\_\_\_\_.
20. Most groundwater flow takes place through \_\_\_\_\_, which are permeable layers of material.
21. Many \_\_\_\_\_ are three-dimensional underground passages, shafts, and chambers that stretch for many kilometers.
22. Calcium carbonate deposits that hang from the ceiling of a cave are called \_\_\_\_\_.

23. Dripstone formations are composed of \_\_\_\_\_, which is a type of limestone.
24. The localized natural discharges of groundwater are called \_\_\_\_\_.

**Matching**

*Match each item with the correct statement below.*

- |               |                  |
|---------------|------------------|
| a. subsidence | d. recharge zone |
| b. geyser     | e. spring        |
| c. drawdown   |                  |

- \_\_\_ 25. Where groundwater discharges a volume of water at the Earth's surface
- \_\_\_ 26. The land surface above an aquifer sinks because of excessive groundwater withdrawal
- \_\_\_ 27. Explosive hot springs that erupt at regular intervals
- \_\_\_ 28. The process that adds water from precipitation to the zone of saturation
- \_\_\_ 29. The difference between the original water-table level and the water level in a pumped well

*Match each item with the correct statement below.*

- |                            |                                |
|----------------------------|--------------------------------|
| a. sandstone and limestone | d. aquifer                     |
| b. silt, clay, and shale   | e. polar ice caps and glaciers |
| c. the ocean               |                                |

- \_\_\_ 30. Permeable layers through which groundwater flows
- \_\_\_ 31. Permeable subsurface material
- \_\_\_ 32. Contains 80 percent of all freshwater
- \_\_\_ 33. Impermeable subsurface materials
- \_\_\_ 34. The ultimate source of all water

*Match each item with the correct statement below.*

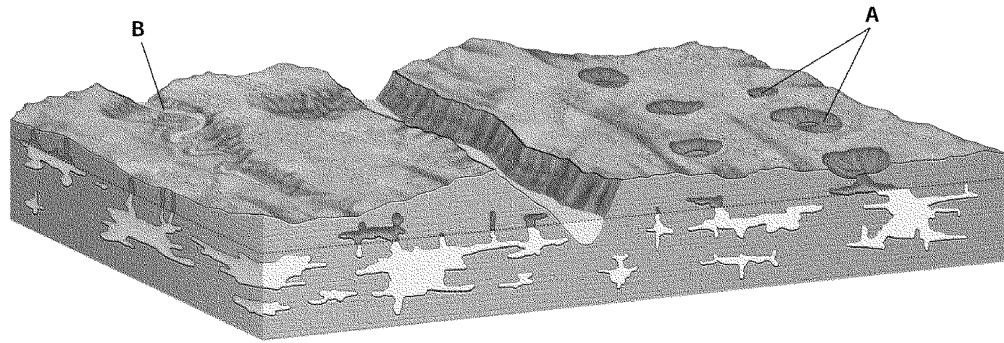
- |                  |                     |
|------------------|---------------------|
| a. hot spring    | c. karst topography |
| b. artesian well | d. groundwater      |

- \_\_\_ 35. Limestone regions with sinkholes and sinking streams
- \_\_\_ 36. Heated water discharged from the ground
- \_\_\_ 37. Water under pressure in a confined aquifer
- \_\_\_ 38. Major source of freshwater for human use

**Short Answer**

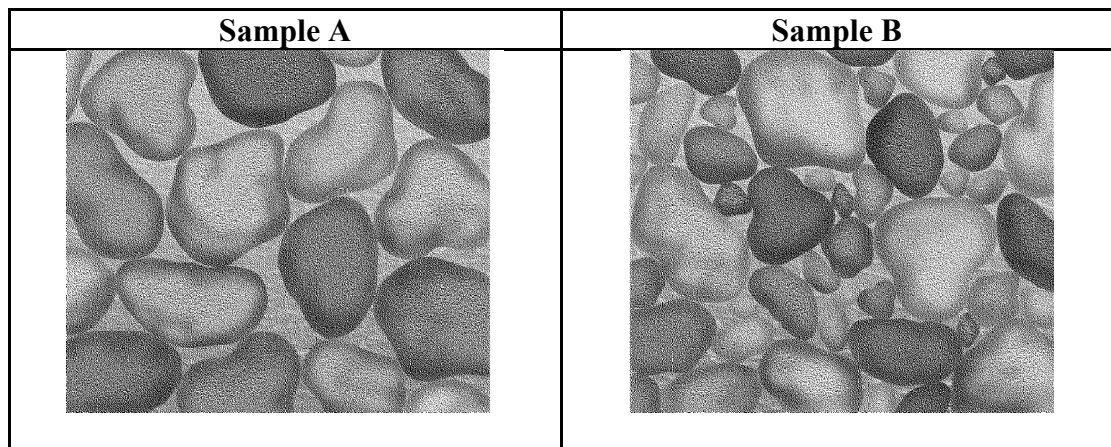
39. Trace a drop of water as it evaporates from the ocean, falls over land, and then finds its way back to the ocean.

40. Look at features A and B in the picture below. What are they? How are they formed?



41. Are water table unconfined aquifers or confined aquifers more easily polluted? Explain your answer.
42. What are the most common sources of groundwater pollution, and how do they enter the aquifers?
43. Give examples of how the depth of the water table varies with the terrain.
44. What two things can happen to a raindrop after it falls on land?
45. What type of subsurface material is able to store groundwater?
46. How are caves formed?
47. How do hard water and soft water differ?
48. How can groundwater resources be protected from pollution plumes?

Use the diagram illustrating mineral size and porosity to help you answer the following questions.



  
 1 millimeter

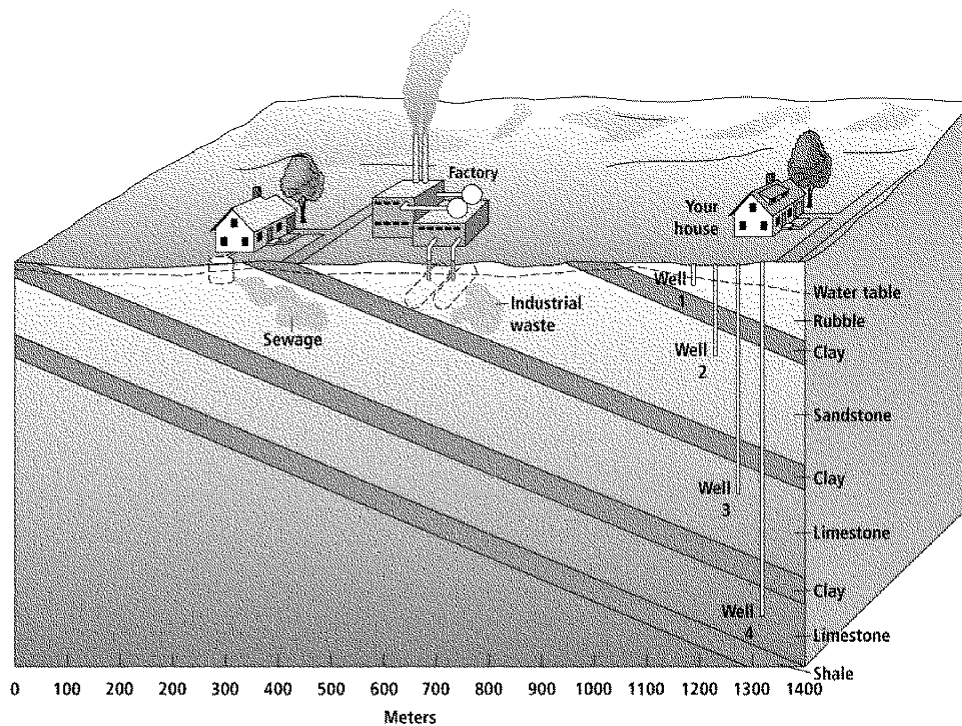
49. Describe the porosity and mineral size of Sample A and Sample B.



50. Describe groundwater flow through the two samples. Explain your answer.
51. Which of the two samples has the greater permeability? Why?

**Problem**

You would like to build a house in a wooded area close to your school. Since city water is not available, you will need to drill a well. The well-drilling company you hired did test drillings to find a clean, accessible, and maintainable aquifer. After completing its work, the company gave you a map of four available drill sites, numbers 1, 2, 3, and 4. Use the map illustration to make your analysis. Then answer the questions that follow.



Flow Rate in Meters Per Year					
Material	Shale	Clay	Limestone	Sandstone	Rubble
Flow Rate	0.5	0.0	100	50	200

52. Compare and contrast wells 1, 2, and 3. Analyze the potential of each well for a clean, accessible, and maintainable water supply.
53. What is the potential for a clean, accessible, and maintainable water supply from well 4? Could there be a problem with the water?
54. Use the flow rate table to determine when the sewage from the broken septic tank will contaminate the water in well 3.

Name: \_\_\_\_\_

ID: A

55. Use the flow rate table to determine when the industrial waste will contaminate the water in well 2. Is it possible that the waste could be made harmless before it reaches the well?
56. Which site has the best potential for your well? Explain your decision.

## Groundwater Study Guide Answer Section

### MODIFIED TRUE/FALSE

1. F, Aquicludes
2. F, acid
3. T
4. F, unconfined
5. F, runoff
6. T
7. F, slope
8. F, dissolves
9. F, carbonic acid ( $H_2CO_3$ )
10. T

### MULTIPLE CHOICE

11. A
12. C
13. C
14. D

### COMPLETION

15. infiltration
16. porosity
17. zone of saturation
18. water table
19. permeability
20. aquifers
21. caves
22. stalactites
23. travertine
24. springs

### MATCHING

25. E
26. A
27. B
28. D

- 29. C
- 30. D
- 31. A
- 32. E
- 33. B
- 34. C
- 35. C
- 36. A
- 37. B
- 38. D

### SHORT ANSWER

- 39. Answers may vary. The water evaporates from the ocean and becomes invisible water vapor and visible clouds. Winds move this atmospheric moisture over Earth. The atmospheric moisture returns to Earth's surface as precipitation. Some precipitation falls directly back into the ocean; some falls on land and eventually returns to the oceans.
- 40. Label A indicates sinkholes, which are depressions in the ground caused by the collapse of a cave or by the direct dissolution of bedrock by acidic rain or soil moisture. Label B indicates a sinking stream. These form when a surface stream drains into a cave system and continues underground, leaving a dry valley above.
- 41. Water table unconfined aquifers, because they are unprotected, and so close to the surface, are more easily polluted. Confined aquifers are usually sandwiched between aquicludes. Because they are relatively sealed by the aquicludes, confined aquifers are more difficult to pollute. Also, because the groundwater in a confined aquifer comes from a distant recharge area, the water is exceptionally pure by the time it reaches the aquifer.
- 42. The most common sources of groundwater pollution are sewage, industrial waste, landfills, and agricultural chemicals. They enter the ground above the water table but are eventually flushed downward by precipitation.
- 43. In stream valleys, the water table is only a few meters deep, while in swampy areas, the water table is close to or at the surface. On hilltops, the water table can be tens of meters or more below the surface.
- 44. The raindrop could become runoff, enter a stream or river, and then return to the ocean. The raindrop could infiltrate into the ground to become part of the groundwater.
- 45. Subsurface material that is porous, so the water is stored in the pore spaces of soil and various rocks.
- 46. Most caves are formed in limestone by the dissolving activity of carbonic acid in groundwater. As groundwater percolates through the cracks and joints of limestone formations, it gradually dissolves adjacent rock and enlarges passages to form an interconnected network of openings called caves.
- 47. Hard water contains high concentrations of calcium, magnesium, or iron. Soft water does not contain high concentrations of these elements. Soft water commonly has been treated with a water softener to remove many of the dissolved ions.



48. Protection from pollution plumes includes identifying the plumes and building barriers to stop them, or pumping the water out for treatment.
49. Sample A shows large pores between large particle sizes. Sample B shows small pore sizes between various sized particles.
50. Groundwater would more readily flow through Sample A because the greater porosity of well-sorted material allows for greater storage of groundwater. Groundwater flow through Sample B would be very slow because the porosity and storage capacity of poorly sorted material is reduced by the smaller grains between the larger fragments.
51. Sample A; its larger, connected pores allow more water to pass through at a higher flow velocity.

## PROBLEM

52. Well 1 would be a shallow well with a clean water supply, but is close to the water table and may not be able to sustain a large withdrawal of water. Well 2 would be a medium well with a good supply of water, but may soon be polluted by industrial wastes. Well 3 is a deep well with a good supply of water, but might be polluted in the future by the sewage from the leaking septic tank.
53. Well 4 is a deep well with a good supply of water. It is close to a shale aquiclude that could protect it from pollution. One problem could be the cost of a deep well.
54. Well 3 is approximately 800 meters from the sewage. If the flow in limestone is 100 meters per year, it would take 8 years to reach well 3.
55. The industrial waste is approximately 400 meters from well 2. If the flow in the sandstone is 50 meters per year, it would take 8 years to reach well 2. If the industrial waste is in an ionic form, it is highly unlikely that it could be removed from the water.
56. Well 4 is the best choice. Its depth has the best potential for a good supply of water. Its location has the least potential for existing harmful pollution. Its location between aquicludes should help protect it from future pollution.