CMU SCIENCE OLYMPIAD

Water Quality

Division C

January 24th, 2026

Directions:

- Welcome to CMU 2026! You have 50 minutes to complete this exam.
- Please have your salinometer ready for when you are called up to test.
- Ties will be broken by (in this order): score on Freshwater Ecology, score on Freshwater Macroinvertebrates, and score on Water Monitering and Analysis. If there is still a tie, the first question missed will be used to break ties.
- Good luck on this exam!

Names: _____

Team Number: _____

School: _____

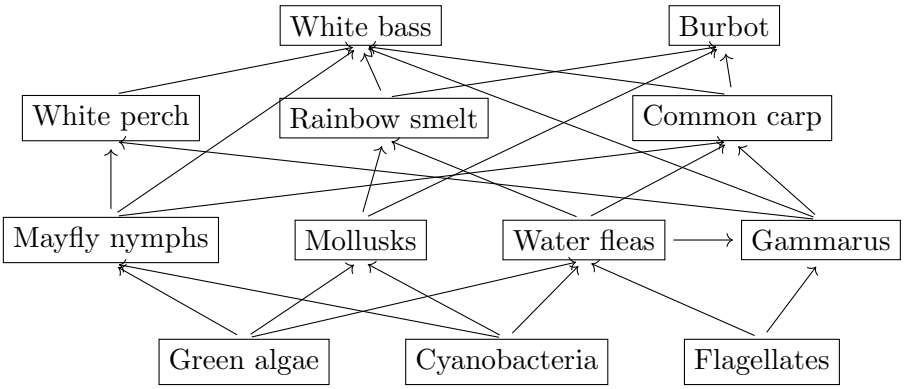
Raw score: _____ **Place:** _____

Written by Krish Shah (Seven Lakes HS '25, CMU '29)

Question	Points	Score
Freshwater Ecology	53	
Freshwater Macroinvertebrates	50	
Water Monitoring and Analysis	50	
Salinometer Score	17	
Total:	170	

Section 1: Freshwater Ecology

Reference this (heavily simplified) food web of Lake Erie for this section.



1. (2 points) Which of the following are primary producers? (select all that apply)
   A. Flagellates B. Gammarus C. Green algae D. Mollusks E. White perch
2. (2 points) Which of the following are primary consumers? (select all that apply)
   A. Flagellates B. Gammarus C. Green algae D. Mollusks E. White perch
3. (2 points) Which of the following are secondary consumers? (select all that apply)
   A. Flagellates B. Gammarus C. Green algae D. Mollusks E. White perch
4. (1 point) The competition between green algae and cyanobacteria is best described as which type of competition?
   A. Apparent B. Exploitative C. Interference D. Territorial
5. (1 point) Competition is a best described as which of the following types of interactions? For reference, - represents one species being harmed, 0 represents the species being unharmed, and + represents the species benefiting.
   A. -/- B. -/0 C. -/+ D. 0/+ E. +/+
6. (1 point) An increase in the population of mollusks would most likely lead to which of these changes in the short term? (select all that apply)
   A. Increase in rainbow smelt
   B. Increase in cyanobacteria
   C. Decrease in green algae
   D. Decrease in white bass
7. (1 point) What is the largest carbon sink in the planet?
   A. Atmosphere B. Oceans C. Rivers and lakes D. Soil
8. (1 point) Which of the major nutrient cycles lacks a significant atmospheric component?
   A. Carbon B. Nitrogen C. Phosphorus D. Sulfur E. Water
9. (1 point) A lake with low nutrient concentrations and high oxygen would most likely be classified as which of the following types?
   A. Eutrophic B. Hypertrophic C. Mesotrophic D. Oligotrophic
10. (2 points) Water from the hypolimnion of a stratified lake in the middle of winter would typically exhibit which of the following characteristics relative to the average of the lake?
    A. Cold, high oxygen B. Cold, low oxygen C. Warm, high oxygen D. Warm, low oxygen

11. (1 point) Pollution from agricultural runoff is best described as which of the following?
    A. Point source B. Nonpoint source
12. (1 point) This stage removes biological nutrients such as nitrates and phosphates.
    A. Primary B. Secondary C. Tertiary
13. (1 point) This stage is not always used and is usually used before water is discharged into a body of water.
    A. Primary B. Secondary C. Tertiary
14. (1 point) This stage typically allows water to settle and removes anything that floats or sinks like oil or sludge.
    A. Primary B. Secondary C. Tertiary
15. (1 point) This stage uses natural organisms like bacteria to decompose sludge and other organic materials.
    A. Primary B. Secondary C. Tertiary
16. (4 points) In one sentence or less, what is the difference between potential and actual evapotranspiration, and in which scenarios are they equal?

17. (4 points) Rank the following from shortest to longest average residence time in the water cycle.
    - Oceans
    - Antarctic glaciers
    - Rivers
    - Atmospheric water

18. (2 points) What is the idea that species must differ in niche by at least a specific amount to coexist referred to as?

19. (3 points) Enhanced biological phosphate removal requires the presence of what kind of tank? Where in the process of treatment is this tank added?

20. (3 points) What type of tank does denitrification use, and when in the process should this tank be placed?

21. (3 points) What is the purpose of course and fine bubble diffusers in sludge treatment? Which one is more efficient, and which one is more commonly used?

22. (2 points) Which type of bacteria are most often used for removal of nitrogen from water?

23. (2 points) Is lime useful in cleaning water from acid mine drainage? Why?

24. (1 point) Which of the following can be used to increase percolation into groundwater?
A. Bioswales B. Gray roofs C. Green roofs D. Impermeable pavement

25. (1 point) Which of the following describes all living organisms in an area?
A. Population B. Community C. Ecosystem D. Biosphere

26. (2 points) Black walnut trees excrete juglone, a compound that stunts the growth of other nearby plants. This interaction, which doesn't benefit the walnut much, hurts the organisms around it. What community interaction is this most emblematic of?
A. Amensalism B. Commensalism C. Mutualism D. Parasitism

27. (2 points) How would the genetic diversity of a population change after a drought where 3/4 of the population dies? What effect is this an example of?

28. (5 points) What are the 5 conditions of Hardy-Weinberg equilibrium?

Section 2: Freshwater Macroinvertebrates

29. (2 points) What organism from the rules is in Image A? Answer with the common name as it appears in the rules.

_____

30. (1 point) What organism from the rules is in Image B? Answer with the common name as it appears in the rules.

_____

Refer to the organism in Image A as organism A and the organism in Image B as organism B. More generally, the organism in Image X will be referred to as organism X

31. (2 points) Which of these organisms are sensitive to pollution?
    A. A B. B C. A and B D. Neither
32. (2 points) Which of these organisms would be described as r-selected?
    A. A B. B C. A and B D. Neither
33. (2 points) Larvae of organism A have a special name. What is this name?

_____

34. (2 points) Males of organism A fight for mates, with males competing for the limited pool of potential female mates. What type(s) of competition is this an example of? (select all that apply)
    A. Apparent B. Exploitative C. Interference D. Interspecific E. Intraspecific
35. (1 point) What is the diet of adults of organism A?

36. (2 points) Which stages, if any, of the life cycle of the organism in B are terrestrial?

37. (1 point) Presence of organism B indicates what about the oxygen content of the body of water it's in?
    A. Low DO B. High DO C. It tells us nothing
38. (2 points) Which of these most likely describes organism B? (select all that apply)
    A. r-selected B. K-selected C. Iteroparous D. Semelparous
39. (1 point) What organism from the rules is in Image C?

_____

40. (3 points) What is the diet of adults of organism C? Based only on their diet, how does this organism affect turbidity? Why?

41. (1 point) What organism from the rules is in Image D?

42. (2 points) What is the diet of adults of the same species as organism D?

43. (2 points) What is the diet of organism E?

44. (3 points) What is parthenogenesis, and what qualities do the offspring produced by it have?

45. (3 points) What are the four stages of a holometabolous life cycle (in order)?

46. (1 point) Which of the following best describes the organism in image F?
A. Ametabolous B. Hemimetabolous C. Homometabolous D. Holometabolous

47. (1 point) The larvae of organism F also have a special name, used to refer to nymphs of aquatic species. What are the nymphs of this species called?

48. (2 points) What organism from the rules is in Image G?

For the rest of the questions, refer to all images of organisms on the answer sheet.

49. (3 points) Which of these images depict larvae?

50. (3 points) Which of these images depict invasive species?

51. (2 points) Which of these images depict organisms moderately sensitive to pollution?

52. (3 points) Which of these images depict organisms that are holometabolous?

53. (3 points) Which of these images depict an organism with a winged, sexually immature stage in their life cycle? What is the name of this stage?

Section 3: Water Monitoring and Analysis

A few weeks after coming to CMU, I decided to go see the majestic Panther Hollow Lake. However, when I looked for it, it took me a minute to find it. Image H shows what I saw, and it's quite difficult to see where the lake even is. Let's discuss the water quality in this lake.

54. (1 point) What is the universal solvent?

    A. H_2O B. HCl C. Hg D. NH_3 E. NaOH

55. (3 points) What is the most common limiting nutrient in aquatic systems like Panther Hollow Lake?

    A. Nitrogen B. Phosphorus C. Potassium D. Sulfur

56. (1 point) Why is the lake green?

    A. There are many plants near the shore whose tendrils extend far into the water.

    B. There is a coating of algae on the water's surface.

    C. There is no lake - this is just a grass patch I took a picture of.

    D. The water is inherently green due to chemical pollution.

57. (1 point) Relative to a normal, healthy lake, how would you estimate the dissolved oxygen of Panther Hollow Lake compares?

    A. About the same B. Higher C. Lower

58. (2 points) How would the dissolved oxygen of Panther Hollow Lake compare in the winter and the summer? Why?

59. (4 points) What time of day would the dissolved oxygen of Panther Hollow Lake be the highest? When would it be the lowest? Why?

As most of you no doubt know, Panther Hollow Lake's was caused at least in part by excessive fertilizer runoff.

60. (1 point) What is the name for this process of excessive accumulation of nutrients in bodies of water?

61. (3 points) What does hypoxia mean, and do you think that Panther Hollow Lake is suffering from it? Why?

62. (2 points) Estimate the trophic state index of this lake.

63. (1 point) How does electrical conductivity change with the salinity of water?

64. (1 point) Which of the following best describes water with 3 ppt (or 0.3% mass per volume) salinity?

A. Fresh B. Brackish C. Saline D. Hypersaline

65. (3 points) How does carbon dioxide contribute to acidification of bodies of water? Your response should be one or more chemical equation(s) that demonstrate the acidic effect starting with carbon dioxide and ending with a product that is a conjugate base.

66. (3 points) Let's say I measured a pHof 7.9 in the lake. Calculate the pOH, H^+ concentration, and OH^- concentration.

pOH: _____

$[H^+]$: _____ M

$[OH^-]$: _____ M

67. (2 points) Which of the following is not used to measure turbidity?

A. Jackson candle B. Nephelometer C. Secchi disk D. Winkler bottle

68. (2 points) Which of the following is not a unit of turbidity?

A. BTU B. FTU C. JTU D. NTU

69. (2 points) How does the temperature of a turbid lake compare to a lake with very low turbidity?

A. Lower B. Same C. Higher

70. (4 points) What tool is shown in image I, and what is it used to measure? How?

71. (4 points) Why must BOD bottles be kept in the dark? If a bottle were kept in light, how would the BOD estimation change?

72. (2 points) What is the difference between cBOD and nBOD?

73. (4 points) You take a 200 mL sample from a river and add 1 L of distilled water to it. The table shows the DO on each day.

Day	0	1	2	3	4	5
DO (mg/L)	42	41	37	38	37	36

Assuming you prepared the sample properly (but did not seed it), what is the BOD_5? Answer with appropriate units.

74. (2 points) Something about the data in the table from the previous question indicates that you did not prepare the sample correctly. What anomaly shows this, and would this mean that the calculated BOD is an over or underestimate?

75. (2 points) What is a negative effect of using chlorine to decrease fecal coliform levels in a natural body of water?