

Water Quality Division C

Summer Study Session

- There are ten stations in this test. Allocate eight minutes to each station if you are taking the test alone, or five minutes to each station if you are taking the test with a partner.
- The first eight stations relate to freshwater and estuary ecology, the ninth to macroflora and fauna, and the final to water monitoring and analysis.
- **All multiple choice questions may have multiple correct answers; credit is awarded only when all correct answers are selected.**
- Complete sentences are not necessary for explanations. Credit is awarded for key words or phrases.
- The total score for the first five stations serves as the tiebreaker.

Name(s): _____

Points: __/194

Station 1 (15 points)

1. Within cyanobacteria, where does nitrogen fixation occur? (2)
 - a. Chromatophores
 - b. Inclusion granules
 - c. Nitrocysts
 - d. Heterocysts
 - e. Nitrolysosomes
 - f. Anammoxosomes
2. Identify an allochthonous and an autochthonous source of carbon for a stream. In this case, do allochthonous or autochthonous sources dominate? (3)
3. The Reynolds number experienced by fish is (greater than / the same as / lower than) that by zooplankton because the effect of viscous forces of the water is (greater / the same / lower) for the fish. (3)
4. Provide an example of an ecosystem engineer common in wetlands. (1)
5. Which of the following is/are SPECIFIC to wetlands and aquatic ecosystems? (2)
 - a. Sydney Declaration
 - b. Basel Convention
 - c. Ramsar Convention
 - d. Cartagena Protocol
 - e. Water Convention
 - f. London Convention
6. What of the following is/are necessary to calculate Carlson's Trophic State Index? (2)
 - a. Total nitrogen
 - b. Total phosphorus
 - c. Chlorophyll content
 - d. Biological Oxygen Demand
 - e. Secchi depth
 - f. Olszewski depth
7. Which of the following is/are true of lake stratification? (2)
 - a. Aeration can be used to lessen thermal stratification
 - b. The thermocline lies between the metalimnion and the hypolimnion
 - c. Only dimictic and polymictic lakes exhibit mixing (turning over) of water
 - d. Overturn in dimictic lakes occurs twice a year in the winter and summer
 - e. Lake stratification can affect the quality of drinking water
 - f. Carbon dioxide accumulating in meromictic lakes can result in a limnic eruption

Station 2 (20 points)

The following is a food chain in a freshwater lake.

Phytoplankton > Amphipod > Minnow > White Perch > Pike > Osprey

1. How many organisms in the food chain are piscivores? (1)
2. How can a trophic cascade be used to control the population of phytoplankton? (3)
3. Sketch a pyramid of biomass for this ecosystem. (2)
4. The osprey in this ecosystem have a sex ratio of 2.5 males to each female. Calculate the effective population size for the osprey. (2)
5. A fishery maximizes its fishing yield by maintaining a population of exactly 500 minnows. When the fishery is stocked with an additional 600 fish, the initial instantaneous population growth rate (dN/dt) is -7 minnows/year. Calculate the intrinsic growth rate and include units with your answer. (4)
6. What are the three primary nutrients found in fertilizer? Which of these limits the growth of phytoplankton?
Hint: your response should include an explanation. (5)
7. Does a Redfield ratio of 100:1:10 make sense for this ecosystem? (1)
8. Micronutrients commonly play a role in limiting population growth through ... (2)
 - a. Serial limitation
 - b. Single limitation
 - c. Independent limitation
 - d. Bioaccumulation
 - e. Biomagnification
 - f. Biostimulation

Station 3 (17 points)

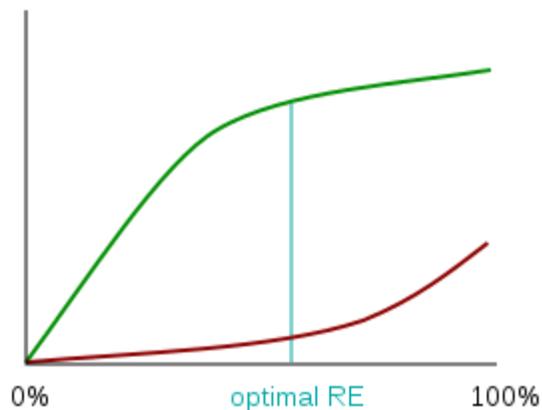
1. Which of the following is/are true of an artesian aquifer? (2)
 - a. It is found under layers of porous rock
 - b. Its water is usually considered a renewable resource
 - c. It is replenished by surface water percolating at a distant site
 - d. The water table is the aquifer's highest limit
 - e. The aquifer is naturally replenished within five years
 - f. It is always a confined aquifer
2. The following questions relate to acid rain.
 - a. Why do lakes have a natural buffering capacity? Write the relevant chemical equation. (2)
 - b. Write the relevant chemical reaction(s) when a strong acid reacts with the buffer. (1)
 - c. Write the chemical reaction for the production of carbonic acid in water. (1)
 - d. If K_{a1} of H_2CO_3 is $4.3e-7$ and K_{a2} of H_2CO_3 is $4.8e-11$, calculate the pH of a solution of 1M H_2CO_3 . Assume nothing else is present in the solution. *Hint: to solve this problem quickly, it is necessary to make assumptions.* (5)
3. Define the following processes of the water cycle. (3)
 - a. Precipitation intercepted by foliage that is evaporated
 - b. Movement of water through the atmosphere
 - c. Flow of water in the vadose zone and aquifers
4. Which of the following reservoirs has the longest average residence time? The shortest? (3)
 - a. Oceans
 - b. Glaciers
 - c. Lakes
 - d. Atmosphere
 - e. Shallow groundwater
 - f. Deep groundwater

Station 4 (19 points)

For questions 1 to 6, refer to the life history table below.

Year (x)	Population (a_x)	Survivorship (l_x)	Mortality (d_x)	Mortality Rate (q_x)	Fecundity (m_x)	... ($l_x m_x$)
1	1000				0.50	
2	800				3.50	
3	300				5.50	
4	175					
5	150					
6	100					
7	20					
8	0					

- Fill in the life history table for the first three life stages of the unknown organism. (4)
- What is the original population being studied called? (1)
- What is $l_x m_x$? (1)
- Why would an ecologist want to calculate $l_x m_x$? (1)
- Calculate R_0 for the first three years and interpret it. (3)
- True or false: the data presented in the table above is sufficient to construct a Leslie matrix for the first three years. If false, identify what additional information is needed. (2)
- What type of survivorship curve best models the life history of this species? (1)



- Refer to the graph above.
 - What type of reproduction is modeled by the graph? (1)
 - Label the x-axis and each of the lines. What determines the “optimal RE”? (3)
 - (True/False) This type of reproduction is consistent with that of a salmon. (1)
 - Is this type of reproduction consistent with r or K selection? (1)

Station 5 (21 points)

1. When warm water thermal pollution occurs ... (3)
 - a. Dissolved oxygen content (increases / remains the same / decreases)
 - b. Aquatic animals consume food at a (faster / unchanged / slower) rate
 - c. Algal blooms are (more / less) likely to occur
2. _____ occurs when a power plant opens or shuts down, causing an abrupt change in water temperature. (1)
3. The rate constant of the pesticide permethrin in a water column is approximately 0.025 1/hour.
 - a. If the initial concentration of permethrin in a water column is 0.60 $\mu\text{g/mL}$, what will the concentration be after two days? (3)
 - b. Would you expect the rate constant for permethrin to be lower or higher in soil? Why? (3)
 - c. Permethrin is not teratogenic but is highly toxic to aquatic organisms. What type of pesticide would the EPA classify permethrin as? (2)



4. Examine the image above.
 - a. What term best describes this phenomenon? (1)
 - b. Identify the primary cause of this phenomenon as well as two mitigation strategies addressing the primary cause. (3)
 - c. Identify two mitigation strategies unrelated to the primary cause of this phenomenon. (2)
 - d. Explain how this phenomenon (in general, not necessarily as represented in the image above) may be used to explain an increase in illness in the surrounding area. (3)

Station 6 (18 points)

For questions 1 to 3, refer to the following list of groundwater treatment technologies.

1. Air sparging
2. Bioreactors
3. Chemical oxidation
4. Constructed wetlands
5. Dual phase extraction
6. Pump and treat
7. Phytoremediation

1. Which of the above are in situ treatments? (2)
2. If you were constrained by time, which technology or technologies would you choose? (2)
3. Which technology or technologies would be most effective in treating volatile organic compounds? (2)
4. Which of the following is/are true about constructed wetlands? (2)
 - a. They are effective in reducing the amount of pathogens from wastewater
 - b. They are most effective when the biological oxygen demand is very large
 - c. They are effective in treating acid mine drainage
 - d. They are a form of primary sewage treatment
 - e. Their main purpose is to restore biodiversity to a region
5. How are cryptosporidium and giardia removed from drinking water? (2)
6. In which stage of sewage treatment do microorganisms play the greatest role? List three ways in which they do so. (4)
7. Which of the following is/are true about sewage treatment? (2)
 - a. *Nitrosomonas* is responsible for oxidizing nitrite to nitrate
 - b. Phosphorus content of wastewater may be reduced biologically
 - c. Chlorine is considered to be more safe than ozone in tertiary treatment
 - d. Micropollutants are significantly reduced in tertiary treatment
 - e. Benzene has arisen as a more effective alternative to chlorine as a disinfectant
8. Which of the following is/are NOT effective in desalinating water? (2)
 - a. Membrane separation
 - b. Reverse osmosis
 - c. Multi-stage flash distillation
 - d. Thermal desorption
 - e. Electrodialysis reversal

Station 7 (21 points)

1. What is the Fermi number of the volume of freshwater on Earth in mL? (2)
2. Identify the four categories of ecosystem services and list two for each category that are provided by freshwater ecosystems. (8)
3. Which of the following is/are impacted by run-of-the-river hydroelectric stations? (2)
 - a. Silt loads
 - b. Water temperatures
 - c. Water pH
 - d. Silt loads
 - e. River flow
 - f. Dissolved oxygen
4. Which of the following is/are true about aquatic ecosystems? (2)
 - a. Riparian zones dissipate energy to reduce soil erosion and flood damage
 - b. Floodplains are of low biodiversity due to periodic flooding
 - c. Marshes are more woody while swamps are more herbaceous
 - d. Vernal pools are critical to the survival and development of certain amphibian and insect species
 - e. Endorheic basins are rarely large because they contain no inflow/outflow to rivers and oceans
 - f. Microbial loops are found in both aquatic and terrestrial ecosystems



5. Examine the image above.
 - a. Identify the type of this river. (1)
 - b. Explain the cause of the color of the river. (3)
 - c. Compared to “regular” rivers, the water in this river has a (higher / lower) pH, (more / less) phosphorus content, and (higher / lower) levels of dissolved solids. (3)

Station 8 (17 points)

Community	Species 1	Species 2	Species 3	Species 4	Species 5
x	3	4	2	0	0
y	3	3	0	4	1

1. A researcher visits two communities and collects data regarding the populations of five different species in the two communities.
 - a. What is Sorensen's coefficient of similarity for these two communities? (2)
 - b. What are the maximum and minimum values of Sorensen's coefficient? What do they signify? (2)
 - c. Calculate Simpson's index of diversity for both communities. Is it appropriate to compare the two values, and why? (3)
2. The results of an experiment to measure the productivity of an aquatic ecosystem are shown below.

	Initial Value (mg O₂/L)	Final Value (mg O₂/L)
Light for 24 hours	6.24	6.39
Dark for 24 hours	6.24	6.16

- a. Name this technique and briefly outline how this experiment was conducted. (4)
- b. Calculate the gross primary productivity for the observed sample. Express your answer in mg fixed carbon/L/day to the nearest hundredth. (2)
- c. What is the net production efficiency for the sample? (2)
- d. This technique is very limited in terms of scale and accuracy. Identify the primary method of measuring aquatic productivity today. (2)

Station 9 (32 points)

A	B	C
		
D	E	F
		

1. Refer to organism A.
 - a. What is the common name of this organism? (1)
 - b. How is sexual dimorphism exhibited in this image? (2)
 - c. The presence of this organism indicates what about the water in the habitat? (2)
2. Refer to organism B.
 - a. This organism was found in the Northeast. What is most likely the genera of this organism? (1)
 - b. Why is this organism an indicator of good water quality? (2)
 - c. What is the approximate size of this organism? (1)
3. Refer to (the eggs of) organism C.
 - a. What is the scientific name of this organism? (1)
 - b. The symbiosis of this organism with _____ results in a reproductive phenomenon called _____ (2)
 - c. What two organisms can be used to biologically control the population of this organism? (2)

4. Refer to organism D.
 - a. What is the scientific name of this organism? (1)
 - b. In what season was this photo taken? (1)
 - c. What type of pollination syndrome does this organism exhibit? (1)
 - d. What are the negative impacts of this organism? (2)
 - e. How is this organism most effectively controlled? (1)
5. Refer to organism E.
 - a. What is the scientific name of this organism? (1)
 - b. What is the trophic level of this organism? (1)
 - c. What is the primary prey of this organism? (1)
 - d. What are the negative impacts of this organism? (2)
6. Refer to organism F.
 - a. What is the scientific name of this organism? (1)
 - b. How do they attach to various surfaces? (1)
 - c. Why is their colonization harmful? (2)
 - d. What is the feeding mechanism of this organism? How is this both beneficial and harmful? (3)

Station 10 (14 points)

1. Identify the most appropriate tool to measure and analyze each of the following indicators. (3)
 - a. Pesticides and organic pollutants
 - b. Heavy metals
 - c. Total dissolved solids
2. Is it safe to drink a sample of water that has passed EPA primary standards for tap water but failed secondary standards? Explain. (3)
3. Identify as many precautions as possible for the field sample collection of water. The intended analysis, which covers all of the WHO guidelines for drinking-water quality, has physical, chemical, and biological components. *Hint: this question is intentionally vague; there are certain precautions that you must include.* (8)