

## 2020 Camas Invite Water Quality

This test is fairly long, so be efficient with your time (I would suggest having each person start from opposite ends of the test to ensure complete coverage). It will be helpful to have a scientific calculator (non-graphing) for a few problems, but answers will not require significant figures. Please round answers as requested in each question. Show work the best you can for any math questions by writing out key equations used.

For subscripts and superscripts, denote with "\_" and "^" respectively. Example: if you want to write  $\text{CO}_3^{2-}$  write  $\text{CO}_3^{(2-)}$ .

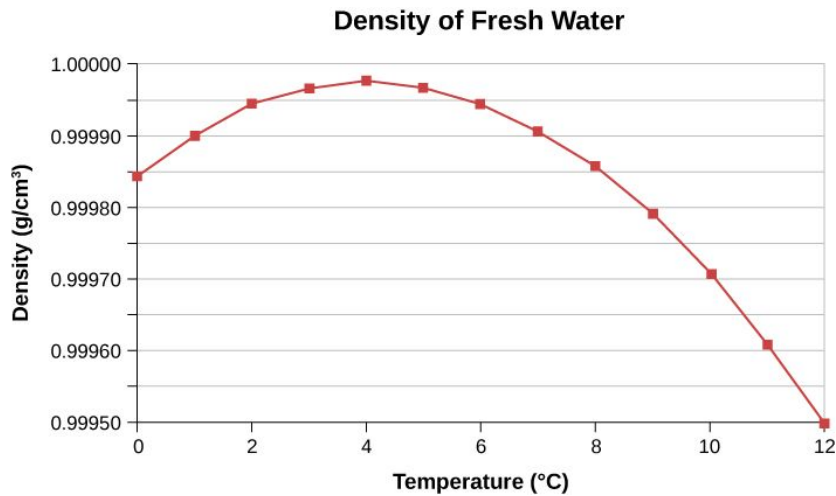
**Note:** The above is an artifact of the intro for the Scilympiad version of this test.

### Properties of Water:

Explain following properties of water and their importance to life on Earth. (2 pts each)

1. Large heat capacity
2. Large heat of vaporization
3. Hydrogen bonding
4. Polar (i.e. good solvent)

Use the following graph to answer questions 5-8:



5. At what temperature (to the nearest degree C) is the density of freshwater the largest? (1)

6. For temperatures above this maximum, \_\_\_\_\_ water rises and \_\_\_\_\_ water descends (1)

- a. Warm, cool
- b. Cool, warm

7. For temperatures below this maximum, \_\_\_\_\_ water rises and \_\_\_\_\_ water descends (1)

- a. Warm, cool
- b. Cool, warm

8. What two implications does this property of water have on the formation of ice? How did these impact life on Earth? (3)

### **Nutrient Cycling:**

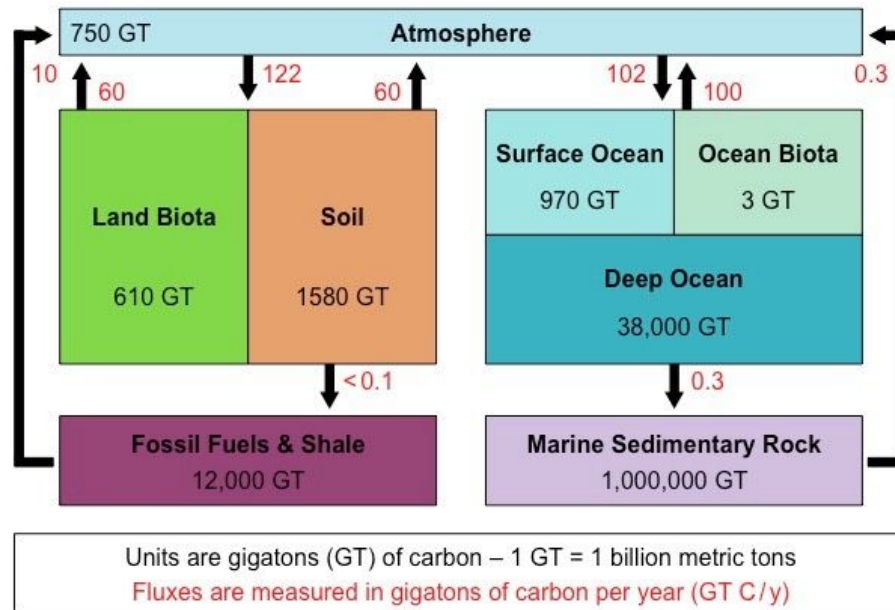
9. Of the following options, which is the largest carbon reservoir? (1)

- a. Atmosphere
- b. Vegetation
- c. Soils and Detritus
- d. Surface ocean
- e. Deep ocean

10. What percent of the atmosphere is carbon dioxide? (1)

- a. 40%
- b. 4%
- c. 0.4%
- d. 0.04%
- e. 0.004%

Use the following diagram of carbon reservoirs and annual fluxes to answer questions 11-15:



Note: the arrow on the far left represents fossil fuel burning by humans, the arrow on the far right represents CO<sub>2</sub> emissions by volcanoes and other geologically active regions.

11. What is the largest carbon reservoir in this diagram? (1)

12. Compared to human emissions of CO<sub>2</sub> from burning fossil fuels, volcanoes and other geological sources of CO<sub>2</sub> emit what percent of human emissions? (2)

13. What is the net increase in GT of carbon in the atmosphere each year (nearest tenth)? (2)

14. How many GT of carbon from human fossil fuel burning end up in the land per year (to the nearest GT)? (2)

15. How many GT of carbon from human fossil fuel burning end up in the oceans per year (nearest tenth)? (2)

16. What is the largest source of accessible nitrogen? (accessible to the nitrogen cycle) (1)

17. Define the term, limiting nutrient. (2)

18. Despite the large amount of nitrogen on Earth, why is nitrogen often the limiting nutrient in many ecosystems? (2)

19. What is one way human activity affects the nitrogen cycle in marine ecosystems? (2)

20. Unlike most of the other nutrient cycles, phosphorus doesn't have a significant presence in which 'sphere'? (1)

21. What is one natural way that phosphorus can enter marine ecosystems? (1)

22. Phosphorus is more commonly the limiting nutrient in: (1)

- a. Freshwater ecosystems
- b. Saltwater ecosystems

**Implications of Ocean Circulation and Garbage Patches:**

23. Which direction do gyres rotate in the northern hemisphere? (1)

- a. Clockwise
- b. Counterclockwise
- c. It depends on the gyre

24. How does the global oceanic circulation affect garbage patches? (2)

25. The largest garbage patch is located in which gyre? (1)

26. **TB1**: Explain the difference between bioaccumulation and biomagnification in terms of microplastics found in garbage patches. (4)

27. What are two negative impacts of the five ocean garbage patches on ocean life? (2)

**Estuaries:**

The Mississippi River watershed drains nearly 3 million square kilometers of North America and is both ecologically and economically important. The estuary at the mouth of the river hosts a wide diversity of different ecosystems as well as several large cities.

28. **TB4:** What is the term for plants and animals that can tolerate both saltwater and freshwater? (1)

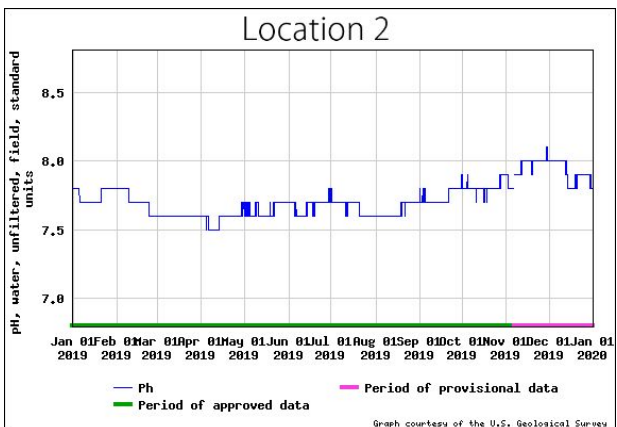
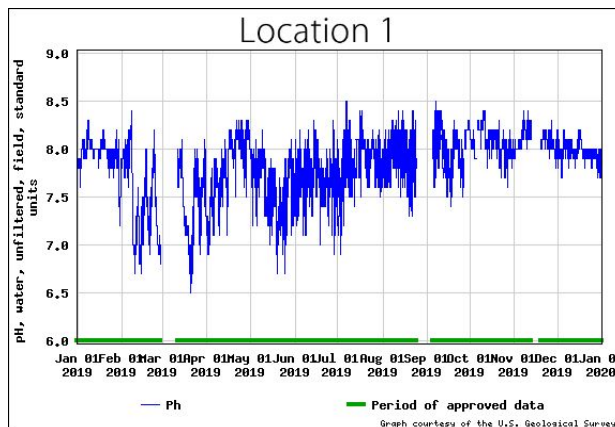
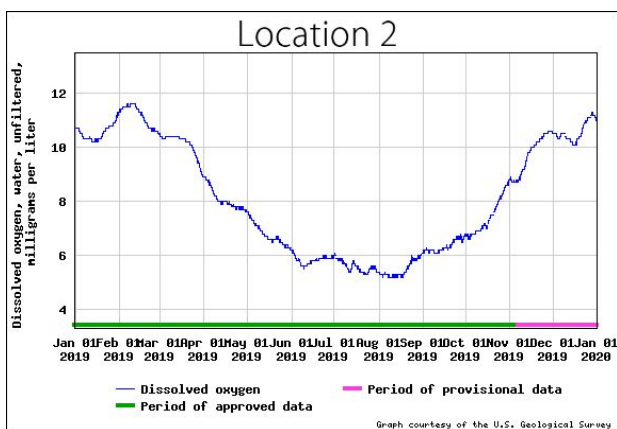
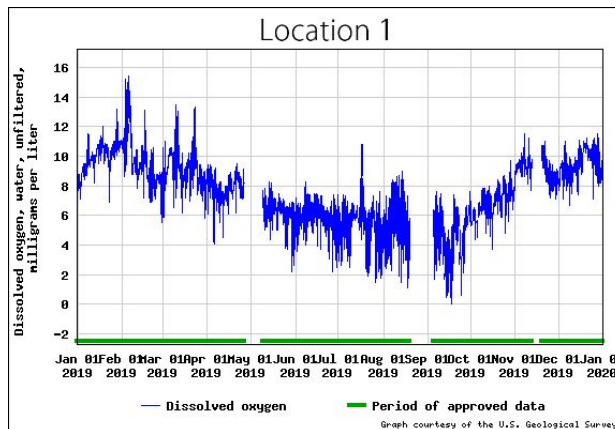
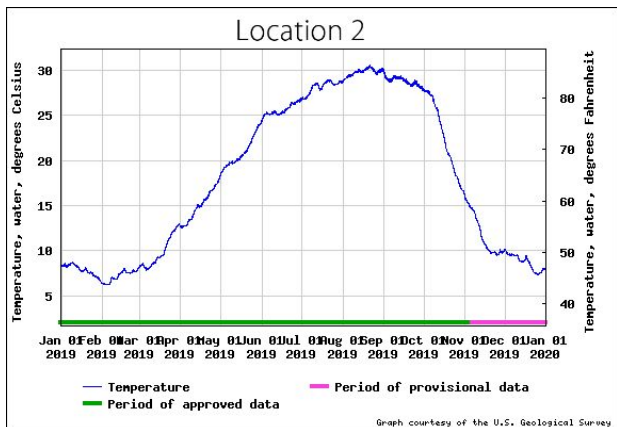
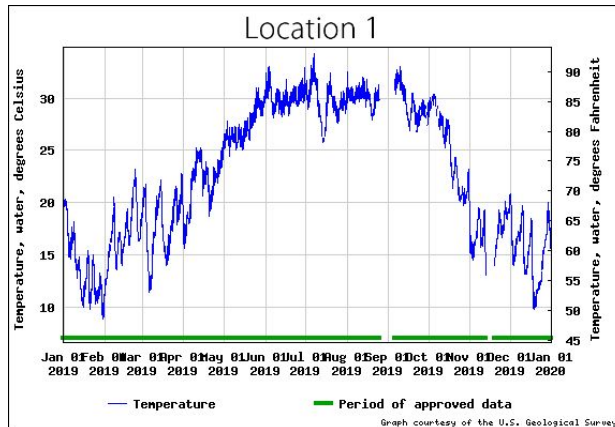
29. Given that the Mississippi River is large and has a high volumetric flow rate, what would its estuary be classified by water circulation? (2)

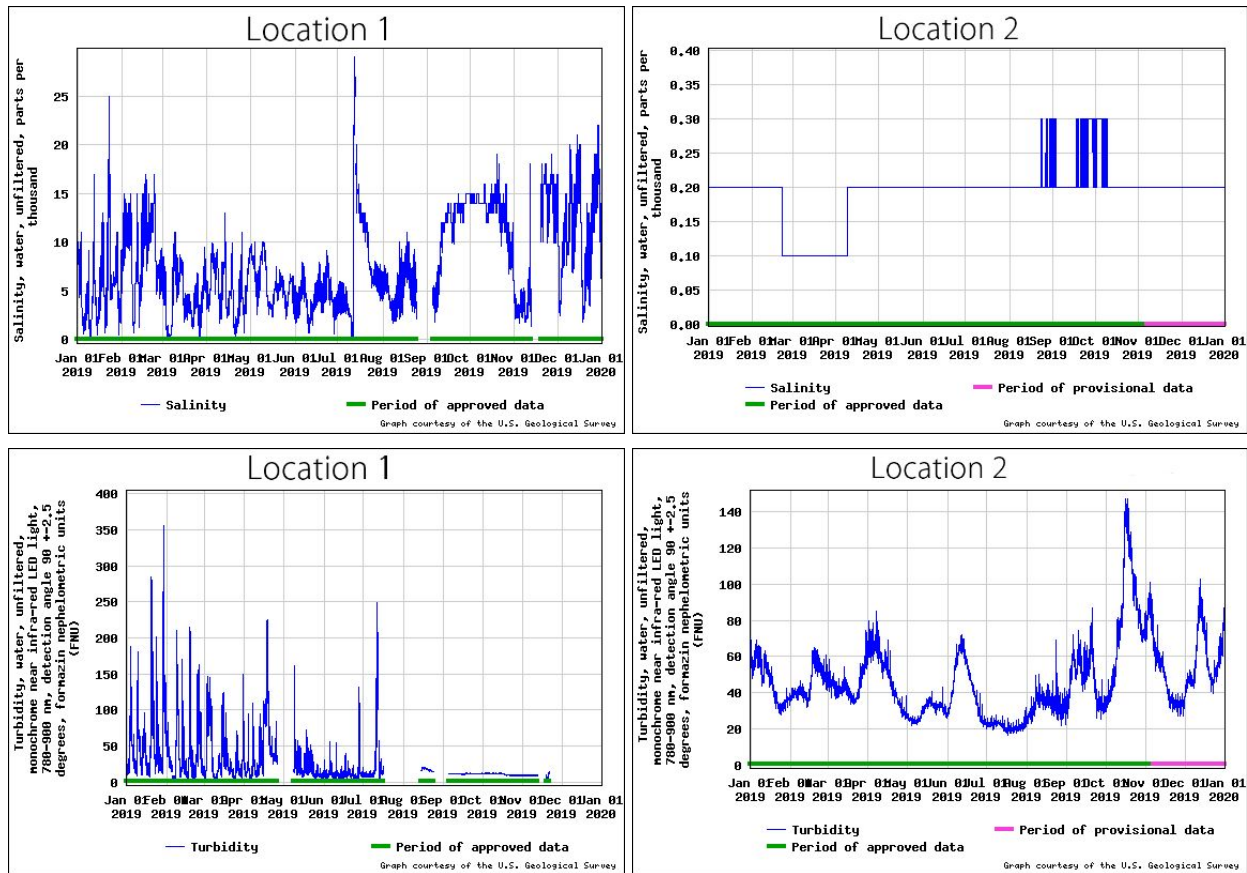
30. What is one consequence of the above to life in the estuary? (1)

31. Name two ecosystem services provided by this estuary. (2)

32. Given that the  $\text{OH}^-$  concentration in the estuary is  $1.5\text{E-}6$ , calculate the pH of the estuary. (round to the nearest tenth) (2)

The following graphs are of two different locations around the estuary: Use them to help answer questions 33-36





33. Judging from the graphs, which location is closer to the mouth of the estuary? Explain using the graphs. (2)

34. What is one possible cause of the unusually high turbidity at location 1 near the beginning of the year? (1)

35. Using the graphs, explain the relationship between temperature and dissolved oxygen. How does this explain the yearly changes of the two? (3)



36. Which is more likely to be near a wastewater treatment plant? Explain using the graphs. (2)

37. Explain what happens in primary, secondary, and tertiary treatment of wastewater. (3)

One of the largest dead zones exists just beyond the mouth of the Mississippi River. A major cause of this dead zone is harmful algae blooms.

38. Explain how harmful algae blooms can cause dead zones. (2)

39. What is a possible cause of these algae blooms in the context of this estuary? (1)

40. Below what dissolved oxygen concentration in mg/L is water considered hypoxic? (1)

41. How will rising sea temperatures affect the size of this dead zone? (2)

42. How would an increase in the frequency, length and size of this dead zone affect the economy of the region? (2)

### **Marine Ecology Case Study: The Deep Ocean**

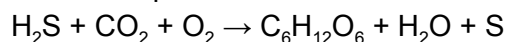
The deep ocean is one of the last relatively unexplored regions on Earth. While originally thought to be mostly devoid of life due to the lack of sunlight, and extreme pressure and temperatures, the deep ocean hosts a surprising amount of biodiversity and complex communities.

43. Aside from hydrothermal vents, what are the two other major sources of nutrients and energy for deep ocean communities? (2)

44. Due to the scarcity of nutrients and energy in the deep ocean, most organisms are: (1)

- a. Producers
- b. Herbivores
- c. Predators
- d. Scavengers

45. Due to the lack of light, many bacteria near hydrothermal vents have developed a different method to generate usable energy called chemosynthesis. The following **unbalanced** equation is an example of one such reaction:

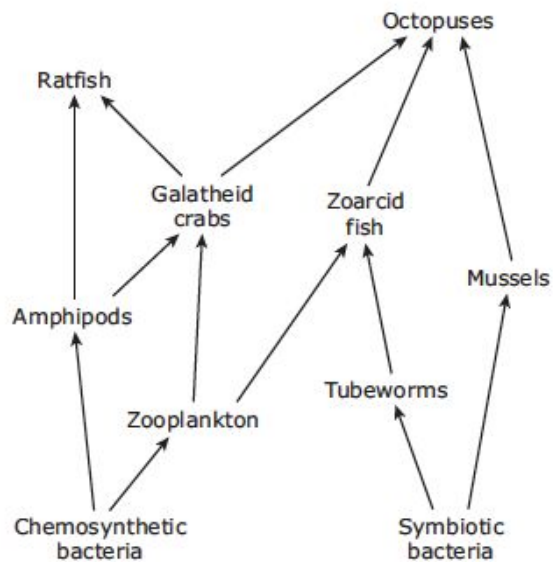


Balance the equation and determine how many moles of  $\text{H}_2\text{S}$  would be required to create 4 mol of glucose assuming  $\text{H}_2\text{S}$  is the limiting factor. (3)

46. The relationship that giant tube worms have with chemosynthetic bacteria is MOST similar to which of the following? (1)

- a. Anemone and clownfish
- b. Banded coral shrimp and most fish
- c. Coral polyps and zooxanthellae
- d. Sharks and remora

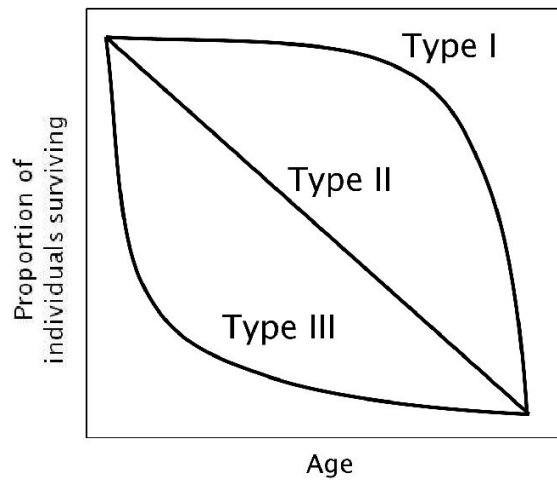
The following is a simple food web of a hydrothermal vent community:



47. Identify one secondary consumer in the food web above. (1)

48. How would a sudden decrease in the population of octopuses affect the rest of the food web? (2)

49. Judging by the survivorship curves shown below, the large majority of the organisms in food web should be classified as: (1)



- a. Type I
- b. Type II
- c. Type III

**Coral Reef Organism Identification and Ecology:**

Identify the common name of the following organisms and explain their role in a coral reef: (2 pts each, 1 for common name, 1 for correct role)

**Please use the common name listed in the Water Quality Rules**



50.

51.



52.



53.



54. Identify the following organism: (1)



55. What kind of relationship does this organism have with the fish pictured above? (1)

- a. Mutualism
- b. Commensalism
- c. Amensalism
- d. Parasitism

56. Identify the following organism: (1)



57. What is this the main diet of the above organism? (1)

58. How would a large decrease in their population affect the health of a coral reef? (2)

**Coral Reef Ecology:**

59. Identify two ways the loss of coral reefs affects humans. (2)

60. Name two conditions necessary for coral reefs. (2)

61. Between what latitudes do most coral reefs occur? (1)

62. Explain the process of coral bleaching (2)

63. What are two possible triggers of coral bleaching? (2)

### **Coral Reef Case Study: The Great Barrier Reef**

The Great Barrier Reef located off the northeast coast of Australia is facing an increasing problem related to the organism shown below.



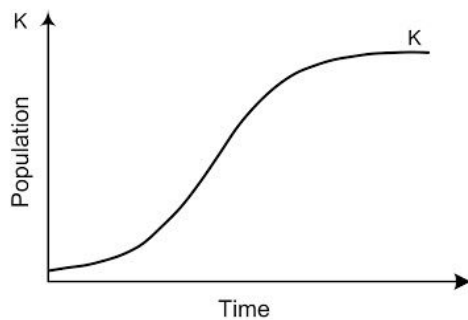
64. Identify the common name of the organism. (1)
65. Is the organism above considered an invasive species to the Great Barrier Reef? (1)
- a. Yes
  - b. no
66. How does an overabundance of this organism affect the Great Barrier Reef? (1)
67. What are two reasons for the increasing number of outbreaks of these organisms? (2)
68. What is the main method of dealing with an outbreak of these organisms in the Great Barrier Reef? (1)



69. Name two natural predators of the above organism from the list in Part 2. of the Water Quality Rules (2)

70. Explain the difference between an r and K selected species. Based on these descriptions, how would you classify the above organism and why? (4)

The following is a graph of the population of the above organism in its native region:

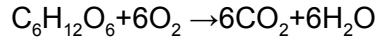


71. **TB 2:** What does the K represent? (1)

72. Name one density independent and one density dependent factor that could affect the population of the above organism. (2)

### Biological Oxygen Demand:

73. Given the following reaction for the oxidation of glucose, calculate the theoretical biochemical oxygen demand in mg O<sub>2</sub>/L for 3.0 E-3 mol glucose. (hint: the molar mass of O<sub>2</sub> is 32 g/mol) (3)



74. We conducted a carbonaceous BOD test at 25°C in which 10 mL of a waste sample was diluted with water to 500 mL. Given the following, calculate the 5 day BOD in mg/L at 25°C. (round to the nearest tenth) (4)

Initial DO of diluted sample: 12.3 mg/L

Final DO of diluted sample after 5 days: 4.2 mg/L

Initial DO of seeded dilution water: 9.5 mg/L

Final DO of seeded dilution water: 6.6 mg/L

75. What does this tell us about the sample? (1)

76. Why do we generally calculate BOD on the fifth day? (2)

77. Why might we need to dilute the original sample? (2)

78. The BOD test requires that the samples be kept in opaque bottles during the five day period. Why? (2)

79. If we **didn't** use an opaque bottle, the calculated BOD would most likely be: (1)
- a. Higher than the actual value
  - b. Lower than the actual value

**Salinity:**

80. What is the average salinity of the ocean? (1)
- a. 0.35 ppt
  - b. 3.5 ppt
  - c. 35 ppt
  - d. 350 ppt

What effect do each of the following have on seawater salinity? (5pts)

81. Precipitation:
- a. increase
  - b. decrease

82. Runoff:
- a. increase
  - b. decrease

83. icebergs melting:
- a. increase
  - b. decrease

84. sea ice forming:

- a. increase
- b. decrease

85. Evaporation:

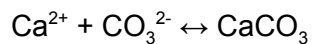
- a. increase
- b. decrease

**Aragonite Saturation:**

86. Why is it important for us to measure aragonite saturation? (2)

87. **TB3:** How does the addition of CO<sub>2</sub> to the atmosphere affect aragonite saturation in the oceans? Therefore, how is aragonite saturation related to pH? (2)

88. Given the precipitation dissolution reaction for aragonite, calculate the aragonite saturation state given  $K_{sp}$  of aragonite =  $6.0E-9$  at 25 degrees C, and the concentration of  $Ca^{2+} = 1.0E-4$  M. (3)



89. Is aragonite dissolving or precipitating in question 88? (1)

- a. Dissolving
- b. Precipitating

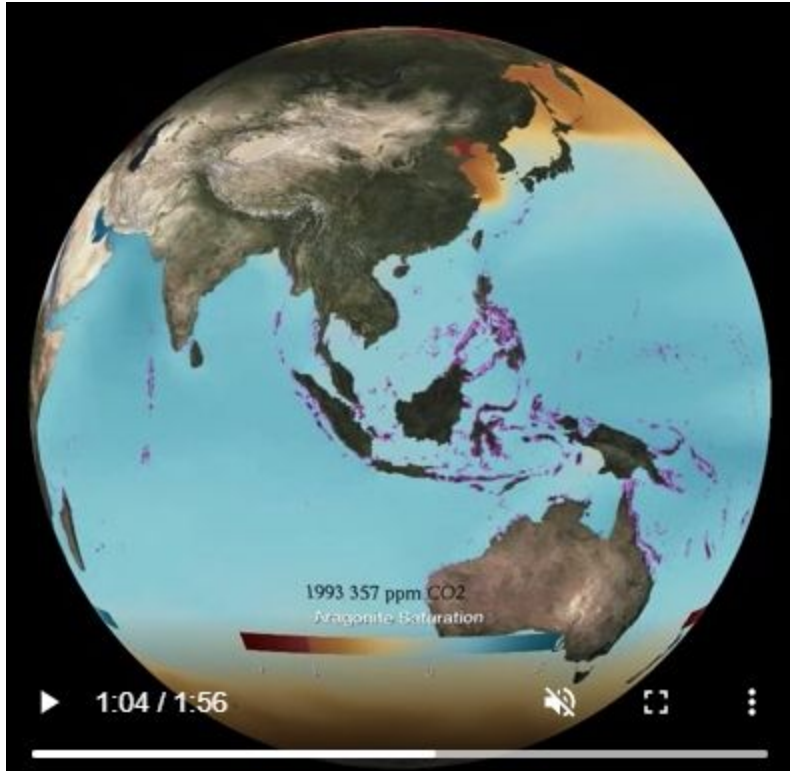
90. What would happen to the above number if the CO<sub>2</sub> levels in the atmosphere were to increase? Explain. (2)

91. What would happen to the above number if the temperature of the water were to increase? Explain. (2)

92. Give an approximate cutoff for aragonite saturations that coral reefs can be found at. (1)

93. Based on the answer to the previous question, is the aragonite saturation level found in question 88 adequate for coral reefs? (1)

94. Given the following simulation of aragonite saturation, explain the differences across latitude of aragonite saturation. (2)



0 is dark red, 1 is between red and orange, 3 is between orange and blue, 6 is at the dark blue

This is a placeholder for the video in the Scilympiad version of this test.

95. According to this simulation, at around what year will most of the oceans not be able to support coral reefs? (2)

- a. Around 2020-2030
- b. Around 2060-2070
- c. Around 2040-2050
- d. Around 2090-2100