Science Olympiad
Water Quality Key
MIT Invitational

Team Name: _____**KEY**_____

Team Number: _____

Directions:

- Welcome to MIT 2026! You have 50 minutes to complete this test.
- **Please write legibly.** If we can't read your answer, we can't grade it.
- For all identification questions, answer with the common name as it appears in the rules. Be as specific as the rules are and use the most specific name from the rules possible.
- The size of a blank is roughly correlated with how much space you'll need to answer. If a question asks for a single word answer, just write the word. More generally, there is no need to elaborate unless explicitly asked to. However, you should show work on any questions requiring a calculation.

Points by Section:
For grading use only

Section	Points	Score
Warm Up!	30	
Graph Theory	54	
Water Doctor	77	
River Walk	76	
Bug Catching	56	
Daily Dips!!	53	
Winooski Watershed Woes	68	
The Salty Dog Rag	46	
Total Score	460	

Section 1: Warm Up!

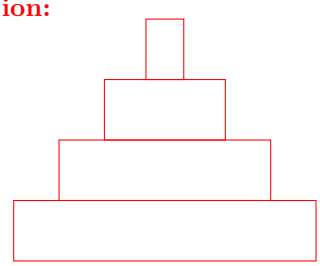
1. (2 points) D
2. (2 points) A
3. (2 points) A
4. (2 points) C
5. (2 points) E
6. (2 points) D
7. (2 points) E
8. (2 points) C
9. (2 points) A
10. (2 points) E
11. (2 points) C
12. (2 points) B
13. (2 points) B
14. (2 points) B
15. (2 points) C

Section 2: Graph Theory

16. (a) (1 point) BC (b) (1 point) AE (c) (1 point) E

17. (a) (1 point)

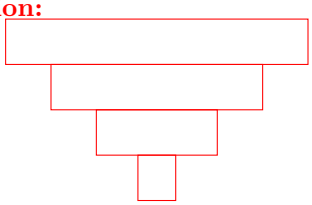
Solution:



1 point for being a pyramid with multiple (at least 3) layers

(b) (2 points)

Solution:



1 point for this shape. 1 point for something about how rapid reproductive rate of primary producers allows the inverted pyramid to exist.

(c) (1 point)

Solution: 990 kJ (1, don't take off for not writing a unit)

18. (a) (1 point) A (b) (1 point) B (c) (1 point) B (d) (1 point) B

19. (a) (1 point) BD (b) (1 point) ABD

20. (a) (2 points) Parasitism (1), obligate (1)

(b) (2 points)

Solution: Lives in saltwater/ocean (1), migrates to freshwater to reproduce (1)

(c) (2 points)

Solution: transfers nutrients from oceans to lakes (1) because they die in lakes and live in oceans (1)

21. (a) (1 point) **Cyanobacteria (0.5 for bacteria)**

(b) (2 points)

Solution: Photosynthesis (1), can absorb green light (1, this is the main advantage, but saying anything about absorbing different wavelengths from chlorophyll/other common pigments should earn the point)

22. (3 points)

Solution: Diel veritcal migration (1), important source of carbon sequestration (1 for saying it removes CO2/carbon) by transferring carbon from higher parts of the water to the lower parts (1)

23. (a) (1 point) **Gause's law/(Principle of) competitive exclusion**

(b) (2 points) **Character displacement**

24. (2 points)

Solution: Reduce intraspecific competition (1) because it separates the niche of different stages of the species' life cycle (1)

25. (a) (2 points)

Solution: $\boxed{3.28 \cdot 10^{10}} = 3.13 \cdot 10^{10} \cdot e^{0.023 \cdot 2}$ **(full credit for** ± 0.01 **in scientific notation)**

(b) (2 points) **30** $(\ln 2/r)$

(c) (3 points) **1.78** $(\ln 2/(\ln(1 + .475)))$

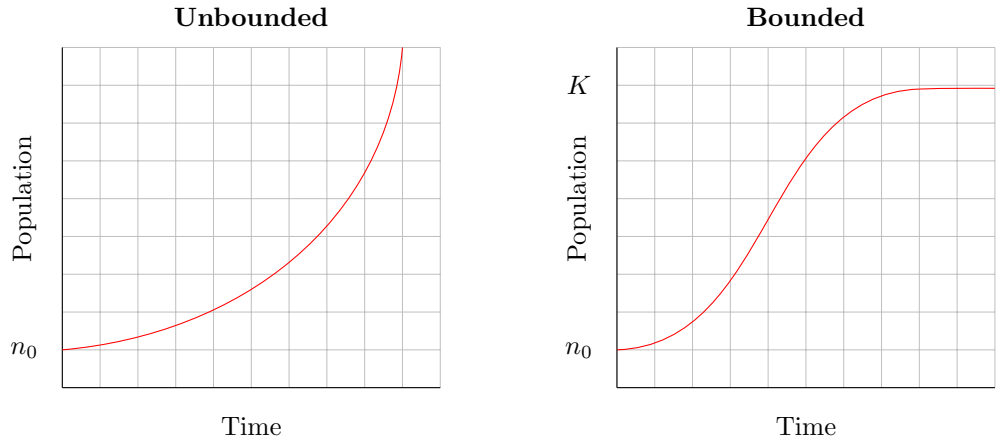
(d) (2 points)

Solution: $\boxed{4.946 \cdot 10^{8}} = \frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right) = 0.023 \cdot 3.13 \cdot 10^{10} \cdot \left(1 - \frac{3.13 \cdot 10^{10}}{10^{11}}\right)$ **(full credit** ± 0.01 **in scientific notation)**

(e) (1 point) $K/2$

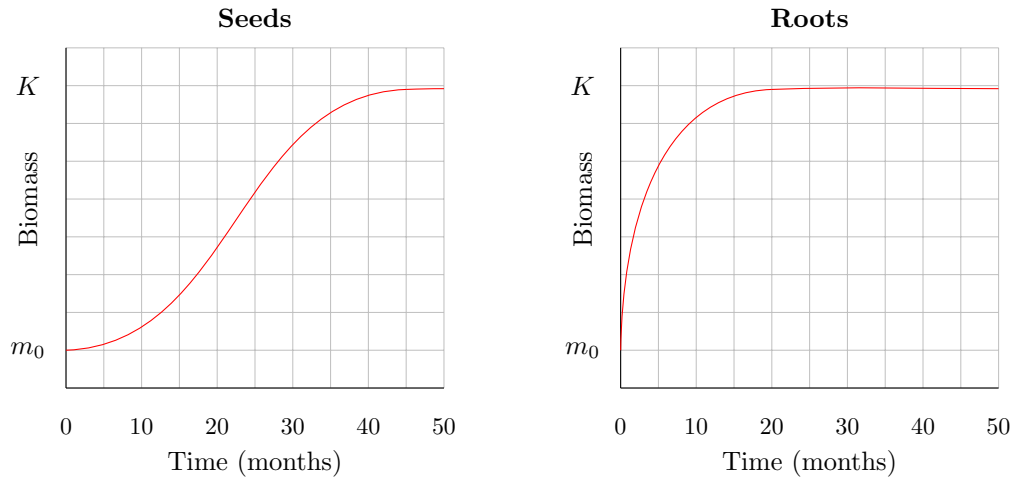
(f) (2 points) **0-1 or as small as possible**

(g) (4 points)



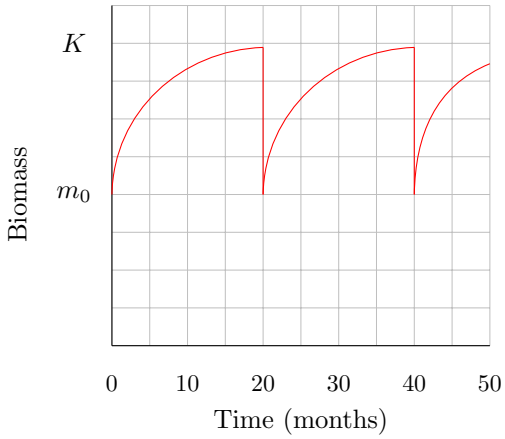
Solution: 2 points per graph, 1 point for being increasing, 1 point for matching the shape (exponential increasing for the unbounded and logistic for the bounded/carrying capacity)

(h) (3 points)



Solution: seeds is like normal, logistic growth (also accept a graph with an overshoot and then drop to carrying capacity) (1), roots grows fast and hits carrying capacity (1 for increasing fastest at start (i.e. being concave down)), 1 for both having carrying capacity

(i) (5 points)



Solution: 1 point for having 2 peaks, [regarding the ascending limb: 1 points for increasing, 1 point for being concave down], 1 point for oscillating, 1 point for very quick decline after

Section 3: Water Doctor

26. (a) (1 point)

Solution: Combined mixes wastewater and stormwater, separate separates them

(b) (1 point) **B**

(c) i. (1 point) **A**

ii. (1 point) **combined sewer overflow**

iii. (1 point)

Solution: Anything related to water pollution - fish death, health issues, unsafe drinking water

27. (a) (1 point) **Fats, oils, greases**

(b) (3 points)

Solution: equalization basins (1), reduces surges/buffers amount, ensures everything is treated sufficiently, steadies amount in later steps, higher efficiency, reduces sewer overflows, longer lasting infrastructure (1 each, 2 max)

(c) (1 point) **A**

(d) (3 points)

Solution: before primary treatment, preliminary treatment/pretreatment, after screening (1), damages future equipment, causes buildups/blockage, requires more frequent maintainence, increase maintainence cost (1 each, max 2)

(e) (2 points)

Solution: high surface area to volume ratio (1), increases adsorption (1)

(f) (1 point) **A**

28. (a) (2 points)

Solution: fine bubble diffuser is more common and efficient (1 each)

(b) (2 points)

Solution: bad idea (1), the tank needs to be anaerobic (1)

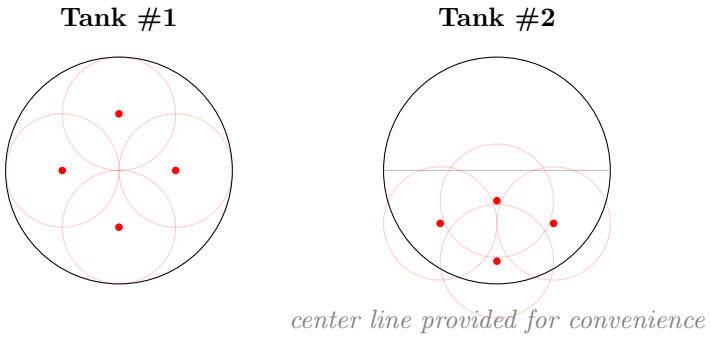
(c) (2 points)

Solution: bad idea (1), denitrification should be in anaerobic conditions (1)

(d) i. (3 points)

Solution: Coarse (1), fine will become clogged by the grit (2)

ii. (3 points)



Solution: evenly distributed in tank 1 (1), tank 2 should be evenly distributed within the bottom half (1), 1 point for putting them far away from each other. it doesn't have to be exactly like the provided solution but should be close. transparent circles are just for clarity and are not graded

iii. (2 points)

Solution: No for both (1), oxygen diffuses throughout the water, not high enough temperature (1 for both reasons, the reasons why both don't work are the same); give 1 point partial for yes to mesophilic with reasonable justification like that there's no mixing

iv. (2 points)

Solution: add an blower to mix the water (2 for anything about mixing)

29. (a) (1 point)

Solution: kills pathogens in water

(b) (1 point) **fecal coliform**

(c) (1 point) **D**

(d) (1 point) **A**

(e) i. (2 points)

Solution: bad idea/ineffective (1), chlorine is used up by organic molecules so less stuff will be killed (1)

ii. (2 points)

Solution: bad idea/unsafe (1), chlorine produces hazardous byproducts

iii. (2 points)

Solution: good idea/safe and effective (2), ozone doesn't need to be removed

iv. (2 points)

Solution: good idea (2), ozone is very corrosive so you want a material that's resistant to corrosion

v. (2 points)

Solution: good idea (2), hard water can be bad because it forms crusts on UV lamps but soft water is fine

vi. (2 points)

Solution: bad idea/not effective (1), turbidity too high (1)

vii. (2 points)

Solution: bad idea (1), will damage the membranes/increase cost (1)

viii. (2 points)

Solution: bad disinfection method (1) because it can only kill bacteria (1)

30. (a) (2 points)

Solution: greywater is water from household uses not from the toilet (e.g. showers, sinks, washing machines, etc.) (1), black water is contaminated with sewage/from toilets

(b) (2 points)

Solution: small communities, isolated areas, when treatment needs to be nearby, new developments (1 for any), cheaper/lower initial investment cost, allows easier separation, quicker/easier to put up, less transportation/infrastructure (1 for any)

31. (a) (2 points)

Solution: No (1), not a representative sample since it's not mixed/are missing stuff that settled to the bottom(1)

(b) (2 points)

Solution: Yes (1), water must be mixed and this is a good, recommended way to do this (1)

(c) (2 points)

Solution: choose dose of 3 mg/L (1) because it has the lowest turbidity while having a reasonable residual aluminum level (1).

(d) (1 point) **Alum/aluminum sulfate (1), also accept aluminum chloride**

(e) (1 point) **flocculation, sedimentation (in this order, all or nothing)**

32. (a) (2 points)

Solution: both produce nitrogen gas (1), anammox uses both ammonium and nitrite while denitrification uses just nitrates (1)

(b) (2 points) **ammonia**

33. (a) (1 point) **Tubifex**

(b) (1 point) **Simultaneous**

(c) (2 points)

Solution: hemoglobin (1), allows it to inhabit low oxygen habitats (1)

(d) (2 points) **0-25 (2), 1 point partial for 25-50**

(e) (3 points)

Solution: Yes (1), it forms cysts (1) that can handle dessication/drying out (1)

Section 4: River Walk

34. (2 points) **Purple Loosestrife**

35. (a) (2 points)

Solution: Yes (1), invasive species are nonnative, usually growing out of control/spreading range (1, also give credit for fast reproduction, generalist, widely adaptable)

(b) (2 points)

Solution: No (1), indicator species presence gives information about some state of the environment like the level of a pollutant (1)

(c) (1 point) **Long term management (1)**

(d) (2 points)

Solution: Pollution removal, pollinator increases (especially bees), increases general diversity (2), 1 partial for medicinal/food/ornamental uses since these aren't environmental

(e) (2 points) ***Galerucella***

36. (a) (3 points)

Solution: control of pests by physical means like weeding them manually (1), would be very ineffective (1) because the species grows too fast and there are too many individuals in too wide of an area (1 for either reason)

(b) (2 points) **Auxin/IAA (1), Yes (1)**

(c) (4 points)

Solution: Importation - importing nonnative species to combat the invasive (1), augmentation - adding more of (or otherwise stimulating) a native predator (1), conservation - preserving native predator populations (1). Importation is main method for loosestrife

37. (3 points)

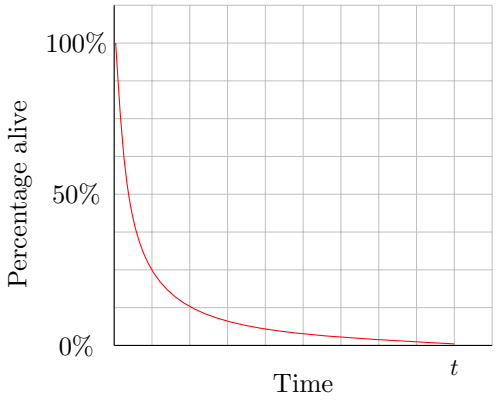
Solution: $\boxed{7.019 \cdot 10^9}$ **plants, full credit if work showed was correct with clear rounding**

$1439 \cdot (2.7 \cdot 10^6) \cdot 0.01 \cdot 0.007 \cdot 0.85 = 2.311 \cdot 10^5$ **after the first year.**

$1439 \cdot \big((2.7 \cdot 10^6) \cdot 0.01 \cdot 0.007 \cdot 0.85\big) \cdot \big((2.7 \cdot 10^6) \cdot 0.01 \cdot 0.007 \cdot 0.85\big) \cdot \big((2.7 \cdot 10^6) \cdot 0.01 \cdot 0.007\big) = 7.019 \cdot 10^9$ **total**

38. (a) (2 points) **Type III survivorship curve (1), r-selected (1)**

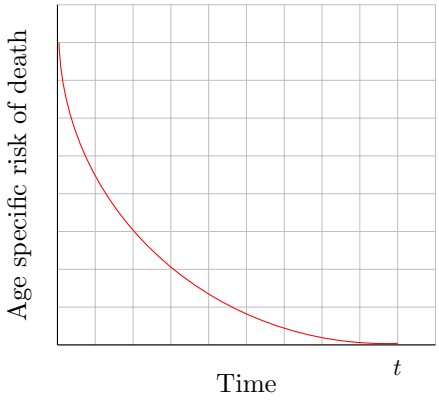
(b) (2 points)



Solution: Should be a type III survivorship curve. (1) point for always decreasing, (1) point for being concave up

curved extra because technically it should be curved more than the type II curve

(c) (2 points)



Solution: Same shape as previous question – starts high, rapidly drops off.

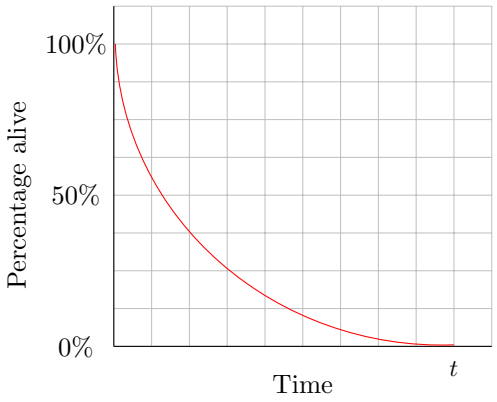
(1) point for always decreasing, (1) point for being concave up

A U shape is also fine and earns both points

(d) (4 points)

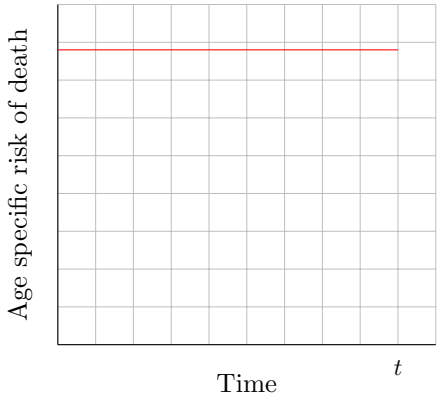
Solution: 4 points for a peak near the middle (graph can be skewed left or right)

(e) (2 points)



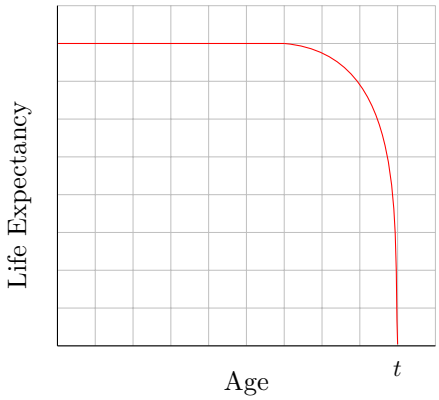
Solution: should be exponentially decreasing (0 points for a linearly decreasing line, that would be for a logarithmic axis)

(f) (1 point)



Solution: full credit for any horizontal line

(g) (3 points)



Solution: 1 for the first part being flat, 1 for never increasing, 1 for the last part having a rapid drop off

39. (a) (2 points)

Solution: Underestimate (1) because it's hard to count everything (1) (also give 2 points for saying that he isn't counting seeds/seedlings and therefore is very inaccurate. I would call this part of the underestimation, but saying this deserves credit)

(b) (3 points)

Solution: Incorrect methodology (1) because there was no dispersal (plants don't move) (1) and the decrease could have been due to a plant getting eaten, plant was moved, tag falling off, not seeing it, plant dying, getting stuck to animal, etc. (1)

(c) (3 points)

Solution: Doesn't necessarily work (1) depending on what Bill chose as his sample region. We have no way of knowing that the number in each square is roughly similar (2 for something similar). (total 1 point partial for saying both that the population is 2190 and giving justification like saying the population is constant - there isn't enough information to say that this method works, but it's a reasonable assumption to think that he chose good regions)

Solution: What if he included the river in this region? Then squares with the center of the river would likely be lower in number than squares including the riverbank.

We also have no way of knowing that this species is distributed randomly - might be clumped which would ruin this measurement. This is a common method, but you would want to take more than one measurement

40. (a) (2 points) Water Hyacinth

(b) (1 point) A

(c) (2 points)

Solution: decreases (1) because the plant physically blocks the water from the air (1)

(d) (3 points) BC (1 for either B/C)

(e) (2 points) Late afternoon (1), carbon (1)

(f) (1 point) Bottom of the lake (1)

(g) (3 points)

Solution: decrease pH, no effect on nitrogen, decrease phosphorus (1 each)

41. (a) (2 points)

Solution: asexual (1), enables very fast reproduction (1)

(b) (2 points) C

(c) (2 points)

Solution: Use of plants to pull pollutants (usually heavy metals) out of the environment (1). This species is good at absorbing heavy metals (1)

42. (a) (3 points)

Solution: Advantage (1 for any of these): cheap, quick, relatively simple; disadvantage (1 for any of these): more ecosystem effects, damaging to other plants, human health risks, more regulation, downstream damage,. Bad idea (1)

(b) (2 points)

Solution: No (1), mechanical control is best used when there's a small populatio, labor intensive, hard to do on large scale (1),

(c) (2 points)

Solution: It can survive outside of water for a long time (2)

43. (2 points)

Solution: (1 each, max 2): long living seeds, could be brought in by someone else, could come from upstream, seeds/plants can survive outside of water (other answers may apply)

Section 5: Bug Catching

44. (a) (1 point) None of them
    (b) (1 point) 8
    (c) (2 points) Asian tiger mosquito
    (d) (3 points)

    Solution: 5, 9, 10, 12, 15 (1 point for getting 2, 1 point for getting another 2, 1 point for the last 1, −1 point for each incorrect image listed)

    (e) (2 points)

    Solution: 10, 11, 12 (1 point for the first 2, 1 point for the third, −1 for each incorrect letter)

    (f) (4 points) Caddisfly (2), 9 (1), 10 (1), −1 for each incorrect letter given
    (g) (2 points) damselfly
    (h) (3 points)

    Solution: 6, 8, 13 (1 point each, −1 for each incorrect)

    (i) (2 points)

    Solution: 18, 6, 16 (1 for the first 2, 1 for the third, −1 for each incorrect letter)

    (j) (1 point) flatworm
    (k) (2 points) dragonfly

45. (a) (1 point) high water quality
    (b) (3 points)

    Solution: 5, 9, 10, 12 (1 for the first 2, 1 point for the other 2, −1 for each incorrect letter)

    (c) (2 points) 4
    (d) (1 point) it's poor

46. (a) (2 points)

    Solution: a few days, even as short as a few minutes (1), has to have been taken on a specific day or two since all naiads of a specific species mature at the same time (1)

    (b) (2 points)

    Solution: species has only one brood per year

47. (a) (2 points) Zebra mussel

(b) (1 point) calcium

(c) (2 points)

Solution: high CO2 decreases pH/makes water more acidic (1), which causes their shells to dissolve/makes it harder to build or maintain shells (1)

(d) (1 point) veligers

(e) (2 points) 15, 18

(f) (1 point)

Solution: decrease (1) by filtering things out of the water

48. (a) (1 point) smaller (1)

(b) (3 points)

Solution: amplexus requires direct contact between male and female (1), broadcast spawning does not (1), uses amplexus (1)

(c) (2 points) shredder

(d) (3 points) 7, 8, 11

49. (a) (1 point) 8

(b) (2 points) founder effect

(c) (1 point)

Solution: filter feeder/eats plankton and detritus (1)

Section 6: Daily Dips!!

50. (a) (4 points)

Solution: Orthophosphates; Condensed / inorganic phosphates; Ortho is a single PO4-, ortho is many connected

(b) (3 points)

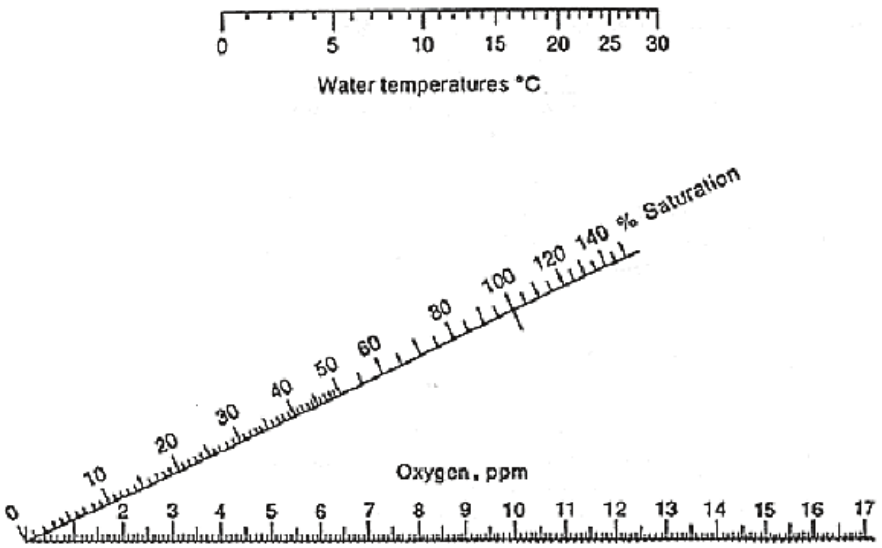
Solution: Turbidity(1); increased runoff (2)

(c) i. (1 point) **A** iii. (1 point) **A** v. (1 point) **A**
ii. (1 point) **A** iv. (1 point) **B**

(d) (3 points)

Solution: Higher temp —> higher kinetic energy —> particles move more and more easily break the intermolecular forces between oxygen and water

(e) (2 points) **86% (accept +/- 3)**



51. (a) (4 points)

Solution: Antimony is a catalyst; Ammonium molybdate makes a complex with phosphate to give it colour; Ascorbic acid is a reducing agent to make the solution blue. 1pt if all are correct

(b) (3 points)

Solution: 0.049 ppm

(c) (8 points)

Solution: TSI(SD) = 60-14ln(2) = 50.012
TSI(CHL) = 9.81ln(9.35)+30.6 = 52.529
TSI(TP) = 14.42ln(49.4)+4.15 = 60.387
TSI = average of the 3 = 54.31
1pt for each correct formulas, 1 pt for all correct values of subparts, 1pt for averaging, 3 pts for correct final answer

(d) (1 point) **C**

(e) (2 points)

Solution: It is endorheic(1); tends to concentrate things since the phosphate remains as water is evaporated (1)

(f) (2 points)

Solution: Make the standards at lower concentrations

52. (a) (2 points)

Solution: Located in the woods, so lots of leaf litter to be broken down.

(b) (3 points)

Solution: 6.6 mg/L

(c) (1 point)

Solution: Waterfalls, so white water

(d) (1 point) **A**

(e) (5 points) **4**

(f) i. (1 point) **A** ii. (1 point) **B** iii. (1 point) **A** iv. (1 point) **A**

Section 7: Winooski Watershed Woes

53. (a) i. (2 points) Hydrolysis
ii. (2 points) Dechlorination

(b) (1 point) B

(c) (1 point) Pyrethrtins

54. (a) (2 points)

Solution: 8% nitrogen by weight, 12% phosphorus by weight, 32% potassium by weight

(b) (2 points)

Solution: Potassium, as it promotes flowering and fruiting

(c) (2 points)

Solution: Smaller (1), less nitrogen fixation has to happen via Haber which is very energy intensive (1)

(d) (1 point) B (e) (1 point) B

55. (a) (2 points) Caddisfly
i. (1 point) 1-2 years
ii. (2 points) Aceytylcholinerase inhibitor

(b) (2 points) Waterboatman
i. (1 point) A

(c) (2 points) Predaceous Diving Beetle
i. (1 point) Water tiger

(d) (2 points) Water penny
i. (1 point) Underside of rocks
ii. (1 point) Nothing!

(e) (2 points) Sowbug
i. (1 point) Shredders
ii. (1 point) A iii. (2 points) C

(f) (2 points) Deer/Horse fly
i. (1 point) Larvae + eggs

(g) (2 points) Midge
i. (1 point) B
ii. (1 point)

Solution: Biting humans, wing size, where they hold their first pair of legs, etc.

56. (5 points)

Solution: 6.35; 2 points for correct set up (even if their ID was wrong, but they had the right formula), 3 points for correct answer

57. (1 point) **C**

58. (6 points)

Solution: 0.95; 2 pt for correct set up, 1 pt for correct substitution, 2 pts for correct answer (1 answer pt for 1.84, which is the value of H)

59. (a) (1 point) **B** (b) (1 point) **A** (c) (1 point) **C** (d) (1 point) **A**

60. (a) (1 point) **B** (b) (1 point) **B** (c) (1 point) **B**

61. (2 points)

Solution: dredging, capping, attenuation, treatment with surfactants, etc.

62. (1 point)

Solution: something like vegetation barriers blocking runoff, fertilizer regulation, etc.

63. (2 points)

Solution: Pervious concrete, bioswales, green roofs, etc. (green infrastructure)

(a) (2 points) **B**

64. (0 points) **many solutions, but the right one is piplup!**

Section 8: The Salty Dog Rag

65. (23 points) **ES or volunteer initials** *(For ES Use Only)*

66. (23 points) **5.9% ± 0.5**