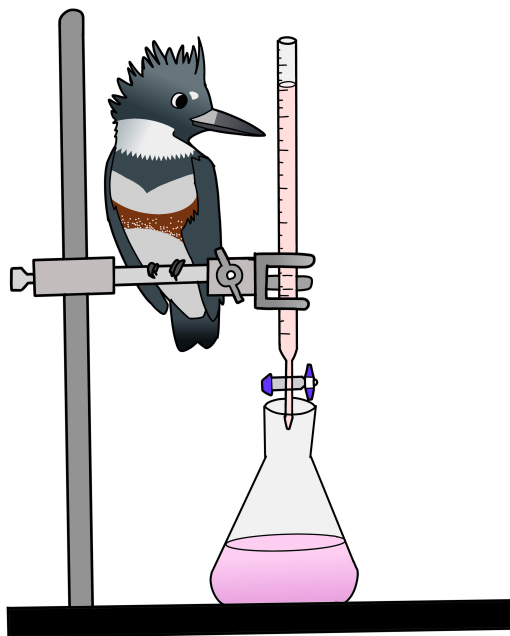


# BirdSO Mini Invitational

Roland Hu and Nayrie Patel

11-18 December 2021



## Directions:

### Basic Introduction + Instructions

Hello competitors! My name is Roland Hu (University of Washington Biochem 2024, formerly Palo Alto HS 2020) and I'll be your BirdSO Environmental Chemistry Co-Event Supervisor. I never actually competed in Environmental Chemistry but I did compete in a lot of Chem Lab and feel confident in my skills at a test writer (I wrote Chem Lab for BirdSO last year!).

Hi y'all, I'm Nayrie Patel (Lexington High School 2022), and I'll be the other BirdSO EnviroChem ES! I'm currently competing in Environmental Chemistry but have a background in Water Quality (rest in peace T-T), GeoMapping, and Forensics. Before you get started please read the following.

1. The test is 50 minutes long and going by BirdSO rules, can be done asynchronously, however we'll be on the event supervisor page on scilympiad for any immediate questions. You can also email Roland or message on discord if something comes up (contact information is below).
2. The test is a collection of 4 sections with 66 questions (140 pts total) on environmental topics, legislation, and chemistry.
3. Each question will start with a textbox full of background information, constants, conditions, procedures, memes, etc. so do read them carefully.
4. You can assume everything is happening at standard lab pressure and temperature (293 K, 1 atm) unless otherwise specified. Most problems will mention this in the background textbox.

5. Type in your work. You don't have to show every single step but do show the important intermediate steps as it makes it easier to give partial credit especially on the longer calculation problems.
6. For anything involving subscripts, superscripts, or any other weird formatting things, you can ignore them as long as what you are typing isn't too ambiguous. For example, typing in  $10^{-5}$  or CO<sub>3</sub><sup>2-</sup> is fine.
7. Sig figs don't really matter in anything beyond that first unit test you take in any general chem class. So for this test I won't be taking sig figs into account but you should still try to use an appropriate number of sig figs. Just don't use too little or too much as certain experimental apparatus are not that accurate or inaccurate.
8. You can use a calculator and notes from your binder as per the National Rules.
9. Another general test taking tip is the principle of Occam's razor. "Sometimes the simpler explanations are more correct".
10. Good luck and have fun! (:

If you have any questions about the exam after it has concluded whether you are a BirdSO competitor, another competitor taking this test for practice, reviewing the solutions and notice a mistake, or have any questions on Section 4 of the exam, please email Roland at [rolandhu123@gmail.com](mailto:rolandhu123@gmail.com) or message me on discord at r\_hudini8811. If you have any questions on sections 1-3, you can email Nayrie at [get2nayrie@gmail.com](mailto:get2nayrie@gmail.com) or message me on discord at nayrie0963. Enjoy!

Page	Points	Score
3	36	
4	29	
5	27	
6	30	
7	18	
Total:	140	

1. (0 points) Please type the following text exactly as written:

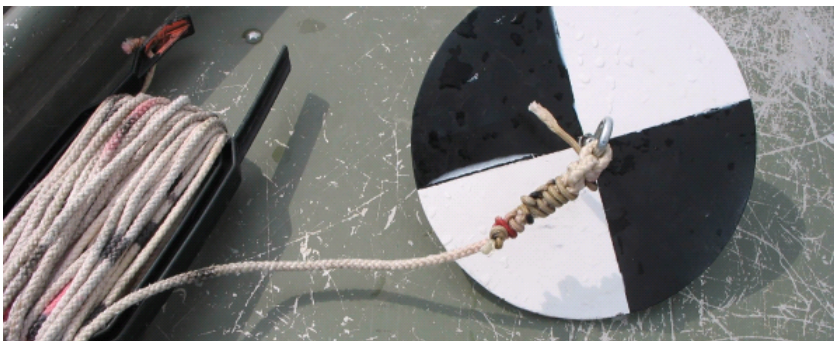
The work on this test is solely our own. I accept the consequences of academic dishonesty.

2. (1 point) What is your favorite branch of chemistry? (This one's a freebie :D)

## 1 General Environmental Concepts

Answer the following questions on topics such as environmental issues, wastewater treatment processes, water quality, etc.

3. (6 points) Describe the process of eutrophication in detail. Include the following terms in your response: HAB(s), limiting nutrient, dead zone(s).



4. (4 points) Name the tool shown in the image above and list 3 units that are used to measure turbidity.

5. (4 points) Answer the following questions related to the nitrogen cycle.

What is the process in which bacteria convert  $\text{NH}_3$  to  $\text{NO}_2$  and  $\text{NO}_3^-$ ? [1pt] What is the process in which  $\text{NO}_3^-$  and  $\text{NH}_3$  are incorporated by plants into proteins, nucleic acids, and other important organic molecules? [1pt] What conditions are required for denitrification to occur? [1pt] Why isn't  $\text{N}_2$  immediately usable for organisms in its gaseous state? [1pt]

6. (2 points) What is the difference between a pollutant and a contaminant?
7. (3 points) List the 6 steps of potable water treatment in order.
8. (7 points) List the steps/processes involved in each of the 3 phases of wastewater treatment.

Primary Treatment   Secondary Treatment   Tertiary Treatment

## 2 Clean Water Act

Answer the following questions regarding pages 1-59 and 150-234 of the Clean Water Act.

9. (2 points) When was the Clean Water Act first introduced, and what was it originally called?
10. (1 point) In which of the following years was the Clean Water Act NOT amended?
  - A. 1977
  - B. 1966
  - C. 2014
  - D. 1952
11. (5 points) List the 5 main titles of the Clean Water Act in order.
12. (1 point) What event did NOT ultimately contribute to the first Earth Day event?

- A. "Earthrise", photographed by the Apollo 8 space mission crew
- B. The Three Mile Island Accident (partial meltdown of nuclear power plant)
- C. The publication of Silent Spring by Rachel Carson
- D. The 1969 Santa Barbara Oil Spill
13. (8 points) Silent Spring, published in 1962 by Rachel Carson, led to a nationwide ban on the use of DDT in agriculture and the formation of the EPA. Answer the following questions regarding this pesticide.
- What is the full name of DDT? [1pt] What was DDT used for before it became widely known as a pesticide? [1pt] List 2 reasons why DDT was used as a pesticide before it was banned. [2pts] Explain why DDT is considered a highly polluting hazard today. [2pts] Describe the effects of DDT on a) birds and b) humans. [2pts]
14. (1 point) The Clean Water Act clearly defines "waters of the United States".
- A. True
- B. False
15. (2 points) If you answered true to the previous question, leave this one blank. You'll still receive points if you have the right answer.
- If you answered false, where is "waters of the United States" actually defined?
- For the following questions, provide the general definitions for each of the following terms as stated in the Clean Water Act.
16. (3 points) Pollutant
17. (2 points) Toxic pollutant
18. (2 points) Medical waste
19. (3 points) Point source
20. (3 points) Floatable material
21. (1 point) Navigable waters
22. (2 points) Coastal recreation waters
- Match the following descriptions to the corresponding section of the Clean Water Act.
23. (1 point) Requires standards for thermal pollution to ensure the protection of fish and wildlife in the body of water into which the discharge is occurring.
- A. 309
- B. 316
- C. 319
- D. 402
24. (1 point) Authorizes the NPDES Permits program which states that conventional industrial and municipal dischargers must obtain permits from the EPA for discharging materials into the waters of the United States.
- A. 309
- B. 316
- C. 319
- D. 402

25. (1 point) The EPA is authorized to seek civil or criminal penalties for some violations of the Clean Water Act.
- A. 309
  - B. 316
  - C. 319
  - D. 402
26. (1 point) Created the Nonpoint Source Management Programs which provide grants to states, territories, and Indigenous tribes to cover program implementation costs.
- A. 309
  - B. 316
  - C. 319
  - D. 402

### 3 IWOCM

Answer the following questions regarding all of the Indiana Wastewater Operator Certification Manual.

27. (4 points) List the 4 steps required to become a certified operator.
28. (4 points) Class I certified operators are certified to operate which of the following types of treatment facilities?
- ☐ Class I-SP
  - ☐ Class I
  - ☐ Class II
  - ☐ Class III
  - ☐ Class A-SO
  - ☐ Class A
29. (2 points) What is the minimum dissolved oxygen requirement in surface waters of the State of Indiana?
- Answer the following Operator Exam Practice Questions from the Indiana Wastewater Operator Certification Manual.
30. (2 points) What are the goals of the state regarding water quality?
31. (3 points) My wastewater treatment plant receives brine wastes from water softeners. Do I have to be concerned about the salt content of my discharge?
32. (4 points) What is meant by “Best Management Practices”, or “BMPs”?
33. (1 point) What does “NPDES” stand for?
34. (1 point) What is the maximum term of a NPDES permit?
35. (2 points) What is a “four day average discharge”?
36. (2 points) If there are two or more wastewater treatment plants at one industrial site and each independent wastewater treatment plant is classified as a Class B or Class C wastewater facility, how will that industrial site be classified?

## 4 Chemistry!

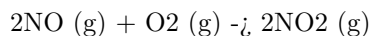
Problem 1: Air is no alternative to air

These questions all relate to the atmosphere with a bit of gas phase kinetics.

37. (6 points) Name the 3 major gases compose the majority of Earth's atmosphere and in what relative percentages? (You can also give a range of percentages: Gas 1: 10-20

38. (3 points) Name 3 other minor gases that account for  $\approx 1\%$

The next set of questions will relate to the following reaction:



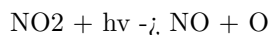
You can assume that this is an elementary process

39. (2 points) What is the rate law for this reaction?

40. (4 points) Going off your previous answer what can you say about the feasibility of this reaction? In air the concentration of NO is 1ppm whereas the O<sub>2</sub> is 210,000 ppm. Using this write a new rate law and give reasoning to why we can do this approximation. Do you expect it to occur as written or in some other way?

41. (5 points) The half-life of NO has been estimated to be 100 hrs. Under the new rate law determined in the previous question, what would the half-life be if the initial NO concentration were increased to 12 ppm?

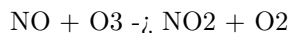
An important aspect of Nitric oxides is that they react with oxygen and ozone within the atmosphere. Given the following reactions and heat of fusions, answer the following questions.



$$\Delta H = 90.3 \text{ kJ/mol}$$



$$\Delta H = 249.3 \text{ kJ/mol}$$



$$\Delta H = 33.2 \text{ kJ/mol}$$

\* $h\nu$  represents UV light, just a catalyst

\*\*Chapman cycle, non-reactive species that takes up energy

42. (4 points) What is the maximum wavelength of light that can photodissociate NO<sub>2</sub>.

43. (2 points) Do you think this reaction to occur in the troposphere and why?

44. (2 points) What color do you expect for NO<sub>2</sub> to be? (hint think about absorption)

Problem 2: Fuel for Climate Change

The majority of the world's power comes from fossil fuels. Fossil fuels are nice since they are convenient to burn, energy dense, "widely" available, and make good subject for comics. What is not so nice about fossil fuels is the carbon emissions they produce. Carbon dioxide emissions from fossil fuels are one of the major contributors to climate change. It is clear that within the next couple decades' humanity has to come up with an alternative to solve this energy crisis. The government has recruited BirdSO test takers to handle this crisis by letting you take command of their fuel research department (lucky you!).

You can assume everything takes place at 298 K and 1 atm.

45. (2 points) You have looked into hydrogen gas as a possible alternative to fossil fuels. However, you are stumped on how to get hydrogen. You figure out one way you can form hydrogen is by reacting methane with water to get CO<sub>2</sub> and Hydrogen gas. Write out this equation and balance it.

46. (2 points) When your supervisors see your expression they get super paranoid. Your reaction produces CO<sub>2</sub> which as stated in the background is a nu Bueno. You assure them that this CO<sub>2</sub> can be easily capture and will not be released into the atmosphere. Suggest 2 ways of capturing CO<sub>2</sub>.

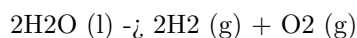
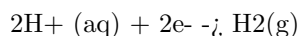
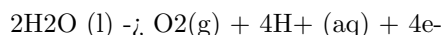
47. (2 points) After getting the approval of your superiors you then set out to calculate the enthalpy for your reaction. Here are some helpful values.

Enthalpy of formation of CH<sub>4</sub>(g) = 74.8 kJ/mol

Enthalpy of formation of CO<sub>2</sub>(g) = 393.5 kJ/mol

Enthalpy of formation of H<sub>2</sub>O(l) = 285.8 kJ/mol

48. (1 point) Another way of producing hydrogen gas is through the electrolysis of water. You are given the 2 following half reactions and overall cell reaction.



Which half reaction occurs at the cathode?

49. (2 points) What is the enthalpy change for the overall cell reaction?

50. (3 points) What is the cell potential? (hint you might want to use this value below)

Entropy of formation of H<sub>2</sub>O(l) = 163.0 J/K/mol

Problem 3: Better “Cop” this Problem

Copper is a wonderful metal, often found in various alloys used in structure, corrosion protection, and of course pennies. One popular use of copper is the production of certain copper salts such as copper (II) nitrate and copper (I) oxide. Copper (II) nitrate is often used as an insecticide/pesticide and copper (I) oxide is used as a corrosion prevention paint. Unfortunately, copper can also be quite toxic and is one of the most common types of metal poisoning, and is especially dangerous to aquatic life.

You are given a 1.00e2 M solution of copper (II) nitrate which a pH of 4.65.

51. (3 points) What is the equation for the formation of the conjugate base of the hydrated Cu<sup>2+</sup> ion?

52. (2 points) What is the pK<sub>a</sub> of the conjugate acid base pair?

53. (3 points) K<sub>sp</sub> Copper (II) hydroxide or Cu(OH)<sub>2</sub> = 1e-20. Using this and the values from the start, calculate the pH of the pH where copper (II) hydroxide precipitates out.

**Conclusion:**

Thank you for participating!