Thermochromic **Summary and Proposal 2**

Your name: Cieran Wong Your email: cieranwong@arizona.edu

Your lab partner’s name(s): Nick Samuels Your lab partner’s email(s): nssamuels014@arizona.edu

Your lab instructor’s name: Pedro Your lab section: 2A

*All work must be* ***very neat*** *and* ***organized****. If you need to organize your thoughts, please use a separate sheet of paper. Proposals are a* ***group******effort****. Please submit the completed document as a PDF to the* ***Thermochromic Proposal 2*** *D2L DropBox folder before the scheduled end of lab.*

1. In your own words, the **goal for this second session** of the *Thermochromic Project* is…

Implement procedure from Proposal 1 and come up with three new volume ratios to better determine the perfect ratio for a thermochromic thermometer. This should help us find the optimal ratio for the cobalt chloride to determine the most distinct color change at 1 degree Celsius or close to freezing temperature.

2. **Observations and Results from Implementing Proposal 1**. Using the numbered steps from your **Proposal 1** (submitted last session), report your results/observations for each procedural step in the left column. In the right column, explain what these results/observations indicate (use the step number to connect the explanations/indications to the observations/results).

|  |  |
| --- | --- |
| Observation | Explanation or Indication |
| When we prepared and tested our cobalt chloride alcohol volume ratios, we observed the following:   1. Gather 7, 5 mL glass vials. 2. In two plastic 20 mL vials, collect the cobalt chloride concentrations that have ethanol (*CoCl2[EtOH]2*) and methanol (*CoCl2[MeOH]2)*. 3. Calculate the amount of mL each ratio divides the total of 4mL into. 4. Using a micro pipette, we then put the calculated volumes into each vial, starting with the 100 -1000 microliters pipette to put the ethanol before the methanol. 5. After micro pipetting the ethanol, we then micropipette the methanol into the respective vials. 6. Shake the vials lightly and let it rest for one minute. 7. Record the color of each vial, noting the different ratios and comparing them to the other ratios. 8. Place the vials in the ice bath for ten minutes. 9. While waiting for the ice bath, set up the spectrometer to record the wavelength and absorption levels once we are done with the ice bath. 10. Take the vials out of the ice bath and record their colors. Compare with the room temperature colors. 11. Place the solutions in cuvettes to undergo the spectrometer. 12. Calculate the concentrations using Beer’s Law. 13. Calculate KC after finding the concentration in step 12. We can then determine the signs of by plotting a KC vs Temperature Graph. | Based on these results/observations, we concluded:   1. The different ratios produced a large spectrum of colors, and it was clear to see the progression as more Methanol was added with a decreasing ratio. 2. There was a vast difference in the color of the solutions when comparing Room Temperature and Freezing Temperature. After undergoing the Freezing process, the solutions all became lighter colors, ex. From a dark blue to a lighter pink/purple. 3. When ran through the spectrometer, Ethanol had the higher absorption peaks compared to Methanol. The wavelength varied, but for the concentrations that were 3:1 to 5:1, the Ethanol was on a higher wavelength while the Methanol was on a lower wavelength. 4. The higher ratios, 3:1 till 5:1 were more consistent with their wavelength as there were all around 660 – 662 nm. The lower ratios varied from 380 – 450 nm. 5. There was not much difference between the absorption levels for the Freezing and Room Temperature. At most there was a slight variation in the absorption levels, however the wavelengths more or less stayed consistent throughout. |

3. **Proposal 2**. Given your **Proposal 1** findings reported above, propose, and justify a plan to systematically design and test inexpensive, self-contained thermochromic thermometers that distinctly change color at 1 °C (the temperature of a typical water-ice mixture *without* Ice Melter®). Specifically, your plan should accomplish two objectives. First, propose **at least three (3)** further **volume ratio** refinements to find the **optimal** cobalt chloride alcohol volume ratio that **most distinctly/sharply changes color at 1 °C** on the **milli-scale level** (no more than 4 mL). This should include calculating *Kc* at **room temperature** and **≈ 0 °C** (5 - 7 °C). Note, for *Kc* at ≈ 0 °C(5 - 7 °C), you will need Ice Melter® in the ice bath to depress the temperature below 0 °C to compensate for the warming when the chilled solution is transferred into a cuvette. Second, your plan should propose **at least four (4) different total volumes** to find the **lower limit** of a **distinct visual color change at 1 °C** for the **optimal** cobalt chloride alcohol volume ratio. Here the water-ice mixture *must not* employ Ice Melter®. ***Please NUMBER your procedural steps.***

|  |  |
| --- | --- |
| Procedural Step | Justification |
| Our new proposal has the following steps:   1. The three new ratios that we have in addition to the ratios we currently have are as follows: 4.5:1, 3.5:1, and 2.75:1. 2. Gather 10, 5 mL glass vials. 3. In two glass 50 mL beakers, collect the cobalt chloride concentrations that have ethanol (*CoCl2[EtOH]2*) and methanol (*CoCl2[MeOH]2)*. The ethanol is the blue solution, and the methanol is the pink solution. 4. To calculate the volume ratios of each respective ratio, take 4mL and divide that by the total ratio. This will give the volume for one part. Then multiply by the number of parts to get how much volume we need for each part of the ratio. Ex. For a 4:1 ratio, we have a total of 5 parts. If we divide 4/5, we get 0.8 for one part. To find the 4 parts, multiply 0.8 by 4. This will give us 3.2. So for our 4:1 ratio, we have 3.2 mL:0.8 mL. 5. Using a micro pipette, we then put the calculated volumes into each vial, starting with the 100 -1000 microliters pipette to put the ethanol (blue) before the methanol (pink). 6. After micro pipetting the ethanol, we then micropipette the methanol into the respective vials. 7. Shake the vials lightly and let it rest for one minute. 8. Record the color of each vial, noting the different ratios and comparing them to the other ratios. 9. Place the vials in the ice bath for ten minutes. 10. While waiting for the ice bath, set up the spectrometer to record the wavelength and absorption levels once we are done with the ice bath. 11. Take the vials out of the ice bath and record their colors. Compare with the room temperature colors. 12. Place the solutions in cuvettes to undergo the spectrometer. 13. Record the wavelength and absorption levels of each solution. Remember to record the wavelength and absorption for both Ethanol and Methanol. The higher peak is the Ethanol and the lower will be the Methanol. 14. Wait for another ten minutes or until the solution has reached Room Temperature. 15. Repeat step 13. 16. After recording all the respective wavelengths and absorption levels for both the Room Temperature and the Freezing Temperature, we can then calculate the concentrations using Beer’s Law. 17. Calculate KC after finding the concentration in step 12. We can then determine the signs of by plotting a KC vs Temperature Graph. 18. Based on the KC vs Temperature Graphs, we can then determine four volumes that might help us to produce the distinct color changes that we are looking for as this will then help us create a basic thermochromic thermometer that will distinctly change color when the temperature changes from Freezing to Room Temperature. 19. Our four total volumes are 4mL, 6mL, 8mL and 10mL. | We are making a change to this step of the procedure, or adding this step, because:   1. We added three new ratios as it will help us determine an optimal volume for the cobalt chloride to produce the sharpest, most distinct color change. 2. Instead of recording just the wavelength and absorption levels of Ethanol, we are also recording the wavelength and absorption levels of Methanol as this will help us when calculating the KC. |

|  |
| --- |
| **Technical Skill Evaluation** |
| Show two *KC* calculations in detail for one CoCl2(EtOH)2 **:** CoCl2(MeOH)4 volume ratio at two different temperatures (≈ 0 °C (5 - 7 °C) and room temperature), then present in an organized table all the *KC* results for the CoCl2(EtOH)2 **:** CoCl2(MeOH)4 volume ratios explored at the two temperatures.   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | Volume Ratio | Volume of *CoCl2[EtOH]2 (mL)* | Volume of *CoCl2[MeOH]2 (mL)* | Total Volume (mL) | Color of solution at Room Temperature | KC at Room Temperature | Color of solution at Freezing Temperature | KC at Freezing Temperature | | 5 | 3.33 | 0.67 | 4 | Blue af |  | Light indigo |  | | 4.5 | 3.27 | 0.73 | 4 | Blue |  | Bluish slight purple |  | | 4 | 3.20 | 0.80 | 4 | Lighter blue |  | Light purple / lilac |  | | 3.5 | 3.11 | 0.89 | 4 | Pale blue |  | Lighter purple |  | | 3 | 3.00 | 1.00 | 4 | Indigo blue |  | Lilac |  | | 2.75 | 2.93 | 1.07 | 4 | Violet |  | Deep purple |  | | 2.5 | 3.25 | 0.75 | 4 | Purplish blue |  | Indigo |  | | 2 | 2.86 | 1.14 | 4 | Pale indigo |  | Light purple |  | | 1.5 | 2.40 | 1.60 | 4 | Light purple |  | Bright pink |  | | 1 | 2.00 | 2.00 | 4 | Pink |  | Bright pink |  | |
| Paste-in or carefully sketch the *KC* vs. *T* plots for the CoCl2(EtOH)2 **:** CoCl2(MeOH)4 volume ratios explored. Reminder: whenever graphs or plots are presented, you are expected to properly scale, title, and label them using the correct units and appropriate sig figs. |
| **Data Analysis** |
| Discuss the trends in the signs of *ΔHrxn* and *ΔSrxn* and the *KC* vs. *T* curves for the various CoCl2(EtOH)2 **:** CoCl2(MeOH)4 volume ratios explaining the observed behavior using the ideas and terminology from lecture and the *Thermochromic Guide*and*Kc vs. T Infographic* (for example endothermic vs. exothermic, product vs. reactant favored, etc.). If the results lack a discernable trend, then discuss two possible *major* errors explaining the chemical/physical mechanism and how it leads to the observed outcome. *To receive credit your response must be well-written and use terms and concepts correctly*. |