General Chemistry Flipped Classroom Module

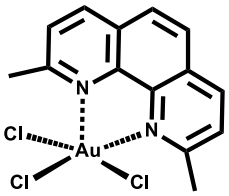
In-class Case Study Activity

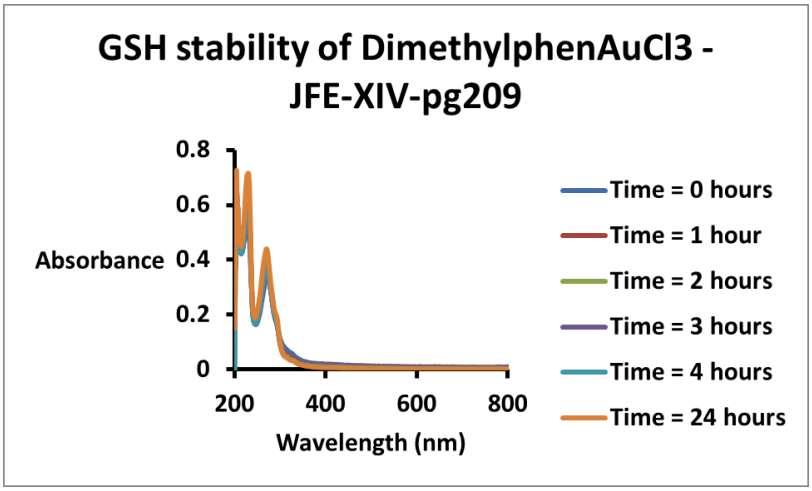
"Time Integrated Rate Laws and the Stability of Gold(III) Anticancer Compounds"

Gold(III) compounds are known to have significant anticancer activity, and are actively being explored for their potential use in the clinical treatment of a variety of cancers. One of the important factors in the final efficacy of gold-based drugs is their stability in biological aqueous buffer systems. If the compound decomposes the drug will likely be deactivated. Therefore, one aspect to consider in designing these gold-based drugs is imparting increased stability to the compound. Compounds that have slower rates of decomposition will potentially have increased anticancer activity.

Undergraduate students in a research lab at the University of California-Riverside have synthesized and characterized a variety of gold(III) compounds, and these compounds have been evaluated for their stability in aqueous buffer solution. Absorption spectroscopy has been used to monitor the concentration of these compounds, and as the gold complexes decompose the absorption maximum decreases. Decomposition/stability studies are shown below for two gold complexes. The following case study questions will allow you apply your knowledge of time integrated rate laws in an effort to compare the stability of these two potential gold-based anticancer drugs.

Compound 1 – [(di-methyl-phenanthroline)$AuCl_3$] (di-methyl-phenanthroline = 2,9-di-methyl-1,10-phenanthroline)



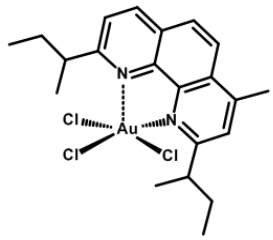


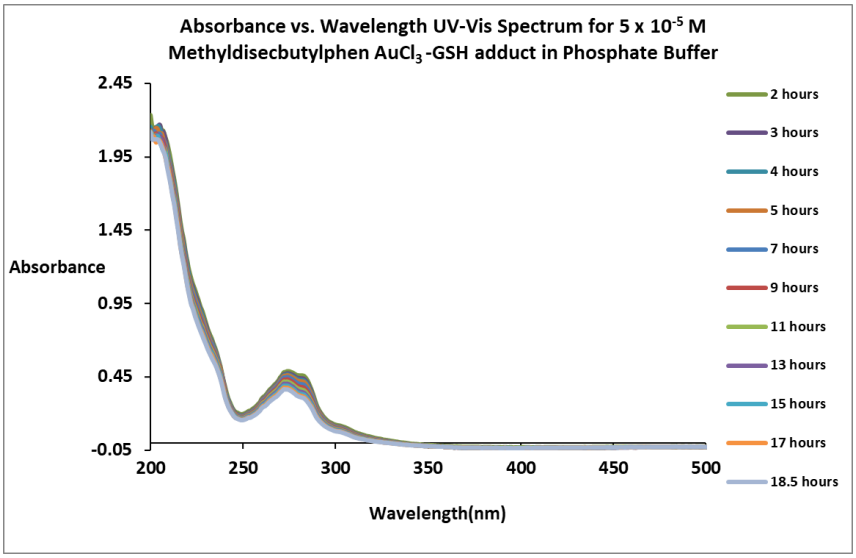
-Absorption maximum at 323 nm at time = 0 minutes (absorption = 0.0625). Use this absorption to calculate the molar absorptivity; the initial concentration = 1.00 x 10^{-5} M

-Use the following kinetic data to determine the time-integrated rate law. This can be done by using Excel to plot ln [ ] vs. time and 1/[ ] vs. time and determine which plot has a better linear fit.

Absorbance	time
0.044705	60 min
0.041725	120 min
0.039537	180 min
0.036528	240 min
0.034014	300 min

Compound 2 – [(di-*sec*-butyl-methyl-phenanthroline)$AuCl_3$] (di-*sec*-butyl-methyl-phenanthroline = 2,9-di-*sec*-butyl-4-methyl-1,10-phenanthroline)





-Absorption maximum at 320 nm at time = 0 minutes (absorption = 0.112). Use this absorption to calculate the molar absorptivity; initial concentration = 1.00×10^{-5} M

- Use the following kinetic data to determine the time-integrated rate law. This can be done by using Excel to plot ln [ ] vs. time and 1/[ ] vs. time and determine which plot has a better linear fit.

Absorbance	time
0.036885	60 min
0.032404	120 min
0.029789	180 min
0.028152	240 min
0.02429	300 min

Case Study Questions:

1) Given the absorption maximum and concentration of the gold complexes at time = 0 minutes, use Beer's Law to calculate the molar absorptivity (ε) for each compound. Assume the cuvette path (l) is 1.00 cm. Be sure to report the correct units for the molar absorptivity.

2) Using the molar absorptivity values from question #1, calculate the concentration of the gold complexes at each time point in the kinetic study. Use these concentrations to plot ln[ ] vs. time and 1/[ ] vs. time and determine the reaction order for the decomposition of each gold complex.

3) Use the best fit linear trend line for the plot that has the higher R^2 value (i.e., is R^2 closer to 1.0 for the ln[ ] vs. time plot or 1/[ ] vs. time plot), and use best fit equation to determine the rate constant for each gold complex.

4. Calculate the half-life for each complex. Which complex would have the slower rate of decomposition?

5. Based on the calculated rate constants and half-lives for each gold complex, which compound might be expected to have higher stability, and therefore potentially greater anticancer activity?