Created by Adam R. Johnson, Harvey Mudd College (adam\_johnson@hmc.edu) and posted on VIPEr (<u>www.ionicviper.org</u>) on March 24, 2025. Copyright Adam R. Johnson 2025. This work is licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0). To view a copy of this license visit <u>https://creativecommons.org/share-your-work/cclicenses/</u>

Interpreting the d<sup>6</sup> Tanabe-Sugano diagram

The UV-Vis spectrum of a 0.0081 M solution of [Co(en)<sub>3</sub>]I<sub>3</sub> is shown below. You will need a copy of the d<sup>6</sup> Tanabe-Sugano diagram (<u>https://en.wikipedia.org/wiki/Tanabe-Sugano\_diagram</u>).



a) What are the molar absorptivities of the absorptions at 330 and 466 nm?

- b) Based on the  $\varepsilon$  values, are these d-d transitions?
- c) Is this a high-spin d<sup>6</sup> or a low-spin d<sup>6</sup> complex? How do you know?

d) What are the energies of the two bands in wavenumbers? What is their ratio (greater than one)?

Created by Adam R. Johnson, Harvey Mudd College (adam\_johnson@hmc.edu) and posted on VIPEr (<u>www.ionicviper.org</u>) on March 24, 2025. Copyright Adam R. Johnson 2025. This work is licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0). To view a copy of this license visit <u>https://creativecommons.org/share-your-work/cclicenses/</u>

- e) Let's determine  $\Delta_{\circ}$  for Co(en)<sub>3</sub><sup>3+</sup>. If you did part c correctly, you should find that the ratio of the two absorptions is 1.41, and the value where this holds is  $\Delta_{\circ}/B \sim 39$ 
  - a. What are the E/B values for the two lowest energy transitions ( ${}^{1}A_{1g}$  to  ${}^{1}T_{1g}$  and  ${}^{1}A_{1g}$  to  ${}^{1}T_{2g}$ ) when  $\Delta_{o}/B$  = 39?
  - b. Use these values to determine B for each transition (to make sure you do the math correctly,  $E_1$  is 30,300 cm<sup>-1</sup> and  $E_2$  is 21,500 cm<sup>-1</sup>).
  - c. What is the average B value?
  - d. Use this B value to determine  $\Delta_{\circ}$