Analytical Chemistry Cumulative Examination
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Professor Michael Trenary

Fourier transform infrared (FTIR) spectrometers are now commonplace in analytical laboratories, and are extensively used in at least two research groups within the UIC Chemistry Department. An FTIR is based on a Michaelson interferometer and uses a blackbody radiation source at a temperature of 1200-1500 K and a helium-neon laser. The Michaelson interferometer consists of a beamsplitter, a moving mirror and a fixed mirror. Use of an FTIR involves measurement of an interferogram, $I(\delta)$, which is the light intensity arriving at a detector as a function of displacement, δ, of the moving mirror. When $\delta = 0$, there is zero path difference between light traveling to the detector from the moving mirror and light traveling to the detector from the fixed mirror. In this exam, assume that the interferograms are measured symmetrically about $\delta = 0$, i.e., they are measured for both positive and negative values of δ. To get an infrared spectrum, light intensity as a function of wavenumber, $B(\overline{\nu})$, is needed, where wavenumber, $\overline{\nu}$, has units of reciprocal centimeters, cm^{-1}.

100 pts total, 5 points for each question.

1. Give a mathematical expression for the relationship between $I(\delta)$ and $B(\overline{\nu})$.

2. Sketch $B(\overline{\nu})$ as a function of $\overline{\nu}$ for the blackbody radiation source.

3. Sketch $B(\overline{\nu})$ as a function of $\overline{\nu}$ for the helium-neon laser.

4. Sketch $I(\delta)$ as a function of δ for the blackbody radiation source.

5. Sketch $I(\delta)$ as a function of δ for the helium-neon laser.

6. Explain in a few sentences the reason a blackbody radiation source is used in an FTIR.

7. Explain the purpose of the laser in an FTIR.

8. Give an approximate value of δ for an FTIR spectrum measured with a resolution of 1 cm^{-1}.

9. Give an approximate value of δ for an FTIR spectrum measured with a resolution of 0.01cm^{-1}.

10. Briefly explain what an apodization function is in FTIR spectroscopy.

11. Explain the relationship between the instrumental line shape (ILS) function and the apodization function.

12. What is the relationship between a transmittance spectrum of a sample and the function $B(\overline{\nu})$ defined above?

13. What is the relationship between an absorbance spectrum and a transmittance spectrum?

14. FTIRs are typically purged by passing certain purified gases through the entire optical path. Explain the purpose of purging.

15. What aspect of the performance of an FTIR, if any, would be improved by using an 18 bit analog-to-digital converter (ADC) instead of a 16 bit ADC?

16. A typical FTIR uses two different laser detectors. Why?

17. For the same level of performance, FTIR spectroscopy was much more expensive thirty years ago than it is today. What is the main reason for the lower cost?

18. What additional spectral region can one measure, if any, with an FTIR that uses a beamsplitter with a cesium iodide substrate that one can not measure with an FTIR that uses a beamsplitter with a potassium bromide substrate?

19. Explain what is meant by "zero-filling" in FTIR spectroscopy.

20. Indicate which of the following time scales would be typical of the minimum time required for 1 scan of the interferometer corresponding to a 2 cm^{-1} resolution spectrum using a liquid nitrogen cooled mercury cadmium telluride detector: 10^{3} sec; 1 sec; 10^{-3} sec; 10^{-6} sec; 10^{-9} sec; or 10^{-12} sec.