AP Chemistry
Spectroscopic Techniques

The purpose of this activity is to compare and contrast the different spectroscopic techniques. Students will work in expert groups to learn about one type of spectroscopy, and then teach about that analytical method to the other students in their base groups. At the end of class, you should be able to describe the different spectroscopic methods and the information that can be derived from each.

Base Group: _____ _____
_____ _____

With your base group, use the following websites to answer questions 1-4.

- http://www.rsc.org/learn-chemistry/collections/spectroscopy/introduction#Introduction
- https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/Spectrpy/spectro.htm

1. What are the regions of the electromagnetic spectrum?

2. What is the relationship between wavelength and frequency?

3. What is the relationship between energy of a photon and its wavelength?

4. What is spectroscopy?

Split up into expert groups:
Expert Group: _____ _____
_____ _____

As a group, use the available resources to prepare a description of the spectroscopic method, an illustration of a typical spectrum, illustration of effects on the molecules, and answers to the key questions. It isn't necessary to use all of the available resources; however, you may find additional resources if needed! When you are done, return to your base groups. Base group members will take turns teaching about each of the spectroscopic techniques. Then, group members will work together to complete the follow-up questions.

Expert Group 1: UV-Vis Spectroscopy

- http://teaching.shu.ac.uk/hwb/chemistry/tutorials/molspec/uvvisab1.htm
- http://www.chemguide.co.uk/analysis/uvvisible/theory.html#top
- http://www.sci.sdsu.edu/TFrey/Bio750/UV-VisSpectroscopy.html
- http://chemwiki.ucdavis.edu/Organic_Chemistry/Organic_Chemistry_With_a_Biological_Emphasis/Chapter_04%3A_Structure_Determination_I/Section_4.3%3A_Ultraviolet_and_visible_spectroscopy

5. Wavelength region of light used:

6. Depends on: electronic transitions vibrations rotations nuclear spin

7. How is the spectrum produced? (a simplified explanation) i.e, what do molecules do when exposed to UV-Vis light? Include an illustration with your answer.

8. Relevant applications

Expert Group 2: Infra-red spectroscopy

- http://chemwiki.ucdavis.edu/Physical_Chemistry/Spectroscopy/Vibrational_Spectroscopy/Infrared_Spectroscopy
- http://www.chemguide.co.uk/analysis/ir/background.html#top
- http://www.mhhe.com/physsci/chemistry/carey/student/olc/ch13ir.html

9. Depends on: electronic transitions vibrations rotations nuclear spin

10. Wavelength region of light used:

11. How is the spectrum produced? (a simplified explanation), i.e, What do molecules do when exposed to infrared light?

12. 3 modes of vibration—include illustrations

13. Relevant applications:

Expert group 3: Nuclear magnetic resonance (NMR)

- http://www.chemguide.co.uk/analysis/nmr/backgroundc13.html#top
- https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/Spectrpy/nmr/nmr1.htm#nmr1
- http://www.rsc.org/learn-chemistry/collections/spectroscopy/introduction#NMRSpectroscopy
- http://chemwiki.ucdavis.edu/Physical_Chemistry/Spectroscopy/Magnetic_Resonance_Spectroscopies/Nuclear_Magnetic_Resonance/Nuclear_Magnetic_Resonance_II

14. Depends on: electronic transitions vibrations rotations nuclear spin

15. Wavelength region of light used: Also uses:

16. How is the spectrum produced: (a simplified explanation) i.e, what do nuclei do when exposed to radiation in a magnetic field? Include a illustration

17. Interesting applications:

Expert group 4: Microwave Spectroscopy

- http://chemwiki.ucdavis.edu/Physical_Chemistry/Spectroscopy/Rotational_Spectroscopy/Microwave_rotational_spectroscopy
- http://www.chemtube3d.com/spectrorotcd0-CE-TEST-ROTATE-ALL.html

18. Depends on: electronic transitions vibrations rotations nuclear spin

19. Wavelength region of light used:

20. What must molecules possess in order to be analyzed using this method?

21. How is the spectrum produced: (a simplified explanation) i.e, what do molecules do when exposed to microwave radiation? Include a illustration

22. Interesting applications:

Follow-up Questions

A choice may be used once, more than once, or not at all

A. Ultraviolet light
B. Microwaves
C. Radiowaves
D. Xrays
E. Infrared light

____1. Absorption of this type of electromagnetic radiation results in electronic transitions

____2. Absorption of this type of electromagnetic radiation results in transitions among allowed rotational motions

____3. Absorption of this type of electromagnetic radiation results in transitions among allowed vibrational motions

____4. Absorption of this type of electromagnetic radiation results in transitions among allowed nuclear spin states

5. In their study of the binding of heme groups to cytochrome c proteins (Dr V's favorite protein EVER!), Allen and Ferguson (Biochem. J. 2003 **375** 721-728) included the following UV-Vis spectrum for the protein.

Based on the spectrum, what wavelength would be optimal for analysis of cytochrome c?