5. Spectroscopy: Bond Frequencies

When light and matter interact, very specific resonant frequencies are absorbed or emitted by matter. These resonant frequencies are determined by the physical structure of the atoms or molecules that are interacting. As a result, knowing the frequencies of light that are absorbed by a particular molecule can give us information about its structure.

The strength of a bond is measured by the amount of energy needed to break apart the atoms in the bond. If the bond is strong, then it will take a large amount of energy to break that bond and vice versa. As a result, molecules with strong bonds will have high natural frequencies because of the high amount of energy holding the atoms together.

1) Which of the following types of bonds would you expect to be the strongest? Why?
   a) Single bonds: C – C
   b) Double bonds: C = C
   c) Triple bonds: C ≡ C

The stronger the bond, the shorter it is. This is because the energy in the bond pulls the two atoms closer together. As a result, it has a higher resonant frequency, and absorbs shorter wavelengths of light.

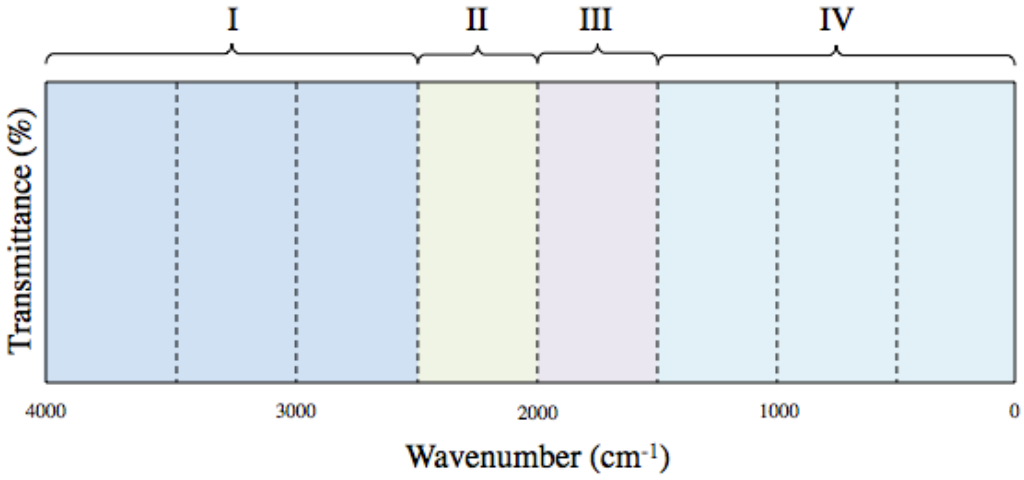
2) Using bond strength as a predictor, which of the two bonds would have the highest frequency? Why?
   a) Single C – H Bonds
   b) Double C = C Bonds

As it turns out, any single bond that includes hydrogen will have a higher frequency than just about any other bond. This is because the hydrogen atom is so small that the bond oscillates at a much higher speed.

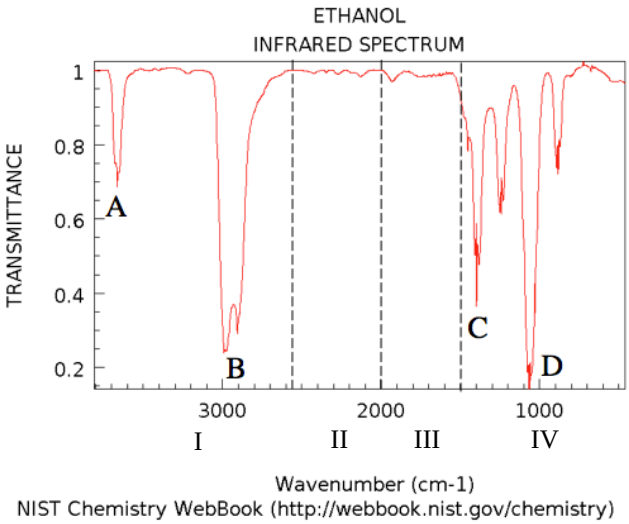
3) The diagram below has four sections, each corresponding to a specific type of molecular bond. Based on your answers above, determine which of the following bonds would show absorption lines in each of the four areas on the diagram. Explain your selections.

(Hint: The diagram is sectioned off by wavenumber. Make sure you think about the relationship between energy, frequency, and wavenumber before making your selection)

a) Single Bond without Hydrogen
b) Double Bond
c) Triple Bond
d) Single Bond with Hydrogen



The diagram below is the spectral data of the absorption of infrared light by ethanol. The regions (I, II, III, and IV) from the diagram on the previous page are labeled in the diagram below. Ethanol is a molecule that consists of all single bonds (C_2H_6O). However, there are two regions (I and IV) of resonant frequencies in the absorption spectra.



4) In the spectrum above, see if you can label the four absorption frequencies (A, B, C, and D) with the four types of bonds in ethanol (C – C, C – O, O – H, and C – H)

5) Why aren't there any absorbing frequencies between 2600 cm^{-1} and 1500 cm^{-1} ?
(Hint: Use the range of wavenumbers and bond strengths above)