In Class Activity

Each group will be given weights and a spring. Attach the spring to a ring stand and a mass to the spring. Extend the spring a few centimeters from its equilibrium position, release the mass, and observe the spring’s stretching frequency. Repeat the experiment with different masses to observe how changing the mass alters the spring’s stretching frequency. Using your results, answer the following questions.

1. How does increasing the mass on the end of the spring alter the frequency of the spring’s oscillations?
2. IR stretching frequencies are often used to assess the NO bond in transition metal nitrosyl complexes. How can you relate this mass and spring system to bonds in molecules (NO in particular)? What part of the system corresponds to the bond? What part corresponds to the atoms?
3. IR isotope labeling experiments are often conducted by chemists to provide evidence for the data on transition metal nitrosyl complexes. Predict how changing the isotope of nitrogen, from 14N to 15N, will alter IR stretching frequency of NO. Why?
4. Given the experimental frequency of 1768 cm-1 for the NO stretch in [Fe14NO], predict whether the stretching frequency for the corresponding [Fe15NO] complex increases or decreases.
5. What general conclusions can you make about the relationship between bond order and stretching frequency?
6. Calculate the expected frequency of the N-O stretch in N2O to check your prediction the observed stretching frequency using the following equation for a harmonic oscillator and given *k* = 1530 N/m for the N-O bond.

 

Where *ν* is the frequency of the oscillation, *k* is the force constant (stiffness of the spring), and *μ* is the “reduced mass” of the system given by

 

 where m1 and m2 are the masses involved in the bond in amu.

1. The IR spectrum of N2O exhibits a stretch at ~2200 cm-1 and a second stretch at a lower frequency. Draw the best Lewis structure of N2O to determine if the N-O and N-N bonds are single, double, or triple. Predict whether this stretch at ~2200 cm-1 is the N-O bond stretch or the N-N bond stretch. Explain your prediction related to mass and bond strength.