# Study the effect of important properties

# Aim:

The aim of this set of tasks is to give students the opportunity to experience themselves how properties of chemical compounds are linked to the vibration frequency of Infrared (IR) radiation, why and how these properties are linked to the frequency (mass-spring parallel) and what the role of bond vibration is.

# Learning outcomes:

After completing this set of tasks, students will be able to:

1. make the connections of a chemical bond with its mechanical equivalent: the mass-spring system;
2. identify which properties of the bond affect its vibration frequency (reduced mass, bond strength and hybridization); and
3. predict the shift of the vibration frequency, when comparing pairs of similar bonds (i.e. C-C/C=C/C≡C or C-C/C-H/C-O).

**Task 1.** The effect of the mass of the bonded atoms

Study the IR spectra of 2-propanol and propylacetate, and complete the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| 2- propanol | | Propylacetate | |
| Functional Group | Wavenumber (nm-1) | Functional Group | Wavenumber (nm-1) |
| C-H |  | C-H |  |
| C-C |  | C-C |  |
| C-O |  | C-O |  |

Find the atomic mass of each atom and explain whether the following statement is true or false

*“the mass of the bonded atoms is in inverse proportion to the vibration wavenumber”*………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………

Match the following vibration frequencies with the functional group for the two compounds:

|  |  |  |  |
| --- | --- | --- | --- |
| Group | Frequency range (nm) | Group | Frequency range (nm) |
| C=O | 1680-1630 | C-H | 3500-3400 |
| C=C | 1750-1680 | O-H | 3500-3200 |
|  |  | N-H | 3000-2850 |
| Group | Frequency range (nm) |
| C≡C | 2250-2100 |
| C≡N | 2260-2240 |

**Task 2.** The effect of the bond order

Study the IR spectra of the four compounds: 2-propanol, 1,5-cyclooctadiene, 1-hexyne, methoxybenzene and complete the table below.

|  |  |
| --- | --- |
| Functional Group | Wavenumber (nm-1) |
| C-C |  |
| C=C |  |
| C≡C |  |
| Aromatic C-C |  |

Find the atomic mass of each atom and explain whether the following statement is true or false

*“The strength of the bond is proportionate to the vibration wavelength.”* ………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………**Task 3.** The effect of the hybridization

### Study the IR spectra of the four compounds: 2-propanol, 1,5-cyclooctadiene, 1-hexyne, methoxybenzene, and complete the table below.

|  |  |
| --- | --- |
| Group | Wavelength (nm) |
| -C-H |  |
| =C-H |  |
| ≡C-H |  |
| Aromatic C-H |  |

Find the atomic mass of each atom and explain whether the following statement is true or false

### *“The hybridization of the bond, from sp3 to sp, is an increase of the strength of the bond. As a result, sp3 hybridization has higher vibration frequency than sp hybridization.”* ………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………