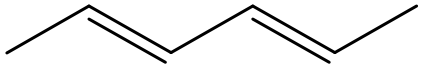
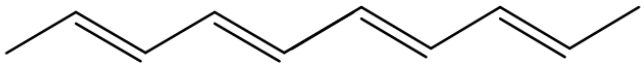
Quantum confinement and "particle in a box" (PIB) model

Nanoscale systems can show new properties for various reasons. One of these reasons is that the size of nanomaterials is on a scale that approaches the size of molecules and atoms. As a result, fundamental building blocks of matter such as electrons experience "confinement" effects. This non-classical behavior can be described by the "particle in a box" (PIB) model, which is a result of the Schrödinger equation.

Q1. Calculate the energy difference between the ground state and first excited state for the following molecules:



and



using the fact that $E_n = \frac{n^2h^2}{8mL^2}, \quad n = 1, 2, 3, \ldots$ and a single energy level can contain up to 2 electrons. Use the following bond lengths:

C=C bond length 1.34 angstrom, C-C bond length 1.54 angstrom

Q2. Write a 500 word paragraph to explain to your fellow students what you observe from the calculations in Q1, and explain the observation using your knowledge about the quantum nature of confined systems.

Q3. Given the figure below, of quantum dots (QDs) of the same composition but different size, sort the images in the correct order. Explain to your fellow students in a 250 word paragraph how you decided to arrange the images, i.e. which criterion did you use and why did you decide on that way of arranging the images? Explain how is this connected to quantum confinement and the "particle in a box" (PIB) model.

4.2 nm 2.3 nm 5.5 nm 4.8 nm