1. **(12 points)** One of the most useful applications of vibrational spectroscopy is to infer the geometry and coordination of a molecule based on the spectra. Below are three hypothetical molecules with a metal atom tetrahedrally coordinated to ligands A and B. What is the point group of each molecule?

![Molecule Diagrams]

a. How many vibrational modes does each molecule have?
b. Write out the characters of the representation for all the motions of the $MA_2B_2$ molecule.
c. Find the symmetries of the vibrations in the $MA_4$ molecule, i.e. write out a reducible representation of the vibrational modes and its component species.
d. Use the correlation tables as a shortcut to find the symmetries of the vibrations in the $MAB_3$ and $MA_3B_2$ molecules.
e. How many vibrational frequencies does each molecule have?
f. How many frequencies are infrared active?
g. Raman active?

2. **(6 points)** Use the selected bond method to determine the symmetries of the stretching modes for the C—O bonds in the following metal carbonyls. Identify whether each one is IR active or silent.

![Metal Carbonyl Diagrams]

a. 
b. 
c.