1. (10 pts) With regard to the following compound:

\[
\begin{align*}
\text{H}_3\text{C} & \text{--} \text{C} & \equiv & \text{N} \\
\end{align*}
\]

(a) How many peaks at different δ will there be in the \(^1\text{H NMR}\) spectrum (ignore any splittings): _________

(b) How many peaks at different δ will there be in the proton-decoupled \(^{13}\text{C NMR}\) spectrum: _________

2. (20 pts) Arrange the following bonds in order of increasing vibrational stretching frequencies in infrared spectroscopy (from 1 to 4, with 1 being lowest frequency), and explain your reasoning.

\[
\begin{align*}
\text{C = C} & \quad \text{C = C} & \quad \text{C = O} & \quad \text{C — C} \\
\end{align*}
\]

_____  _____  _____  _____
3. (40 pts) Describe the characteristic infrared absorption frequencies, intensities or spectral features that would allow you to distinguish between the following pairs of compounds.

(a) \[
\text{OH} \quad \text{and} \quad \text{O} \quad \text{H}
\]

(b) \[
\text{O} \quad \text{OH} \quad \text{and} \quad \text{O} \quad \text{H}
\]

(c) \[
\text{O} \quad \text{NH}_2 \quad \text{and} \quad \text{O} \quad \text{CH}_3
\]

(d) \[
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{C} \equiv \text{C} \quad \text{H} \quad \text{and} \quad \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{C} \equiv \text{C} \quad \text{H} \quad \text{H} \quad \text{H}
\]
4. (40 pts) Tell precisely how you would use $^1$H NMR spectroscopy to distinguish between the following pairs of compounds.

(a) $\text{H}_3\text{C}$

(b) $\text{CH}_3\text{CH}_2\text{O}$

(c) $\text{CH}_3\text{CH}_2\text{H}$

(d) $\text{H}_3\text{C}$
5. (20 pts) Both ethyl bromide (CH₃CH₂Br) and anisole (methoxybenzene, C₆H₅OCH₃) have nominal molecular weights of 108 atomic mass units (amu). The low-resolution electron-impact mass spectra of each compound show a significant peak for the M⁺ ion at m/z = 108 amu in each case. What distinguishing feature in the mass spectra would distinguish CH₃CH₂Br from C₆H₅OCH₃ based solely on the low-resolution data? Explain.

6. (20 pts) Propose a structure for the alcohol with the molecular formula C₆H₁₄O that has the following NMR spectral data. (Explain your reasoning for partial credit.)

**¹H NMR:**
- δ 0.90 (6H, doublet, J = 7 Hz)
- δ 1.10 (6H, singlet)
- δ 1.25 (1H, broad singlet, disappears after D₂O shake)
- δ 1.3 – 1.8 (1H, multiplet)

**¹³C NMR (off-resonance decoupled):**
- δ 17.7 (quartet)
- δ 26.4 (quartet)
- δ 38.9 (doublet)
- δ 73.0 (singlet)