1. [3 pts] Concisely describe one type of important information about a compound that is given by mass spectrometry.

   If the molecular ion (M⁺) is detected, the molecular weight of the compound is known.

2. [7 pts] (a) How many peaks are there in the proton-decoupled ¹³C-nmr spectrum of the 1-tert-butyl-4-ethylbenzene?  8

   (b) Provide a structural formula for 1-tert-butyl-4-ethylbenzene. For each carbon atom in the structure, clearly indicate the multiplicity that would be observed in the off-resonance decoupled ¹³C-nmr spectrum.

3. [6 pts] Give a multistep synthesis for the conversion of benzene into the product shown below. For each functional group transformation, give all necessary other organic reactants, reagents, and catalysts; For each functional group transformation, show the structure of the organic product.

   ![Chemical structures]

4. [4 pts] Provide a structural formula for the Lewis acid–Lewis base complex formed between AlCl₃ and propanoyl chloride (CH₃CH₂CCl). Be sure to show nonzero formal charges.

   ![Chemical structure]