For this set of problems, work in the same groups that were formed for the hydrogenation lab group presentations.

1. Aqueous ammonia reacts with formaldehyde to produce a crystalline solid of empirical formula C₃H₆N₂. The mass spectrum shows a molecular ion at m/z 140, and both the ¹H (δ 4.72) and ¹³C (δ74.8 ppm) NMR spectra are singlets. Provide the structure of the compound, along with a reasonable mechanism for its formation.

2. Reaction of 1-chloro-1-methylcyclohexanone with hydrazine and potassium t-butoxide in refluxing 1,2-dimethoxyethane (DME) solvent produces an organic product that has the following properties:

MS: M⁺ at m/z 96; base peak (100%) m/z 81; next most intense peak m/z 67.

¹H NMR: δ 1.63 (s, 3 H); 1.5-1.62 (complex, 4 H); 1.89-1.96 (complex, 4 H); 5.38 (t, 1 H).

¹³C NMR: δ 22.6, 23.2, 24.0, 25.4, 30.2, 121.3, 134.0.

Deduce the structure of the product, assign the NMR spectra and the given mass spectral peaks, and provide a reasonable mechanism for the formation of the product.

3. For the scheme shown below, provide a structure for product A, and a mechanism for the second reaction.