The synthesis and characterization and of two closely related cobalt compounds is the primary focus of this paper (*Dalton Trans.* **2006**, 4164). These compounds contain N-heterocyclic carbene (NHC) ligands which are somewhat similar to phosphines. Related phosphine compounds are frequently used as catalysts in hydroformylation reactions, so preliminary investigations into the catalytic activity of cobalt compounds with NHC ligands is also reported.

1. The starting material for the synthesis of the new compounds in this study is [Co(CO)3(PPh3)Me]. Classify this compound using CBC MLlX­xZz classification, determine the electron number, ligand bond number, metal valence and the dn count for the cobalt center present in the molecule.
2. In the first paragraph of the results and discussion section as well as numerous times in the introduction, the authors describe the formation of NHC complexes occurring by the displacement of an L-type ligand, most frequently a phosphine. This suggests that NHC ligands are also L-type ligands. Account for the this by describing the interactions between an NHC ligand and a metal center.
3. Confirm that there are no significant changes in the classification, electron number, ligand bond number, metal valence and the dn count in compounds **1** and **2** as compared to the starting material.
4. Compound **2** is formed when CO is passed through a solution of compound **1**. The authors describe the reaction occurring “by ligand exchange and CO-induced migratory-insertion”. This is sometimes called a CO-insertion reaction. These reactions typically happen via one of two pathways, the migration of the alkyl group or the insertion of the CO into the metal-carbon bond. Which pathway seems more likely in this case? Why?
5. The X-ray crystal structures of compounds **1** and **2** were reported. Looking at the carbonyl ligands can provide insight into the relative electron density at the cobalt center. For the terminal carbonyl ligands, consider the average Co-C and C-O distances in these two compounds. In which compound is the cobalt more electron rich? How did you determine this?
6. Compare the Co-C(1) distances in compounds **1** and **2**. Do the arguments you made in your answer to the previous question provide a rationale for these reported distances? Explain your answer.
7. Compare the average C(1)-N distances in compounds **1** and **2**. Do these difference make sense based on your answers to the two previous questions? Why or why not?
8. Assuming free rotation about the Co-C(1) bond and the Co-C(22) bonds in compounds **1** and **2**, determine the point groups of compounds **1** and **2**.
9. Based on the point groups you assigned in the previous question and using group theory, how many IR active CO vibrations would you expect to observe for compounds **1** and **2**?
10. How does your prediction from group theory match up with what was reported in the paper?
11. In the paragraph discussing the NMR data for these compounds, it is suggested that compounds **1** and **2** have Cs symmetry. Suggest how this might be possible. Perform a group theory analysis of compounds **1** and **2** using Cs symmetry and compare and contrast that to the results you obtained previously.
12. Is there any data in the X-ray crystal structures (in particular that of compound **1**) that could help rationalize slow rotation of one of the ligands? If so, explain what measurements you are comparing and how this comparison helps explain the slowed rotation. *Hint: You might review question 2 as you answer this.*
13. Compound **4** is formed by the addition of H2 to compound **2**. Suggest a series (3 or less) of reactions that could be taking place in this conversion. As part of your suggested path, what other product(s) would be detected?
14. The authors examine the effectiveness of compound **4** as a catalyst for hydroformylation. The reaction is performed with syngas. What is syngas?
15. Write out a balanced reaction for the formation of the major product in Table 4.
16. What is unusual about the catalytic activity of compound **4**?
17. Suggest an experiment that could be performed to provide further insight into the results reported in table 4.