

Chem 341
Inorganic Chemistry
Midterm Exam #3, Fall 2000

NAME: _____

- Calculators and model sets are the only aids allowed for this exam. A periodic is provided at the end of the exam (feel free to separate and keep in front of you).
- Partial marks will be rewarded where applicable, so be sure to show all your work and explain your answers.
- **Choose four of the following five questions. Each question is worth 20 marks, and there is a bonus question worth 7 marks, for a maximum possible score of 87 (the exam will be out of 80). Distribute your time accordingly.**
- Duration: 60 minutes.

Some potentially useless constants:

$$h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s}$$

$$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

$$F = e \cdot N_A = 9.649 \times 10^4 \text{ C}\cdot\text{mol}^{-1}$$

$$m_e = 9.109 \times 10^{-31} \text{ kg}$$

$$\pi \simeq 3.1416$$

$$R = 0.08206 \text{ L}\cdot\text{atm}\cdot\text{K}^{-1}\cdot\text{mol}^{-1} = 8.314 \text{ J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1} = 8.314 \text{ V}\cdot\text{C}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$$

$$c = 3.00 \times 10^8 \text{ m}\cdot\text{s}^{-1}$$

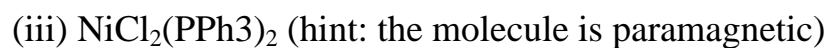
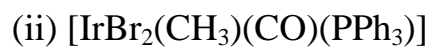
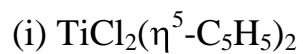
$$e = 1.602 \times 10^{-19} \text{ C}$$

$$m_p = 1.673 \times 10^{-27} \text{ kg}$$

$$k = 1.381 \times 10^{-23} \text{ J}\cdot\text{K}^{-1}$$

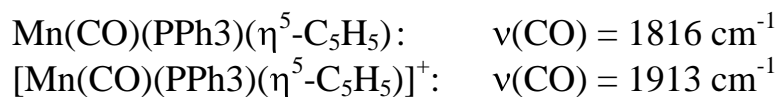
$$e = \text{the natural number} \simeq 2.718$$

1. (a) For each of the following complexes, sketch the structure, give the ideal geometry and full name, and state whether or not the 18-electron rule is satisfied [4 marks each, 12 total]:

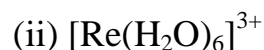
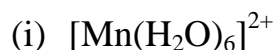


(b) Define stereochemical non-rigidity and give one example, using diagrams and give its specific name. [8 marks]

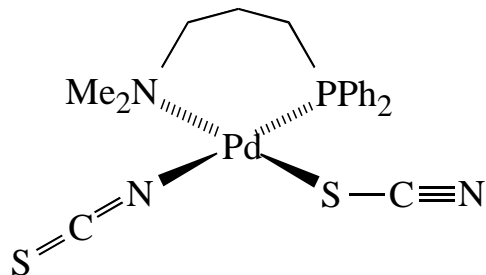
2. (a) Account for the differences in carbonyl IR stretching frequencies for the following pair of compounds [4 marks]:



(b) Give the frontier diagram (d-splitting only, with its electrons) and give the LFSE and total spin (S) value for the following coordination complexes [6 marks each, 12 total]:

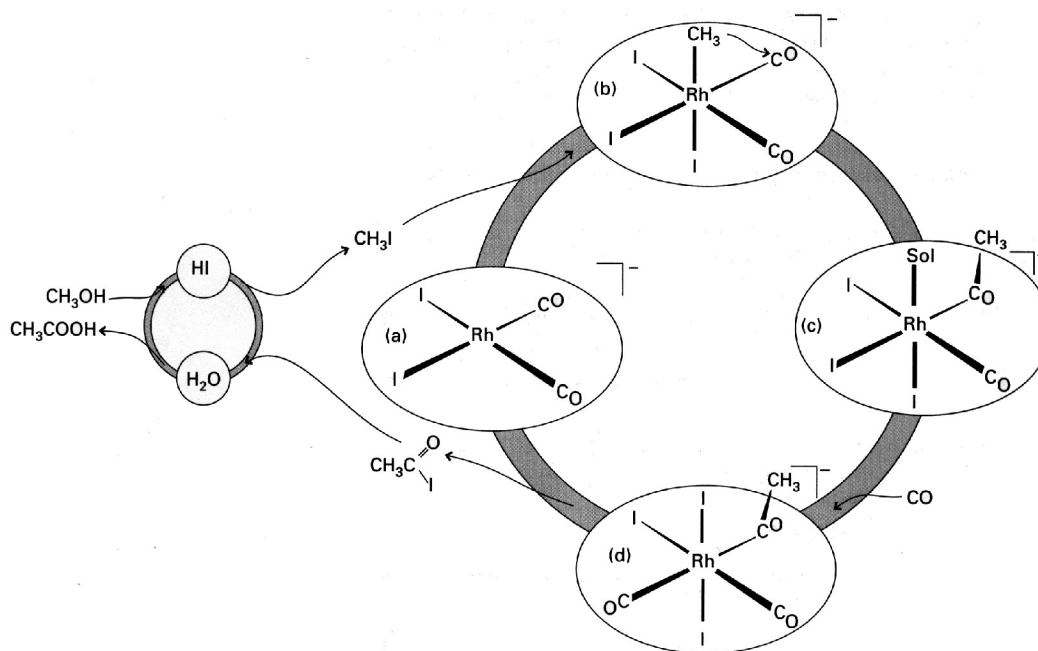


(c) For the square planar molecule isothiocyanatothiocyanto(1-diphenylphosphino-3-dimethylaminopropane)palladium(II), explain why the two amidentate ligands bond through the different ends of the molecule, and indicate the bonding involved [4 marks]:



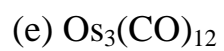
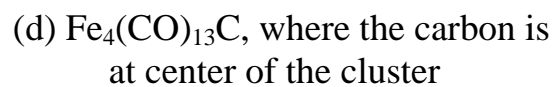
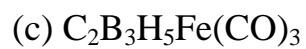
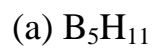
3. (a) Give three properties that make a catalyst industrially useful. [3 marks]

(b) Since 1971, the Monsanto Process has been used for the production of industrial amounts of concentrated acetic acid. Outline the mechanistic steps involved in the main cycle shown below, and include the transition metal oxidation state, electron count (treat the methyl and solvent ligands as electroneutral) and geometry for each of the four complexes. [15 marks]



(c) Give the overall reaction for the Monsanto Process (note: do not include molecules that are only part of the cycle). [2 marks]

4. Using Wade's Rules, predict the structures of the following clusters [4 marks each]:



5. (a) Draw a fully labeled MO diagram for $\text{W}(\text{CO})_6$. Include the electrons for the metal, ligand and MO orbitals in your diagram. [12 marks]

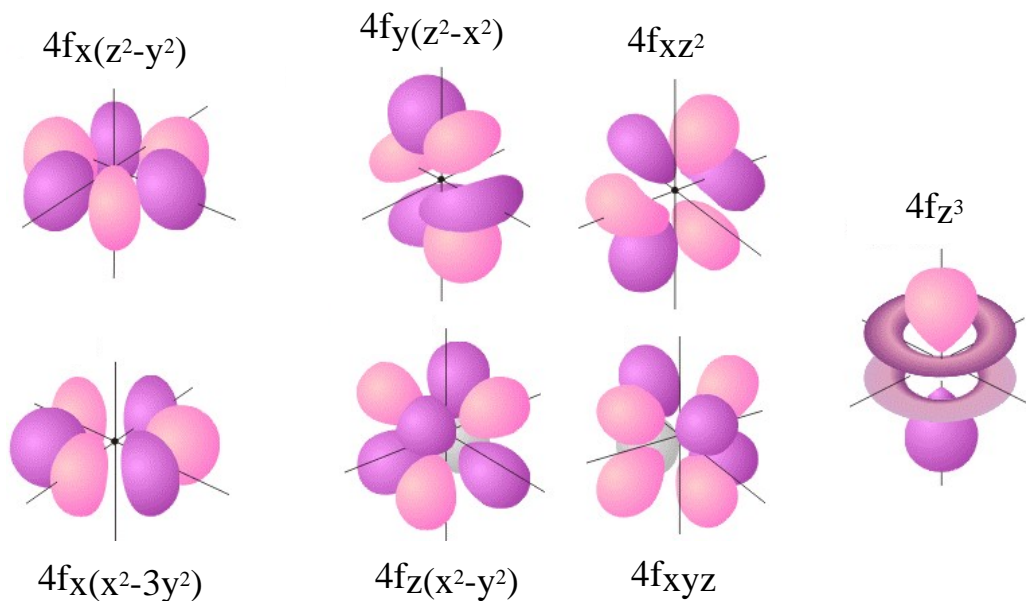
(b) Sketch and label the orbital diagram for the metal d-orbitals when going from an octahedral complex to a tetragonally distorted complex, where:

(i) The axial ligands are extended away from the metal centre and the ligands in the xy square plane are compressed towards the metal centre. [4 marks]

(ii) The ligands in the xy square plane are extended away from the metal centre and the axial ligands are compressed towards the metal centre. [4 marks]

*****Bonus Question*** [7 marks]**

Predict how the f-orbitals would split in an octahedral crystal field, where the ligands lie on the cartesian axes of the figures of the 7 f-orbitals:



(Draw the orbitals below,
split to the right,
labeling each orbital.)

4f

1. (a) For each of the following complexes, sketch the structure, give the ideal geometry and full name, and state whether or not the 18-electron rule is satisfied [4 marks each, 12 total]:

