1. (20 pts) Which of the following metal hydrides should be the most acidic? Clearly explain your reasoning.

a) HNb(CO)$_6$ -or- HV(CO)$_5$(PMe$_3$)

b) HRh(CO)(PPh$_3$)$_2$ -or- HRh(CO)$_2$[P(OPh)$_3$]

c) [HOs(PMe$_3$)(dmpe)$_2$]$^+$ -or- HRe(CF$_3$)$_2$(CO)$_2$[P(OMe$_3$)$_3$]$_2$

d) [HCoCl(NH$_3$)$_4$]$^+$ -or- CpFe(H)(dppe)

2. (10 pts) a) (5 pts) Electron-count W(NMe$_2$)$_6$ clearly showing the W oxidation state, ligand charges, and # of electrons donated from the ligands to the metal center.

b) (5 pts) Based on your electron-counting, what feature(s) about the W-NMe$_2$ bonding/geometry might you expect to show up in an X-Ray structure of this complex?
c) **(5 pts BONUS)** How would you explain the structure of W(NMe₂)₆ if it showed all approximately planar W-NMe₂ ligands (trigonal planar geometry about the nitrogen center)?

3. **(15 pts)** Consider the following reaction sequence:

The deuterated methyl group in the complex A does a migratory insertion with the carbene ligand to form the ethyl group in B. Migratory insertion is the reaction of an anionic ligand with a neutral ligand to produce a new anionic ligand (examples: M-carbene + M-CD₃ → M-CH₂CD₃; M-ethylene + M-H → M-Et). The product C₂, however, shows that one can get some scrambling of the deuterium labels from the original CD₃ methyl group. Clearly explain and show the properly labeled reaction steps that convert B to C₂. Don’t worry about bromide coordination till the last step. **[Hint: an ethylene ligand can freely rotate about the metal-ethylene bond]**
4. (20 pts) Consider the following two substitution reactions. Sketch out the most likely reaction steps to produce the most stable product (substitute only one ligand with that shown). Briefly & clearly state your reasoning/explanation for each reaction and the final product shown.

\[
\begin{align*}
&\text{a) } \text{(t-Bu-O)}_3\text{PFeC}≡\text{O} + \text{PMe}_3 \rightarrow \text{CFe(t-Bu-O)}_3\text{P(t-Bu-O)}_3\text{P} \text{P(O-t-Bu)}_3 \\
&\text{b) } \text{H}_3\text{C}≡\text{NiSMe}_2 + \text{CO} \rightarrow \text{H}_3\text{C}≡\text{NiSMe}_2 \text{CO}
\end{align*}
\]

5. (10 pts) Explain why square-planar \(d^8\) complexes of Rh(+1), Ir(+1), Ni(+2), Pd(+2), Pt(+2), and Au(+3) are stable with 16e- configurations and why they only bind a fifth ligand weakly (to moderately).
6. (15 pts) Circle the complex that should have the \textit{weakest} M-CO bonding. Clearly explain your answer.

a) \( \text{Tc(CH}_3\text{)(CO)}_5 \) -or- \( \text{Re(F)(CO)}_5 \)

b) \( \text{WO}_3\text{(CO)}_3 \) -or- \( \text{Cr(CMe)(CO)}_4 \)

c) \( \text{HCo(CO)}_4 \) -or- \( \text{HMn(CO)}_4\text{(PMe}_3\text{)} \)

7. (10 pts) \([\text{CpIr(dmpe)(Et)}]^+\) is quite stable while \([\text{CpCo[P(OMe)}_3\text{]}_2\text{(Et)}]^+\) readily reacts with one equivalent of \(\text{PMe}_3\) to produce \(\{\text{CpCo(H)(PMe}_3\text{)[P(OMe)}_3\text{]}}\}^+\) plus a gas that bubbles off the solution.

a) (5 pts) Write out a mechanism for the reaction of \([\text{CpCo[P(OMe)}_3\text{]}_2\text{(Et)}]^+\) to form \(\{\text{CpCo(H)(PMe}_3\text{)[P(OMe)}_3\text{]}}\}^+\).

\[
\begin{array}{c}
\text{Cp} \\
\text{Co} \\
\text{H} \\
\text{CH}_3
\end{array}
\quad \overset{\text{+}}{\rightarrow}
\quad \begin{array}{c}
\text{Cp} \\
\text{Co} \\
\text{H} \\
\text{CH}_3
\end{array}
\]

b) (5 pts) Why is \([\text{CpIr(dmpe)(Et)}]^+\) considerably more stable?