1.) [3 points] Draw the $d$ orbital splitting, and label the split levels with their corresponding $d$ electrons for the following molecules.

\[
\text{[Co(NH}_3\text{)_6]^{3+}} \quad \text{Ni(CO)}_4
\]

a.) Calculate the crystal field stabilization energy (CFSE) for both molecules in $\Delta_o$ units.

b.) Suggest a ligand to diminish the CFSE for both.

2.) [3 points] The complex $[\text{Ni(CN)}_4]^{2-}$ is diamagnetic but $[\text{Ni(Cl)}_4]^{2-}$ is paramagnetic with $S = 1$. Based on this magnetic data, propose a structure for each and rationalize the magnetic properties by way of crystal field theory.

3.) [4 points] Calculate the effective moment $\mu_{\text{eff}}$ for the following molecules.

a.) $[\text{Ti(H}_2\text{O)}_6]^{3+}$

b.) $[\text{Co(en)}_3](\text{NO}_3)_3$

c.) $[\text{Mn(H}_2\text{O)}_6]^{2+}$

d.) $[\text{NiCl}_4]^{2-}$

4.) [3 points] Typically, transition metal complexes are brightly colored, however several are not. Explain the following observations.

a.) $[\text{Cu(NH}_3\text{)}_4]^+$ is completely colorless, while $[\text{Cu(NH}_3\text{)}_4]^{2+}$ is not.

b.) $[\text{Co(H}_2\text{O)}_6]^{2+}$ is very pale pink, but $[\text{CoCl}_4]^{2-}$ is deep blue.

c.) Unlike $\text{Co}^{2+}$, $\text{Mn}^{2+}$ forms pale pink complexes with both water and chloride ions as ligands: $[\text{Mn(H}_2\text{O)}_6]^{2+}$ and $[\text{MnCl}_4]^{2-}$

5.) [7 points] In problem set 7, you drew out the dispersion curves for a hypothetical linear chain of $d$-orbitals. It turns out such a system does exist in $\text{K}_2\text{Pt(CN)}_4$. This compound polymerizes as the linear chain shown below, where $K$ cations are not shown, and the Pt is coordinated to the CN$^-$ anions in a square planar geometry.
a.) Use CFT to show how the \( d \)-orbitals of Pt(II) split from its coordination environment.

b.) Now that you know the relative energies of each \( d \)-orbital with respect to one another, draw the dispersion curves for each on the same graph. Assume one does not overlap with the others at all.

c.) Which \( d \)-orbital would constitute the valence band and which ones the conduction band?

d.) Upon being oxidized through co-crystallization with chloride (other anions possible too), the compound \( \text{K}_2\text{Pt(CN)}_4\text{Cl}_{0.3} \) forms. Extraordinarily, the Pt—Pt distance shrinks from ~\( 3.3 \) Å to around ~\( 2.7 \) Å in the chain. In addition, the white insulator becomes a black metallic conductor! Explain this phenomenon from your answers to parts a) through c).