Please answer the following questions:

**Part I: Multiple Choices (21 pts: 7 @ 3 pts). Please circle the ONE best answer:**

1. Which of the following complexes one would expect to be labile?
   a) \([\text{Co(NH}_3\text{)}_5(\text{NO}_2)]^{2+}\)  
   b) \(\text{cis-Pt(NH}_3\text{)}_2\text{Cl}_2\)  
   c) \([\text{Cr(en)}_3]\text{Cl}_2\)  
   d) \([\text{Cr(CN)}_6]^{3-}\)

2. Which of the following species does not obey the 18-e rule?
   a) \((\eta^5-\text{C}_5\text{H}_5)\text{Rh(}\eta^2-\text{C}_2\text{H}_4)(\text{PMe}_3)\)  
   b) \([((\eta^5-\text{Cp})\text{(CO)}_2\text{Ru-Ru(}\eta^5-\text{Cp})\text{(CO)}_2)]\)  
   c) \(\text{HCo(CO)}_3\)  
   d) \([\text{HF}_\text{e(CO)}_4]^-\)

3. What is the IUPAC name of the complex \([\text{Cu(NH}_3\text{)}_4][\text{PtCl}_4]\)  
   a) Tetraaminecopper(II) tetrachloroplatinate(IV)  
   b) Tetraaminecopper(II) tetrachloroplatinate(II)  
   c) Tetraaminecopper(II) tetrachloroplatinum(II)  
   d) Tetraaminocopper(II) tetrachloroplatinate(II)

4. What is the point group of \(\text{cis-difluorotetraaminecobalt(III)}\) ion?  
   a) \(D_{4h}\)  
   b) \(T_d\)  
   c) \(C_{2v}\)  
   d) \(C_{2h}\)

5. Consider the molecules and ions:  
   I) \([\text{CoCl}_4]^{2-}\)  
   II) \(\text{SF}_4\)  
   III) \(\text{XeF}_4\)  
   IV) \(\text{Ni(CO)}_5\)  
   Which of these species belong to the point group \(C_{4v}\)?  
   a) **only II**  
   b) **II and III**  
   c) **I, II and III**  
   d) **only IV**

6. Which of the following species is expected to diamagnetic?  
   a) \([\text{V(H}_2\text{O)}_6]^{2+}\)  
   b) \([\text{Fe(C}_2\text{O}_4)]^{4-}\)  
   c) \([\text{CoCl}_4]^{2-}\)  
   d) \([\text{Fe(CN)}_6]^{3-}\)

7. Arrange the following complex ions in order of decreasing \(\Delta_{\text{oct}}\) (largest \(\Delta_{\text{oct}} = 1\) & smallest \(\Delta_{\text{oct}} = 4\)): \([\text{CoF}_6]^{3-}, [\text{CoF}_6]^{4+}, [\text{Rh(H}_2\text{O)}_6]^{3+}\) and \([\text{Rh(CN)}_6]^{3-}\)  
   a) \([\text{Rh(H}_2\text{O)}_6]^{3+} > [\text{Rh(CN)}_6]^{3-} > [\text{CoF}_6]^{3-} > [\text{CoF}_6]^{4+}\)  
   b) \([\text{CoF}_6]^{4+} > [\text{CoF}_6]^{3-} > [\text{Rh(H}_2\text{O)}_6]^{3+} > [\text{Rh(CN)}_6]^{3-}\)  
   c) \([\text{Rh(CN)}_6]^{3-} > [\text{Rh(H}_2\text{O)}_6]^{3+} > [\text{CoF}_6]^{3-} > [\text{CoF}_6]^{4+}\)  
   d) \([\text{Rh(CN)}_6]^{3-} > [\text{CoF}_6]^{3-} > [\text{Rh(H}_2\text{O)}_6]^{3+} > [\text{CoF}_6]^{4+}\)
Part II. (26 pts) Coordination Chemistry

1. (4 pts) Write the structural formula for tetraamminechromium(III)-μ-amido-μ-hydroxo-
   bis(ethylenediamine)iron(III) sulfate

2. (4 pts) Sketch all possible geometrical isomers for \([\text{Co(C}_2\text{O}_4)_2\text{Cl}_2]^+\) ion \((\text{C}_2\text{O}_4)^{2-} = \text{oxalate ion})\), and
   then indicate which of these complexes would exhibit optical activity.

3. (18 pts) Rationalize for the following observations:
   a) (5 pts) Diamagnetic compounds of cobalt(III) such as \([\text{Co(NH}_3)_6]^3+\) and \([\text{Co(NO}_2)_6]^3-\) are
   orange-yellow. In contrast, the paramagnetic complexes \([\text{CoF}_6]^3-\) and \([\text{Co(H}_2\text{O})_3\text{F}_3]\) are blue.
b) (5 pts) The visible spectra of \([\text{Ni(NH}_3\text{)}_6]^{2+}\) and \([\text{Ni(H}_2\text{O)}_6]^{2+}\) give the same number of bands but at different positions (sketch a graph to explain your answer showing how many bands you expect to find).

c) (5 pts) A complex of nickel(II), \([\text{NiCl}_2(\text{PPh}_3)_2]\) is paramagnetic with a magnetic moment value \(\mu = 2.96\) BM. The analogous complex of palladium(II) is diamagnetic (\(\mu = 0\)). Include diagrams showing the molecular geometry and d-orbital energy levels for each complex ion as part of your answer.

d) (3 pts) The color of \(\text{trans-}[\text{Co}(\text{en})_2\text{Cl}_2]^+\) is less intense than that of \(\text{cis-}[\text{Co}(\text{en})_2\text{Cl}_2]^+\).
Part III, (17 pts) Organometallic Compounds

1. (5 pts) Show the structural (show all bonds clearly) for (OC)₃Fe(C₈H₈)Fe(CO)₃, where C₈H₈ = cyclooctatetraene.

2. (12 pts: 2 @ 6 pts each) Rationalize for the following observations:
   
a) On going from Fe(CO)₅ to Fe(CO)₃(PPh₃)₂, absorptions in the IR spectrum at 2025 cm⁻¹ are replaced by bands at 1944, 1886 and 1881 cm⁻¹.

   b) The reaction of (η⁵-C₅)Fe(CO)₂Br with Na[Co(CO)₄] gave [(η⁵-C₅)(CO)Fe(µ-CO)₂Co(CO)₃] in which an Fe-Co bond does exist. Solely on the basis of the 18 e-rule explain your answer.
Part IV. (20 pts) Bioinorganic Chemistry:

1. (6 pts) The precise mechanism of *cis*-platin anticancer is uncertain. However, several possibilities have been identified that it includes blocking of DNA replication. Discuss one of these possible mechanisms.
2. **(6 pts)** Cis-platin shows several prominent side effects that include kidney and gastrointestinal problems and nausea. These arise as a result of the high dosage required and reactivity with a variety of other biomolecules including inhibition of enzymes.

To counteract these effects, second generation of Pt-drugs, such as those shown above have been developed that show similar therapeutic activities but at a lower dosages. What structure and chemical characteristics of these molecules can be used to rationalize their enhanced therapeutic properties?
3. **(8 pts)**
   a) Do you expect $O_2$ to be a weak or strong ligand field?

   
b) Recall that deoxygenated myoglobin (Mb) is high spin, while MbO$_2$ is low-spin. Is this consistent to part (a)? If not explain the inconsistency.

   
c) What prevents simple iron porphyrins from functioning as O$_2$-carrier?

   
d) Briefly explain the role of the peptide portion of hemoglobin in preventing the irreversible oxidation of Fe$^{2+}$?
Part V. (16 pts) Transition Metals:

1. (10 pts) Explain the following observations:

   a) Aqueous solutions of Cr$^{2+}$ are rapidly oxidized in air, as are solutions of Fe$^{2+}$, though more slowly, whereas the aqueous solutions of the intervening ion, Mn$^{2+}$ should be stable towards aerobic oxidation.

   b) The uniformity in the properties of the lanthanides and the great diversity observed in the chemistry of actinides.
2. **(6 pts)** Predict the probable structure (bond order & electron configuration and magnetic properties) for the following metal-metal bonded tetragonal-prismatic complexes:

a) \([\text{Cr}_2(\mu-\text{O}_2\text{CMe})_4]\)

![Diagram a)

b) \([\text{Rh}_2(\mu-\text{O}_2\text{CMe})_4(\text{H}_2\text{O})_2]\)

![Diagram b)
When you are told to do so, tear off the Periodic Table cover sheet and use as required during exam.