Student name:

1. Fill the following table. Tanabe-Sugano diagrams are reproduced on the last page. (40 points)

Complex	<i>dⁿ</i> ; HS/LS (if relevant)	Ground state term symbol for the free ion	Ground state term symbol for the complex	Excited state term symbols for the allowed transitions (see note* below)
$\left[\operatorname{Cr}(\operatorname{CN})_{6}\right]^{4}$				
$[V(H_2O)_6]^{3+}$				
$[\operatorname{ReCl}_6]^{4-}$				
$\left[\mathrm{CrF}_{6}\right]^{4-}$				
[NiCl ₄] ²⁻				

* If there is more than one spin-allowed transition, list them in order of increasing energy.

2. Explain the following:

a. In atomic absorption and emission spectroscopy, lines due to s-p and p-d transitions are observed while no lines are seen for s-s, s-d, p-p, and p-f transitions. (4 points)

b. The electronic absorption spectra of organic compounds such as benzene have bands that can be assigned to $\sigma-\sigma^*$ and $\pi-\pi^*$ transitions but not to $\sigma-\pi^*$ and $\pi-\sigma^*$ transitions. (4 points)

3. The low energies of d-d transitions give most coordination compounds their various visible colors. However, the following complexes are usually colorless or have pale colors. Explain for each case.

(8 points)

a. Octahedral complexes of Mn^{II} with weak-field ligands:

b. Zn^{II}, Hg^{II}, and Au^I complexes:

c. Sc^{III} and V^{V} complexes:

d. The organometallic complex [Ni(CO)₄]:

4. Classify the following complexes as having <u>STRONG</u>, <u>WEAK</u>, or <u>NO</u> Jahn-Teller distortion: (8 points) a. $[CoF_6]^{3-}$: c. $[Co(H_2O_6)^{4+}$:

b. $[Co(en)_3]^{3+}$: d. $[Co(CN)_6]^{4-}$:

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5. For each of the following organometallic dimer complexes, determine the metal-metal bond order assuming that each complex obeys the 18-electron rule. To get full credit, you need to draw the structure of each complex and show how you counted the 18 electrons next to each structure

(18 points)

(18 points)

di-µ-carbonylbis(tricarbonylcobalt)(0)

 $[(\eta^{5}-C_{5}H_{5})Mn(CO)_{2}]_{2}$

 $[(\eta^{5}-C_{5}H_{5})Mo(\mu-CO)_{2}]_{2}$

6. On the basis of the 18-electron rule, identify the first-row transition metal in each of the following. To get full credit, draw the structure and show how you counted the 18 electrons for each complex.

 $[M(CO)_7]^+$

 $[M(CO)_5(CH_3)]$

 $[M(\eta^{5}-C_{5}H_{5})(\eta^{1}-C_{5}H_{5})(CO)_{2}]$

BONUS QUESTION. The M-CO bonding is synergetic or involves synergism. (+8 points) a. What is synergism?

b. Explain the following trend in the magnitude of v_{C-O} IR frequencies: free CO> terminal M-CO > $(\mu_2$ -CO)M₂ > $(\mu_3$ -CO)M₃