Name _____ Test 3 (12/5)
CHEM 0211 (Adv. Inorganic) Fall 2025

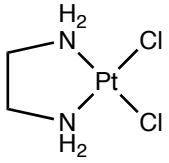
1. One cobalt complex with the empirical formula $CoN_4H_{12}Cl_3$ has a molecular formula of *cis*-$[Co(NH_3)_4Cl_2]Cl$.

a. (6 pts.) How many Cl atoms/ions are in the inner coordination sphere?

b. (6 pts) Draw a wedge and dash representation of the compound. The transition metal complex has an octahedral geometry. Draw only the complex ion and remember to indicate the charge of the complex ion.

2. (12 pts.) Determine the oxidation state/charge of the metal at the center of the following complexes. Names and charges for common ligands are listed on the last page.

a. $K_3[Fe(CN)_6]$ b. $Cr(NH_3)_3Cl_3$ c.

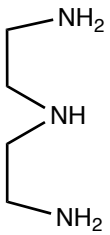


3. (12 pts.) Provide molecular formulas for the following compounds.

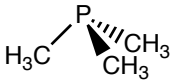
a. sodium hexachloroplatinate(IV) b. pentaaminebromoiron(III) nitrate

4. (12 pts.) Determine whether the following ligands are monodentate, bidenate, tridentate, tetradentate, etc.

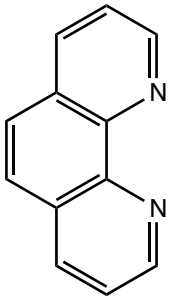
a.



b.

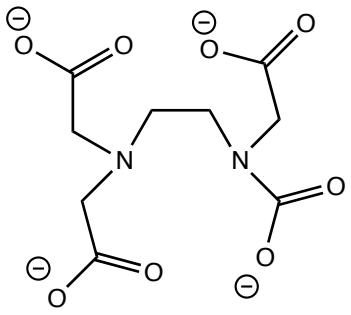


c.

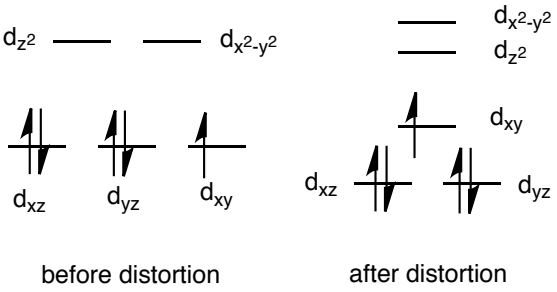


1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____

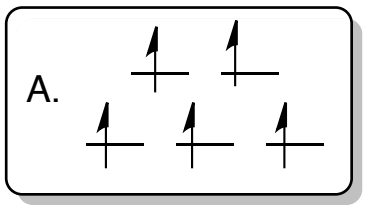
5. (10 pts.) Ethylenediaminetetraacetate (EDTA), the structure drawn below, is used to treat heavy metal poisoning because it is exceptionally good at binding with metals thus preventing those metals from interfering with biological processes. Briefly explain why EDTA so strongly binds to metals.

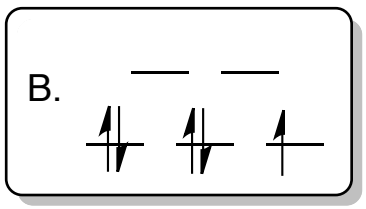


6. (10 pts.) According to the Jahn-Teller Theorem the low-spin d^5 electron configuration on the left is unstable, and the molecule will distort to remove the uneven filling of the t_{2g} set of degenerate orbitals. Does the electron configuration on the right result from an elongation or a compression along the z axis. Briefly explain your choice.



7. (10 pts.) Magnetic susceptibility can be used to determine the arrangement of the electrons in a metal's d orbitals. Which of the following arrangements of electrons would have the highest magnetic susceptibility. Briefly explain your choice.





8. (6 pts.) Carbonyl ligands are σ-donor, π-acceptor ligands. As such they the tend not to bond to a metal center trans to each other. Thus, in $[Re(CO)_3(H_2O)_3]^+$ the CO ligands and the H_2O ligands adopt a facial geometry. Draw a wedge and dash representation of the octahedral complex *fac*-$[Re(CO)_3(H_2O)_3]^+$.

9. (10 pts.) Sketch the bonding interaction between a π* orbital of carbon monoxide and a filled d orbital on a metal.

10. To the right is a rate law that is consistent with a dissociative mechanism that forms ML_5Y from a reaction of ML_5X and Y.

$$\frac{d[ML_5Y]}{dt} = \frac{k_1 k_2 [ML_5X][Y]}{k_{-1}[X] + k_2[Y]}$$

a. (6 pts.) Will the initial rate of the reaction depend on the the concentration of the incoming ligand [Y]? Explain briefly.

b. (6 pts.) Will adding X to the reaction increase or decrease the rate of product formation?

11. (12 pts.) Three mechanisms for substitution reactions are drawn below. Label the mechanisms as "associative", "dissociative", or "interchange".

$$ML_5X + Y \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} YML_5X \qquad YML_5X \xrightarrow{k_2} ML_5Y + X$$

$$ML_5X + Y \longrightarrow [Y\cdots ML_5\cdots X]^{\ddagger} \longrightarrow ML_5Y + X$$

$$ML_5X \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ML_5 + X \qquad ML_5 + Y \xrightarrow{k_2} ML_5Y$$

O_h	E	8 C_3	6 C_2	6 C_4	3 C_2 (C_4^2)	i	6 S_4	8 S_6	3 σ_h	6 σ_d		
A_{1g}	1	1	1	1	1	1	1	1	1	1		$x^2 + y^2 + z^2$
A_{2g}	1	1	-1	-1	1	1	-1	1	1	-1		
E_g	2	-1	0	0	2	2	0	-1	2	0		$(2z^2 - x^2 - y^2, x^2 - y^2)$
T_{1g}	3	0	-1	1	-1	3	1	0	-1	-1	(R_x, R_y, R_z)	
T_{2g}	3	0	1	-1	-1	3	-1	0	-1	1		(xy, yz, xz)
A_{1u}	1	1	1	1	1	-1	-1	-1	-1	-1		
A_{2u}	1	1	-1	-1	1	-1	1	-1	-1	1		
E_u	2	-1	0	0	2	-2	0	1	-2	0		
T_{1u}	3	0	-1	1	-1	-3	-1	0	1	1	(x, y, z)	
T_{2u}	3	0	1	-1	-1	-3	1	0	1	-1		

formula and charge	compound/ion name	ligand name
CO	carbon monoxide	carbonyl
CN^-	cyanide	cyano
CH_3CN	acetonitrile	acetonitrile
NH_3	ammonia	ammine
$H_2NCH_2CH_2NH_2$	ethylene diamine	ethylene diamine
NCS^-	thiocyanate	thiocyanato
H_2O	water	aqua
F^-	fluoride	fluoro
$CH_3CO_2^-$	acetate	acetato
OH^-	hydroxide	hydroxo
Cl^-	chloride	chloro
Br^-	bromide	bromo
I^-	iodide	iodo

1 H 1.0079																	2 He 4.0026
3 Li 6.941	4 Be 9.012											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.1797
11 Na 22.989	12 Mg 24.305											13 Al 26.981	14 Si 28.086	15 P 30.974	16 S 32.065	17 Cl 35.453	18 Ar 39.948
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br 79.904	36 Kr
37 Cs	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Rb	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110	111	112		114		116		118

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr