Inorganic Chemistry 411/511 **Final Exam**
115 minutes; 200 points total
Show your work for partial credit.

1. **Draw** the **molecular geometry** *and* give the **point group** for the following. Indicate any deviations from ideal VSEPR coordination angles.

   (a) **[10 pts]** ClO_3^- (chlorate anion)

   (b) **[10 pts]** XeF_4

   (c) **[7 pts]** Is XeF_4 a polar molecule? Explain using symmetry rules.

2. [14 pts] Write down a Born-Haber analysis (give all the reaction steps) needed to estimate ΔH_f for BaF_2 (s) from the elements in standard states.

(b) **[7 pts]** Do you predict that BaF_3(s) will be stable? Explain briefly.

(c) **[7 pts]** Which structure is likely for BaF_2 (s), rocksalt, fluorite, or sphalerite? Explain briefly.

3. (a) [16 pts] Construct a molecular orbital diagram for carbon monoxide, CO (g), including valence atomic and molecular orbitals, with symmetry labels, and with the correct electron filling of the MO's.

(b) [7 pts] Draw the geometry of the orbital on CO that acts as a π–acceptor with transition metal cations.

4. A Latimer diagram for Cl at pH=0 is:

$$ClO_4^- \xrightarrow{1.20\ V} ClO_3^- \xrightarrow{1.18} HClO_2 \xrightarrow{1.67} HClO \xrightarrow{1.63} Cl_2 \xrightarrow{1.36} Cl^-$$

(a) [10 pts] What is the standard potential for reduction of ClO_4^- to Cl_2 at pH = 0 ?

(b) [10 pts] Does $HClO_2$ disproportionate spontaneously in aqueous acid? Explain.

(c) **[10 pts]** Write a balanced half-reaction for the reduction of ClO_4^- to ClO_3^- in acidic solution.

(d) **[12 pts]** Calculate the potential for the half-reaction in part (c) at pH = 3. The Nernst equation is $E = E^0 - (0.059\ V/\ n) \log Q$

5. (a) **[10 pts]** Write out the full name of both isomers of $[PtBr_2\{NH_3)_2\}]$

(b) **[10 pts]** Give the d orbital energy level diagram for the complex in part (a), assuming an approximately square planar structure. Label the d-orbitals (z^2, x^2-y^2, xy, xz, yz).

6. (a) **[10 pts]** Draw the d-orbital energy levels and electron occupancies for both the strong-field (low spin) and weak-field (high spin) O_h complexes of Fe(II).

(b) **[10 pts]** Calculate the ligand field stabilization energies (LFSE) relative to Δ_O for each of the two configurations in part (a).

(c) **[8 pts]** How would you experimentally determine the actual configuration (high or low-spin) for an O_h complex of Fe(II)?

7. [4 pts each] Circle the ONE best choice.

(a) MgO has the stacking sequence of $(AcBaCb)_n$. What is the coordination geometry around the cation in the lattice?
(1) tetrahedral (2) square planar (3) octahedral
(4) trigonal prismatic (5) linear (6) trigonal bipyramidal

(b) Which of the following is the strongest acid?
(1) HClO (2) $HClO_2$ (3) $HClO_3$ (4) $HClO_4$ (5) ClO_4^- (6) H_2O

(c) Which of the following will rapidly react with water to form H_2 ?
(1) NH_3 (2) KH (3) HF (4) CH_4 (5) SF_6 (6) F_2

(d) Which acts as a π-donor with a weak ligand field effect?
(1) $N(CH_3)_3$ (2) H^- (3) CN^- (4) Cl^- (5) NH_3 (6) CO

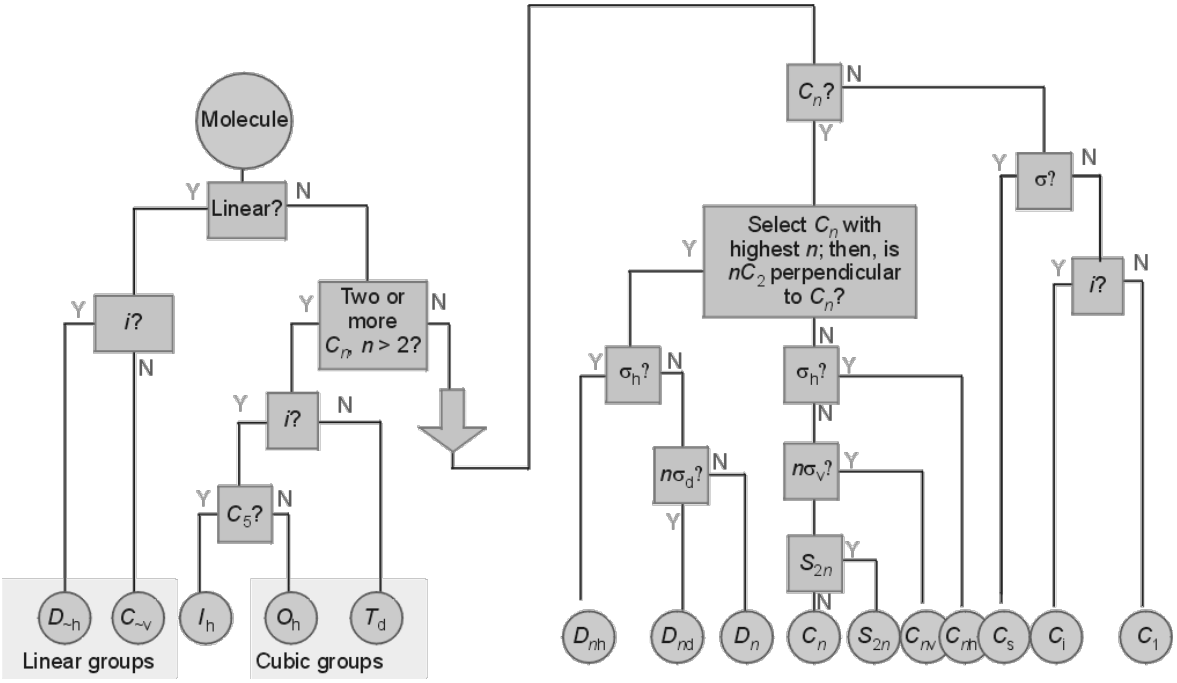
(e) Which ligand will form the strongest complex with the soft acid Pd^{2+} ?
(1) F^- (2) Cl^- (3) Br^- (4) I^- (5) all complexes will have the same K_f

(f) Which statement is NOT true for transition metal complexes?
(1) Td complexes are generally high spin
(2) d^8 complexes are often square planar
(3) 3rd row transition metal ions often show higher coordination than 1st row ions
(4) Hg(I) often exists as the species Hg_2^{2+}
(5) the ligand-field splitting energy for Td complexes (Δ_T) is generally greater than the ligand-field splitting energy for octahedral complexes (Δ_O)

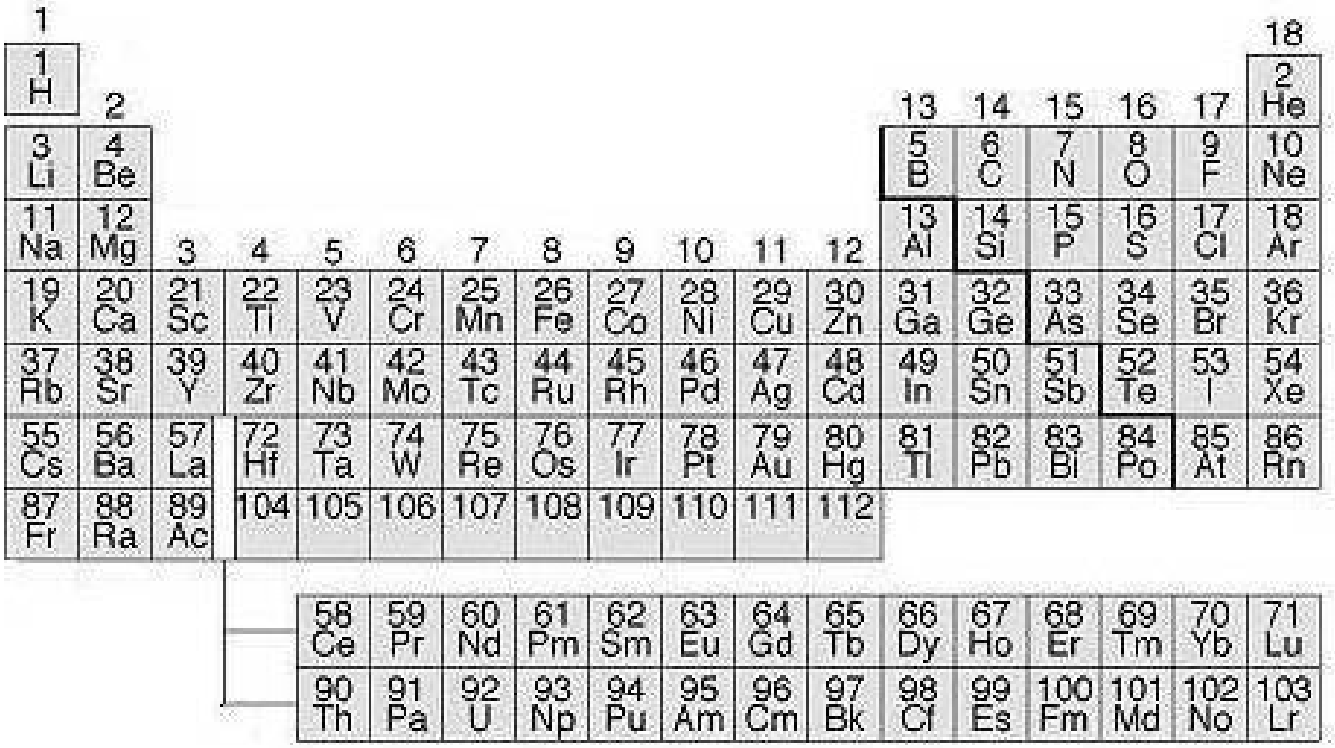
(g) Which complex has the largest LFSE?
(1) $[Ti(OH_2)_6]^{2+}$ (2) $[V(OH_2)_6]^{2+}$ (3) $[Cr(OH_2)_6]^{2+}$
(4) $[Fe(OH_2)_6]^{2+}$ (5) all these complexes have the same LFSE

(h) Which of the following octahedral complexes has no geometric isomers?
(1) $[FeCl(OH_2)_5]^{2+}$ (2) $[IrCl_3F_3]^{2-}$ (3) $[RuCl_4(bipy)]^{2-}$
(4) $[CoBr_2Cl_2(NH_3)_2]^{+}$ (5) $[W(CO)_4(PMe_3)_2]^{0}$ (6) $[CrCl_4(NH_3)_2]^{1-}$

T_d	E	$8C_3$	$3C_2$	$6S_4$	$6\sigma_d$	
A_1	1	1	1	1	1	$x^2+y^2+z^2$
A_2	1	1	1	-1	-1	
E	2	-1	2	0	0	$(2z^2-x^2-y^2, x^2-y^2)$
T_1	3	0	-1	1	-1	(R_x, R_y, R_z)
T_2	3	0	-1	-1	1	(x, y, z), (xy, xz, yz)



O_h	E	$8C_3$	$6C_2$	$6C_4$	$3C_2$	i	$6S_4$	$8S_6$	$3\sigma_h$	$6\sigma_d$	
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	(z^2, x^2-y^2)
T_{1g}	3	0	-1	1	-1	3	1	0	-1	-1	
T_{2g}	3	0	1	-1	-1	3	-1	0	-1	1	(xz, yz, xy)
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	


1
1 H
2
3 Li
4 Be
11 Na
12 Mg
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
2 He
5 B
6 C
7 N
8 O
9 F
10 Ne
13 Al
14 Si
15 P
16 S
17 Cl
18 Ar
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
36 Kr
37 Rb
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 Cs
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
105
106
107
108
109
110
111
112
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