1. Explain the following with an example. (8%)
(a) nonstoichiometric compounds. (b) π-acceptor ligands.
(c) three-center two-electron bonds. (d) outer orbital complexes.

2. Draw the structures of the following: (8%)
(a) diborane (b) $BeCl_2$ (crystal) (c) $Fe(C_5H_5)_2(CO)_2$ (d) $N_4S_4F_4$.

3. Choose and explain: (16%)
(a) stronger Lewis base: $(CH_3)_2S$ or $(CH_3)_2O$
(b) stronger Lewis acid: BF_3 or BCl_3
(c) larger Ka value: $Cr^{3+}_{(aq)}$ or $Cu^{2+}_{(aq)}$.
(d) longer B-F bond: H_3N-BF_3 or BF_3.

4. Give the number of unpaired electrons, and the predicted spin-only magnetic moment of the following complexes. State whether or not an orbital contribution to the magnetic moment is expected. (8%)
(a) $Rh(C_2O_4)_3^{3-}$ (b) FeF_6^{4-}

5. Give hydrocarbon fragments, $[CH_m]^n$ ($m = 0, 1, 2, 3, 4$; $n = 0, \pm1, \pm2, \pm3$), which are isolobal analog for each of the following metal fragments. (8%)
(a) $Fe(CO)_3$ (b) $Ni(CO)_3$ (c) $[CpFe(C_6H_6)]^+$ (d) $Mn(CO)_5^+$

6. Find the number, and symmetry species, of the infrared and Raman active vibrations of NH_3 (C_{3v}). (8%)

C_{3v}	E	$2C_3$	$3\sigma_v$		
A_1	1	1	1	z	x^2+y^2, z^2
A_2	1	1	−1	R_z	
E	2	−1	0	(x, y) (R_x, R_y)	(x^2-y^2, xy) (xz, yz)

7. Explain each of the following: (24%)
   (a) The bond angle of nitrogen dioxide species is $NO_2^+ > NO_2 > NO_2^-$.
   (b) In aqueous solution, the order of base strength is $Me_2NH > MeNH_2 > Me_3N > NH_3$.
   (c) The optical absorption bands of lanthanide compounds are much narrower than those of transition complexes.

8. Write the major product(s) for the following reactions: (6%)
   (a) $BF_3 + NaBH_4 \longrightarrow$
   (b) $B_4H_{10} + (CH_3)_3N \longrightarrow$
   (c) $Fe(CO)_5 + NaC_5H_5 \longrightarrow$

9. Explain why Mn_3O_4 is a normal spinel while Fe_3O_4 is an inverse spinel. (6%)

10. Clearly explain the relation between the symbols below, which are used to identify optical isomers: (8%)
   (a) + or − (b) d or l (c) Δ or Λ (d) δ or λ