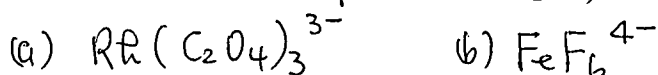


1. Explain the following with an example. (8%)  
 (a) nonstoichiometric compounds. (b)  $\pi$ -acceptor ligands.  
 (c) three-center two-electron bonds. (d) outer orbital complexes.

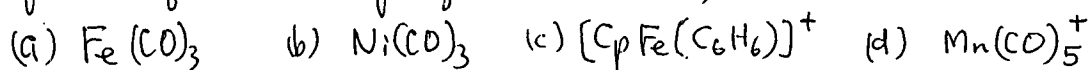
2. Draw the structures of the following: (8%)  
 (a) diborane (b)  $\text{BeCl}_2$  (crystal) (c)  $\text{Fe}(\text{C}_5\text{H}_5)_2(\text{CO})_2$  (d)  $\text{N}_4\text{S}_4\text{F}_4$ .

3. Choose and explain: (16%)  
 (a) stronger Lewis base:  $(\text{CH}_3)_2\text{S}$  or  $(\text{CH}_3)_2\text{O}$   
 (b) stronger Lewis acid:  $\text{BF}_3$  or  $\text{BCl}_3$   
 (c) larger  $K_a$  value:  $\text{Cr}^{3+}(\text{aq})$  or  $\text{Cu}^{2+}(\text{aq})$ .  
 (d) longer B-F bond:  $\text{H}_3\text{N}-\text{BF}_3$  or  $\text{BF}_3$ .

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%)



5. Give hydrocarbon fragments,  $[\text{C}_m\text{H}_n]^m$  ( $m=0, 1, 2, 3, 4$ ;  $n=0, \pm 1, \pm 2, \pm 3$ ), which are isolobal analog for each of the following metal fragments. (8%)



6. Find the number, and symmetry species, of the infrared and Raman active vibrations of  $\text{NH}_3$  ( $\text{C}_{3v}$ ). (8%)

$\text{C}_{3v}$	E	$2\text{C}_3$	$3\text{C}_2$		
$A_1$	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  $\text{NO}_2^+ > \text{NO}_2 > \text{NO}_2^-$ .
- (b) In aqueous solution, the order of base strength is  $\text{Me}_2\text{NH} > \text{MeNH}_2 > \text{Me}_3\text{N} > \text{NH}_3$ .
- (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)  $\text{BF}_3 + \text{NaBH}_4 \longrightarrow$
- (b)  $\text{B}_4\text{H}_{10} + (\text{CH}_3)_3\text{N} \longrightarrow$
- (c)  $\text{Fe}(\text{CO})_5 + \text{NaC}_5\text{H}_5 \longrightarrow$

9. Explain why  $\text{Mn}_3\text{O}_4$  is a normal spinel while  $\text{Fe}_3\text{O}_4$  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)  $\Delta$  or  $\Lambda$  (d)  $\delta$  or  $\lambda$