1. (10%) Use hard and soft acids and bases to explain the following reactions:

$$R_3SiNC \xrightarrow{AgCl} R_3SiCl \xrightarrow{AgF} R_3SiF$$

2. Although water and ammonia contain intermolecular hydrogen bonds, water has a higher boiling point than ammonia. Why? (10%)

3. Na^+ and Ag^+ have about the same ionic radius, the chemical bonding interaction between Na^+ and H_2O in Na^+-OH_2 is weaker than that between Ag^+ and H_2O in Ag^+-OH_2. Why? (10%)

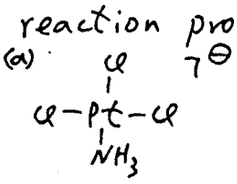
4. 100 mL of water at 25°C dissolve 70 g of LiCl but only 30 g of KCl. Why? (10%)

5. Which of the following species are (a) polar (b) chiral (c) containing a C_4 axis as the symmetry element (10%)
(i) CO_3^{2-} (ii) HCN (iii) NH_2Cl (iv) SiF_4 (v) SiFClBrI (vi) BrF_4^-

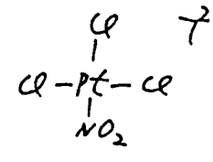
6. Draw all possible isomers for (a) octahedral $[CoCl_2(NH_3)_2(en)]^+$ (b) cis-$[PtCl_2(en)]$ (10%)

7. Give ^{19}F NMR spectra for (a) ClF_3 (b) PF_3 (^{19}F and ^{31}P have nuclear spins $I = \frac{1}{2}$ at 100% natural abundance) (10%)

8. Use the trans effect $NO_2^- > Cl^- > NH_3$ to predict the reaction products (10%)

(a) 

$\xrightarrow{NO_2^-}$?

(b) 

$\xrightarrow{NH_3}$?

9. Is $Mo(CO)_7$ likely present? Give your reasoning. (4%)

10. Which complex, (a) $[Fe(CO)_4]^{2-}$ or $[Co(CO)_4]^-$ (b) $[Mn(CO)_5]^-$ or $[Re(CO)_5]^-$, should be more basic toward proton? (6%)

11. CO is known to undergo dissociative chemisorption on Ni(s) at high temperatures, which results in surface carbide and oxide. With this as an initial step, propose a series of plausible reactions for the nickel-catalyzed conversion of CO and H_2 to CH_4 and H_2O. (10%)