

- Experimental evidence indicates that the bond between Cr and O in the CrO_4^{2-} ion is in between a single and a double bond. (a) Draw resonance structures for CrO_4^{2-} . (b) Calculate the formal charge and the oxidation state of Cr in CrO_4^{2-} . (8%)
- (a) Apply the method of hybridization to predict the geometric structure of ClF_3 . (b) Draw the high-resolution ^{19}F ($I = \frac{1}{2}$) nmr spectra of ClF_3 at a low temperature (220 K) and at a high temperature (above 330 K). (8%)
- Predict the bond order of the bond in each of the following species and give brief explanations. (9%)
(a) NO^+ (b) H_2^+ (c) OCl^-
- Calculate the spin-only magnetic moment of the Mn^{2+} ion in its ground state. (3%)
- Explain why FeI_3 can not be made in aqueous solution. (3%)
- Explain why the ligand field (d-d) bands are shifted only slightly for the $[\text{Co}(\text{NH}_3)_5\text{X}]^{2+}$ ions for different halides, but the charge-transfer bands are shifted greatly. (6%)
- List all symmetry elements of $\text{cis-PdCl}_2(\text{CN})_2$. (5%)
- (a) Give a linkage isomer for $[\text{Co}(\text{NH}_3)_4(\text{NO}_2)\text{Cl}]\text{Cl}$. (2%)
(b) Give two optical isomers for $[\text{Co}(\text{en})_3]^{3+}$. (2%)
- Give formulas for the following: (5%)
(a) hexakispyridinecobalt(III) chloride (b) tetrachloroferrate(III) ion.
(c) potassium tetracyanonickelate(II) (d) monoaquopentaamineruthenium(III) ion (e) trisethylenediamminenickel(II) bromide.
- Compounds of copper(II) are generally colored, but compounds of copper(I) are not. Why? (4%)
- Why are CN^- and CO toxic to humans? (3%)
- Write two compounds which are isoelectronic to $(\pi\text{-C}_5\text{H}_5)\text{Mo}(\text{CO})_3(\text{CH}_3)$. (4%)
- How many unpaired electrons are in the following complexes in the ground state. (5%)
(a) $\text{Ru}(\text{H}_2\text{O})_6^{2+}$ (b) $\text{Fe}(\text{CN})_6^{3-}$ (c) $\text{Mo}(\text{CO})_6$ (d) $\text{Ni}(\text{H}_2\text{O})_6^+$ (e) $\text{V}(\text{en})_3^{3+}$

14. Describe, in detail, the structure and bonding in the B_2H_6 molecule. (5%)
15. The absorption spectra of the lanthanide cations are typically sharp, line like spectra as opposed to the broad absorptions of the transition metals. Explain. (6%)
16. One of the prerequisites for the formation of metal-metal bonds is a low formal oxidation state. Explain. (6%)
17. What is the Jahn-Teller effect as observed in the ground state structures of certain transition metal complexes? Use $_{24}Cr^{2+}$ ion as an illustration. (5%)
18. Write the major products for the following reactions: (6%)
- (a) $LiOH \xrightarrow{\text{red heat}}$
- (b) $CF_3I + OH^- \rightarrow$
- (c) $OPCl_3 + NH_3 \rightarrow$
19. The trimeric phosphonitriles are usually planar but can be forced out of the planar arrangement. In contrast, benzene derivatives are strictly planar. Discuss the reasons for the greater flexibility of the phosphonitriles. (5%)