Birla Institute of Technology and Science, Pilani (Rajasthan)

First Semester (2023-24), 14th October, 2023

Mid-Semester Test (Closed Book)

CHEM F214: Inorganic Chemistry I

Marks: 60 **Time: 90 min**

Instruction to the students: There are **5** questions in all. Attempt all the questions. Answer all parts of the question together.

Useful Data: Electronegativity χ: $\chi_H = 2.1$; $\chi_C = 2.5$; $\chi_{Si} = 1.8$; I_2 ($E_A = 0.5$, $C_A = 2.00$); $B(OCH_3)_3$ ($E_A = 0.54$, $C_A = 1.22$); Me_2S ($E_B = 0.25$, $C_B = 3.75$); DMSO ($E_B = 2.40$, $C_B = 1.47$).

Q1. Silicon hydride reacts with the sources of protons to give molecular hydrogen whereas hydrocarbons do not. Explain the observation. If the bond energies of C-H, Si-H and H-H bonds are 413 kJ/mole, 160 kJ/mole and 436 kJ/mole respectively, calculate the bond energy of C-C bond. **[2+3]**

(b) Calculate the average bond energy of N-N bond from the following data:
Total heat of atomization of N_2H_4 and N_2F_4 are 1703 kJ/mole and 1305 kJ/mole respectively
Bond energies of N-H bond (assumed from NH_3) and N-F (assumed from NF_3) are 386 kJ/mole and 283.5 kJ/mole respectively. **[3]**

(c) Me_3N, pyridine, acetonitrile (CH_3CN) have distinctly different basicity. In presence of water how do they behave and why are the differences observed? **[4]**

Q2. (a) Using acid-base theory, predict whether the following reactions have equilibrium constants greater or less than 1. Provide the justifications
(i) $SO_2 + Ph_3P\text{-}HOCMe_3$ (ii) $[AgCl_2]^- + 2\ CN^-$ **[3+2]**

(b) Compare the strength of acidity with proper reasoning: (i) aqua ion of Na^+ and Ag^+ (ii) conjugate acids of ClO_4^-, PO_4^{3-}, SO_4^{2-}, SiO_4^{4-}. **[2+3]**

(c) Fluorosulphuric acid and antimony pertafluoride form superacid. Write down the reaction. **[2]**

Q3. (a) Compare the basicity of Me_2S and DMSO with respect to the acids I_2 and $B(OCH_3)_3$ by calculating the ΔH of the adduct formation. **[5]**

(b) Write down the reaction involved in each of the cases and comment on the comparative strength of the acids in the solvent, H_2SO_4.
(i) $HClO_4$ in H_2SO_4 **(ii)** $H_2S_2O_7$ in H_2SO_4 **[3+1]**

(c) Draw the structures of $HMnO_4$ and $HClO_4$ and justify their relative acid strength. **[3]**

Q4. (a) Draw the Frost diagram from the given Latimer diagram for Tl (Thallium) in aqueous acid mentioning the **axes** and **coordinates**. Which species is the strongest oxidant and How do justify it?

$$Tl^{3+} \xrightarrow{1.25} Tl^{+} \xrightarrow{-0.336} Tl$$

[3+2]

(b) In a figure show the C_2 and C_3 rotational axes of symmetry (one each) for a perfect octahedron. How many of such axes are present for each of the cases? (ii) Find out the principal axis of rotation present in octahedron. **[2+1+1]**

(c) Write down the balanced reaction of oxidation of H_2O by Fe^{2+}. If $E^0(Fe^{2+}/Fe)$ = -0.44V, and E^0 (O_2/H_2O) = 1.23 V, then comment on the spontaneity of the above mentioned reaction **[3]**

Q5. (a) Find out the point groups of *cis-planar* and *trans-planar* configurations of H_2O_2 by mentioning all the symmetry elements. **[3]**

(b) In which of the species ICl_4^- or SF_4 is the bond angle closest to that predicted by VSEPR by predicting the structures of these molecules? **[4]**

(c) Find out the minimum size of the tetrahedral hole in terms of the radius of anions. **[3]**

(d) What could be the plausible reason(s) for $MgSO_4$ (radius of Mg^{2+}= 0.72 Å) to be more soluble in water than $SrSO_4$ (radius of Sr^{2+} = 1.16 Å)? **[2]**

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