國立成功大學109學年度碩士班招生考試試題

系　　所：化學工程學系

考試科目：無機化學及分析化學

考試日期：0210，節次：2

※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

Inorganic Chemistry and Analytical Chemistry (total points: 100)

Part I: Inorganic Chemistry (total points: 50)

1. Give the ground-state electron configurations of the copper molecule and its ions, Cu, Cu^{+}, and the Cu^{2+}. (6 pts)

2. Give the valence electron count at the meal center for the following metal complexes, and indicate whether they obey the Effective atomic number (EAN) rule or not? (10 pts)
   (a) $K(Ag(CN)_2)$; (b) $H(Mn(CO)_5)$; (c) $K_4(Fe(CN)_6)$; (d) $K_3(Cr(C_2O_4)_3)$;
   (e) $(Co(H_2O)_6)Cl_2$

3. For each of the following pairs of complexes, indicate the one that has the larger ligand field stabilization energy (LFSE): (9 pts)
   (a) $[Cr(H_2O)_6]^{2+}$ or $[Mn(H_2O)_6]^{2+}$
   (b) $[Mn(H_2O)_6]^{2+}$ or $[Fe(H_2O)_6]^{3+}$
   (c) $[Fe(H_2O)_6]^{3+}$ or $[Fe(CN)_6]^{3-}$

4. Predict which of the following complex is Jahn-Teller active (Jahn-Teller effect: describes the geometrical distortion of molecules and ions that result from certain electron configurations.) (5 pts) a) $[Cr(NH_3)_6]^{3+}$; b) $[Co(CN)_6]^{3-}$; C) $[Ti(H_2O)_6]^{3+}$

5. On the basis of Valence shell electron pair repulsion theory (VSEPR), predict the structures of XeF_4, NH_3, SF_6, and I_3^-. (8 points)

6. Draw the models of the following molecules and answer the questions a) to (d) for each of them: $CHCl_3$; PCl_5 ; 1,5-dibromonaphthalene (12 pts)
   (a) Does the molecule have an axis of symmetry? If so, is it 2-fold, 3-fold, or what?
   (b) Does the molecule have an inversion center?
   (c) Does the molecule have any mirror planes? If so, how many?
   (d) What is point group of the molecule?

Part II: Analytical Chemistry (total points: 50)

7. A spectrum has a signal-to-noise ratio (S/N) of 25/1 which means that a signal, S, with 4% uncertainty, e. (S±e=25±4)

(a) Using the rules for propagation of uncertainty to show that the signal = $25n/\sqrt{n}$ for overlapping n spectra. (5 pts)

(b) How many spectra must be averaged to increase the S/N to 100/1? (3 pts)

8. Mn was used as an internal standard for measuring Fe by atomic absorption. A standard mixture containing 2.50 μg/mL Mn and 2.50 μg/mL. Fe gave a quotient (Fe signal area/Mn signal area) 1.05/1.00. A solution was prepared by mixing 10.00 mL of unknown Fe solution with 10.00 mL of standard containing 8.5 μg/mL Mn, and diluting to 50.00 mL; the measured absorbance signal area at the Fe wavelength was 0.200, and at the Mn wavelength was 0.120.

(a)Calculate the molar concentration of Fe in the original unknown solution. (4 pts)

(b) if, a standard mixture containing 2.50 μg/mL Mn and 10.00 μg/mL. Fe gave a quotient (Fe signal area/Mn signal area) 1.05/1.00. Calculate the molar concentration of Fe in the original unknown solution (4 pts)

9. Explain the difference between(a) Scanning electron microscope (SEM) and transmission electron microscope (TEM) ; (b) fluorescence and phosphorescence; (c) Small-angle x-ray scattering (SAXS) and wide-angle x-ray scattering (WAXS); (d) Differential scanning calorimetry (DSC) and differential thermal analysis (DTA). (8 pts)

10. From the following reduction potentials,

$Fe^{3+}(aq)+e^- \longrightarrow Fe^{2+}(aq)$ $E^0=0.77V$ and $I_2(s)+2e^- \longrightarrow 2I^-$ $E^0=0.535$ V

(a) Is $2Fe^{3+}(aq)+2I^-(aq) \longrightarrow 2Fe^{2+}(aq)+I_2(s)$ reaction spontaneous at 25°C? (3 pts)

(b) Calculate the equilibrium constant of reaction in question (a) (5 pts)

11. Propionic acid ($CH_3CH_2CO_2H$) dissociate as $HA \leftrightharpoons H^+ + A^-$ $K_a=1.34\times10^{-5}$

(a) calculate the pH and fraction of dissociation of 10^{-2} M Propionic acid (4 pts)

(b) calculate the pH and fraction of dissociation of 10^{-10} M Propionic acid (4 pts)

12. What compound, if any, will precipitate when 50.0 mL of 1.0×10^{-5} M $Ba(OH)_2$ (aq) is added to 50.0 mL 2.0×10^{-5} M $Fe_2(SO_4)_3$? (10pts)

$BaSO_4$ (s) ↔ Ba^{2+} (aq) + SO_4^{2-} (aq); $K_{sp} = 1.1 \times 10^{-10}$

$Fe(OH)_3$ (s) ↔ Fe^{3+} (aq) + 3 OH^- (aq); $K_{sp} = 2.6 \times 10^{-39}$

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