

※ 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<sup>+</sup>, and the Cu<sup>2+</sup>. (6 pts)
2. Give the valence electron count at the metal 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)<sub>2</sub>); (b) H(Mn(CO)<sub>5</sub>); (c) K<sub>4</sub>(Fe(CN)<sub>6</sub>); (d) K<sub>3</sub>(Cr(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub>);  
(e) (Co(H<sub>2</sub>O)<sub>6</sub>)Cl<sub>2</sub>
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<sub>2</sub>O)<sub>6</sub>]<sup>2+</sup> or [Mn(H<sub>2</sub>O)<sub>6</sub>]<sup>2+</sup>  
(b) [Mn(H<sub>2</sub>O)<sub>6</sub>]<sup>2+</sup> or [Fe(H<sub>2</sub>O)<sub>6</sub>]<sup>3+</sup>  
(c) [Fe(H<sub>2</sub>O)<sub>6</sub>]<sup>3+</sup> or [Fe(CN)<sub>6</sub>]<sup>3-</sup>
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<sub>3</sub>)<sub>6</sub>]<sup>3+</sup>; b) [Co(CN)<sub>6</sub>]<sup>3-</sup>; c) [Ti(H<sub>2</sub>O)<sub>6</sub>]<sup>3+</sup>
5. On the basis of Valence shell electron pair repulsion theory (VSEPR), predict the structures of XeF<sub>4</sub>, NH<sub>3</sub>, SF<sub>6</sub>, and I<sub>3</sub><sup>-</sup>. (8 points)
6. Draw the models of the following molecules and answer the questions a) to (d) for each of them: CHCl<sub>3</sub>; PCl<sub>5</sub>; 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. ( $S \pm e = 25 \pm 4$ )

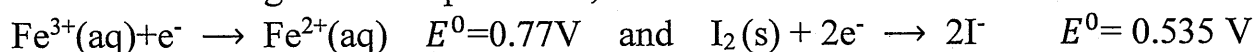
- (a) Using the rules for propagation of uncertainty to show that the signal =  $25n/\sqrt{n}$  for overlapping n spectra. (5 pts)
- (b) How many spectra must be averaged to increase the S/N to 100/1? (3 pts)

8. Mn was used as an internal standard for measuring Fe by atomic absorption. A standard mixture containing 2.50  $\mu\text{g/mL}$  Mn and 2.50  $\mu\text{g/mL}$  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  $\mu\text{g/mL}$  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  $\mu\text{g/mL}$  Mn and 10.00  $\mu\text{g/mL}$  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,

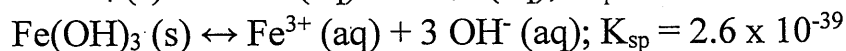
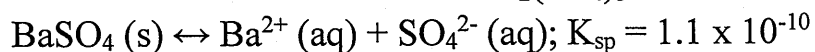


- (a) Is  $2\text{Fe}^{3+}(\text{aq}) + 2\text{I}^{-}(\text{aq}) \rightarrow 2\text{Fe}^{2+}(\text{aq}) + \text{I}_2(\text{s})$  reaction spontaneous at 25°C? (3 pts)
- (b) Calculate the equilibrium constant of reaction in question (a) (5 pts)

11. Propionic acid ( $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$ ) dissociate as  $\text{HA} \rightleftharpoons \text{H}^{+} + \text{A}^{-}$   $K_a = 1.34 \times 10^{-5}$

- (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  $1.0 \times 10^{-5}$  M  $\text{Ba}(\text{OH})_2$  (aq) is added to 50.0 mL  $2.0 \times 10^{-5}$  M  $\text{Fe}_2(\text{SO}_4)_3$ ? (10pts)



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.00794	2 He Helium 4.002602	3 Li Lithium 6.941	4 Be Beryllium 9.012182	5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.998403	10 Ne Neon 20.1797	11 Na Sodium 22.98976928	12 Mg Magnesium 24.305	13 Al Aluminum 26.9815386	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.06	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955912	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.933195	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.796
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium [97.9072]	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.757	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.293
55 Cs Cesium 132.9054519	56 Ba Barium 137.327	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 193.22	77 Ir Iridium 192.222	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium [209]	85 At Astatine [209]	86 Rn Radon [222]
87 Fr Francium [223]	88 Ra Radium [226]	89-103	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [277]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [271]	111 Rg Roentgenium [272]	112 Uub Ununbium [285]	113 Uut Ununtrium [284]	114 Uuq Ununquadium [289]	115 Uup Ununpentium [288]	116 Uuh Ununhexium [289]	117 Uus Ununseptium [289]	118 Uuo Ununoctium [284]

Metals	Alkali metals
	Alkaline earth metals
	Lanthanoids
	Actinoids
	Transition metals
	Poor metals
	Other nonmetals
	Noble gases
	Nonmetals

C Solid	Hg Liquid	H Gas	Rf Unknown
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