

※ 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 (50 points)

(1) Which of the following pairs may be expected to be more ionic? (8 pts)

- | | |
|--|--|
| (a) CaCl_2 or MgCl_2 | (e) NaCl or CuCl |
| (b) NaCl or CaCl_2 | (f) TiCl_3 or TiCl_4 |
| (c) NaF or CaO | (g) ZnO or ZnS |
| (d) EuO or EuS | (h) BaF_2 or ZnCl_2 |

(2) Give the d^n count and the total valence electron count at the metal for the following compounds. (9 pts)

- (a) (ethylene) PtCl_3^-
(b) $\text{Co}(\text{CO})_3(\text{NO})$
(c) ($\eta^4\text{-C}_6\text{H}_6$) $\text{Ru}(\text{CO})_3$

(3) Answer the following questions:

- (a) CoO is an insulator whereas TiO is a metallic conductor. Briefly discuss the origins of the different electronic behaviors (4 pts).
(b) Predict and draw the shape associated with the following molecules using VSEPR theory. (4 pts)
(i) ClF_3
(ii) CH_2

(4) Draw the models of the following molecules and answer the questions (a) to (d) for each of them (15 pts):

SiH_3Cl B_2Cl_4 (planar) B_2Cl_4 (twisted 90° about the B-B bond)

- (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 the point group of the molecule?

(5) Based on ligand field theory, draw d orbital energy level splitting of the following complexes (label all orbitals, e.g., e_g , t_{2g} , d_{xy} , d_{yz} , etc.) and fill the resulting orbitals with d -electrons (10 pts):

- (a) $[\text{Fe}(\text{CN})_6]^{3-}$
(b) square planar $[\text{Ni}(\text{CN})_4]^{2-}$

Analytical Chemistry (50 points)

(1) Iron (Fe) can be obtained from its ore, iron(III) oxide (Fe_2O_3), by reaction with coke (C) at high temperature according to the equation: $\text{Fe}_2\text{O}_3(\text{s}) + 3\text{C}(\text{s}) \rightarrow 2\text{Fe}(\text{l}) + 3\text{CO}(\text{g})$

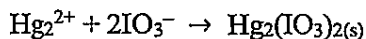
In a certain operation, 2.86×10^4 kg of Fe_2O_3 is reacted with 9.82×10^3 kg of C.

(a) Calculate the theoretical yield of Fe in kilograms (5 pts)

(b) Calculate the percent yield if 1.52×10^4 kg of Fe is actually obtained (5 pts)

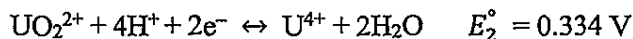
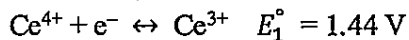
(2) 25 mL of pyridine solution (0.08364 M) is titrated with HCl acid solution (0.1067 M). Calculate the pH of the solution when 4.63 mL of HCl solution is added (K_b of pyridine = 1.69×10^{-9}). (10 pts)

(3) 25 mL of $\text{Hg}_2(\text{NO}_3)_2$ solution (0.04132 M) is titrated with KIO_3 solution (0.05789 M).



If K_{sp} of $\text{Hg}_2(\text{IO}_3)_2$ is equal to 1.3×10^{-18} , calculate the concentration of Hg_2^{2+} in the solution when KIO_3 solution is added (34 mL, 36 mL, and at the endpoint). (10 pts)

(4) A 1.0 M acidic solution (50 mL) containing U^{4+} (0.025 M) is titrated with a 0.1 M Ce^{4+} solution. The reaction is as follows: $\text{U}^{4+} + 2\text{H}_2\text{O} + 2\text{Ce}^{4+} \leftrightarrow \text{UO}_2^{2+} + 2\text{Ce}^{3+} + 4\text{H}^+$



Calculate E_{cell} vs. standard hydrogen electrode, when 5 mL of Ce^{4+} is added. (10 pts)

(5) When highly concentrated silver nitrate solution is added drop by drop into a solution mixture containing 0.05 M Br^- and 0.03 M I^- , which type of ions will precipitate first? Why? Show all calculations if necessary (K_{sp} of $\text{AgI} = 8.3 \times 10^{-17}$ and K_{sp} of $\text{AgBr} = 5.0 \times 10^{-13}$). (10 pts)

Periodic Table of the Elements

1 H Hydrogen 1.01																	2 He Helium 4.00
3 Li Lithium 6.94	4 Be Beryllium 9.01											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
11 Na Sodium 22.99	12 Mg Magnesium 24.31											13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.07	17 Cl Chlorine 35.45	18 Ar Argon 39.95
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 51.99	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.63	33 As Arsenic 74.92	34 Se Selenium 78.97	35 Br Bromine 79.90	36 Kr Krypton 84.80
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.95	43 Tc Technetium 98.91	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.6	53 I Iodine 126.90	54 Xe Xenon 131.29
55 Cs Cesium 132.91	56 Ba Barium 137.33	57-71 La-Lu Lanthanides	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.09	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium [209]	85 At Astatine 209	86 Rn Radon 222.02
87 Fr Francium 223.02	88 Ra Radium 226.03	89-103 Ac-Lr Actinides	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]
57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium 144.91	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.06	71 Lu Lutetium 174.97			
89 Ac Actinium 227.03	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium 237.05	94 Pu Plutonium 244.06	95 Am Americium 243.06	96 Cm Curium 247.07	97 Bk Berkelium 247.07	98 Cf Californium 251.08	99 Es Einsteinium [254]	100 Fm Fermium 257.10	101 Md Mendelevium 258.1	102 No Nobelium 259.10	103 Lr Lawrencium [262]			