計算及問答題：（100分）

1. (10 points) A 1.00-g sample of a gaseous compound of boron and hydrogen occupies 0.820 L at 1.00 atm and 3 °C. What is the molecular formula for the compound?

2. (20 points total) Calculate the pH when 100.0 mL of a 1.00 M solution of H_2A ($K_{a_1} = 1.0 \times 10^{-4}$, $K_{a_2} = 1.0 \times 10^{-8}$) is titrated with the following volumes of 1.00 M NaOH.
(A) (5 points) Calculate the initial pH of the solution.
(B) (5 points) Calculate the pH of the resulting solution after 75.0 mL of 1.00 M NaOH has been added.
(C) (5 points) Calculate the pH of the resulting solution after 100.0 mL of 1.00 M NaOH has been added.
(D) (5 points) Calculate the [H^+] of the resulting solution after 200.0 mL of 1.00 M NaOH has been added.

3. (10 points total) Give a short answer for the following questions:
(A) (2 points) What is the maximum number of electrons per orbital?
(B) (2 points) The five 4d orbitals can collectively hold how many electrons?
(C) (2 points) Each electron in the 8s orbital would have what four quantum numbers?
(D) (2 points) How many corresponding orbitals are there for l = 2?
(E) (2 points) What is the lowest energy "f" orbital?

4. (15 points) Construct the molecular orbital diagram of O_2 and fill in the electrons. Can it describe the paramagnetism of O_2? Explain.

5. (16 points total) At room temperature, Fe crystallizes in a body centered cubic structure. The radius of an iron atom is 124 pm.
(A) (3 points) How many Fe atoms are there in a unit cell? Show your work.
(B) (4 points) What is the volume of a unit cell in cm^3?
(C) (4 points) What is the mass of a unit cell in grams?
(D) (5 points) Calculate the density of Fe in g/cm^3.

6. (15 points total) Ethylene glycol ($C_2H_6O_2$) is added to 15.0 L water to produce an antifreeze solution that has a freezing point of −30 °C.
(A) (5 points) Calculate the molality of ethylene glycol of this solution.
(B) (5 points) Calculate the volume of ethylene glycol in L needed to produce such solution.
(C) (5 points) What is the boiling point of this solution?

7. (14 points total) Consider two coordination compounds: $Na_3[CoF_6]$ and $[Co(NH_3)_6]Cl_3$, one of them is high-spin and the other one is low-spin:
(A) (4 points) Give the name for both compounds.
(B) (6 points) Draw the crystal field splitting diagrams for both compounds and fill in the electrons into the diagram. Which one is high-spin, and which one is low-spin? Are they paramagnetic or diamagnetic?
(C) (4 points) One of the compounds is green color and the other one is orange color. Which one is most likely to be green? Which one is most likely to be orange? Briefly explain your choice.

科目名稱	普通化學A	類組代碼	共同考科
		科目碼	E0017

※本項考試依簡章規定所有考科均「不可」使用計算機。 　　本科試題共計 2 頁

Conversions:

1 atm = 760 Torr = 760 mmHg = 101,325 Pa, 1 gal = 3.785 L, 2.54 cm = 1.00 in, 1 cm³ = 1 mL

101.325 J = 1 L atm, 1 lb = 453.6 g, 1 cal = 4.184 J, 10^{10} Å = 1 m = 10^{12} pm = 100 cm

$\sqrt{2}$=1.414, $\sqrt{3}$=1.732, $\sqrt{5}$=2.236, $\sqrt{7}$=2.646

log 2 =0.301, log 3 =0.477, log 5 =0.699, log 7 =0.845

Constants:

R = 8.3145 J / mol K　　　　　　　　　　F = 96,485 C / mol e^-

R = 0.08206 L atm / mol K　　　　　　　c = 2.9979 × 10^8 m / s

K_w = 1.0 × 10^{-14} at 25 °C　　　　　$K_b(H_2O)$ = 1.86 °C kg/mol　　　$K_f(H_2O)$ = 0.51 °C kg/mol

$C_p(H_2O_{(l)})$ = 4.184 J/g °C　　　　　$C_p(H_2O_{(g)})$ = 2.08 J/g °C

Equations:

$K_p = K(RT)^{\Delta n}$　　　　$K_w = [H^+][OH^-]$　　　　pH + pOH = 14.00　　　　pH = $-\log[H^+]$　　　　$pH = pK_a + \log\frac{[B]}{[A]}$

$ax^2 + bx + c = 0$, $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$　　　　$[H^+] = \frac{pK_{a_1} + pK_{a_2}}{2}$

$\Delta T_b = iK_b m$　　　$\Delta T_f = -iK_f m$

side = 2R, side = $\frac{4R}{\sqrt{3}}$, side = $\sqrt{8}R$

Spectrochemical series:

$CN^- > NO_2^- > en > NH_3 > H_2O > OH^- > F^- > Cl^- > Br^- > I^-$

1 H 1.008																	2 He 4.003
3 Li 6.94	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57/71	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89/103	104 Rf (267)	105 Db (268)	106 Sg (271)	107 Bh (272)	108 Hs (270)	109 Mt (276)	110 Ds (281)	111 Rg (280)	112 Cn (285)	113 Nh (284)	114 Fl (289)	115 Mc (288)	116 Lv (293)	117 Ts (294)	118 Og (294)

57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.2	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.2	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
89 Ac (227)	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)