系所組別： 生科、地科、化工、材料、環工系

考試科目： 普通化學

考試日期：0710，節次：1

※ 考生請注意：本試題 ☑可 ☐不可 使用計算機

請勿在本試題紙上作答，否則不予計分

說明：答案一律寫在答案卷上；請依序作答，並標明題號。

(h=6.626x10^{-34} J s, R= 8.314 J/mol K, $K_a(NH_4^+)$: 5.6x10^{-10}, $K_a(HNO_2)$: 4.0x10^{-4}, $K_{a1}(H_2CO_3)$: 4.3x10^{-7}, $K_{a2}(H_2CO_3)$: 4.8x10^{-11})

一、選擇題：（單選，每題 3 分，不倒扣，共 75 分）

1. What's the hybridization of the central atom in FNO?
   (A)*sp* (B)sp^2 (C)sp^3 (D)dsp^3 (E)d^2sp^3
2. What's the molecular shape for $SeOF_2$?
   (A)trigonal pyramidal (B)seesaw (C)trigonal bipyramidal (D)tetrahedral (E)bent
3. Which of the following species (NO^+, NO^-, NO, NO^{2-}, NO^{3-}) has the largest and smallest bond energy for N-O bond, respectively? (Assume that the orbital energy order is the same as that for N_2.)
   (A)NO^+, NO^- (B)NO, NO^{3-} (C)NO, NO^- (D)NO^+, NO^{3-} (E) NO^-, NO^{3-}
4. To make a buffered solution with pH 10.0, the ratio of NH_4Cl to NH_3 must be
   (A)1.8 : 1 (B)1 : 1.8 (C)0.18 : 1 (D)1 : 0.18 (E)none of above
5. The molecular orbital electron configuration $(\sigma_{1s})^2 (\sigma_{1s}^*)^2 (\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4 (\sigma_{2p})^1$ applies to which of the following species?
   (A)N_2^- (B)C_2^- (C)BC (D)BN (E)CO
6. Which of the following are paramagnetic: (a)CN, (b)NO^-, (c)O_2^-, (d)BN?
   (A)a, b, c (B)b, c (C)a, b, d (D)a, b (E)a, b, c, d
7. Given that $Ag^+(aq) + 2\ NH_3(aq) \rightleftharpoons Ag(NH_3)_2^+(aq)$ (K_{eq}=1.72 x10^7) calculate $[Cl^-]_{eq}$ when the solid AgCl (K_{sp}=1.6x10^{-10}) is put in a 10.0 M NH_3 solution.
   (A)0.39 M (B)0.14 M (C)0.47 M (D)0.28 M (E)0.52 M
8. Rank the following 0.10 M solutions in order from most acidic to most basic:
   (1)$CaBr_2$, (2)KNO_2, (3)NH_4ClO_4, (4)NH_4NO_2, (5)HNO_2
   (A)5, 3, 1, 2, 4 (B)3, 5, 2, 4, 1 (C)5, 3, 4, 2, 1 (D)5, 3, 4, 1, 2 (E)5, 4, 1, 3, 2
9. Consider the titration of 25.0 mL of a 0.1 M solution of Na_2CO_3 with 0.1 M HCl. What's the pH of the solution after adding 12.5 mL HCl?
   (A)8.9 (B)9.3 (C)9.8 (D)10.1 (E)10.3
10. If K_w(0 °C)= 1.14x10^{-15} and K_w(40 °C)= 2.92x10^{-14}. Calculate $\Delta S°$ (in J/K,mol) for the autoionization of water: $H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$
    (A)-30.6 (B)-52.8 (C)-75.1 (D)-84.2 (E)-104.3
11. Calculate ΔH (in kJ/mol) in Problem 10.
    (A)57.6 (B)29.5 (C)48.3 (D)25.9 (E)33.8
12. Given that C_p=37.27 J/K, mol and $S°$= 213.64 J/K, mol for CO_2 at 25 °C and 1.0 atm, Calculate the molar entropy (in J/K,mol) at 350 K and 2.0 atm.
    (A)213.9 (B)218.3 (C)215.3 (D)208.5 (E)210.6
13. 3.0 mole of ideal gas ($\bar{C}_v$=3R/2) at 25 °C expands reversibly and adiabatically from 10.0 atm to 1.0 atm. Calculate the work (in kJ).

(背面仍有題目,請繼續作答)

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(A)-6.7 (B)-2.2 (C)-8.5 (D)-12.4 (E)-10.8

14. What's the final temperature (in K) in Problem 13?
(A)180.3 (B)196.2 (C)126.5 (D)232.8 (E)118.6

15. How many reactions listed below at constant pressure are predicted to have greater ΔH than ΔE?
(a) $2\ HF(g) \rightarrow H_2(g) + F_2(g)$ (b) $N_2(g) + 3\ H_2(g) \rightarrow 2\ HH_3(g)$
(c) $4\ HH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g)$ (d) $2\ O_3(g) \rightarrow 3\ O_2(g)$
(A)0 (B)1 (C)2 (D)3 (E)4

16. A certain reaction has the following general form: $a\,A \rightarrow b\,B$
At a particular temperature and $[A]_o=2.80\times10^{-3}$ M, a plot of 1/[A] vs. time resulted in a straight line with a slope of 3.60×10^{-2} L/mol,s. What's the "third" half-life (in s)?
(A)1.98×10^4 (B)3.96×10^4 (C)4.35×10^3 (D)2.25×10^4 (E)7.92×10^4

17. In 6 *M* HCl, the decomposition of the complex ion $Ru(NH_3)_6^{3+}$ is first order with a half-life of 14 h at 25°C. How long (in hours) will it take for the $[Ru(NH_3)_6^{3+}]$ to decrease to 53.0% of its initial value?
(A)15 (B)5.6 (C)6.6 (D)7.4 (E)13

18. The reaction $2A + B \rightarrow C$ has the following proposed mechanism:
Step 1: $A + B \rightleftharpoons D$ (rate constant: k_1 and k_{-1}, fast equilibrium)
Step 2: $D + B \rightarrow E$ (rate constant: k_2)
Step 3: $E + A \rightarrow C + B$ (rate constant: k_3)
If step 2 is the rate-determining step, what should be the rate of formation of C?
(A)k[A] (B)$k[A]^2[B]$ (C)$k[A][B]^2$ (D)k[A][B] (E)$k[A]^2[B]^2$

19. Calculate the equilibrium constant at 25 °C for $AgCl(s) \rightarrow Ag^+(aq) + Cl^-(aq)$
given that $E^o= 0.22$ V for $AgCl(s) + e^- \rightarrow Ag(s) + Cl^-(aq)$ and $E^o= 0.80$ V for $Ag^+(aq) + e^- \rightarrow Ag(s)$.
(A) 1.2×10^{-10} (B) 1.6×10^{-10} (C) 2.4×10^{-9} (D) 7.2×10^{-9} (E) 1.2×10^{-9}

20. Calculate the potential for the following cell at 25 °C
Pt | $H_2(g)$(0.79 atm) | $H_3O^+(aq)$(0.50 M) || $Cl^-(aq)$(0.05 M) | $Cl_2(g)$(0.10 atm) | Pt
given that $E^o= 1.3595$ V for $Cl_2(g) + 2\ e^- \rightarrow 2\ Cl^-(aq)$.
(A)1.26 V (B)1.42 V (C)0.96 V (D)1.58 V (E)1.06 V

21. What's the systematic name of $(CH_3)_2CHCH_2CHOHCH_3$?
(A)1-Methyl-4-hydroxypentane (B)2-Methyl-4- hydroxypentane
(C)1,1-Dimethyl-3-hydroxybutane (D)2- Methyl-4-pentanol (E) 4- Methyl-2-pentanol

22. Which of the following compounds doesn't react with the acidic $KMnO_4$ solution?
(A)propanol (B)isopropanol (C)2-methyl-1-propanol (D)2-methyl-2-propanol
(E)glycerol

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23. How many unpaired electrons are there for the tetrahedral complex $[CoCl_4]^{2-}$?
(A)0 (B)1 (C)2 (D)3 (E)4

24. Which of the following orders is correct for the ligands in the spectrochemical series?
(A)$CN^- > OH^- > NH_3 > F^- > I^-$ (B)$CN^- > NH_3 > OH^- > F^- > I^-$
(C)$CN^- > NH_3 > OH^- > I^- > F^-$ (D)$OH^- > CN^- > NH_3 > I^- > F^-$ (E)none of above

25. Consider the synthesis of NH_3 from N_2 and H_2, an exothermic reaction. The reaction begins with a 3:1 mixture of H_2 and N_2 with temperature 400, 500, 600 °C, and total pressure 300, 400, 500 atm, respectively. Which experimental condition will give the highest yield of NH_3 at equilibrium?
(A)600 °C, 500 atm (B)600 °C, 300 atm (C)400 °C, 500 atm (D)400 °C, 300 atm
(E)500 °C, 400 atm

二、非選擇題：（共 25 分，計算題務必列出計算過程，只寫答案不計分）

1. The wave function of 2s orbital for hydrogen atom may be represented as $A\,[2-(r/a_0)]\,\exp(-r/(2\,a_0))$, where A and a_0 are constants, r is the distance between electron and nucleus, and exp represents an exponential function with a base of e.

(a)What's the probability of finding the electron at $r = 3a_0$ relative to that at $r = a_0$?

(b)Plot the radial probability distribution function, and calculate the location of local maximum. (9%)

2. The rotational transition of $^1H^{35}Cl$ from J=0 to J=1 requires electromagnetic radiation with a wavelength of 4.85×10^{-4} m. The masses of ^1H and ^{35}Cl are 1.0078 and 34.9689 amu, respectively. The energy level is $E_J = h^2J(J+1)/(8\pi^2I)$, where I is the moment of inertia. Calculate I (in kg m^2) and the bond length (in pm) of this molecule? (8%)

3. The reaction $2\,NO(g) + H_2(g) \rightarrow N_2O(g) + H_2O(g)$ is believed to take place by the following mechanism:

(1) $NO + NO \rightleftharpoons N_2O_2$ (rate constant: k_1 and k_{-1})
(2) $H_2 + N_2O_2 \rightarrow N_2O(g) + H_2O(g)$ (rate constant k_2)

(a)Calculate the concentration of N_2O_2 at steady state?
(b)Calculate $-d[NO]/dt$ under the condition $k_{-1} >> k_2[H_2]$? (8%)