

## 臺灣綜合大學系統 105 學年度學士班轉學生聯合招生考試試題

科目名稱	普通化學 B	類組代碼	E00
		科目碼	E0018
※本項考試依簡章規定各考科均「不可以」使用計算機		本試題共計	3 頁

說明：答案一律寫在答案卷上；請依序作答，並標明題號。

( $h=6.626 \times 10^{-34}$  J s,  $R=8.314$  J/mol K,  $K_a(\text{NH}_4^+): 5.6 \times 10^{-10}$ ,  $K_a(\text{HNO}_2): 4.0 \times 10^{-4}$ ,  
 $K_{a1}(\text{H}_2\text{CO}_3): 4.3 \times 10^{-7}$ ,  $K_{a2}(\text{H}_2\text{CO}_3): 4.8 \times 10^{-11}$ )

一、選擇題：(單選 21 題，每題 3 分，不倒扣，共 63 分)

- The wave function of 2s orbital for hydrogen atom is  $A [2 - (r/a_0)] \exp(-r/(2a_0))$ . Calculate the ratio of the probability of finding the electron at  $r=4a_0$  relative to that at  $r=a_0$ ?  
 (A)  $4e^{-3}$  (B)  $4e^{-1}$  (C)  $2e^{-3}$  (D)  $2e^{-3/2}$  (E)  $4e^{-3/2}$
- The percentage of the ionic character of H-Cl bond is 18.2%. The bond length is  $1.27 \times 10^{-8}$  cm. What's the dipole moment (in D) of HCl(g)? (Note:  $e=1.6 \times 10^{-19}$  coul,  $D=3.336 \times 10^{-30}$  Coul m)  
 (A) 1.56 (B) 2.24 (C) 0.95 (D) 1.87 (E) 1.11
- For how many of the following species ( $\text{B}_2^-$ ,  $\text{C}_2$ ,  $\text{N}_2^-$ ,  $\text{O}_2^-$ , and  $\text{F}_2$ ) does the bond order decrease if one electron is removed?  
 (A) 0 (B) 1 (C) 2 (D) 3 (E) 4
- Rank the following bonds in order from less polar to most polar: (1)P-S, (2)Ca-S, (3)K-Cl, (4)Si-Cl, (5)K-F.  
 (A) 1, 4, 2, 3, 5 (B) 1, 2, 4, 5, 3 (C) 4, 1, 2, 3, 5 (D) 4, 1, 3, 2, 5 (E) 1, 4, 2, 5, 3
- How many of the following molecules or ions ( $\text{IO}_2\text{F}_2^-$ ,  $\text{TeF}_4$ ,  $\text{ICl}_3$ ,  $\text{XeF}_4$ ,  $\text{ClO}_4^-$ ,  $\text{SOF}_4$ ) have see-saw (翹翹板) structures?  
 (A) 2 (B) 3 (C) 4 (D) 5 (E) 6
- How many molecules or ions listed in Problem 5 have a hybridization of  $dsp^3$  on the central atom?  
 (A) 3 (B) 4 (C) 5 (D) 6 (E) 7
- How many of the followings ( $\text{CN}^-$ ,  $\text{NO}^-$ ,  $\text{O}_2$ ,  $\text{OF}^+$ ,  $\text{OF}^-$ ) are paramagnetic?  
 (A) 1 (B) 2 (C) 3 (D) 4 (E) 5
- Rank the following 0.10 M solutions in order from most acidic to most basic: (1)CaBr<sub>2</sub>, (2)KNO<sub>2</sub>, (3)NH<sub>4</sub>ClO<sub>4</sub>, (4)NH<sub>4</sub>NO<sub>2</sub>, (5)HNO<sub>2</sub>  
 (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
- In a common car battery, six identical cells each carry out the following reaction:  

$$\text{Pb} + \text{PbO}_2 + 2\text{HSO}_4^- + 2\text{H}^+ \rightarrow 2\text{PbSO}_4 + 2\text{H}_2\text{O}$$
 For such a cell,  $E^\circ$  is 2.04 V. Calculate  $\Delta G^\circ$  (in kJ) at 25°C.  
 (A) -787 (B) -1182 (C) -394 (D) -197 (E) -2364
- 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)  $k[A]^2[B]^2$

背面有題，請繼續作答。

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11. Consider the titration of 50.0 ml of 0.10 M acetic acid ( $K_a = 1.8 \times 10^{-5}$ ) with 0.10 M NaOH. Calculate  $[H^+]$  (in M) if 25.0 ml of NaOH is added?  
 (A)  $1.2 \times 10^{-6}$  (B)  $3.8 \times 10^{-6}$  (C)  $7.5 \times 10^{-6}$  (D)  $1.8 \times 10^{-5}$  (E)  $5.4 \times 10^{-5}$
12. Same as Problem 11, but calculate  $[H^+]$  (in M) if 50.0 ml (total) of NaOH is added?  
 (A)  $1.9 \times 10^{-9}$  (B)  $3.2 \times 10^{-9}$  (C)  $7.5 \times 10^{-9}$  (D)  $1.9 \times 10^{-8}$  (E)  $3.6 \times 10^{-8}$
13. The complex  $FeL_6^{2+}$ , where L is a neutral ligand, is known to be diamagnetic. The number of  $d$  electrons in this complex ion is:  
 (A) 4 (B) 5 (C) 6 (D) 7 (E) 8
14. For the process  $Co(NH_3)_5Cl^{2+} + Cl^- \rightarrow Co(NH_3)_4Cl_2^+ + NH_3$ , what would be the ratio of *cis* to *trans* isomers in the product?  
 (A) 1:1 (B) 1:2 (C) 1:4 (D) 4:1 (E) 2:1
15. Consider 2.0 mole of a monatomic ideal gas that is taken from state A ( $P_A = 2.0$  atm,  $V_A = 10.0$  L) to state B ( $P_B = 2.0$  atm,  $V_B = 30.0$  L), and then to state C ( $P_C = 1.0$  atm,  $V_C = 30.0$  L). Calculate  $\Delta E_{AB}$  (in atm L).  
 (A) 30 (B) 36 (C) 45 (D) 52 (E) 60
16. Same as Problem 15, but calculate  $\Delta H_{BC}$  (in atm L).  
 (A) -38 (B) -60 (C) -75 (D) -82 (E) -90
17. Same as Problem 15, but calculate  $\Delta S_{AB}$ .  
 (A)  $(5/2)R \ln 2$  (B)  $5R \ln 3$  (C)  $3R \ln 3$  (D)  $(5/2)R \ln 3$  (E)  $(3/2)R \ln 3$
18. Consider a face-centered cubic unit cell. What's the fraction of the space actually occupied by the packed sphere?  
 (A) 0.68 (B) 0.72 (C) 0.74 (D) 0.76 (E) 0.78
19. 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
20. Which of the following is optically active (that is, chiral)?  
 (A) dimethylamine (B) difluoromethane (C) 2-chloropropane (D) 2-chlorobutane (E) 1-bromohexane
21. When heat is added to proteins, the hydrogen bonding in the secondary structure breaks apart. What are the algebraic signs of  $\Delta H$  and  $\Delta S$  for the denaturation process?  
 (A) Both  $\Delta H$  and  $\Delta S$  are positive. (B) Both  $\Delta H$  and  $\Delta S$  are negative.  
 (C)  $\Delta H$  is positive and  $\Delta S$  is negative. (D)  $\Delta H$  is negative and  $\Delta S$  is positive.  
 (E)  $\Delta H$  is positive and  $\Delta S$  is 0.

## 二、非選擇題：(共 37 分，計算題務必列出計算過程，只寫答案不計分)

1. Consider the model for a particle of mass  $m$  in a one-dimensional box of size  $L$ . The potential is 10 inside the box, and infinite outside the box. (14 %)
- (a) Solve the Schrodinger equation by using  $A \sin(kx)$  as a trial solution to determine  $k$  and total energy  $E$  in terms of quantum number  $n$ .
- (b) What's the probability of finding the particle between  $L/3$  to  $L/2$  if  $n = 3$ ?

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2. Consider a second order reaction  $A + B \rightarrow P$ , where the rate equation is  $d[P]/dt = k [A] [B]$  and  $[B]_0 = 2 [A]_0 = 2 a$ . (9%)
- (a) Derive the expression of  $\ln ([B]/[A])$  as a function of  $a$ ,  $k$ , and  $t$ .
- (b) Calculate the time required for half of A is reacted.
3. Consider a Van der Waals gas. (14%)
- (a) If the molecular attraction can be neglected, derive the expression of  $PV$  as a function of  $P$  and  $T$ , and plot  $PV$  vs.  $P$ .
- (b) If the excluded volume effect can be neglected, derive the expression of  $PV$  as a function of  $P$  and  $T$ , and plot  $PV$  vs.  $P$ . (Hint: use  $PV = nRT$  as approximation if needed.)