

*注意事項：請於答案卷內之「非選擇題作答區」標明題號依序作答。計算題需書寫計算過程。

I. 選擇題 (76%，每題答案可能一至多個，全部選對始得題分 4 分)

- (1) Which of the following molecules has the highest acidity?
(A) $\text{CH}_2\text{ClCH}_2\text{OH}$, (B) $\text{CH}_3\text{CH}_2\text{OH}$, (C) $\text{C}_6\text{H}_5\text{OH}$, (D) CH_3OH .
- (2) Which of the following names are correct?
(A) $\text{C}_{10}\text{H}_{22}$ octane, (B) N_2O_3 dinitrogen trioxide, (C) CsCl cesium chlorate, (D) Al_2O_3 aluminum trioxide.
- (3) One mole ideal gases A and two mole ideal gas B are in two containers with the initial volumes V_0 , $2V_0$ respectively (at the same pressure 1atm). They are mixed to the final state with the total volume $3V_0$. What is the entropy change of this mixing process? (R is the gas constant.)
(A) $3R \ln 3$, (B) $R(2 \ln(3/2) + \ln 3)$, (C) $3R \ln(1/3)$, (D) None of the above.
- (4) Which of the following wave function $\psi(r, \theta, \phi)$ describes the 3p atomic orbital? (C_0 is a constant. a_0 is the Bohr radius.)
(A) $\psi(r, \theta, \phi) = C_0(6r/a_0 - r^2/a_0^2) \exp(-r/3a_0) \sin \theta \cos \phi$, (B) $\psi(r, \theta, \phi) = C_0(27 - 18r/a_0 + 2r^2/a_0^2) \exp(-r/3a_0)$, (C) $\psi(r, \theta, \phi) = C_0 r^2 \exp(-r/3a_0)(3 \cos^2 \theta - 1)$, (D) None of the above.
- (5) Which of the following compounds have the molar conductivity comparable to that of the compound $\text{CoCl}_3 \cdot 5\text{NH}_3$?
(A) NaOH , (B) $\text{Mg}(\text{NO}_3)_2$, (C) $\text{Mg}(\text{OH})_2$, (D) $\text{Al}(\text{NO}_3)_3$.
- (6) One uses 1.0 mole of HCOOH and 1.3 mole of NaHCOO to prepare a buffer solution of 1L. Given that $K_a = 1.8 \times 10^{-4}$, what is the pH of the solution?
(A) 3.63, (B) 3.74, (C) 3.86, (D) None of the above.
- (7) How many isomers of butanol are there?
(A) 2, (B) 3, (C) 4, (D) 5, (E) None of the above.
- (8) Which of the following electron configurations are correct?
(A) Zn^{2+} : $[\text{Ar}] 3d^8 4s^2$, (B) Pd : $[\text{Kr}] 4d^{10}$, (C) Ca^{2+} : $[\text{Kr}]$, (D) Hg : $[\text{Xe}] 4f^{14} 5d^{10} 6s^2$.
- (9) According to the quantum theory, a particle of the mass m , confined in one dimension box of size L , will have the quantized energy. Which result bellow describes its energy?
(A) $E_n = \frac{h^2}{2mL^2} n^2$, (B) $E_n = \hbar \omega (n + \frac{1}{2})$, (C) $E_n = \frac{h^2}{8mL^2} n^3$, (D) None of the above.
- (10) Consider the hydrogen gas. Which of the following statements are correct?
(A) Its molar heat capacity c_p remains a constant as one increases the temperature. (B) Its molar heat capacity c_p does not change much as one decreases the pressure. (C) At the room temperature, the molecular vibration contribution to c_p is not significant. (D) At the room temperature, the molecular rotation contribution to c_p is not significant.
- (11) Compare the bond energies of the molecules/ions H_2^+ , O_2 , and N_2^+ . Which of the following relation is correct?
(A) $\text{N}_2^+ > \text{O}_2 > \text{H}_2^+$, (B) $\text{O}_2 > \text{N}_2^+ > \text{H}_2^+$, (C) $\text{N}_2^+ > \text{H}_2^+ > \text{O}_2$, (D) $\text{O}_2 > \text{H}_2^+ > \text{N}_2^+$, (E) None of the above.
- (12) Among the following molecules/ions, which have the metal oxidation numbers equal or greater than +3?
(A) Mn_2O_7 , (B) $[\text{Ni}(\text{CO})_4]$, (C) $[\text{Mo}_2\text{Cl}_8]^{4-}$, (D) $[\text{Pt}(\text{NH}_3)_4\text{I}_2]^{2+}$.

- (13) The rate constant of a chemical reaction doubles when the temperature increases from 30°C to 30°C. Which of the following values is closer to the activation energy? (Gas constant $R=8.314 \text{ J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$)
 (A) 160kJ/mol, (B) 100kJ/mol, (C) 60kJ/mol, (D) 30kJ/mol, (E) None of the above.
- (14) Which of the following compounds can act both as acid and base?
 (A) SO_3 , (B) CO_2 , (C) Ti_2O_3 , (D) Na_2O , (E) Al_2O_3 .
- (15) The gas molecule N_2O_5 decomposes according to the first order rate equation. It decomposes 10% every 6200sec. What is the rate constant of the decomposition?
 (A) $1.7 \times 10^{-3}\text{s}^{-1}$, (B) $1.7 \times 10^{-4}\text{s}^{-1}$, (C) $1.7 \times 10^{-5}\text{s}^{-1}$, (D) $1.7 \times 10^{-6}\text{s}^{-1}$, (E) None of the above.
- (16) Which molecules are polar?
 (A) H_2CO , (B) H_2O_2 , (C) NF_3 , (D) PF_5 , (E) CO_2 .
- (17) Which of the following bonding/attraction have the typical energy weaker than 100kJ/mol?
 (A) van der Waals interaction, (B) hydrogen bond, (C) π bond, (D) strong dipole-dipole attraction.
- (18) Which of the following compounds have the low solubility?
 (A) $\text{Pb}(\text{NO}_3)_2$, (B) PbCrO_4 , (C) PbF_2 , (D) PbI_2 , (E) $\text{Pb}(\text{OH})_2$.
- (19) Which of the following statements about the gas-liquid critical point are correct?
 (A) The latent heat vanishes at the critical point. (B) The molar heat capacity c_p vanishes at the critical point. (C) The density difference between the gas and liquid phases vanishes at the critical point. (D) The surface tension between the gas liquid interface vanishes at the critical point.

II. 非選擇題 (24%)

- (1) (5%) Calculate the solubility of MgF_2 , where $K_{sp} = 6.6 \times 10^{-9}$. (Atomic mass: Mg=24.3, F=19.0)
- (2) (12%) Draw the Lewis diagrams for the following molecules. (a) NaSCN , (b) HNO , (c) XeF_2 .
- (3) (7%) An enzyme-catalyzed reaction $E + S \rightleftharpoons ES \rightarrow E + P$ obeys the Michaelis-Menten kinetics. At the low substrate concentration $[S]$, the reaction is approximately the first order in the substrate concentration, as $d[P]/dt = C_1[S][E_T]$, where $[E_T]$ is the (total) enzyme concentration, and $C_1 = 1.0 \times 10^6 \text{ Ms}^{-1}$. At high substrate concentration, the reaction rate approaches its maximum $d[P]/dt = V_{max}[E_T]$ with $V_{max} = 0.5 \text{ sec}^{-1}$. What is the substrate concentration K_m at which the reaction rate is $[E_T]V_{max}/2$?