一、選擇題（每題 3 分，共 78 分）

1. In the coordination compound [Pt(NH₃)₂Cl₂], the coordination number and oxidation number of the central atom are, respectively:
   (A) 2,0  (B) 4,4  (C) 5,0  (D) 4,+2  (E) 6,+2

2. Given the following notation for an electrochemical cell:
   Pt(s)|H₂(g)|H⁺(aq)||Ag⁺(aq)|Ag(s)
   What is the balanced overall (net) cell reaction?
   (A) 2H⁺(aq) + 2Ag⁺(aq) → H₂(g) + 2Ag(s)
   (B) H₂(g) + 2Ag(s) → H⁺(aq) + 2Ag⁺(aq)
   (C) 2H⁺(aq) + 2Ag(s) → H₂(g) + 2Ag⁺(aq)
   (D) H₂(g) + Ag⁺(aq) → H⁺(aq) + Ag(s)
   (E) H₂(g) + 2Ag⁺(aq) → 2H⁺(aq) + 2Ag(s)

3. A negative sign for ΔG indicates that:
   (A) ΔS must be > 0.
   (B) the reaction is spontaneous.
   (C) the reaction is fast
   (D) the reaction is endothermic.
   (E) the reaction is exothermic.

4. Which one of the following combinations cannot be a buffer solution?
   (A) HCN and KCN
   (B) NH₃ and (NH₄)₂SO₄
   (C) HNO₃ and NaNO₃
   (D) HF and NaF
   (E) HNO₂ and NaNO₂

5. The pH at the equivalence point of a titration may differ from 7.0 because of:
   (A) the initial concentration of the standard solution
   (B) the indicator used.
   (C) the self-ionization of H₂O.
   (D) the initial pH of the unknown
   (E) hydrolysis of the salt formed.
6. When comparing acid strength of binary acids HX, as X varies within a particular group of
the periodic table, which one of the following factors dominates in affecting the acid
strength?
   (A) bond strength
   (B) electron withdrawing effects
   (C) percent ionic character of H-X bond
   (D) solubility
   (E) Le Chatelier's principle

7. What is the pH of 0.10 M sodium acetate (NaAc) solution? The $K_a$ of acetic acid (HAc) is
   $1.8 \times 10^{-5}$.
   (A) 1.0
   (B) 0.10
   (C) 7.0
   (D) 8.9
   (E) 5.1

8. Which of the following is true about chemical equilibrium?
   (A) At equilibrium the total concentration of products equals the total concentration of
      reactants, that is \([\text{products}] = [\text{reactants}]\).
   (B) Equilibrium is the result of the cessation of all chemical change.
   (C) There is only one set of equilibrium concentrations that equals the $K_c$ value.
   (D) The rate constant of the forward reaction is equal to the rate constant for the reverse
      reaction.
   (E) At equilibrium the rate of the forward process is the same as the rate of the reverse
      process.

9. The value of $K_p$ for the reaction of SO$_2$(g) with O$_2$ to produce SO$_3$(g) is $3 \times 10^{24}$ atm$^{-1}$.
    Calculate $K_c$ for this equilibrium at 25°C?
    \[2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{SO}_3(\text{g})\]
    (A) $3 \times 10^{24}$ mol/L
    (B) $5 \times 10^{21}$ mol/L
    (C) $2 \times 10^{20}$ mol/L
    (D) $5 \times 10^{22}$ mol/L
    (E) $7 \times 10^{25}$ mol/L

10. According to the VSEPR theory, the geometry of the SO$_3$ molecule is:
    (A) pyramidal
    (B) tetrahedral
    (C) trigonal planar
    (D) distorted tetrahedron
    (E) square planar

11. What is the hybridization of the central atom in ClO$_3^-$?
    (A) sp
    (B) sp$^2$
    (C) sp$^3$
    (D) sp$^3d$
    (E) sp$^3d^2$

12. What is the formal charge on the sulfur atom in the resonance structure of SO$_2$ which has one
    single bond and one double bond?
    (A) 0
    (B) +1
    (C) -1
    (D) +2
    (E) -2

13. Which type of organic compound does not contain a carbonyl group?
    (A) ethers
    (B) carboxylic acids
    (C) ketones
    (D) aldehydes
    (E) esters
14. Combustion of a 0.9835-g sample of a compound containing only carbon, hydrogen, and oxygen produced 1.900 g of CO₂ and 1.070 g of H₂O. What is the empirical formula of the compound?
(A) C₂H₅O
(B) C₄H₁₀O₂
(C) C₄H₁₁O₂
(D) C₄H₁₀O
(E) C₂H₃O₂

15. The molecular weight of the acetic acid (CH₃CO₂H), rounded to the nearest integer, is __________ amu.
(A) 60
(B) 48
(C) 44
(D) 32

16. Calculate the percentage by mass of nitrogen in PtCl₂(NH₃)₂. (Pt=195.08, Cl=35.45, N=14.01, H=1.01)
(A) 4.67
(B) 9.34
(C) 9.90
(D) 4.95
(E) 12.67

17. How many grams of NaOH (MW = 40.0) are there in 500.0 mL of a 0.175 M NaOH solution?
(A) 2.19 x 10⁻³
(B) 114
(C) 14.0
(D) 3.50
(E) 3.50 x 10³

18. Of the elements below, __________ has the largest first ionization energy.
(A) Li
(B) K
(C) Na
(D) H
(E) Rb

19. Which one of the following species has the electron configuration [Ar]3d⁴?
(A) Mn²⁺
(B) Cr²⁺
(C) V³⁺
(D) Fe³⁺
(E) K⁺
20. A nonpolar bond will form between two __________ atoms of __________ electronegativity.
   (A) different, opposite
   (B) identical, different
   (C) different, different
   (D) similar, different
   (E) identical, equal

21. Which one of the following substances will not have hydrogen bonding as one of its intermolecular forces?
   (A)
   \[
   \begin{array}{c}
   \text{O} \\
   \text{CH}_3 - \text{C} - \text{CH}_3
   \end{array}
   \]
   (B)
   \[
   \begin{array}{c}
   \text{H} - \text{O} - \text{O} - \text{H}
   \end{array}
   \]
   (C)
   \[
   \begin{array}{c}
   \text{H} \\
   \text{CH}_3 - \text{C} - \text{O} - \text{H}
   \end{array}
   \]
   (D)
   \[
   \begin{array}{c}
   \text{H} \\
   \text{N} - \text{N} \\
   \text{H} - \text{H}
   \end{array}
   \]
   (E)
   \[
   \begin{array}{c}
   \text{H} \\
   \text{H} \\
   \text{C} - \text{N} - \text{C} - \text{H}
   \end{array}
   \]

22. A solution is prepared by dissolving 23.7 g of CaCl₂ in 375 g of water. The density of the resulting solution is 1.05 g/mL. The concentration of Cl⁻ in this solution is __________ M. (Ca=40.08, Cl=35.45)
   (A) 0.214
   (B) 0.562
   (C) 1.12
   (D) 1.20
   (E) 6.64 \times 10^{-2}

23. Which of the following aqueous solutions will have the highest boiling point?
   (A) 0.10 m Na₂SO₄
   (B) 0.20 m glucose
   (C) 0.25 m sucrose
   (D) 0.10 m NaCl
   (E) 0.10 m SrSO₄
24. Consider the following reaction at equilibrium:

\[ 2\text{NH}_3 (g) \rightleftharpoons \text{N}_2 (g) + 3\text{H}_2 (g) \]

Le Châtelier's principle predicts that the moles of \( \text{H}_2 \) in the reaction container will increase with __________.

(A) some removal of \( \text{NH}_3 \) from the reaction vessel (V and T constant)
(B) a decrease in the total pressure (T constant)
(C) addition of some \( \text{N}_2 \) to the reaction vessel (V and T constant)
(D) a decrease in the total volume of the reaction vessel (T constant)
(E) an increase in total pressure by the addition of helium gas (V and T constant)

25. Table below

<table>
<thead>
<tr>
<th>Half-reaction</th>
<th>( \text{E}^\circ ) (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{Cr}^{3+} (aq) + 3e^- \rightarrow \text{Cr} (s) )</td>
<td>-0.74</td>
</tr>
<tr>
<td>( \text{Fe}^{2+} (aq) + 2e^- \rightarrow \text{Fe} (s) )</td>
<td>-0.440</td>
</tr>
<tr>
<td>( \text{Fe}^{3+} (aq) + e^- \rightarrow \text{Fe}^{2+} (aq) )</td>
<td>0.771</td>
</tr>
<tr>
<td>( \text{Sn}^{4+} (aq) + 2e^- \rightarrow \text{Sn}^{2+} (aq) )</td>
<td>0.354</td>
</tr>
</tbody>
</table>

The standard cell potential (\( \text{E}^\circ \text{cell} \)) for the voltaic cell based on the reaction below is __________ V.

\[ \text{Sn}^{2+} (aq) + 2\text{Fe}^{3+} (aq) \rightarrow 2\text{Fe}^{2+} (aq) + \text{Sn}^{4+} (aq) \]

(A) +0.46
(B) +0.617
(C) +1.39
(D) -0.46
(E) +1.21

26. A disproportionation reaction is one in which

(A) a single element is both oxidized and reduced.
(B) a compound is separated into its constituent elements.
(C) the ratio of combination of two elements in a compound changes.
(D) aqueous ions combine to form an insoluble salt.
(E) an insoluble salt separates into ions.

二、簡答題（共 22 分）

1. Complete the following reaction \( \text{P}_4\text{O}_{10} + 6\text{H}_2\text{O} \) (5 分)

2. Calculate the bond energy of C-F given that the heat of atomization of CHFCIBr is 1502 kJ/mol, and that the bond energies of C-H, C-Br, and C-Cl are 413, 276, and 328 kJ/mol, respectively. (6 分)

3. Write net ionic equations to show the reactions that occur in a \( \text{CO}_3^{2-}/\text{HCO}_3^- \) buffer solution when:

(a) a strong acid is added
(b) a strong base is added
4. Ethanol and acetic acid interact to form ethyl acetate and water, according to the equation:
\[ \text{C}_2\text{H}_5\text{OH} + \text{CH}_3\text{COOH} \rightarrow \text{CH}_3\text{COOC}_2\text{H}_5 + \text{H}_2\text{O} \]
When two moles each of ethanol and acetic acid are allowed to react at 100°C in a sealed tube, equilibrium is established when two thirds of a mole of each of the reactants remains. Calculate the equilibrium constant. (4 分)