I. Multiple choice questions (choose only one answer) 〔60%, 每題 3分〕

1. When 0.2 M sodium hydroxide and 0.2 M barium nitrate are mixed, a precipitate is formed.　What is the net ionic equation for the formation of this precipitate?
    (A) $Ba^{2+}(aq) + 2NO_3^-(aq) \rightarrow Ba(NO_3)_2(s)$　　(D) $Na^+(aq) + NO_3^-(aq) \rightarrow NaNO_3(s)$
    (B) $Na^+(aq) + OH^-(aq) \rightarrow NaOH(s)$　　　　　(E) none of these.
    (C) $Ba^{2+}(aq) + 2OH^-(aq) \rightarrow Ba(OH)_2(s)$

2. Iron is biologically important in the transport of oxygen by red blood cells from the lungs to the various organs of the body. In the blood of an adult human, there are approximately 2.60×10^{13} red blood cells with a total of 2.90 g of iron. On the average, how many iron atoms are present in each red blood cell? (atomic mass for Fe = 55.85 g/mol)
    (A) 8.33×10^{-10}　(B) 1.20×10^9　(C) 3.12×10^{22}　(D) 2.60×10^{13}　(E) 5.19×10^{-2}

3. In the redox reaction: $4NH_3 + 3Ca(ClO)_2 \rightarrow 2N_2 + 6H_2O + 3CaCl_2$
    which element is oxidized and which is reduced?
    (A) H is oxidized and N is reduced.　(D) Cl is oxidized and O is reduced.
    (B) N is oxidized and Cl is reduced.　(E) Cl is oxidized and N is reduced.
    (C) N is oxidized and O is reduced.

4. The molecules of different samples of an ideal gas have the same average kinetic energies, at the same
    (A) pressure.　(B) temperature.　(C) volume.　(D) density.

5. What is the oxidation state of the sulfur atom in sulfuric acid?
    (A) +6　(B) +8　(C) +4　(D) −8　(E) −4

6. The ion $[Co(NH_3)_6]^{2+}$ is octahedral and high spin.　This complex is
    (A) diamagnetic.　　　　　　　　　　　(D) paramagnetic, with 1 unpaired electron.
    (B) paramagnetic, with 5 unpaired electrons.　(E) paramagnetic, with 3 unpaired electrons.
    (C) paramagnetic, with 4 unpaired electrons.

7. Ozone (O_3) and oxygen gas (O_2) are examples of
    (A) isotopes.　(B) polymorphs.　(C) allotropes.　(D) alloys.　(E) amphoterism.

8. When heat is added to proteins, the hydrogen bonding in the secondary structure breaks apart. What are the algebraic signs of ΔH and ΔS for the denaturation process?
    (A) Both ΔH and ΔS are positive.　(D) ΔH is negative and ΔS is positive.
    (B) Both ΔH and ΔS are negative.　(E) ΔH is positive and ΔS is 0.
    (C) ΔH is positive and ΔS is negative.

9. Choose the element with the smallest radius.
    (A) Li(s)　(B) In(s)　(C) K(s)　(D) Mg(s)　(E) Si(s)

10. Choose the correct molecular structure for CH_4.
    (A) trigonal bipyramidal　　(D) octahedral
    (B) trigonal planar　　　　　(E) linear
    (C) tetrahedral

11. Which of the following is a primary amine?
    (A) diphenylamine (B) ethylamine (C) dimethylamine (D) trimethylamine.

12. For the conformations of cyclohexane. Which one is more stable at room temperature?
    (A) chair form (B) boat form (C) random form (D) helical form

13. Which of the following is the interaction that stabilizes the tertiary structure of a protein?
    (A) ionic
    (B) hydrogen bonding
    (C) covalent
    (D) London dispersion
    (E) dipole–dipole
    (F) all of the above.

14. The DNA double helix contains two sugar-phosphate backbones. How do the two chains interact with each other to stabilize the structure?
    (A) covalent (B) ionic (C) hydrogen bonding (D) hydrophobic interaction (E) all of the above.

15. The K_a values for the three common monoprotic acids NH_4^+, HF and HOCl are:
    (A) $3.5 \times 10^{-8}, 5.6 \times 10^{-10}, 7.2 \times 10^{-4}$　(C) $7.2 \times 10^{-4}, 5.6 \times 10^{-10}, 3.5 \times 10^{-8}$
    (B) $3.5 \times 10^{-8}, 7.2 \times 10^{-4}, 5.6 \times 10^{-10}$　(D) $5.6 \times 10^{-10}, 7.2 \times 10^{-4}, 3.5 \times 10^{-8}$

16. The order of increasing base strength is:
    (A) $Cl^- < H_2O < F^- < CN^-$　(C) $F^- < H_2O < CN^- < Cl^-$
    (B) $CN^- < H_2O < F^- < Cl^-$　(D) $H_2O < Cl^- < CN^- < F^-$

17. Which is the Lewis acid in the reaction: $BF_3 (g) + F^- (aq) \rightarrow BF_4^- (aq)$
    (A) BF_4^- (B) BF_3 (C) F^-

18. Given that the K_a value for CH_3COOH is 1.8×10^{-5}, and the K_a value for HNO_2 is 4.0×10^{-4}. Which is the stronger base?
    (A) CH_3COOH (B) CH_3COO^- (C) HNO_2 (D) NO_2^-

19. The K_{sp} values for the three salts CuS, Ag_2S and Bi_2S_3 are 8.5×10^{-45}, 1.6×10^{-49} and 1.1×10^{-73}. The order of solubility when they dissolve is:
    (A) $CuS > Ag_2S > Bi_2S_3$　(C) $CuS < Ag_2S < Bi_2S_3$
    (B) $Bi_2S_3 < CuS < Ag_2S$　(D) $Ag_2S < CuS < Bi_2S_3$

20. Which of the following statements is correct?
    (A) A buffered solution can be prepared by a weak acid and its conjugated base.
    (B) The pH of a buffered solution is determined by the ratio $[A^-]/[HA]$.
    (C) Buffer capacity represents the amounts of H^+ or OH^- the buffer can absorb without significant change in its pH.
    (D) All of the above.

II. Answer the following questions 〔**40%**〕

   Note : (1) Must show detailed calculation processes in your answer.

          (2) The calculation results might be ignored if calculator is prohibited.

1. If the right half-cell contain 5.0 μM $AgNO_{3(aq)}$ and the left half-cell contains 1.0 M $Cd(NO_3)_{2(aq)}$. ($E^0_{Ag} = 0.799V$, $E^0_{Cd} = -0.402$ V) 〔**9%**〕
   (a) Write the net cell reaction.
   (b) What is the cell voltage?
   (c) State whether it is spontaneous in the forward or reverse direction.
2. The rate constant of a first order reaction is 3.46×10^{-2} s^{-1} at 298 K. What is the rate constant at 350 K if the activation energy for the reaction is 50.2 kJ/mol? 〔**3%**〕
3. The N_2^+ ion can be prepared by bombarding the N_2 molecule with fast moving electrons. Predict the following properties of N_2^+: 〔**8%**〕
   (a) electron configuration, (b) bond order, (c) magnetic properties, (d) bond length relative the the bond length of N_2 (is it longer or shorter?)
4. Give all of the structural isomers of hexane C_6H_{14}. 〔**10%**〕
5. Calculate $[OH^-]$, $[H^+]$ and the pH of a 0.5 M solution of NH_3 ($K_b = 1.8 \times 10^{-5}$). 〔**10%**〕