一、Choose the best answer (33%)

1. Which one of the following valence shell configurations is the ground state?

   (A) [↑↓][↑↓][ ][ ] 3s 3p   (B) [↑↓][↑][↑][ ] 3s 3p   (C) [↑↓][↑][↓][ ] 3s 3p   (D) [↑][↑][↑][↑] 3s 3p

2. Which one of the following species has the same shape as XeF_4?

   (A) $Ni(CO)_4$ (B) PF_4^- (C) IBr_4^- (D) SCl_4

3. All of the following have resonance structures except

   (A) $CH_3CO_2^-$ (B) O_3 (C) benzene   (D) H_2NNH_2

4. Which one of the following molecules or ions has the shortest S-O bond?

   (A) SO_2 (B) SO_3 (C) SO_3^{2-} (D) SO_4^{2-}

5. Which one of the following organic molecules has the highest boiling point?

   (A) C_2H_5OH (B) CH_3CHO (C) $CH_3CH_2CH_3$ (D) HCO_2CH_3

6. Which one of the following polymers is conducting polymer.

   (A) polystyrene   (B) polypeptide   (C) polyvinylchloride   (D) polyacetylene

7. A reaction: $2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$ $\Delta H^\circ = 93$ kJ , $\Delta S^\circ = 199$ J/K   would be spontaneous at high temperature. Which one of the following is responsible for this fact?

   (A) enthalpy   (B) entropy   (C) activation energy   (D) bond energy

8. For a polyprotic acid H_4A, which species is the form present in highest concentration in aqueous solution at pH = 8.0?   (H_4A : $pK_{a1} = 2.0$, $pK_{a2} = 5.0$, $pK_{a3} = 7.0$, $pK_{a4} = 10.0$)

   (A) H_3A^- (B) H_2A^{2-} (C) HA^{3-} (D) A^{4-}

9. Which of the following reactions has the largest value of ΔS?

   (A) $K(s) + O_2(g) \rightarrow KO_2(s)$ (B) $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

   (C) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ (D) $BaCl_2 \cdot 2H_2O(s) \rightarrow BaCl_2(s) + 2H_2O(g)$

10. In a Born-Haber cycle for the formation of NaCl(s), which enthalpy change is exothermic?

    (A) the formation of Cl(g) from $Cl_2(g)$ (B) the electron affinity of chlorine

    (C) the lattice enthalpy of sodium chloride   (D) the ionization energy of sodium

11. The rate law for the hydrolysis of thioacetamide (CH_3CSNH_2) is rate = k $[H^+]$ $[CH_3CSNH_2]$.
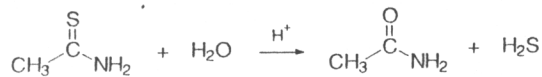
    If some sodium acetate is added to a solution that is 0.10 M in both CH_3CSNH_2 and H^+ at 25 °C,
    (A) the reaction rate decreases but k remains the same.
    (B) both the reaction rate and k decrease
    (C) the reaction rate remains the same but k decrease
    (D) the reaction rate increases but k remains the same

二、Write a balanced chemical equation for each of the following reactions.　　　(15%)

1. Lithium metal dissolved in water.

2. Butanoic acid reacted with 2-propanol in the presence of concentrated sulfuric acid.

3. $C_6H_5CH_2CHO$ reduced by sodium borohydride ($NaBH_4$) in alcohol.

4. Nitration of bromobenzene happened in concentrated nitric acid using concentrated sulfuric acid as catalyst.

5. A β-decay of carbon-14 proceeded spontaneously.

三、Suggest a reasonable explaination for each of the following observations.　　　(28%)

1. CO_2 is nonpolar molecule but CO is polar.

2. Copper (II) compounds are often colored but copper (I) compounds are colorless.

3. Oxygen molecule is paramagnetic but fluorine molecule is diamagnetic.

4. In an aqueous electrolytic cell, nitrate ions never react at the anode, but nitrite ions do.

5. The redox reaction:　$2Ag^+(aq) + 2I^-(aq) \rightarrow 2Ag(s) + I_2(s)$　is spontaneous process under standard condition.　(E^o of $I_2 \rightarrow I^- = 0.54$ V;　E^o of $Ag^+ \rightarrow Ag = 0.80$ V;　E^o of $AgI \rightarrow Ag + I^- = -0.15$ V)

6. When equal volumes of a solution of 2.0 M $AgNO_3$(aq) and a solution of 2.0 M NaI(aq) are mixed, the redox reaction in (5) does not occur, instead a precipation takes place.

7. A gas expands against a constant external pressure of 3.0 atm from an initial volume of 1.0 L to a final volume of 6.0 L.　If the container is well insulated so that no heat enters or leaves the system, the temperature of the gas decreases.

四、Give the answer for each of the following calculations　　　(24%)

1. The equilibrium constant, K, for the reaction, $N_2O_4 \rightleftharpoons 2NO_2$, is 4.6×10^{-3}.　Calculate the K for the reaction: $NO_2 \rightleftharpoons \frac{1}{2} N_2O_4$

2. Blood, sweat and tears are about 0.15 M in sodium chloride.　Estimate the osmotic pressure of these solution at 37^oC.

3. Consider the following reaction: $CuSO_4(s) \rightarrow CuO(s) + SO_3(g)$, $\Delta G = -14.6$ kJ at 927^oC.　Estimate the ΔG for an $SO_3(g)$ pressure of 10 bar at this temperature.

4. A 2.0 L of 0.50 M AcONa(aq) is diluted to 5.0 L.　Calculate the concentration of hydroxide ion at equilibrium.　(Ka of AcOH = 1.8×10^{-5})

5. When titanium tetrachloride is mixed with water, TiO_2 and HCl produce immediately.　If the reaction of 1.90 g of titanium tetrachloride with enough water, determine the volume of HCl gas produced at 1.00 atm and 300 K.　(atomic mass:　titanium = 48; chlorine = 35.5)

6. Solid sodium chloride is slowly added to a solution that is 0.010 M in Pb^{2+}(aq) and 0.010 M in Ag^+(aq). What is the molarity of the silver cation when lead cation begins to precipitate?
　　　(Ksp of $PbCl_2 = 1.6 \times 10^{-5}$; Ksp of AgCl = 1.6×10^{-10})