

1. A highly toxic gas gives the following elemental analysis: 12.1% carbon, 16.2% oxygen, and 71.7% chlorine by mass. Its molar mass is 98.9 g/mol. (a) Determine the molecular formula. (b) Write the Lewis structure. (c) Is it polar compound? (d) What kind of hybrid orbital does the carbon use? (e) What is the shape of the gas molecule? (10%)

2. 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, (a) write a chemical equation for this reaction. (b) what is the change of oxidation number of titanium? (c) what mass of TiO_2 is produced (d) determine the volume of HCl gas produced at 1.00 atm and 300 K. (atomic mass: titanium = 48; chlorine = 35.5) (10%)

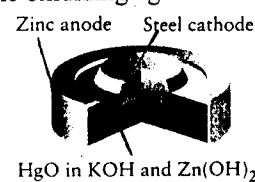
3. The entropy of vaporization of benzene is 85 J/K·mol. (a) Estimate the enthalpy of vaporization of benzene at its normal boiling point of 80°C . (b) What is the entropy change of the surroundings when 10 g of benzene vaporizes at its normal boiling point? (10%)

4. Give the effect that an increase in temperature has on each of the following properties: (a) viscosity; (b) surface tension; (c) vapor pressure; (d) evaporation rate; (e) equilibrium constant. (10%)

5. For the reaction $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$, $K_p = 144$ at 500 K. An analysis of a reaction mixture at 500 K showed that it had the composition: $[\text{H}_2] = 2.4 \times 10^{-3} \text{ M}$; $[\text{I}_2] = 2.4 \times 10^{-3} \text{ M}$; $[\text{HI}] = 4.8 \times 10^{-3} \text{ M}$. (a) Calculate the reaction quotient. (b) Is the reaction mixture at equilibrium? (c) If not, is there a tendency to form more reactants or more products? (d) Determine the equilibrium concentration of HI . (10%)

6. A solution is 0.010 M $\text{Pb}^{2+}(\text{aq})$ and 0.010 M $\text{Ag}^+(\text{aq})$. Chloride ions are added from a sodium chloride solution. (a) Determine the chloride ion concentration required for the precipitation of each cation. (b) Which cation precipitates first? (c) What is the molarity of the first cation that precipitates when the second cation begins to precipitate? (d) Determine the percentage of the first cation that remains in solution when the second cation begins to precipitate? (K_{sp} of $\text{PbCl}_2 = 1.6 \times 10^{-5}$; K_{sp} of $\text{AgCl} = 1.6 \times 10^{-10}$) (10%)

7. In a mercury cell, (a) is it a secondary cell? (b) what is the electrolyte? (c) what is the oxidizing agent? (d) write the overall cell reaction



8. A reaction mechanism: (i) $\text{ClO}^- + \text{H}_2\text{O} \xrightleftharpoons[k_2]{k_1} \text{HClO} + \text{OH}^-$ (fast, equilibrium)
(ii) $\text{HClO} + \text{I}^- \xrightarrow{k_3} \text{HIO} + \text{Cl}^-$ (very slow)
(iii) $\text{HIO} + \text{OH}^- \xrightleftharpoons[k_5]{k_4} \text{IO}^- + \text{H}_2\text{O}$ (fast, equilibrium)

(a) what is the overall reaction? (b) write the rate law based on this mechanism. (c) will the reaction rate be dependent on the pH of the solution? (d) how would the rate law differ if the reactions were carried out in an organic solvent? (10%)

9. For complexes $[\text{MnCl}_6]^{4-}$ and $[\text{Mn}(\text{CN})_6]^{4-}$; (a) what is(are) the shapes of the complexes? (b) what is the hybrid orbital of Mn? (c) sketch the d-orbital energy level diagram (d) how many unpaired electrons are present in $[\text{Mn}(\text{CN})_6]^{4-}$? (e) which complex transmits the longer wavelength of incident electromagnetic radiation?. (atomic number of Mn = 25) (10%)

10. Predict the major product of each of the following reactions. (10%)

