1. A sample of solid $KClO_3$ was heated in a test tube and decomposed according to the reaction: $2KClO_{3\,(g)} \rightarrow 2KCl_{(s)} + 3O_{2\,(g)}$. The oxygen produced was collected by displacement of water at 22°C at a total pressure of 754 torr. The volume of the gas collected was 0.650 L, (gas constant R = 0.08206 L atm K^{-1} mol^{-1}) and the vapor pressure of water at 22°C is 21 torr. Given the atomic weight of K = 39.1, Cl = 35.5 and O = 16.0, calculate the partial pressure of O_2 in the gas collected and the mass of $KClO_3$ in the sample that was decomposed. 10%

2. Assume that the reaction for the formation of gaseous hydrogen fluoride from hydrogen and fluorine has an equilibrium constant K_c of 1.21×10^2 at a certain temperature. In a particular experiment at this temperature 3.00 mol of each component (H_2, F_2 and HF) was added to a 1.50L flask. Calculate the equilibrium concentrations of all species. 10%

3. The K_a value for HF is 7.2×10^{-4}. Calculate the $[H^+]$ of a 0.30 M NaF solution. 10%

4. (a) Calculate the change in entropy for the vaporization of 2.00 mole of water at 100°C and 1 atm pressure. The enthalpy of vaporization for water is 40.7 kJ/mol at 100°C. (b) The molar heat capacities for $H_2O_{(l)}$ and $H_2O_{(g)}$ are 75.3 J/(K mol) and 36.4 J/(K mol), respectively. Calculate the change in entropy that occurs when a sample containing 2.00 mol of water is heated from 50°C to 150°C at 1 atm pressure. 10%

5. Draw geometrical isomers of $MBr(NH_3)(en)_2$ where en is $H_2NCH_2CH_2NH_2$. Indicate optical isomers for each of them. 10%

6. The osmotic pressure of a 1 mL water solution containing 1.00×10^{-3} g of a certain protein was found to be 1.12 torr at 25°C. Calculate the molar mass of the protein. 10%

7. (a) Give the electron configuration for sulfur (S, hint: O and S are on the same group), cadmium (Cd, hint: Zn, Cd and Hg are on the same group) and iron (Fe, hint: Fe, Co and Ni are elements of Group 8, 9 and 10, respectively). (b) Consider atoms with the following electron configurations: A: $1s^2 2s^2 2p^6$, E: $1s^2 2s^2 2p^6 3s^1$, G: $1s^2 2s^2 2p^6 3s^2$, which atom has the largest first ionization energy, and which one has the smallest second ionization energy? Explain. 10%

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8. The decomposition of N_2O_5 in the gas phase was studied at constant temperature. $2N_2O_{5(g)} \rightarrow 4NO_{2(g)} + O_{2(g)}$. The following results were collected: at 0, 50, 100, 200, 300 and 400 seconds the concentrations of $N_2O_{5(g)}$ are $[N_2O_5] = 0.1000, 0.0707, 0.0500, 0.0250, 0.0125$ and 0.00625 mol/L, respectively. Write the first order rate law for this reaction and derive the integrated first-order rate law and find the rate constant and half life for this reaction. Calculate $[N_2O_5]$ at 150 second after the start of the reaction. 10%

9. A zinc-copper battery is constructed as follows: $Zn \mid Zn^{2+}(0.10M) \mid\mid Cu^{2+}(2.50M) \mid Cu$. (Standard reduction potential for Cu and Zn are 0.34 and –0.76 V respectively) The mass of each electrode is 200 g. (Atomic weight of Cu = 63.5, Zn = 65.4) (a) Calculate the cell potential when this battery is first connected. (b) Assume each half-cell contains 1.00 L of solution, calculate the cell potential after 10.0 A of current has flowed for 10.0 h. (c) Calculate the mass of each electrode after 10.0 h. (d) How long can this battery deliver a current of 10.0 A before it goes dead. 10%

10. Place the species below in order from the shortest to the longest nitrogen-oxygen bond, H_2NOH, N_2O, NO^+, NO_2^-, NO_3^-. Draw resonance forms if there is any. 10%

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