1. A 0.500-L sample of H_2SO_4 solution was analyzed by taking a 100.0-mL aliquot and adding 50.0 mL of 0.213 M NaOH. After the reaction occurred, an excess of OH^- ions remained in the solution. The excess base required 13.21 mL of 0.103 M HCl for neutralization. Calculate the molarity of the original sample of H_2SO_4. (4%)

2. A compound contains only C, H, and N. It is 58.51% C and 7.37% H by mass. Helium effuses through a porous frit 3.20 times faster than the compound does. Determine the empirical and molecular formulas of this compound. (6%)

3. Consider the reaction $2\,HCl_{(aq)} + Ba(OH)_{2(aq)} \longrightarrow BaCl_{2(aq)} + 2H_2O_{(l)}$ $\Delta H = -118$ kJ, How much heat is evolved when 100.0 mL of 0.500 M HCl is reacted with 300.0 mL of 0.500 M $Ba(OH)_2$? (10%)

4. One mole of an ideal gas with a volume of 6.67 L and a pressure of 1.50 atm is contained in a vessel with a movable piston. The external pressure is suddenly increased to 5.00 atm and the gas compressed isothermally (T = 122 K). Calculate (a) ΔE (b) ΔH (c) ΔS (d) w (e) q (f) ΔS_{surr}, (g) ΔS_{univ}, and (h) ΔG. (16%)

5. Use the following data to estimate ΔH_f° for sodium chloride. $Na_{(s)} + 1/2\ Cl_{2(g)} \longrightarrow NaCl_{(s)}$ Lattice energy for NaCl (-786 kJ/mol), Ionization energy for Na (495 kJ/mol), Electron affinity of Cl (-349 kJ/mol), Bond energy of Cl_2 (239 kJ/mol), Enthalpy of sublimation for Na (109 kJ/mol), (8%)

6. The ionic radius of gold is 144 pm and the density is 19.32 g/cm^3. Does elemental gold have a face-centered cubic structure or body-centered cubic structure? (Mw. of Au =197 g/mol) (10%)

7. Draw the structure for the hydrocarbon 2-ethyl-3-methyl-5-isopropylhexane. The name given here is incorrect. supply the correct systematic name. (6%)

8. A rock containing $^{238}_{92}U$ and $^{206}_{82}Pb$ was examined to determine its approximate age. Analysis showed the ratio of $^{206}_{82}Pb$ atoms to $^{238}_{92}U$ atoms to be 0.115. Assuming that no lead was originally present, that all the $^{206}_{82}Pb$ formed over the years has remained in the rock, and that the number of nuclides in the intermediate stages of decay between $^{238}_{92}U$ and $^{206}_{82}Pb$ is negligible, calculate the age of the rock. The half-life of $^{238}_{92}U$ is 4.5×10^9 yr. (10%)

9. The following mechanism has been proposed to account for the rate law of the decomposition of ozone to $O_{2(g)}$:

$$O_3 + M \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} O_2 + O + M$$

$$O + O_3 \xrightarrow{k_2} 2\,O_2$$

Apply the steady-state hypothesis to the concentration of atomic oxygen, and derive the rate law for the decomposition of ozone. (M stands for an atom or molecule that can exchange kinetic energy with the particles undergoing the chemical reaction.) (10%)

10. Cadmium sulfide (CdS) is used in some semiconductor applications. Calculate the log value of the solubility product (log Ksp) for CdS given the following standard reduction potentials:

$CdS + 2e^- \longrightarrow Cd + S^{2-}$ $\varepsilon^\circ = -1.21$ V

$Cd^{2+} + 2e^- \longrightarrow Cd$ $\varepsilon^\circ = -0.402$ V (10%)

11. A first-order reaction has rate constants of $4.6 \times 10^{-2}\ s^{-1}$ and $8.1 \times 10^{-2}\ s^{-1}$ at 0 °C and 20 °C respectively. What is the value of the activation energy? (10%)