Some Review Problems for the Final Exam – Part 2

(Note: this selection of problems is NOT comprehensive!)

1. Given the following proposed mechanism, determine the rate law and the overall reaction. Identify any catalysts or intermediates.
   $A + B \Leftrightarrow C + D + E$ (fast, eq)
   $C + D + A \rightarrow F$ (slow)
   $F + G \rightarrow H + I + B$ (fast)
2. Given the following proposed mechanism, determine the rate law and the overall reaction. Identify any catalysts or intermediates.
   $A + 2B \rightarrow C + D$ (slow)
   $C + A \rightarrow E$ (fast)
   $E \rightarrow F + G$ (fast)
3. For first-order, second-order, and zero-order reactions, what do you graph to get a straight line?
4. How would you go about finding the activation energy of a reaction?
5. If you mix 100. mL of 0.100 M Zn^{2+} and 100. mL of 5.0 M NaOH, what is the concentration of Zn^{2+} at equilibrium? K_f of $Zn(OH)_4^{2-}{}_{(aq)} = 2.8 \times 10^{15}$. (Ignore the formation of any precipitates.)
6. What is the pH at the halfway point in the titration of trimethylamine with nitric acid? What is the pH at the 3/4 way point?
   K_b of $(CH_3)_3N = 7.4 \times 10^{-5}$
7. For the equilibrium: $N_{2\,(g)} + 3\ H_{2\,(g)} \Leftrightarrow 2\ NH_{3\,(g)}$ $\Delta H^o = 54$ kJ
   Predict the direction of the shift in equilibrium and how the concentrations will change when:
   a. Nitrogen is added
   b. Ammonia is added
   c. The temperature is increased.
   d. The volume of the container is decreased.
   e. A catalyst is added.
8. For the reaction: $NO_{(g)} + 1/2\ O_{2\,(g)} \Leftrightarrow NO_{2\,(g)}$
   At 25°C, the system is at equilibrium when 6.5×10^{-4} moles of NO, 0.25 moles of O_2, and 1.4×10^{-3} moles of NO_2 are contained in a 1.0 L flask.
   a. Determine K_c for this reaction at 25°C.
   b. If 4.0×10^{-4} moles of NO, 0.10 moles of O_2, and 1.0×10^{-3} moles of NO_2 are added to the reaction mixture, in which direction will the reaction proceed to reach equilibrium?
9. For the equilibrium: $N_{2\,(g)} + 3\ H_{2\,(g)} \Leftrightarrow 2\ NH_{3\,(g)}$ $K_c = 1.5 \times 10^{-6}$
   Determine the equilibrium concentration of NH_3 after equilibration of 2.0 moles of hydrogen and 4.0 moles of ammonia in a 2.0 L flask.
10. For the reaction: $2\ NO_{2\,(g)} \Leftrightarrow N_{2\,(g)} + 2\ O_{2\,(g)}$
    The system is at equilibrium when 0.80 moles of NO_2, 0.20 moles of N_2, and 0.60 moles of O_2 are contained in a 0.50 L flask. How many moles of N_2 must be removed from the flask to decrease the equilibrium quantity of NO_2 to 0.70 moles?
11. Estimate the normal boiling point of CCl_4 using thermodynamic data.

12. Estimate the vapor pressure of CCl_4 at 50.°C using thermodynamic data. Why is this an estimate?
13. Estimate the solubility (in g/L) of Ag_2S in water at 45°C using thermodynamic data. Without doing another calculation, will this solid be <u>more</u> or <u>less</u> soluble at room temperature? Explain.
14. Predict the sign of ΔS for the following reaction and explain your reasoning:
    $2\ Na_{(s)} + Cl_{2\,(g)} \rightarrow 2\ NaCl_{(s)}$
15. For each of the following pairs, which substance has a higher entropy and why?
    a. 1 mole of $CH_3CH_2CH_{3\,(g)}$ or 1 mole of $CH_{4\,(g)}$
    b. 1 mole of $N_2O_{4\,(g)}$ or 2 moles of $NO_{2\,(g)}$
    c. 1 mole of $H_2O_{(l)}$ or 1 mole of $H_2O_{(s)}$
16. What are the signs of ΔH and ΔS for the following phase changes?
    a. freezing
    b. melting
    c. condensation

Substance	ΔH°_f, kJ/mol	ΔG°_f, kJ/mol	S°, J/K•mol
$CCl_{4\,(g)}$	- 106.7	- 64.0	309.4
$CCl_{4\,(l)}$	- 139.3	- 68.6	214.4
$Ag_2S_{(s)}$	- 31.8	- 40.3	146
$Ag^+_{(aq)}$	105.9	77.111	73.93
$S^{2-}_{(aq)}$	41.8	83.7	22

Some answers:

1. $rate = \dfrac{k_2 k_1 [A]^2 [B]}{k_{-1}[E]}$
2. $rate = k[A][B]^2$
5. 6.4×10^{-19} M Zn^{2+}
6. halfway: 9.87 3/4-way: 9.39
7. a. Rt b. Lf c. Rt d. Rt
8. Rt (Q<K)
9. $[NH_3]$ = 0.0098 M, $[N_2]$ = 1.0 M, $[H_2]$ = 4.0 M
10. 0.14 mol N_2
11. 70. °C
12. 0.49 atm
13. 10^{-13} g/L, less soluble at room temp (see explanation)
14. ΔS – (getting more ordered – gas is consumed)
15. a. $CH_3CH_2CH_3$ b. 2 mol NO_2 c. $H_2O_{(l)}$
16. a. ΔH -, ΔS- b. ΔH +, ΔS+ c. ΔH -, ΔS -