Semester Review Problems for General Chemistry 2 All Chapters

(Challenging questions are in red)

1. When ethylene glycol ($C_2H_6O_2$) is used as antifreeze in automobiles it is mixed with water to make a 30.0 % (v/v) solution. Assume that the volumes are additive and that the solution behaves ideally.
   Notes: at 25 °C the densities of water and ethylene glycol are 1.00 g/mL and 1.11 g/mL, respectively, the vapor pressures are approximately 17.54 torr and 0.06 torr, respectively, and the boiling point elevation and freezing point depression constants of water are 0.51 °C/m and 1.86 °C/m, respectively.
   The molar masses of water and ethanol are 18.0 g and 46.0 g; the universal gas constant R is 0.0821 L-atm/mol-K.
   a. Calculate the molality of this solution.
   b. Calculate the molarity of this solution.
   c. Calculate the mass percentages of water and ethylene glycol in this solution.
   d. Calculate the mole fractions of water and ethanol in this solution.
   e. Calculate the vapor pressure of this solution.
2. The following data were measured for the reaction $BF_3(g) + NH_3(g) \rightarrow F_3BNH_3(g)$:

Experiment	$[BF_3]$ (M)	$[NH_3]$ (M)	Initial Rate (M/s)
1	0.250	0.250	0.2130
2	0.250	0.125	0.1065
3	0.200	0.100	0.0682
4	0.350	0.100	0.1193
5	0.175	0.100	0.0596

   a. What is the order of this reaction with respect to each reactant?
   b. What is the rate constant, with proper units, for this reaction?
   c. What is the rate law for this reaction?
   d. What would be the activation energy for this reaction if increasing its temperature doubled the rate constant? Note: R=8.314 J/mol-K

3. Consider a reversible reaction $2A(g) \rightleftharpoons B(g) + C(g)$ with $K_c = 0.40$ in which there are initial concentrations of all three substances are 0.20 M.
   a. What is the equilibrium expression for this reaction?
   b. Construct an ICE table for this system and determine the equilibrium expression for this reaction in terms of "x".
   c. Determine the equilibrium concentrations for this system
   d. Imagine that upon reaching equilibrium, the concentration of A somehow was suddenly doubled. Construct a second ICE table and determine the new equilibrium concentrations of A, B and C.
4. Calculate the approximate percent ionizations and pH of the following solutions:
   a. 0.175 M NH_3 $K_b = 1.8 \times 10^{-5}$.
   b. 0.875 M acetic acid $K_a = 1.8 \times 10^{-5}$.
5. Calculate the pH of the following solutions:
   a. 50.0 mL of 0.275 M acetic acid is mixed with 100. mL of 0.100 M HCl.
   b. 50.0 mL of 0.175 M NH_3 is mixed with 5.0 mL of 0.10 M HCl.
6. Calculate the pH of the following solutions:
   a. 50.0 mL of 0.275 M acetic acid is mixed with 100. mL of 0.125 M sodium acetate
   b. The pH at the equivalence point of a 50.0 mL solution of 0.120 M acetic acid titrated by 0.100 M NaOH.
7. A solution contains 2.0 x 10^{-4} M Ag^+(aq) and 1.5 x 10^{-3} M Pb^{2+}(aq). If NaI is added, will AgI ($K_{sp} = 8.3 \times 10^{-17}$) or PbI_2 ($K_{sp} = 7.9 \times 10^{-9}$) precipitate first? Specify the concentration of I^-(aq) needed to begin precipitation.n t
8. Calculate the standard free energy changes in kJ/mol, and based on their standard enthalpies and entropies, classify each of the following reactions as either: (i) spontaneous at all T; (ii) nonspontaneous at all T; (iii) spontaneous at low T but nonspontaneous at high T; (iv) spontaneous at high T but not spontaneous at T.

Reaction	$\Delta H^o (kJ/mol)$	$\Delta S^o (J/K)$
$N_2(g) + 3F_2(g) \rightarrow 2NF_3(g)$	-249	-278
$N_2(g) + 3Cl_2(g) \rightarrow 2NCl_3(g)$	460	-275
$N_2F_4(g) \rightarrow 2NF_2(g)$	85	198

9. Complete and balance the following equations, then identify the oxidizing and reducing agents.
    a. $Cr_2O_7^{2-}(aq) + I^-(aq) \rightarrow Cr^{3+}(aq) + IO_3^-(aq)$ (acidic solution)
    b. $MnO_4^-(aq) + CH_3OH(aq) \rightarrow Mn^{2+}(aq) + HCO_2H(aq)$ (acidic solution)
    c. $I_2(s) + OCl^-(aq) \rightarrow IO_3^-(aq) + Cl^-(aq)$ (acidic solution)
    d. $As_2O_3(aq) + NO_3^-(aq) \rightarrow H_3AsO_4(s) + N_2O_3(aq)$ (acidic solution)
    e. $MnO_4^-(aq) + Br^-(aq) \rightarrow MnO_2(s) + BrO_3^-(aq)$ (basic solution)
    f. $Pb(OH)_4^{2-}(aq) + ClO^-(aq) \rightarrow PbO_2(s) + Cl^-(aq)$ (basic solution)
10. Most internal-combustion engines in cars are started by a nominal 12.0 V lead-acid battery, made by connecting six cells in series (note: in a series connection, the total potential is the sum of the potentials of each cell). The redox reaction that takes place involves the following half-reactions whose respectively standard reduction potentials are also listed:

Half-reaction 1: $PbO_2(s) + 3H^+(aq) + HSO_4^-(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$	$E_{red}^0 = +\ 1.685\ V$
Half-reaction 2: $PbSO_4(s) + H^+(aq) + 2e^- \rightarrow Pb(s) + HSO_4^-(aq)$	$E_{red}^0 = -\ 0.356\ V$

    a. Identify which half-reaction would occur at the anode, and which would occur at the cathode of each cell in this battery.
    b. Write the overall balanced spontaneous redox reaction.
    c. Calculate the standard potential for each cell of this battery at 25.0 °C. Note: R = 8.314 J/mol·K
    d. Imagine that the concentration of sulfuric acid in a brand-new battery has a concentration of 4.5 M. What would be the actual voltage of each cell of that battery, brand-new?
    e. What concentration of sulfuric acid would produce a total battery voltage of exactly 12.0 V?