1. A 2.21 L vessel was found to contain 4.18×10^{-2} mol of CO_2, 2.81×10^{-2} mol of CO, and 8.89×10^{-3} mol of O_2. Is the system at equilibrium for the following reaction? If not, which direction must the reaction proceed to achieve equilibrium?

$$2CO_2 \rightleftharpoons 2CO + O_2 \qquad K_c = 1.2 \times 10^{-13}$$

a) yes   b) no, to the right   c) no, to the left

2. Consider the following reaction at equilibrium.

$$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g) \qquad \Delta H^\circ = +92.4 \text{ kJ}$$
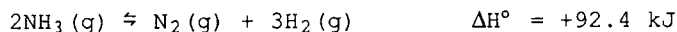
This reaction can be driven further to completion by using conditions of
a) high temperature and high pressure
b) high temperature and low pressure
c) low temperature and low pressure
d) low temperature and high pressure

3. Consider the following reaction at equilibrium.

$$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g) \qquad \Delta H^\circ = +92.4 \text{ kJ}$$
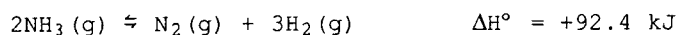
Adding $N_2(g)$ to this reaction will
a) decrease the concentration of $NH_3(g)$ at equilibrium
b) decrease the concentration of $H_2(g)$ at equilibrium
c) increase the value of the equilibrium constant
d) cause the reaction to shift to the right

4. The hydronium-ion concentration of a 0.010-molar hypochlorous acid solution, HOCl, is 5.48×10^{-6} M. What is the pH of the solution?

5. A solution has a pH value of 5.48. The $[OH^-]$ concentration for this solution is

_____ .

6. The hydronium-ion concentration of a 0.050 M lactic acid solution is 2.62×10^{-3}. The acid dissociation constant is 1.37×10^{-4}. The pH of this lactic acid solution is _____ .

7. A solution which is formed by combining 200. mL of 0.15 M HCl with 300. mL of 0.090 M NaOH has a $[OH^-]$ concentration of _____ .

8. Which of the following acids has the strongest conjugate base?
   a. $HClO_4$ b. $HClO_3$ c. $HClO_2$ d. HClO   e. HCl

9. Which of the following is true with regard to a 0.030 M H_2CO_3 solution?
   a. $[H^+] > [H_2CO_3]$ b. $[H_2CO_3] > [H^+]$ c. $[HCO_3^-] > [H_2CO_3]$
   d. $[CO_3^{2-}] > [H_2CO_3]$ e. $[CO_3^{2-}] > [HCO_3^-]$

10. Which of the following pairs of solutions could be mixed to produce a buffer?
    a. NaOH and HCl only   b. HF and NaF only   c. NH_3 and NH_4Cl only
   d. both a and b   e. both b and c

11. Which of the following salts when added to pure water will not change the pH of the solution?
    a. KI   b. $NaCH_3COO$ c. BaS   d. Li_2SO_4 e. Na_2O

12. In a sample of pure water, only one of the following statements is **always** true at all conditions of temperature and pressure. Which one is always true?

    a) $[H_3O^+] = 1.9 \times 10^{-7}\ M$ b) $[OH^-] = 1.0 \times 10^{-7}\ M$
    c) pH = 7.0   d) pOH = 7.0   e) $[H_3O^+] = [OH^-]$

13. Calculate the concentrations of H_3O^+ and OH^- ions in a 0.050 M $Ba(OH)_2$ solution.

14. Dichloroacetic acid is a weak monoprotic acid. A 0.100 M solution of this acid has [H_3O^+] = 0.0070 M. What is the value of K_a for $Cl_2HCCOOH$? The reaction is

$$Cl_2HCCOOH + H_2O \rightleftharpoons H_3O^+ + Cl_2HCCOO^-$$
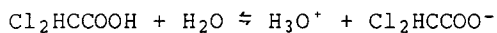
15. The ionization constant for the hypothetical weak acid, HA, is 1.0×10^{-5}. What is the equilibrium concentration of [H_3O^+] in 0.20 M HA solution?

16. Calculate the pH of a solution that is 0.20 M in $NaCH_3COO$ and 0.10 M in CH_3COOH.

    a) 4.63   b) 4.74   c) 4.95   d) 5.05   e) 5.22

17. If 0.090 mole of solid NaOH is added to 1.0 liter of 0.180 M CH_3COOH, what will the pH of the resulting solution be? Assume no volume change due to addition of NaOH. K_a(HOAc)= 1.8×10^{-5})

    a) 4.51   b) 4.74   c) 5.08   d) 5.70   e) 5.94

18. The molar solubility of $BaCO_3$ is 9.0×10^{-5} M at 25°C. What is the solubility product constant for $BaCO_3$?

19. One liter of saturated zinc hydroxide solution contains 0.000222 g of dissolved $Zn(OH)_2$. Calculate K_{sp} for $Zn(OH)_2$.

20. Magnesium hydroxide is a slightly soluble substance. If the pH of a saturated solution of $Mg(OH)_2$ is 10.49 at 25°C, calculate K_{sp} for $Mg(OH)_2$.

21. The value of K_{sp} for $SrSO_4$ is 2.8×10^{-7}. What is the molar solubility of $SrSO_4$?

22. The K_{sp} for magnesium arsenate is 2.1×10^{-20} at 25°C. What is the molar solubility of $Mg_3(AsO_4)_2$ at 25°C?

23. Calculate the concentration of F^- ions in saturated CaF_2 solution at 25°C. K_{sp} = 3.9×10^{-11}.

24. The K_{sp} for $Fe(IO_3)_3$ is 10^{-14}. We mix two solutions, one containing Fe^{3+} and one containing IO_3^- ions at 25°C. At the instant of mixing, [Fe^{3+}] = 10^{-4} M and [IO_3^-] = 10^{-5} M. Which one of the following statements is true?

    a) A precipitate forms, because $Q_{sp} > K_{sp}$.
    b) A precipitate forms, because $Q_{sp} < K_{sp}$.
    c) No precipitate forms, because $Q_{sp} > K_{sp}$.
    d) No precipitate forms, because $Q_{sp} < K_{sp}$.
    e) None of the preceding statements is true.

25. Calculate the [Ca^{2+}] required to start the precipitation of calcium fluoride, CaF_2, from a solution containing 0.0025 M F^- at 25°C. K_{sp} for CaF_2 = 3.9×10^{-11}

26. Solid Na_2SO_4 is added to a solution that is 0.30 M in both Sr^{2+} and Pb^{2+}. Assuming no volume change, what will be the [Pb^{2+}] at the point at which $SrSO_4$ just begins to precipitate at 25°C? K_{sp} for $SrSO_4$ = 2.8×10^{-7} and for $PbSO_4$ = 1.8×10^{-8}.

ANSWERS:
1C, 2B, 3B, 4 (5.26), 5(3.0 x 10⁻⁹), 6(2.58), 7(1.67 x 10⁻¹²), 8D, 9B, 10E, 11A, 12E, 13 [H_3O^+] = 1.0 x 10⁻¹³ M, [OH^-] = 0.10 M, 14 b)   5.3 x 10⁻⁴ , 15 c)   1.4 x 10⁻³ M , 16D, 17B, 18 b)   8.1 x 10⁻⁹ , 19 c)   4.5 x 10⁻¹⁷ , 20 e)   1.5 x 10⁻¹¹ , 21 c)   5.3 x 10⁻⁴ M , 22 c)   4.5 x 10⁻⁵ M , 23 b)   4.3 x 10⁻⁴ M , 24D, 25 d)   6.2 x 10⁻⁶ M , 26 d)   0.019 M