Name: _____ Date: _____

1. The solubility of silver bromide can be increased by dissolving it in a solution containing the thiosulfate anion.

$AgBr(s) \rightleftharpoons Ag^+(aq) + Br^-(aq) \quad K_1 = 7.7 \times 10^{-13}$

$Ag^+(aq) + 2S_2O_3^{2-}(aq) \rightleftharpoons Ag(S_2O_3)_2^{3-}(aq) \quad K_2 = 4.7 \times 10^{13}$

What is the value of the equilibrium constant for the overall reaction?

$AgBr(s) + 2S_2O_3^{2-}(aq) \rightleftharpoons Ag(S_2O_3)_2^{3-}(aq) + Br^-(aq)$

A) 3.6×10^{-9}
B) 12.4×10^{13}
C) 4.7×10^{-9}
D) 4.7×10^{13}
E) 36

2. Given the following information:

$2A(g) + B(g) \rightleftharpoons A_2B(g) \quad K_{p1}$

$2A(g) + C_2(g) \rightleftharpoons 2AC(g) \quad K_{p2}$

$3/2A_2(g) + B(g) + C(g) \rightleftharpoons AC(g) + A_2B(g) \quad K_{p3}$

Which relationship represents the equilibrium constant for the reaction:

$3A_2(g) + 3B(g) + 2C(g) \rightleftharpoons 3A_2B(g) + C_2(g) \quad K_{net} = ?$

A) $K_{net} = K_{p1} \times K_{p2} \times K_{p3}$
B) $K_{net} = K_{p1} \times 2K_{p3} / K_{p2}$
C) $K_{net} = K_{p1} - K_{p2} + 2\,K_{p3}$
D) $K_{net} = K_{p1} \times K_{p3}^2 / K_{p2}$
E) $K_{net} = K_{p1} \times K_{p2} \times K_{p3}^2$

3. 2.50 mol NOCl was placed in a 2.50 L reaction vessel at 400ºC. After equilibrium was established, it was found that 28% of the NOCl had dissociated according to the equation

$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g).$

Calculate the equilibrium constant, K_c, for the reaction.

A) 0.021
B) 0.039
C) 0.169
D) 26
E) 47

4. The brown gas NO_2 and the colorless gas N_2O_4 exist in equilibrium, $2NO_2 \rightleftharpoons N_2O_4$. In an experiment, 0.625 mole of N_2O_4 was introduced into a 5.00 L vessel and was allowed to decompose until equilibrium was reached. The concentration of N_2O_4 at equilibrium was 0.0750 M. Calculate K_c for the reaction.
   A) 7.5
   B) 0.125
   C) 0.0750
   D) 0.10
   E) 0.050

5. At 700 K, the reaction $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ has the equilibrium constant $K_c = 4.3 \times 10^6$, and the following concentrations are present: $[SO_2] = 0.10$ M; $[SO_3] = 10.$ M; $[O_2] = 0.10$ M. Which of the following is true based on the above?
   A) $Q_c > K_c$, the reaction proceeds from left to right to reach equilibrium
   B) $Q_c > K_c$, the reaction proceeds from right to left to reach equilibrium
   C) $Q_c < K_c$, the reaction proceeds from left to right to reach equilibrium
   D) $Q_c < K_c$, the reaction proceeds from right to left to reach equilibrium
   E) $Q_c = K_c$, the reaction is currently at equilibrium

6. Consider the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$. The production of ammonia is an exothermic reaction. Will heating the equilibrium system *increase* or *decrease* the amount of ammonia produced?

7. In the reaction $HSO_4^-(aq) + OH^-(aq) \rightleftharpoons SO_4^{2-}(aq) + H_2O(l)$, the conjugate acid-base pairs are

	pair 1	*pair 2*
A.	HSO_4^- and SO_4^{2-};	H_2O and OH^-.
B.	HSO_4^- and H_3O^+;	SO_4^{2-} and OH^-.
C.	HSO_4^- and OH^-;	SO_4^{2-} and H_2O.
D.	HSO_4^- and H_2O;	OH^- and SO_4^{2-}.
E.	HSO_4^- and OH^-;	SO_4^{2-} and H_3O^+.

   A) A
   B) B
   C) C
   D) D
   E) E

8. The OH^- concentration in a 1.0×10^{-3} M $Ba(OH)_2$ solution is
   A) 0.50×10^{-3} M.
   B) 1.0×10^{-3} M.
   C) 2.0×10^{-3} M.
   D) 1.0×10^{-2} M.
   E) 0.020 M.

9. A 0.14 M HNO_2 solution is 5.7% ionized. Calculate the H^+ ion concentration.
   A) 8.0×10^{-3} M
   B) 0.057 M
   C) 0.13 M
   D) 0.14 M
   E) 0.80 M

10. Calculate the pH of a 3.5×10^{-3} M HNO_3 solution.
    A) –2.46
    B) 0.54
    C) 2.46
    D) 3.00
    E) 3.46

11. A 2.1 L sample of a 0.23 M NaOH solution is mixed with 1.9 L of a 0.021 M KOH solution. What is the pH of the mixture?
    A) 13.40
    B) 13.12
    C) 11.68
    D) 12.84
    E) 13.04

12. Given the following K_b values, which cation is the strongest acid?

Base	K_b
NH_3	1.8×10^{-5}
$C_2H_5NH_2$	5.6×10^{-4}
C_5H_5N	1.7×10^{-9}
$C_8H_{10}N_4O_2$	5.3×10^{-14}
$(NH_2)_2CO$	1.5×10^{-14}

    A) NH_4^+
    B) $C_2H_5NH_3^+$
    C) $C_5H_6N^+$
    D) $[C_8H_{11}N_4O_2]^+$
    E) $[NH_2NH_3CO]^+$

13. Arrange the acids H_2Se, H_2Te, and H_2S in order of increasing acid strength.
    A) $H_2S < H_2Se < H_2Te$
    B) $H_2S < H_2Te < H_2Se$
    C) $H_2Te < H_2S < H_2Se$
    D) $H_2Se < H_2S < H_2Te$
    E) $H_2Se < H_2Te < H_2S$

14. Which one of these equations represents the reaction of a *weak acid* with a *weak base*?
    A) $H^+(aq) + OH^-(aq) \rightarrow H_2O(aq)$
    B) $H^+(aq) + CH_3NH_2(aq) \rightarrow CH_3NH_3^+(aq)$
    C) $OH^-(aq) + HCN(aq) \rightarrow H_2O(aq) + CN^-(aq)$
    D) $HCN(aq) + CH_3NH_2(aq) \rightarrow CH_3NH_3^+(aq) + CN^-(aq)$

15. Predict the direction in which the equilibrium will lie for the reaction
    $H_3PO_4(aq) + HSO_4^-(aq) \rightleftharpoons H_2PO_4^-(aq) + H_2SO_4(aq)$.
    $K_{a1}(H_3PO_4) = 7.5 \times 10^{-3}$; $K_a(H_2SO_4)$ = very large
    A) to the right
    B) to the left
    C) in the middle

16. Which of the following is both a Lewis Acid and Brønsted Acid?
    A) BF_3
    B) NH_3
    C) CO_2
    D) HNO_2
    E) PCl_3

17. Which one of the following combinations cannot function as a buffer solution?
    A) HCN and KCN
    B) NH_3 and $(NH_4)_2SO_4$
    C) HNO_3 and $NaNO_3$
    D) HF and NaF
    E) HNO_2 and $NaNO_2$

18. Which of the following yields a buffer solution when equal volumes of the two solutions are mixed?
    A) 0.050 M H_3PO_4 and 0.050M HCl
    B) 0.050M H_3PO_4 and 0.025 M HCl
    C) 0.050M NaH_2PO_4 and 0.025M NaOH
    D) 0.050M Na_3PO_4 and 0.050M M NaOH
    E) 0.050M Na_3PO_4 and 0.025M NaOH

19. Calculate the pH of a buffer solution prepared by dissolving 0.2 mole of sodium cyanate (NaCNO) and 1.0 mole of cyanic acid (HCNO) in enough water to make 1.0 liter of solution. [K_a(HCNO) = 2.0×10^{-4}]
    A) 0
    B) 3.0
    C) 3.7
    D) 4.4
    E) 5.0

20. Starting with 0.250L of a buffer solution containing 0.250 M benzoic acid (C_6H_5COOH) and 0.20 M sodium benzoate (C_6H_5COONa), what will the pH of the solution be after the addition of 25.0 mL of 0.100M HCl? (K_a (C_6H_5COOH) = 6.5×10^{-5})
    A) 4.19
    B) 4.10
    C) 4.28
    D) 4.05
    E) 3.78

21. Acid dissociation constants for phosphoric acid are given below.

	K_{a1}	K_{a2}	K_{a3}
H_3PO_4	7.5×10^{-3}	6.2×10^{-8}	4.8×10^{-13}

    A buffer with a pH = 7.4 can best be made by using
    A) H_3PO_4 and NaH_2PO_4.
    B) NaH_2PO_4 and Na_2HPO_4.
    C) Na_2HPO_4 and Na_3PO_4.
    D) only NaH_2PO_4.
    E) only Na_2HPO_4.

22. 35.0 mL of a 0.250 M solution of KOH is titrated with 0.150 M HCl. After 35.0 mL of the HCl has been added, the resultant solution is:
    A) Basic and before the equivalence point
    B) Basic and after the equivalence point
    C) Acidic and before the equivalence point
    D) Acidic and after the equivalence point
    E) Neutral and at the equivalence point

23. What is the pH at the equivalence point in the titration of 100 mL of 0.10 M HCN ($K_a = 4.9 \times 10^{-10}$) with 0.10 M NaOH?
    A) 3.0
    B) 6.0
    C) 7.0
    D) 11.0
    E) 12.0

Answer Key

1. E
2. D
3. A
4. A
5. C
6. The amount of NH_3 produced will decrease.
7. A
8. C
9. A
10. C
11. B
12. E
13. A
14. D
15. B
16. D
17. C
18. C
19. B
20. D
21. B
22. A
23. D