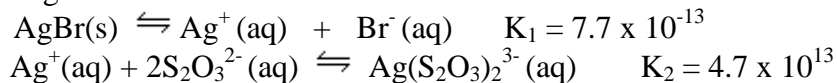
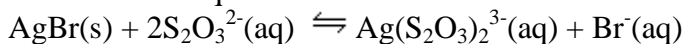


Name: \_\_\_\_\_ Date: \_\_\_\_\_

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

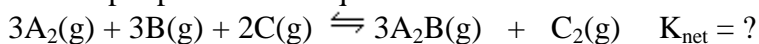


What is the value of the equilibrium constant for the overall reaction?

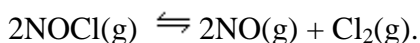


- A)  $3.6 \times 10^{-9}$   
B)  $12.4 \times 10^{13}$   
C)  $4.7 \times 10^{-9}$   
D)  $4.7 \times 10^{13}$   
E) 36
2. Given the following information:
- $$2\text{A(g)} + \text{B(g)} \rightleftharpoons \text{A}_2\text{B(g)} \quad K_{p1}$$
- $$2\text{A(g)} + \text{C}_2(\text{g}) \rightleftharpoons 2\text{AC(g)} \quad K_{p2}$$
- $$3/2\text{A}_2(\text{g}) + \text{B(g)} + \text{C(g)} \rightleftharpoons \text{AC(g)} + \text{A}_2\text{B(g)} \quad K_{p3}$$

Which relationship represents the equilibrium constant for the reaction:



- A)  $K_{\text{net}} = K_{p1} \times K_{p2} \times K_{p3}$   
B)  $K_{\text{net}} = K_{p1} \times 2K_{p3} / K_{p2}$   
C)  $K_{\text{net}} = K_{p1} - K_{p2} + 2 K_{p3}$   
D)  $K_{\text{net}} = K_{p1} \times K_{p3}^2 / K_{p2}$   
E)  $K_{\text{net}} = K_{p1} \times K_{p2} \times K_{p3}^2$
3. 2.50 mol NOCl was placed in a 2.50 L reaction vessel at 400°C. After equilibrium was established, it was found that 28% of the NOCl had dissociated according to the equation



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  $\text{NO}_2$  and the colorless gas  $\text{N}_2\text{O}_4$  exist in equilibrium,  $2\text{NO}_2 \rightleftharpoons \text{N}_2\text{O}_4$ . In an experiment, 0.625 mole of  $\text{N}_2\text{O}_4$  was introduced into a 5.00 L vessel and was allowed to decompose until equilibrium was reached. The concentration of  $\text{N}_2\text{O}_4$  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  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$  has the equilibrium constant  $K_c = 4.3 \times 10^6$ , and the following concentrations are present:  $[\text{SO}_2] = 0.10 \text{ M}$ ;  $[\text{SO}_3] = 10. \text{ M}$ ;  $[\text{O}_2] = 0.10 \text{ M}$ . 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  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$ . 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  $\text{HSO}_4^-(\text{aq}) + \text{OH}^-(\text{aq}) \rightleftharpoons \text{SO}_4^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l})$ , the conjugate acid-base pairs are
- |    | <i>pair 1</i>                                 | <i>pair 2</i>                                   |
|----|---|---|
| A. | $\text{HSO}_4^-$ and $\text{SO}_4^{2-}$ ;     | $\text{H}_2\text{O}$ and $\text{OH}^-$ .        |
| B. | $\text{HSO}_4^-$ and $\text{H}_3\text{O}^+$ ; | $\text{SO}_4^{2-}$ and $\text{OH}^-$ .          |
| C. | $\text{HSO}_4^-$ and $\text{OH}^-$ ;          | $\text{SO}_4^{2-}$ and $\text{H}_2\text{O}$ .   |
| D. | $\text{HSO}_4^-$ and $\text{H}_2\text{O}$ ;   | $\text{OH}^-$ and $\text{SO}_4^{2-}$ .          |
| E. | $\text{HSO}_4^-$ and $\text{OH}^-$ ;          | $\text{SO}_4^{2-}$ and $\text{H}_3\text{O}^+$ . |
- A) A  
 B) B  
 C) C  
 D) D  
 E) E

8. The  $\text{OH}^-$  concentration in a  $1.0 \times 10^{-3}$  M  $\text{Ba}(\text{OH})_2$  solution is
- $0.50 \times 10^{-3}$  M.
  - $1.0 \times 10^{-3}$  M.
  - $2.0 \times 10^{-3}$  M.
  - $1.0 \times 10^{-2}$  M.
  - 0.020 M.
9. A 0.14 M  $\text{HNO}_2$  solution is 5.7% ionized. Calculate the  $\text{H}^+$  ion concentration.
- $8.0 \times 10^{-3}$  M
  - 0.057 M
  - 0.13 M
  - 0.14 M
  - 0.80 M
10. Calculate the pH of a  $3.5 \times 10^{-3}$  M  $\text{HNO}_3$  solution.
- 2.46
  - 0.54
  - 2.46
  - 3.00
  - 3.46
11. A 2.1 L sample of a 0.23 M  $\text{NaOH}$  solution is mixed with 1.9 L of a 0.021 M  $\text{KOH}$  solution. What is the pH of the mixture?
- 13.40
  - 13.12
  - 11.68
  - 12.84
  - 13.04
12. Given the following  $K_b$  values, which cation is the strongest acid?

Base	$K_b$
$\text{NH}_3$	$1.8 \times 10^{-5}$
$\text{C}_2\text{H}_5\text{NH}_2$	$5.6 \times 10^{-4}$
$\text{C}_5\text{H}_5\text{N}$	$1.7 \times 10^{-9}$
$\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$	$5.3 \times 10^{-14}$
$(\text{NH}_2)_2\text{CO}$	$1.5 \times 10^{-14}$

- $\text{NH}_4^+$
- $\text{C}_2\text{H}_5\text{NH}_3^+$
- $\text{C}_5\text{H}_6\text{N}^+$
- $[\text{C}_8\text{H}_{11}\text{N}_4\text{O}_2]^+$
- $[\text{NH}_2\text{NH}_3\text{CO}]^+$

13. Arrange the acids  $\text{H}_2\text{Se}$ ,  $\text{H}_2\text{Te}$ , and  $\text{H}_2\text{S}$  in order of increasing acid strength.
- A)  $\text{H}_2\text{S} < \text{H}_2\text{Se} < \text{H}_2\text{Te}$
  - B)  $\text{H}_2\text{S} < \text{H}_2\text{Te} < \text{H}_2\text{Se}$
  - C)  $\text{H}_2\text{Te} < \text{H}_2\text{S} < \text{H}_2\text{Se}$
  - D)  $\text{H}_2\text{Se} < \text{H}_2\text{S} < \text{H}_2\text{Te}$
  - E)  $\text{H}_2\text{Se} < \text{H}_2\text{Te} < \text{H}_2\text{S}$
14. Which one of these equations represents the reaction of a *weak acid* with a *weak base*?
- A)  $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{aq})$
  - B)  $\text{H}^+(\text{aq}) + \text{CH}_3\text{NH}_2(\text{aq}) \rightarrow \text{CH}_3\text{NH}_3^+(\text{aq})$
  - C)  $\text{OH}^-(\text{aq}) + \text{HCN}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{aq}) + \text{CN}^-(\text{aq})$
  - D)  $\text{HCN}(\text{aq}) + \text{CH}_3\text{NH}_2(\text{aq}) \rightarrow \text{CH}_3\text{NH}_3^+(\text{aq}) + \text{CN}^-(\text{aq})$
15. Predict the direction in which the equilibrium will lie for the reaction
- $$\text{H}_3\text{PO}_4(\text{aq}) + \text{HSO}_4^-(\text{aq}) \rightleftharpoons \text{H}_2\text{PO}_4^-(\text{aq}) + \text{H}_2\text{SO}_4(\text{aq}).$$
- $K_{a1}(\text{H}_3\text{PO}_4) = 7.5 \times 10^{-3}$ ;  $K_a(\text{H}_2\text{SO}_4) = \text{very large}$
- 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)  $\text{BF}_3$
  - B)  $\text{NH}_3$
  - C)  $\text{CO}_2$
  - D)  $\text{HNO}_2$
  - E)  $\text{PCl}_3$
17. Which one of the following combinations cannot function as a buffer solution?
- A)  $\text{HCN}$  and  $\text{KCN}$
  - B)  $\text{NH}_3$  and  $(\text{NH}_4)_2\text{SO}_4$
  - C)  $\text{HNO}_3$  and  $\text{NaNO}_3$
  - D)  $\text{HF}$  and  $\text{NaF}$
  - E)  $\text{HNO}_2$  and  $\text{NaNO}_2$

18. Which of the following yields a buffer solution when equal volumes of the two solutions are mixed?
- 0.050 M  $\text{H}_3\text{PO}_4$  and 0.050M HCl
  - 0.050M  $\text{H}_3\text{PO}_4$  and 0.025 M HCl
  - 0.050M  $\text{NaH}_2\text{PO}_4$  and 0.025M NaOH
  - 0.050M  $\text{Na}_3\text{PO}_4$  and 0.050M M NaOH
  - 0.050M  $\text{Na}_3\text{PO}_4$  and 0.025M NaOH
19. Calculate the pH of a buffer solution prepared by dissolving 0.2 mole of sodium cyanate ( $\text{NaCNO}$ ) and 1.0 mole of cyanic acid ( $\text{HCNO}$ ) in enough water to make 1.0 liter of solution. [ $K_a(\text{HCNO}) = 2.0 \times 10^{-4}$ ]
- 0
  - 3.0
  - 3.7
  - 4.4
  - 5.0
20. Starting with 0.250L of a buffer solution containing 0.250 M benzoic acid ( $\text{C}_6\text{H}_5\text{COOH}$ ) and 0.20 M sodium benzoate ( $\text{C}_6\text{H}_5\text{COONa}$ ), what will the pH of the solution be after the addition of 25.0 mL of 0.100M HCl? ( $K_a(\text{C}_6\text{H}_5\text{COOH}) = 6.5 \times 10^{-5}$ )
- 4.19
  - 4.10
  - 4.28
  - 4.05
  - 3.78

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

	$K_{a1}$	$K_{a2}$	$K_{a3}$
$\text{H}_3\text{PO}_4$	$7.5 \times 10^{-3}$	$6.2 \times 10^{-8}$	$4.8 \times 10^{-13}$

A buffer with a  $\text{pH} = 7.4$  can best be made by using

- $\text{H}_3\text{PO}_4$  and  $\text{NaH}_2\text{PO}_4$ .
- $\text{NaH}_2\text{PO}_4$  and  $\text{Na}_2\text{HPO}_4$ .
- $\text{Na}_2\text{HPO}_4$  and  $\text{Na}_3\text{PO}_4$ .
- only  $\text{NaH}_2\text{PO}_4$ .
- only  $\text{Na}_2\text{HPO}_4$ .

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  $\text{NH}_3$  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