Week 5 Acids & Bases 2

**QUESTION 1**
Which statements are true about strong acids?

I. Strong acids are weak electrolytes.
II. Strong acids have spectator ions as conjugate bases.
III. Strong acids have very large $K_a$ values.

A. I and II only  
B. II and III only  
C. I, II and III only  
D. I and III only  
E. I only

**QUESTION 2**
Which of the following is *NOT* a strong acid?

A. HCl  
B. HClO₃  
C. H₂SO₄  
D. H₃PO₄  
E. HClO

**QUESTION 3**
Which of the following substances are spectator ions in aqueous solution?

I. $\text{Br}^-$  
II. $\text{NO}_3^-$  
III. $\text{S}^{2-}$  
IV. $\text{OH}^-$  
V. $\text{ClO}_3^-$  
VI. $\text{F}^-$  
VII. $\text{H}^+$  
VIII. Cl⁻  
IX. $\text{CH}_3\text{COO}$⁻

**QUESTION 4**
What is the concentration of $\text{HNO}_3$ in a solution that has a pH of 0.98?

**QUESTION 5**
Which of the following is true regarding a 0.10 M solution of a weak acid $\text{HX}$, which has a $K_a = 1 \times 10^{-5}$?

A. $[\text{X}^-] = 0.10 \text{ M}$  
B. $[\text{H}^+] = 0.10 \text{ M}$  
C. pH = 1  
D. $[\text{HX}] > [\text{H}^+]$  
E. pH = 10

**QUESTION 6**
Write the chemical equation and the equilibrium constant expression $K_a$ for the following acids in aqueous solution (you may write $\text{H}^+$ instead of the hydronium ion):

a. $\text{H}_2\text{S}$  
b. $\text{HCO}_3^-$  
c. $\text{CF}_3\text{COOH}$

**QUESTION 7**
What is the pH of an aqueous solution labeled 0.075 M HCN at 25°C? $K_a = 4.9 \times 10^{-10}$

A. 5.2  
B. 8.8  
C. 7.0  
D. 10.4  
E. 3.6
QUESTION 8

Calculate the hydronium ion concentration, [H$_3$O$^+$], in 0.020 M hypochlorous acid at 25°C ($K_a = 3.0 \times 10^{-6}$).

A. 6.1 × 10$^{-10}$ M  
B. 4.6 × 10$^{-8}$ M  
C. 2.4 × 10$^{-5}$ M  
D. 7.2 × 10$^{-1}$ M  
E. 1.0 × 10$^{-7}$ M

QUESTION 9

What is the value of $K_a$ for the weak acid HA if a 0.35 M solution of HA has a pH of 5.95?

A. 3.2 × 10$^{-6}$  
B. 1.7  
C. 1.1 × 10$^{-6}$  
D. 3.6 × 10$^{-12}$  
E. 2.2 × 10$^{-16}$

QUESTION 10

What percent ionization would be expected for 0.400 M HN$_2$ at 25°C? ($K_a = 1.9 \times 10^{-5}$)

A. 70 %  
B. 35 %  
C. 3.5 %  
D. 0.7 %  
E. 5.0 %

QUESTION 11

What is the % ionization of hypochlorous acid (HClO) in a 0.015 M aqueous solution at 25°C? ($K_a = 3.0 \times 10^{-8}$)

A. 4.5 × 10$^{-8}$ %  
B. 14 %  
C. 2.1 × 10$^{-5}$ %  
D. 0.14 %  
E. 4.5 × 10$^{-10}$ %

QUESTION 12

Consider the following two solutions: 0.01 M acetic acid and 0.001 M acetic acid ($K_a = 1.8 \times 10^{-5}$).

a. Which solution has a greater percent ionization, and why?

b. Which solution has a lower pH?

QUESTION 13

Which one of the following is true for any triprotic acid, H$_3$X?

A. $K_{a1} > K_{a2}$  
B. $K_{a2} = K_{a1}$  
C. $K_{a1} < K_{a2}$  
D. $K_{a2} < K_{a3}$  
E. $K_{a1} = K_{a2} = K_{a3}$

QUESTION 14

A diprotic acid, H$_2$A, has values of $K_{a1} = 1.0 \times 10^{-5}$ and $K_{a2} = 1.0 \times 10^{-10}$. In a 0.10 M solution of H$_2$A, what is the concentration of the anion A$^{2-}$?

A. 0.10 M  
B. 0.20 M  
C. 3.2 × 10$^{-3}$ M  
D. 1.0 × 10$^{-3}$ M  
E. 1.0 × 10$^{-10}$ M
QUESTION 15

Given the acid-dissociation constants of phosphoric acid below (H₃PO₄), what is the concentration of phosphate ions in a 2.5 M aqueous solution of phosphoric acid if the pH of the solution is 0.87 at 25°C?

\[ K_{a1} = 7.5 \times 10^{-3} \]
\[ K_{a2} = 6.2 \times 10^{-8} \]
\[ K_{a3} = 4.2 \times 10^{-13} \]

A. 1.9 × 10⁻¹⁹ M
B. 1.0 × 10⁻⁶ M
C. 0.13 M
D. 6.2 × 10⁻⁸ M
E. 4.2 × 10⁻¹³ M

QUESTION 16

Which of the following statements is true concerning the equilibria shown below?

\[ H₃PO₄(aq) = H₂PO₄⁻(aq) + H⁺(aq) \quad K_{a1} \]
\[ H₂PO₄⁻(aq) = HPO₄²⁻(aq) + H⁺(aq) \quad K_{a2} \]
\[ HPO₄²⁻(aq) = PO₄³⁻(aq) + H⁺(aq) \quad K_{a3} \]

A. \( K_{a3} \) is larger than \( K_{a1} \).
B. \( H₂PO₄⁻(aq) \) dissociates completely.
C. The pH of this aqueous solution is determined mainly by \( K_{a3} \).
D. The strongest conjugate base involved is the \( PO₄³⁻ \) species.
E. \( HPO₄²⁻(aq) \) is a stronger acid than \( H₂PO₄⁻(aq) \).

QUESTION 17

Considering the equilibria below, what would change if 5 drops of concentrated HCl were added to an aqueous solution of H₃PO₄?

I. \([H₃PO₄]\) would increase
II. \([PO₄³⁻]\) would decrease
III. \([OH⁺]\) would increase

\[ H₃PO₄(aq) = H₂PO₄⁻(aq) + H⁺(aq) \quad K_{a1} \]
\[ H₂PO₄⁻(aq) = HPO₄²⁻(aq) + H⁺(aq) \quad K_{a2} \]
\[ HPO₄²⁻(aq) = PO₄³⁻(aq) + H⁺(aq) \quad K_{a3} \]

A. I, II and III
B. II and III only
C. I and III only
D. I and II only
E. III only

QUESTION 18

Hydrogen sulfite ion has a formula of HSO₃⁻.

a. Write an equation for the reaction in which hydrogen sulfite ion acts as an acid in aqueous solution.
b. Write an equation for the reaction in which hydrogen sulfite ion acts as a base in aqueous solution.
c. What type of substance can act as either an acid or a base?
QUESTION 19

Which of the following substances are spectator ions in aqueous solution?

I. \( \text{NH}_4^+ \)
II. \( \text{Li}^+ \)
III. \( \text{CO}_3^{2-} \)
IV. \( \text{Na}^+ \)
V. \( \text{OH}^- \)
VI. \( \text{Ca}^{2+} \)
VII. \( \text{CN}^- \)

QUESTION 20

Write the chemical equation and the equilibrium constant expression \( K_b \) for the following bases in aqueous solution:

a. \( \text{CH}_3\text{CH}_2\text{NH}_2 \)
b. \( \text{HCO}_3^- \)
c. \( \text{N}_3^- \)

QUESTION 21

Which of the following bases is the strongest?

<table>
<thead>
<tr>
<th>Base</th>
<th>( K_b )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Ammonia</td>
<td>( 1.8 \times 10^{-5} )</td>
</tr>
<tr>
<td>B. Methylamine</td>
<td>( 4.4 \times 10^{-4} )</td>
</tr>
<tr>
<td>C. Nicotine</td>
<td>( 7.0 \times 10^{-7} )</td>
</tr>
<tr>
<td>D. Hydroxylamine</td>
<td>( 1.1 \times 10^{-8} )</td>
</tr>
<tr>
<td>E. Trimethylamine</td>
<td>( 6.4 \times 10^{-5} )</td>
</tr>
</tbody>
</table>

QUESTION 22

Which of the following is the strongest base: \( \text{NH}_3, \text{SO}_4^{2-}, \text{PO}_4^{3-}, \text{NO}_3^- \)? (\( K_b \) for \( \text{NH}_3 \) is \( 1.8 \times 10^{-5} \), \( K_{a2} \) for \( \text{H}_2\text{SO}_4 \) is \( 1.2 \times 10^{-2} \), \( K_{a3} \) for \( \text{H}_3\text{PO}_4 \) is \( 4.8 \times 10^{-13} \))

A. \( \text{NH}_3 \)
B. \( \text{SO}_4^{2-} \)
C. \( \text{PO}_4^{3-} \)
D. \( \text{NO}_3^- \)
E. \( \text{PO}_4^{3-} \) and \( \text{SO}_4^{2-} \) are equally the strongest

QUESTION 23

Calculate the pH of a 0.50 M solution of \( \text{NH}_3 \) at 25°C. The \( K_b \) of \( \text{NH}_3 \) is \( 1.8 \times 10^{-5} \).

A. 8.95
B. 11.48
C. 2.52
D. 5.05
E. 9.26

QUESTION 24

What is the [OH\(^-\)] in a 0.80 M solution of hydrazine, \( \text{N}_2\text{H}_2 \), at 25°C? \( K_b = 1.7 \times 10^{-6} \)

A. \( 1.2 \times 10^{-3} \) M
B. \( 8.6 \times 10^{-12} \) M
C. \( 2.2 \times 10^{-3} \) M
D. 0.80 M
E. \( 1.4 \times 10^{-6} \) M
QUESTION 25

What is the value of the equilibrium constant for the following reaction? (For HNO₂, K_a = 4.5 × 10^{-4})

\[ \text{NO}_2^- (aq) + \text{H}_2\text{O} (l) \rightarrow \text{HNO}_2 (aq) + \text{OH}^- (aq) \]

A. \( 4.5 \times 10^{-4} \)
B. \( 5.0 \times 10^{-4} \)
C. \( 2.0 \times 10^{-4} \)
D. \( 5.0 \times 10^{-11} \)
E. \( 2.2 \times 10^{-11} \)

QUESTION 26

Which of the following combinations is correct in aqueous solution?

<table>
<thead>
<tr>
<th>Species</th>
<th>Strength</th>
<th>Conjugate</th>
<th>Conjugate Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. F^-</td>
<td>weak base</td>
<td>HF</td>
<td>strong acid</td>
</tr>
<tr>
<td>B. O^-</td>
<td>weak base</td>
<td>OH^-</td>
<td>strong base</td>
</tr>
<tr>
<td>C. K^-</td>
<td>negligible acid</td>
<td>KOH</td>
<td>strong base</td>
</tr>
<tr>
<td>D. NO_3^-</td>
<td>weak base</td>
<td>HNO_2^-</td>
<td>weak acid</td>
</tr>
<tr>
<td>E. CH_3NH_3^+</td>
<td>weak base</td>
<td>CH_3NH_3^2+</td>
<td>strong acid</td>
</tr>
</tbody>
</table>

QUESTION 27

Place the following salts in the table below by predicting the pH of their aqueous solutions:

NaN_3, KBr, CH_3NH_2Cl, CaF_2, KClO_3, FeBr_3, LiOH, NaNO_3, NH_4Br, AlCl_3, CH_3COOK, SrCl_2.

<table>
<thead>
<tr>
<th>Acidic Salts, pH &lt; 7</th>
<th>Basic Salts, pH &gt; 7</th>
<th>Neutral Salts, pH ~ 7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

QUESTION 28

Predict the products of the following acid-base reactions, write the net ionic reaction, and predict whether the equilibrium lies to the left or to the right of the equation:

a. \( \text{CH}_3\text{NH}_2^+ (aq) + \text{OH}^- (aq) \rightarrow \)

b. \( \text{CH}_3\text{COO}^- (aq) + \text{HCl}(aq) \rightarrow \)

c. \( \text{Ca(OH)}_2(aq) + 2 \text{HNO}_3(aq) \rightarrow \)

QUESTION 29

A solution is made by mixing 100 mL of 0.1 M HCl with 100 mL of 0.1 M NH_3 at 25°C. What is the pH of the final solution? (\( K_b \) for NH_3 = \( 1.8 \times 10^{-5} \))

QUESTION 30

What is the pH of a 0.05 M solution of CH_3COOK at 25°C? (\( K_a \) for CH_3COOH = \( 1.8 \times 10^{-5} \))

A. 4.8
B. 7.0
C. 5.3
D. 8.7
E. 9.2
QUESTION 31

Which of the following salts will give the most basic solution when dissolved in water?

A. KBrO₄
B. KBrO₃
C. KBrO₂
D. KBrO
E. KClO

QUESTION 32

Which of the following substances will form acidic aqueous solutions: NH₄Cl, Cu(NO₃)₂, K₂CO₃, NaF?

A. NaF only
B. NaF and K₂CO₃ only
C. NH₄Cl and Cu(NO₃)₂ only
D. NH₄Cl and K₂CO₃ only
E. NH₄Cl only

QUESTION 33

Which of these salts will form a basic aqueous solution?

I. KCl
II. CsF
III. KCN
IV. NH₄Cl

A. I only
B. II only
C. III only
D. IV only
E. II and III only

QUESTION 34

Which of the following halogen oxyacids will be the weakest acid?

A. HIO
B. HBrO
C. HClO₂
D. HClO₃
E. HIO₃

QUESTION 35

Which one of the following compounds produces an acidic solution when dissolved in water?

A. Na₂O
B. KO₂
C. MgO
D. CaO
E. CO₂

QUESTION 36

Which of the following oxides is amphoteric?

A. Na₂O
B. Sb₂O₃
C. P₂O₅ (sometimes called phosphorous pentoxide, P₂O₅)
D. BaO
E. SO₂
QUESTION 37

Which of the following is NOT likely to be a Lewis acid?

A. Fe$^{3+}$  
B. BF$_3$  
C. CH$_4$  
D. Be$^{2+}$  
E. Ca$^{2+}$

QUESTION 38

Which of the following is NOT likely to be a Lewis acid?

A. Cr$^{3+}$  
B. BF$_3$  
C. H$^+$  
D. Na$^+$  
E. CF$_4$

QUESTION 39

Which of the following aqueous solutions would have the lowest pH?

A. FeCl$_3$ (aq)  
B. KOH (aq)  
C. NaCl (aq)  
D. ZnI$_2$ (aq)  
E. Mg(NO$_3$)$_2$ (aq)

QUESTION 40

An aqueous solution of Al(NO$_3$)$_3$ was demonstrated in class to be an acidic solution. What is the source of the protons in this solution?