1. Which of the following statements is characteristic of acids?

   1. They turn blue litmus red.
   2. They neutralize bases.
   3. They increase the pH of aqueous solutions.

   a) 1 only       b) 2 only       c) 3 only       d) 1 and 2 only       e) 1, 2, and 3

2. List the formulas and names of the six strong acids.

   a) ___________________________  d) ___________________________
   b) ___________________________  e) ___________________________
   c) ___________________________  f) ___________________________

3. Which one of the following has the weakest conjugate base?

   c) HF  e) HIO₃  e) HC₂H₃O₂  e) H₂SO₃  e) HClO₄

4. What is the conjugate base of HSeO₄⁻²?

   a) H₂O⁻  b) H₂SeO₄  c) H₂SeO₃  d) H₂Se  e) SeO₄⁻²

5. Given the net ionic equation:

   \[ H₂O(l) + HSO₄⁻¹(aq) \rightarrow SO₄⁻²(aq) + H₃O⁺(aq) \]

   a) H₂O is an acid and H₃O⁺ is its conjugate acid.  d) H₂O is a Lewis acid because it is a proton donor.
   b) H₂O is an acid and SO₄⁻² is its conjugate base.  e) HSO₄⁻¹ is an acid and SO₄⁻² is its conjugate base.
   c) HSO₄⁻¹ is a Bronsted acid because it is a proton acceptor.

6. For a given weak acid, HA, the value of Kₐ

   a) will change with the pH.  d) cannot be less than 1 x 10⁻⁷.
   b) will change with the pOH.  e) cannot be greater than 1 x 10⁻⁷.
   c) will change with temperature.

7. Which of the following salts when added to water will not change the pH?

   a) NaHCO₃  b) NaHSO₄  c) KNO₃  d) NH₄NO₃  e) NaNO₂
8. Calculate the **pH of seawater** whose hydrogen-ion concentration is $1.9 \times 10^{-9}$ M.

$$\text{pH} = \rule{3cm}{0.5mm}$$

9. The pH of a bowl of tomato soup at 25°C is 4.82. What is the **hydrogen-ion concentration**?

$$[\text{H}^+] = \rule{3cm}{0.5mm}$$

10. Milk of Magnesia has a pH of 9.40. Calculate the **hydroxide ion concentration**, $[\text{OH}^-]$.

$$[\text{OH}^-] = \rule{3cm}{0.5mm}$$

11. Which of the following should be the **stronger acid** and why? HBrO$_4$ or HIO$_4$?

12. A 0.10 M solution of a weak monoprotic acid has a hydrogen ion concentration of $2.0 \times 10^{-4}$. **What is the equilibrium constant**, $K_a$, for this acid?

$$K_a = \rule{3cm}{0.5mm}$$

13. What is the **hydrogen ion concentration**, $[\text{H}^+]$, in a titration when 500.0 mL of 0.25 M NaOH has been added to 500.0 mL of 0.20 M HBr? (Note that the resulting salt is neutral)

$$[\text{H}^+] = \rule{3cm}{0.5mm}$$

14. What is the **pOH** of a 0.15 M aqueous solution of the weak base pyridine, C$_5$H$_5$N ($K_{b} = 4.0 \times 10^{-9}$)?

\[ \text{C}_5\text{H}_5\text{N} + \text{H}_2\text{O} \rightleftharpoons \text{C}_5\text{H}_5\text{NH}^+ + \text{OH}^- \]

$$\text{pOH} = \rule{3cm}{0.5mm}$$
15. Tellurous acid, $\text{H}_2\text{TeO}_3^-$, can interact with water in two stages:

$$
\text{H}_2\text{TeO}_3^{\text{aq}} + \text{H}_2\text{O}(l) \rightleftharpoons \text{HTeO}_3^{-1}(\text{aq}) + \text{H}_3\text{O}^{+}(\text{aq}) \quad K_a = 2.0 \times 10^{-5}
$$

$$
\text{HTeO}_3^{-1}(\text{aq}) + \text{H}_2\text{O}(l) \rightleftharpoons \text{TeO}_3^{2-}(\text{aq}) + \text{H}_3\text{O}^{+}(\text{aq}) \quad K_a = 6.2 \times 10^{-8}
$$

What are the equilibrium concentrations of $\text{H}_2\text{O}^{+}$, $\text{HTeO}_3^{-1}$, and $\text{TeO}_3^{2-}$, respectively, in a 0.055 M aqueous solution of tellurous acid?

$$
[\text{H}_2\text{O}^{+}] = 
$$

$$
[\text{HTeO}_3^{-1}] = 
$$

$$
[\text{TeO}_3^{2-}] = 
$$

16. A titration of an acid and a base to the equivalence point results in a noticeably basic solution. It is likely the titration involved:

a) a strong acid and weak base.

b) a weak acid and strong base.

c) a weak acid and weak base (where $K_a$ equals $K_b$)

d) a strong acid and strong base

17. Which one of the following is a buffer solution?

a) 0.40 M HCN and 0.10 M KCN

b) 0.20 M HC$_2$H$_3$O$_2$

c) 1.0 M HNO$_3$ and 1.0 M NaNO$_3$

d) 0.10 M KCN

e) 0.50 M HCl and 0.10 M NaCl

18. What is the pH of a solution that 0.410 M in HClO and also 0.050 M in NaClO ($K_a$ for HClO = $3.2 \times 10^{-8}$)?

a) 0.39

b) 3.94

c) 6.58

d) 7.49

e) 8.40

19. Given the equilibrium constants for the following equilibria at 25°C,

$$
\text{H}^+_{(aq)} + \text{CO}_3^{2-}_{(aq)} \rightleftharpoons \text{HCO}_3^{-1}_{(aq)} \quad K = 2.1 \times 10^{10}
$$

$$
\text{H}^+_{(aq)} + \text{HCO}_3^{-1}_{(aq)} \rightleftharpoons \text{H}_2\text{CO}_3^{2-}_{(aq)} \quad K = 2.4 \times 10^{8}
$$

Calculate the $K$ at 25°C for the following reaction.

$$
\text{H}_2\text{CO}_3^{2-}_{(aq)} \rightleftharpoons 2 \text{H}^+_{(aq)} + \text{CO}_3^{2-}_{(aq)}
$$

a) $5.04 \times 10^{-16}$

b) $1.98 \times 10^{-17}$

c) $4.76 \times 10^{25}$

d) $2.1 \times 10^{10}$

e) none of these

20. You are asked to go into the lab and prepare an acetic acid-sodium acetate buffer with a pH of 4.40. What molar ratio of sodium acetate to acetic acid should be used? (the $K_a$ for acetic acid is $1.8 \times 10^{-5}$)

$$
\frac{\text{NaC}_2\text{H}_3\text{O}_2}{\text{HC}_2\text{H}_3\text{O}_2} = 
$$
21. Diet cola drinks have a pH about 3.0 while milk has a pH of about 7.0. How many times greater is the H⁺ concentration in diet cola than milk?
   a) 2.3 times higher in cola than milk
   b) 400 times higher in cola than milk
   c) 0.43 times higher in cola than milk
   d) 1000 times higher in cola than milk
   e) 10,000 times higher in cola than milk

Questions 22-25 deal with nitrous acid, HNO₂. (Kₐ = 3.5 x 10⁻⁴)

22. A 25.0 mL sample of a 0.120 M nitrous acid solution, HNO₂ (monoprotic), is titrated with 0.160 M NaOH. Calculate the volume of NaOH required to reach the equivalence point.

   mL NaOH = ________________

23. If 25.0 mL of 0.100 M HNO₂ is titrated with 25.0 mL of 0.100 M NaOH, what is the concentration of the nitrite ion, NO₂⁻? 

   [NO₂⁻] = ________________

24. What is the K₆₆ for the nitrite ion discussed in questions #22 and #23?

   K₆₆ = ________________

25. What is the pH of a 0.050 M NaNO₂ solution?

   pH = ________________
1. Which of the following statements is characteristic of acids?
   
   1. They turn blue litmus red.
   2. They neutralize bases.
   3. They increase the pH of aqueous solutions.
   a) 1 only  
   b) 2 only  
   c) 3 only  
   d) 1 and 2 only  
   e) 1, 2, and 3

2. List the formulas and names of the six strong acids.
   a) $\text{HCl}$ HYDROCHLORIC ACID  
   b) $\text{HBr}$ HYDROBROMIC ACID  
   c) $\text{HI}$ HYDROIODIC ACID  
   d) $\text{HNO}_3$ NITRIC ACID  
   e) $\text{H}_2\text{SO}_4$ SULPHURIC ACID  
   f) $\text{HClO}_4$ PERCHLORIC ACID

3. Which one of the following has the weakest conjugate base? (Strongest acid is weakest conjugate)
   c) $\text{HF}$  
   e) $\text{HI}$  
   c) $\text{HC}_2\text{H}_3\text{O}_2$  
   c) $\text{H}_2\text{SO}_3$  
   e) $\text{HClO}_4$

4. What is the conjugate base of $\text{HSeO}_4^{-1}$? (Remove 1 H)
   a) $\text{H}_2\text{O}^-$  
   b) $\text{H}_2\text{SeO}_4$  
   c) $\text{H}_2\text{SeO}_3$  
   d) $\text{H}_2\text{Se}$  
   e) $\text{SeO}_4^{2-}$

5. Given the net ionic equation:
   $$\text{H}_2\text{O}_{(l)} + \text{HSO}_4^{-1}_{(aq)} \rightarrow \text{SO}_4^{2-}_{(aq)} + \text{H}_2\text{O}^+_{(aq)}$$
   a) $\text{H}_2\text{O}$ is an acid and $\text{H}_2\text{O}^+$ is its conjugate acid.
   b) $\text{H}_2\text{O}$ is an acid and $\text{SO}_4^{2-}$ is its conjugate base.
   c) $\text{HSO}_4^{-1}$ is a Bronsted acid because it is a proton acceptor.
   d) $\text{H}_2\text{O}$ is a Lewis acid because it is a proton donor.
   e) $\text{HSO}_4^{-1}$ is an acid and $\text{SO}_4^{2-}$ is its conjugate base.

6. For a given weak acid, $\text{HA}$, the value of $K_a$
   a) will change with the pH.  
   b) will change with the pOH.  
   c) will change with temperature  
   d) cannot be less than $1 \times 10^{-7}$.  
   e) cannot be greater than $1 \times 10^{-7}$.

7. Which of the following salts when added to water will not change the pH?
   a) $\text{NaHCO}_3$  
   b) $\text{NaHSO}_4$  
   c) $\text{KNO}_3$  
   d) $\text{NH}_4\text{NO}_3$  
   e) $\text{NaNO}_2$. 

   CATION OF STRONG BASE  
   ANION OF STRONG ACID
8. Calculate the pH of seawater whose hydrogen-ion concentration is $1.9 \times 10^{-9}$ M.

$$\text{pH} = -\log \left(1.9 \times 10^{-9} \text{ M H}^+\right)$$

$$= 8.72$$

9. The pH of a bowl of tomato soup at 25°C is 4.82. What is the hydrogen-ion concentration?

$$[\text{H}^+] = 10^{-4.82} = 1.51 \times 10^{-5}$$

10. Milk of Magnesia has a pH of 9.40. Calculate the hydroxide ion concentration, [OH⁻].

$$[\text{OH}^-] = \frac{K_{w}}{[\text{H}^+] =} \frac{1 \times 10^{-14}}{3.98 \times 10^{-10}} = 2.5 \times 10^{-5}$$

11. Which of the following should be the stronger acid and why? HBrO₄ or HIO₄?

WHEN # OF OXYGENS ARE NOT AN ISSUE, ACIDIC STRENGTH OF OXO-ACIDS INCREASES WITH INCREASING ELECTRON NEGATIVITY OF THE CENTRAL ATOM. IN THIS CASE, THAT'S BR, SO HBrO₄ IS STRONGER.

12. A 0.10 M solution of a weak monoprotic acid has a hydrogen ion concentration of $2.0 \times 10^{-4}$. What is the equilibrium constant, $K_a$, for this acid?

$$[\text{H}^+] = [\text{A}^-] = 2.0 \times 10^{-4} \quad K_a = \frac{[\text{H}^+] [\text{A}^-]}{[\text{HA}]} = \frac{(2 \times 10^{-4})(2 \times 10^{-4})}{0.1} = 4 \times 10^{-13}$$

13. What is the hydrogen ion concentration, [H⁺], in a titration when 500.0 mL of 0.25 M NaOH has been added to 500.0 mL of 0.20 M HBr? (Note that the resulting salt is neutral)

$$\begin{align*}
\text{NaOH} + \text{HBr} &\rightarrow \text{NaBr} + \text{H}_2\text{O} \\
500.0 \text{ mL} \times 0.25 \text{ M NaOH} &\rightarrow 125 \text{ mmol OH}^- \\
500.0 \text{ mL} \times 0.20 \text{ M HBr} &\rightarrow 100 \text{ mmol H}^+ \\
\left(\frac{25 \text{ mmol excess OH}^-}{1000 \text{ mL}}\right) &\rightarrow 0.025 \text{ M OH}^- \\
\end{align*}$$

$$[\text{H}^+] = \frac{2.5 \times 10^{-14}}{0.025} = 4 \times 10^{-13}$$

14. What is the pOH of a 0.15 M aqueous solution of the weak base pyridine, C₅H₅N (Kₙb = $4.0 \times 10^{-10}$)

$$\text{C}_5\text{H}_5\text{N} + \text{H}_2\text{O} \rightarrow \text{C}_5\text{H}_5\text{NH}^+ + \text{OH}^-$$

$$\text{pOH} = 5.11$$

$$4 \times 10^{-10} = \frac{(x)(x)}{0.15}$$

$$x = \sqrt{(0.15)(4 \times 10^{-10})} = 7.75 \times 10^{-6} = [\text{OH}^-] \quad \Rightarrow \quad \text{pOH} = 5.11$$
15. Tellurous acid, $\text{H}_2\text{TeO}_4$, can interact with water in two stages:

\[
\text{H}_2\text{TeO}_4^{(aq)} + \text{H}_2\text{O}^{(l)} \rightleftharpoons \text{HTeO}_3^{-1}^{(aq)} + \text{H}_3\text{O}^{+1}^{(aq)} \quad K_1 = 2.0 \times 10^{-5}
\]

\[
\text{HTeO}_3^{-1}^{(aq)} + \text{H}_2\text{O}^{(l)} \rightleftharpoons \text{TeO}_3^{2-}^{(aq)} + \text{H}_2\text{O}^{+1}^{(aq)} \quad K_2 = 6.2 \times 10^{-8}
\]

What are the equilibrium concentrations of $\text{H}_2\text{O}^{+1}$, $\text{HTeO}_3^{-1}$ and $\text{TeO}_3^{2-}$, respectively, in a 0.055 M aqueous solution of tellurous acid?

\[
x = \sqrt{0.055 \times (2 \times 10^{-5})} = 1.05 \times 10^{-3} = [\text{H}_3\text{O}^{+}] \\
= \sqrt{0.055 \times (2 \times 10^{-5})} = 1.05 \times 10^{-3} = [\text{HTeO}_3^{-1}]
\]

16. A titration of an acid and a base to the equivalence point results in a noticeably basic solution. It is likely the titration involved:

- a) a strong acid and weak base.
- b) a weak acid and strong base.
- c) a weak acid and weak base (where $K_a$ equals $K_b$)
- d) a strong acid and strong base.

17. Which one of the following is a buffer solution?

- a) 0.40 M HCN and 0.10 M KCN
- b) 0.20 M HCl and 1.0 M NaI
- c) 1.0 M HNO$_3$ and 1.0 M NaNO$_3$
- d) 0.10 M KCN
- e) 0.50 M HCl and 0.10 M NaCl

18. What is the pH of a solution that 0.410 M in HClO and also 0.050 M in NaClO ($K_a$ for HClO = $3.2 \times 10^{-8}$)?

- a) 0.39
- b) 3.94
- c) 6.58
- d) 7.49
- e) 8.40

19. Given the equilibrium constants for the following equilibria at 25°C,

\[
\text{H}_2\text{O}^{(l)} + \text{CO}_3^{2-}^{(aq)} \rightleftharpoons \text{HCO}_3^{-1}^{(aq)} \quad K = 2.1 \times 10^{16}
\]

\[
\text{H}_2\text{O}^{(l)} + \text{HCO}_3^{-1}^{(aq)} \rightleftharpoons \text{H}_2\text{CO}_3^{(aq)} \quad K = 2.4 \times 10^6
\]

Calculate $K$ at 25°C for the following reaction.

\[
\text{H}_2\text{CO}_3^{(aq)} \rightarrow 2 \text{H}^{+1}^{(aq)} + \text{CO}_3^{2-}^{(aq)}
\]

- a) $5.04 \times 10^{-16}$
- b) $1.98 \times 10^{-17}$
- c) $4.76 \times 10^{-25}$
- d) $2.1 \times 10^{-10}$
- e) none of these

20. You are asked to go into the lab and prepare an acetic acid-sodium acetate buffer with a pH of 4.40. What molar ratio of sodium acetate to acetic acid should be used? (the $K_a$ for acetic acid is $1.8 \times 10^{-5}$)

\[\log \frac{[\text{Ac}^3]}{[\text{HAc}]} = -0.34 \quad \text{so} \quad \frac{[\text{Ac}^3]}{[\text{HAc}]} = 10 \quad \Rightarrow \text{pH} = 0.46.\]
21. Diet cola drinks have a pH about 3.0 while milk has a pH of about 7.0. How many times greater is the \( \text{H}^+ \) concentration in diet cola than milk?

- a) 2.3 times higher in cola than milk
- b) 400 times higher in cola than milk
- c) 0.43 times higher in cola than milk
- d) 1,000 times higher in cola than milk
- e) 10,000 times higher in cola than milk

Questions 22-25 deal with nitrous acid, \( \text{HNO}_2 \). \( K_a = 3.5 \times 10^{-4} \)

22. A 25.0 mL sample of a 0.120 M nitrous acid solution, \( \text{HNO}_2 \) (monoprotic), is titrated with 0.100 M \( \text{NaOH} \). Calculate the volume of \( \text{NaOH} \) required to reach the equivalence point.

\[
\text{ml NaOH} = \frac{(25.0 \text{ mL})(0.120 \text{ M H}^+)}{(0.100 \text{ M OH}^-)} = 18.75 \text{ ml}
\]

23. If 25.0 mL of 0.100 M \( \text{HNO}_2 \) is titrated with 25.0 mL of 0.100 M \( \text{NaOH} \), what is the concentration of the nitrite ion, \( \text{NO}_2^- \)?

2.5 mmol of \( \text{NO}_2^- \)

\[
\text{NOS in 50 mL} = \frac{2.5 \text{ mmol NO}_2^-}{50 \text{ mL}} = 0.05 \text{ M}
\]

\[ [\text{NO}_2^-] = 0.05 \text{ M} \]

24. What is the \( K_{\text{bn}} \) for the nitrite ion discussed in questions #22 and #23?

\[ K_{\text{bn}} = \frac{K_a}{K_w} = \frac{1 \times 10^{-14}}{3.5 \times 10^{-4}} = 2.9 \times 10^{-11} \]

\[ K_{\text{bn}} = 2.9 \times 10^{-11} \]

25. What is the pH of a 0.050 M \( \text{NaNO}_2 \) solution?

\[
\text{pH} = 8.08
\]

\[ \text{pOH} = 5.92 \]

\[ \text{pH} = 8.08 \]