Review for Unit Test 6: Acids, Bases and Salts (Chapter 8)

Objectives:

1. Write definitions for, or explain the meaning of: Bronsted-Lowry acid and base, neutral, strong acid, strong base, weak acid, weak base, concentrated, dilute, ionization, dissociation, hydrolysis, pH, $K_w$, $K_a$ and $K_b$.

2. Understand what is meant by the terms: salt, hydrolyze, percent dissociation, conjugate acid-base pair, parent acid, parent base, amphiprotic (amphoteric), monoprotic and polyprotic.

3. Does the H+ ion exist in aqueous solution? Explain why or why not.

4. Know the general chemical and physical properties of acids and bases.

5. Be able to recognize acids, bases and salts from their chemical formulas.

6. Be able to name common acids and bases, using an ion chart.

7. Be able to recognize strong acids and bases, from their names or chemical formulas.

8. Identify or describe chemical and physical properties that could be used to distinguish between:
   a) acids, bases and salts
   b) strong and weak acids
   c) strong and weak bases

9. Be able to predict the products of the following types of reactions:
   a) acids and metals
   b) acids and carbonates
   c) acids and bases
   d) Group I and II metal oxides in water

10. Be able to identify conjugate acid/base pairs.

11. Be able to write the ionization reactions of weak acids and bases, and their conjugate partners, in water.

12. Be able to write and use the $K_a$ and $K_b$ expressions of weak acids and bases. What factor(s) affect the value of $K_a$ and $K_b$?

13. Be able to predict whether a salt will dissolve in water to form an acidic, basic or neutral solution. Write any ionization (hydrolysis) reactions that may take place.

14. Know, and be able to apply, the relationships between the following:
   a) pH and pOH
   b) $[H_3O^+]$ and $[OH^-]$
   c) $K_a$, $K_b$ and $K_w$

15. Be able to calculate the pH of solutions of:
   a) strong acids
   b) strong bases
   c) weak acids and acid salts
   d) weak bases and basic salts

16. Be able to calculate $K_a$ or $K_b$ given:
   a) the initial concentration of an acid or base and the pH of the final solution
   b) the $K_a$ or $K_b$ for its conjugate partner

17. Be able to calculate percent dissociation (ionization) for weak acids and bases.
Sample Questions: Review for Acids, Bases and Salts

1. Acids are proton ______________. Complete the following chart for these acids:

<table>
<thead>
<tr>
<th>Acid</th>
<th>Ionization Reaction in Water</th>
<th>Conjugate Base</th>
<th>Ka</th>
<th>Kb</th>
</tr>
</thead>
<tbody>
<tr>
<td>H_2SO_3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCHO_2</td>
<td></td>
<td></td>
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<tr>
<td>HPO_4^{2-}</td>
<td></td>
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<tr>
<td>H_2O</td>
<td></td>
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<tr>
<td>NH_4^{1+}</td>
<td></td>
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<tr>
<td>HCO_3^{1-}</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>H_2SO_4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C_5H_5NH^+</td>
<td></td>
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</tbody>
</table>

2. Bases are proton ______________. Complete the following chart for these bases:

<table>
<thead>
<tr>
<th>Base</th>
<th>Ionization Reaction</th>
<th>Conjugate Acid</th>
<th>Ka</th>
<th>Kb</th>
</tr>
</thead>
<tbody>
<tr>
<td>ClO^-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N_2H_4 (aq)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CH_3COO^-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HPO_4^{2-}</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F^-</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>H_2O</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH_2OH</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>NH_3</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>C_5H_5N</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>HCO_3^{1-}</td>
<td></td>
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</tr>
</tbody>
</table>

3. For nitrogen compounds, how can you recognize when they will behave as bases? As acids?

4. As a general rule for weak acids and bases, negative ions in solution will behave as __________.

5. Using your knowledge of trends for acid strengths, arrange the following acids in order from highest to lowest strength: HCl, H_3PO_4, HI, H_3PO_3

6. Using Ka values, arrange the following acids in order from highest to lowest strength:

   HNO_2, H_3PO_4, HF, HCH_3COO, H_2S, H_2SO_3, H_2CO_3

7. Which of the acids in Q6 has the strongest conjugate base? __________

8. Calculate the pH of the following solutions:
   a) 15.4 g of potassium hydroxide in a total volume of 600.0 mL solution (13.660, 3 decimal places)
   b) 125 mL of 15.0 M of nitric acid diluted to 1.00 litre of solution (-0.273, 3 decimal places)
   c) a 0.0125 M solution of magnesium hydroxide (12.398, 3 decimal places)
   d) a 1.35 M solution of acetic acid (2.31, 2 decimal places from K_a)
   e) a 2.00 M solution of pyridine (C_5H_5N) (9.77, 2 decimal places from K_b)
   f) 0.555 M solution of hypobromite ion (from sodium hypobromite) (11.15, 2 decimals from K_a)
   g) 100.0 mL of 18.0 M H_2SO_4 diluted to 500.0 mL of solution (-0.556, 3 decimal places)
9. Complete the following chart. Include the correct number of sig digs in your answers:

<table>
<thead>
<tr>
<th>pH</th>
<th>pOH</th>
<th>[H$_3$O$^+$]</th>
<th>[OH$^-$]</th>
<th>acid/base/neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.25</td>
<td></td>
<td>4.63 x 10$^{-10}$</td>
<td>9.10</td>
<td></td>
</tr>
<tr>
<td>5.00</td>
<td></td>
<td></td>
<td>0.750</td>
<td></td>
</tr>
</tbody>
</table>

10. The following reaction strongly favours the reactants:
   \[
   \text{HCO}_3^-(aq) + \text{HSO}_4^-(aq) \leftrightarrow \text{CO}_3^{2-}(aq) + \text{H}_2\text{SO}_4(aq)
   \]
   a) the strongest acid in this system is: _________________________
   b) the strongest base in this system is: _________________________
   c) Will this reaction have a large or small value of $K_{eq}$? __________ Explain.

11. The pH of a 0.16 M solution of phenolic acid is 3.20.
   a) What is the $K_a$ for phenolic acid? \(K_a = 2.5 \times 10^{-6}\)
   b) What is the percent dissociation of the acid in this solution? (only 0.39% dissociated)

12. Name the following substances and then predict whether their solutions will be acidic, basic or neutral:
   a) NaCH$_3$COO _____________________________________________________________________
   b) NH$_4$Cl _____________________________________________________________________
   c) Li$_2$O _____________________________________________________________________
   d) Sr(NO$_3$)$_2$ _____________________________________________________________________
   e) HBrO (HOBr) _____________________________________________________________________
   f) CoBr$_2$ _____________________________________________________________________
   g) Cr(NO$_3$)$_2$ _____________________________________________________________________
   h) Na$_3$PO$_4$ _____________________________________________________________________
   i) HSCN _____________________________________________________________________
   j) CaC$_2$O$_4$ _____________________________________________________________________
   k) Mg(ClO$_3$)$_2$ _____________________________________________________________________
   l) K$_3$BO$_3$ _____________________________________________________________________
   m) SnCl$_4$ _____________________________________________________________________

13. What are two tests or properties you could distinguish between the following solutions?
   a) NaCl and NaClO _____________________________________________________________________
   b) H$_2$O and Li$_2$O _____________________________________________________________________
   c) HClO$_2$ and HClO$_3$ _____________________________________________________________________
   d) H$_2$S and Na$_2$S _____________________________________________________________________
   e) Ca(OH)$_2$ and Co(OH)$_2$ _____________________________________________________________________

14. Write the products of the following reactions (if any) and then balance each reaction:
   a) Mg (s) + CH$_3$COOH (aq) →
   b) NaOH (aq) + Ba (s) →
   c) HBrO$_3$ (aq) + K$_2$CO$_3$ (s) →
   d) K$_2$O (s) + H$_2$O (l) →
Long Calculation Questions: Be prepared to write out full solutions to questions such as:

1. The pH of a 0.10 M solution of periodic acid, HIO₄, is 1.42. Calculate the Kₐ for periodic acid. (Kₐ = 0.023)

2. Butanoic acid, C₃H₇COOH, is found in small quantities in human perspiration and is responsible for the foul odour often associated with locker rooms. A 0.0010 mol/L solution of butanoic acid has a pH of 3.91 at 25°C. Calculate the acid dissociation constant (Kₐ) of butanoic acid. (Kₐ = 1.7 x 10⁻⁵)

3. What is the percent ionization of a 0.18 M solution of cyanic acid, HOCN? (4.4%)

4. What is the percent ionization of 0.20 M CH₃NH₂ (aq) if the pH of the solution is 11.90? (4.0%)

5. Calculate the pH of a 0.040 M solution of CsBrO (aq). (pH = 10.58)

6. Calculate the pH of a 1.00 M solution of N₂H₃Cl (aq). (pH = 4.06)

Practice Multiple Choice Questions: Acids, Bases and Salts

1. Which of the following is typical of bases?
   a) conduct electric current in solution       b) taste sour       c) concentration of H₃O⁺ > concentration of OH⁻
   d) turns litmus red

2. Which of the following is/are properties of strong acids?
   I) they react with carbonates to produce hydrogen gas
   II) they have very high pH
   III) they are good electrolytes
   IV) they turn phenolphthalein pink
   a) I, II and III only                         b) I and IV only
   c) III only                                  d) II and III only

3. A student tests a solution. It is colourless with phenolphthalein, green with bromothymol blue and a good electrolyte. This solution is probably:
   a) hydrofluoric acid                          b) calcium hydroxide
   c) potassium sulfate                         d) ammonium nitrate

4. Which of the following substances will have the highest percent dissociation (ionization)?
   a) H₂S                                           b) H₂SO₄
   c) H₂SO₃                                         d) H₃PO₄

5. Which of the following substances will ionize in water?
   I) CH₃COOH
   II) Mg(OH)₂
   III) NH₃
   IV) Fe(OH)₃
   a) I only                                       b) I and III only
   c) II and IV only                              d) I, II, III and IV

6. Which of the following aqueous solutions will have the highest pH?
   a) MgSO₄ (aq)                                   b) (NH₄)₂SO₄ (aq)
   c) Na₂C₂O₄ (aq)                                d) HClO₂ (aq)
7. Which of the following substances would be classified as salts?
   I) NaHCO₃
   II) K₃PO₄
   III) LiH₂C₂O₄
   IV) NH₄SCN
   a) I, II, III and IV  c) II and IV only
   b) I, II and III  d) II only

8. Which of the following is/are polyprotic, strong acids?
   I) HNO₃
   II) HClO₄
   III) H₂SO₄
   IV) H₃PO₄
   a) I, II, III and IV  c) III and IV only
   b) II and III only  d) III only

9. Which of the following will have the lowest electrical conductivity?
   a) 1.00 M H₂SO₄ (aq)  c) 1.00 M HNO₃ (aq)
   b) 1.00 M H₃PO₄ (aq)  d) 1.00 M HCl (aq)

10. The conjugate base of H₂PO₄⁻ is
    a) HPO₄⁻²  b) HPO₄⁻³  c) H₃PO₄  d) OH⁻

11. The value of K_b for H₂PO₄⁻ is
    a) 1.4 x 10⁻¹²  b) 6.2 x 10⁻⁸  c) 1.6 x 10⁻⁷  d) 7.5 x 10⁻³

12. What is the pH of a 0.10 M Sr(OH)₂ solution?
    a) 0.20  b) 0.70  c) 13.30  d) 13.00

13. Which of the species below is/are present in a reagent bottle labelled 1.0M H₂SO₄?
    I) H₂SO₄ (aq)
    II) HSO₄⁻¹ (aq)
    III) SO₄²⁻ (aq)
    a) I only  c) II and III only
    b) I and II only  d) I, II and III

14. A 0.20 M solution of hydrobromic acid is best described as:
    a) strong and dilute  c) strong and concentrated
    b) weak and concentrated  d) weak and dilute

15. Which of the following statements is/are true about neutralization reactions?
    a) the products of all neutralization reactions are neutral
    b) when strong acids are neutralized with strong bases, the reaction goes to completion
    c) when strong acids are neutralized with weak bases, the reaction does not go to completion
    d) all of the above

16. Which of the following is the relationship between [H₃O⁺] and [OH⁻] in any aqueous solution?
    a) [H₃O⁺] + [OH⁻] = 1.0 x 10⁻¹⁴  c) [H₃O⁺] [OH⁻] = 1.0 x 10⁻¹⁴
    b) [H₃O⁺] + [OH⁻] = 14  d) [H₃O⁺] [OH⁻] = 14
17. Which of the following tests could be used to distinguish between HI (aq) and HIO₃ (aq)?
   I) the rate of reaction with magnesium metal
   II) pH
   III) the reaction with blue litmus paper
   IV) the reaction with phenolphthalein
   a) I and II only   c) I, II, III and IV
   b) III and IV only  d) none of these tests will distinguish these substances

18. What are the two Bronsted-Lowry bases in this equilibrium?
   \[ \text{HSO}_3^- + \text{H}_2\text{PO}_4^- \rightleftharpoons \text{SO}_3^{2-} + \text{H}_3\text{PO}_4^- \]
   a) HSO₃⁻ (aq) and H₂PO₄⁻ (aq)   c) SO₃²⁻ (aq) and HSO₃⁻ (aq)
   b) H₂PO₄⁻ (aq) and H₃PO₄ (aq)   d) H₂PO₄⁻ (aq) and SO₃²⁻ (aq)

19. What is the pH of a solution of NiCl₃ and what ion determines this?
   a) solution is basic because of Ni³⁺ (aq)   c) solution is acidic because of Ni³⁺ (aq)
   b) solution is basic because of Cl¹⁻ (aq)   d) solution is acidic because of Cl¹⁻ (aq)

20. Which of the following solutions has a pH less than 7.00?
   a) NH₄NO₃ (aq)   c) LiOH (aq)
   b) NaCl (aq)   d) KCH₃COO (aq)

21. Which of the following ions will hydrolyze?
   a) NO₃⁻ (aq)   c) F⁻ (aq)
   b) I⁻ (aq)   d) ClO₃⁻ (aq)

22. The amphiprotic ions are:
   a) I and II only   b) II and III only
   c) I and III only   d) I, II and III

23. What is the pH of a solution of (NH₄)₂SO₄ and what ion determines this?
   a) solution is basic because of NH₄¹⁺ (aq)   c) solution is acidic because of NH₄¹⁺ (aq)
   b) solution is basic because of SO₄²⁻ (aq)   d) solution is acidic because of SO₄²⁻ (aq)

24. Which of the following solutions will have the lowest electrical conductivity?
   a) 0.1M NaHSO₃ (aq)   c) 0.1M NaF (aq)
   b) 0.1M H₂SO₃ (aq)   d) 0.1M HF (aq)

25. The conjugate acid of HAsO₄²⁻ is:
   a) H₂AsO₄⁻ (aq)   c) H₃AsO₄ (aq)
   b) AsO₄³⁻ (aq)   d) H₃O⁺ (aq)

26. Which of the following 1.0M solutions would have a pH greater than 7.00?
   a) NaCH₃COO (aq)   c) NH₄Cl (aq)
   b) HCN (aq)   d) KNO₃ (aq)

27. The relationship shown to the far right is the
   a) Kₐ for H₂P₂O₇⁻ (aq)   c) Kₐ for H₂P₂O₇⁻ (aq)
   b) K₈ for H₂P₂O₇⁻ (aq)   d) K₈ for H₂P₂O₇⁻ (aq)
28. The value of $K_b$ for $\text{HPO}_4^{2-}$ is
   a) $2.1 \times 10^{-2}$  
   b) $6.2 \times 10^{-8}$  
   c) $2.2 \times 10^{-13}$  
   d) $1.6 \times 10^{-7}$

29. Which of the following graphs describes the relationship between pH and pOH?
   a) ![Graph A]  
   b) ![Graph B]  
   c) ![Graph C]  
   d) ![Graph D]

30. The value of $K_b$ for hydrogen oxalate ($\text{HC}_2\text{O}_4^-$) is:
   a) $6.7 \times 10^{-11}$  
   b) $5.6 \times 10^{-2}$  
   c) $1.8 \times 10^{-13}$  
   d) $1.5 \times 10^{-4}$

31. The $K_b$ expression for $\text{HSe}^-$ is
   a) $K_b = \frac{[\text{H}_2\text{Se}[\text{OH}^-]}{[\text{HSe}^-]}$  
   b) $K_b = \frac{[\text{HSe}^-][\text{H}_3\text{O}^+]}{[\text{H}_2\text{Se}]}$
   c) $K_b = \frac{[\text{HSe}^-][\text{OH}^-]}{[\text{Se}^2-]}$
   d) $K_b = \frac{[\text{Se}^2-][\text{H}_3\text{O}^+]}{[\text{HSe}^-]}$

32. The $K_b$ expression for the reaction of $\text{HC}_2\text{O}_4^-$ with water is:
   a) $K_b = \frac{[\text{HC}_2\text{O}_4^-]}{[\text{C}_2\text{O}_4^{2-}][\text{OH}^-]}$  
   b) $K_a = \frac{[\text{C}_2\text{O}_4^{2-}][\text{H}_3\text{O}^+]}{[\text{HC}_2\text{O}_4^-]}$
   c) $K_a = \frac{[\text{HC}_2\text{O}_4^-][\text{H}_3\text{O}^+]}{[\text{C}_2\text{O}_4^{2-}]}$
   d) $K_b = \frac{[\text{H}_2\text{C}_2\text{O}_4][\text{OH}^-]}{[\text{HC}_2\text{O}_4^-]}$

33. Which species is/ are amphiprotic?
   a) I and II only  
   b) II and III only  
   c) I and III only  
   d) I, II and III

34. Which of the following represents the ionization of water?
   a) $\text{H}_2\text{O} \rightleftharpoons \frac{1}{2}\text{O}_2 + 2\text{H}^+ + 2\text{e}^-$  
   b) $2\text{H}_2\text{O} + \text{O}_2 \rightleftharpoons 2\text{H}_2\text{O}_2$  
   c) $2\text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{OH}^-$  
   d) $\text{H}_2\text{O} \rightleftharpoons \text{H}_2 + \frac{1}{2}\text{O}_2$

35. The relationship shown is the expression for:
   a) $K_b$ for $\text{H}_3\text{BO}_3$  
   b) $K_b$ for $\text{H}_2\text{BO}_3^-$  
   c) $K_a$ for $\text{H}_3\text{BO}_3$  
   d) $K_a$ for $\text{H}_2\text{BO}_3^-$

36. Which of the following represents the reaction between MgO and H$_2$O?
   a) $\text{MgO} + \text{H}_2\text{O} \rightarrow \text{Mg(OH)}_2$  
   b) $2\text{MgO} + \text{H}_2\text{O} \rightarrow 2\text{MgOH} + \frac{1}{2}\text{O}_2$  
   c) $\text{MgO} + \text{H}_2\text{O} \rightarrow \text{Mg} + \text{H}_2\text{O}_2$  
   d) $\text{MgO} + \text{H}_2\text{O} \rightarrow \text{MgH}_2 + \text{O}_2$
37. The salt produced by the reaction of HSCN (aq) and Mg(OH)\(_2\) (s) will be:
   a) neutral  b) acidic  c) basic  d) no such reaction will occur

38. Arrange the following 0.10 M solutions in order from highest to lowest pH:
   HBr (aq)  HBrO (aq)  HBrO\(_2\) (aq)  HBrO\(_3\) (aq)
   a) HBr (aq) > HBrO (aq) > HBrO\(_2\) (aq) > HBrO\(_3\) (aq)
   b) HBrO (aq) > HBrO\(_2\) (aq) > HBrO\(_3\) (aq) > HBr (aq)
   c) HBr (aq) > HBrO\(_3\) (aq) > HBrO\(_2\) (aq) > HBrO (aq)
   d) HBrO\(_3\) (aq) > HBrO\(_2\) (aq) > HBrO (aq) > HBr (aq)

39. Calculate the [OH\(^{-}\)] of a solution if the pH = 11.00:
   a) 0.0010 M  b) 1.0 x 10\(^{-11}\) M  c) 11 M  d) -1.0 x 10\(^{-11}\)

40. Calculate the pH of a solution if it contains 0.22 mol/L Ba(OH)\(_2\)
   a) 0.44  b) 0.36  c) 13.64  d) 13.34

41. Sodium benzoate (NaC\(_6\)H\(_5\)COO) is the salt of benzoic acid, C\(_6\)H\(_5\)COOH. It is commonly used as a
   food preservative. A solution of this salt is:
   a) acidic  b) basic  c) neutral  d) insoluble in water

42. What is the percent ionization of a 0.95 M solution of HF at 25°C?
   a) 95%  b) 0.063%  c) 2.6%  d) 6.0%

43. 25.0 mL of 12.0 M HCl is diluted to a final volume of 500.0 mL. What is the concentration of the
   solution?
   a) 0.600 M  b) 0.00600 M  c) 2.40 M  d) 9.60 M

44. 32.5 g of Fe(SCN)\(_2\) are dissolved in 2.00 L of solution. What is the molar concentration?
   a) 0.143 M  b) 0.189 M  c) 0.0945 M  d) 0.378 M

45. 6.75 g of solid calcium hydroxide is dissolved in 250.0 mL of solution. What is the [OH\(^{-}\)]?
   a) 0.364 M  b) 0.473 M  c) 0.946 M  d) 0.729 M

46. How many grams of NaOH must be dissolved in 1.00 L of solution to make a final concentration of
   0.10 M NaOH?
   a) 40.0 g  b) 4.00 g  c) 0.400 g  d) 1.00 g

47. Which of these 1.00 M solutions will have the highest pH?
   a) CH\(_3\)OH  b) Ca(NO\(_3\))\(_2\)  c) HCl  d) NH\(_4\)OH

48. Which salt is not neutral?
   a) MgCl\(_2\)  b) LiClO\(_2\)  c) Ba(NO\(_3\))\(_2\)  d) CsBr

49. Which one of the following is a strong electrolyte?
   a) H\(_2\)O  b) HF  c) KF  d) HNO\(_2\)

50. The pOH of a solution of NaOH is 11.30. What is the [H\(^{+}\)] for this solution?
   a) 2.0 x 10\(^{-3}\)  b) 5.0 x 10\(^{-12}\)  c) 2.5 x 10\(^{-3}\)  d) 4.0 x 10\(^{-12}\)

51. The [H\(_3\)O\(^{+}\)] in a 0.050 M solution of Ba(OH)\(_2\) is:
   a) 1.0 x 10\(^{-3}\) M  c) 5.0 x 10\(^{-2}\) M
   b) 1.0 x 10\(^{-13}\) M  d) 5.0 x 10\(^{-10}\) M
52. What is the approximate pH of a solution labeled $6 \times 10^{-5}$ M HBr?
   a) 4.2    b) 5.8    c) 4.5    d) 9.8

53. What is the pH of 500.0 mL of solution containing 0.0124 grams of Ca(OH)$_2$?
   a) 11.04   b) 2.96   c) 9.68   d) 10.83

54. The pH of a solution is 4.80. What is the concentration of hydroxide ions in this solution?
   a) $4.2 \times 10^{-9}$ M   b) $3.6 \times 10^{-12}$ M   c) $1.6 \times 10^{-5}$ M   d) $6.3 \times 10^{-10}$ M

55. A solution in which $[H^+] = 1 \times 10^{-8}$ M has a pOH of ___ and is ___________.
   a) 8.0, acidic   b) 8.0, basic   c) 6.0, acidic   d) 6.0, basic

56. A 0.020 M solution of an unknown weak acid has a pH of 3.70. What is the $K_a$ of this acid?
   a) $2.0 \times 10^{-6}$   b) $6.3 \times 10^{-4}$   c) $1.3 \times 10^{-5}$   d) $1.6 \times 10^{-3}$

57. What is the approximate pH of a solution labeled 0.05 M HClO?
   a) 5.1   b) 4.3   c) 3.9   d) 2.1

58. What is the pH of a solution labeled 0.3 M (CH$_3$)$_3$N?
   a) 9.5   b) 9.2   c) 10.8   d) 11.6

59. Which of the following solutions has the lowest pH at 25$^\circ$C?
   a) 0.2 M sodium hydroxide   b) 0.2 M ammonia   c) 0.2 M hypochlorous acid   d) 0.2 M benzoic acid

60. A 0.10 M solution of a weak acid, HX, is 0.059% ionized. Evaluate $K_a$ for the acid.
   a) $3.5 \times 10^{-8}$   b) $7.0 \times 10^{-6}$   c) $6.5 \times 10^{-7}$   d) $4.2 \times 10^{-6}$

61. What is the percent ionization of an 1.2 M HF solution?
   a) 2.3 %   b) 0.84 %   c) 4.2 %   d) 0.22 %

62. Which of the following weak acids ionizes to give the strongest conjugate base?
   a) HClO   b) HF   c) CH$_3$COOH   d) HCN

63. What is $K_b$ for the cyanide ion, CN$^-$.
   a) $1.6 \times 10^{-5}$   b) $6.2 \times 10^{-10}$   c) $1.0 \times 10^{-7}$   d) $8.4 \times 10^{-9}$

64. What is the pH of a 0.50 M solution of NaNO$_2$?
   a) 7.00   b) 1.82   c) 5.52   d) 8.48

65. What is the concentration of a sodium acetate solution if the pH of the solution is 9.19?
   a) 0.30 M   b) 2.1 M   c) 0.43 M   d) 0.068 M

66. What is the pH of 0.060 M NH$_4$Cl?
   a) 5.06   b) 5.18   c) 5.12   d) 5.24

67. What is the concentration of ammonium chloride in a solution if its pH is 4.80?
   a) 0.25 M   b) 0.45 M   c) 0.30 M   d) 0.60 M