Acids, Bases, and Properties - HW

PSI AP Chemistry                                Name____________________________

Earlier definitions, conjugate acid/base, strong and weak acids and bases, Ka and Kb
relation to the strength of the acid or base, pH, pOH, [OH−], [H+] , percent ionization of
weak acid/base

1) According to the Arrhenius concept, an acid is a substance that __________.
   A) is capable of donating one or more H⁺
   B) causes an increase in the concentration of H⁺ in aqueous solutions
   C) can accept a pair of electrons to form a coordinate covalent bond
   D) reacts with the solvent to form the cation formed by autoionization of that solvent
   E) tastes bitter

2) A Brønsted-Lowry base is defined as a substance that __________.
   A) increases [H⁺] when placed in H₂O
   B) decreases [H⁺] when placed in H₂O
   C) increases [OH−] when placed in H₂O
   D) acts as a proton acceptor
   E) acts as a proton donor

3) A Brønsted-Lowry acid is defined as a substance that __________.
   A) increases Kₐ when placed in H₂O
   B) decreases [H⁺] when placed in H₂O
   C) increases [OH−] when placed in H₂O
   D) acts as a proton acceptor
   E) acts as a proton donor

4) A substance that is capable of acting as both an acid and as a base is __________.
   A) autosomal
   B) conjugated
   C) amphoteric
   D) saturated
   E) miscible

5) The molar concentration of hydronium ion in pure water at 25 °C is __________.
   A) 0.00
   B) 1.0 x 10⁻⁷
   C) 1.0 x 10⁻¹⁴
   D) 1.00
   E) 7.00

6) The molar concentration of hydroxide ion in pure water at 25 °C is __________.
   A) 1.00
   B) 0.00
   C) 1.0 x 10⁻¹⁴
   D) 1.0 x 10⁻⁷
   E) 7.00
7) The magnitude of $K_w$ indicates that __________.
A) water autoionizes very slowly
B) water autoionizes very quickly
C) water autoionizes only to a very small extent
D) the autoionization of water is exothermic

8) In basic solution, __________.
A) $[H_3O^+] = [OH^-]$
B) $[H_3O^+] > [OH^-]$
C) $[H_3O^+] < [OH^-]$
D) $[H_3O^+] = 0$ M
E) $[OH^-] > 7.00$

9) Which solution below has the highest concentration of hydroxide ions?
A) pH = 3.21
B) pH = 12.6
C) pH = 7.93
D) pH = 9.82
E) pH = 7.00

10) Which one of the following statements regarding $K_w$ is false?
A) $pK_w$ is 14.00 at 25 °C
B) The value of $K_w$ is $1.0 \times 10^{-14}$
C) $K_w$ changes with temperature.
D) The value of $K_w$ shows that water is a weak acid.
E) $K_w$ is known as the ion product of water.

11) The hydride ion, $H_3O^-$, is a stronger base than the hydroxide ion, $OH^-$. The product(s) of the reaction of hydride ion with water is/ are __________.
A) $H_3O^+ (aq)$
B) $OH^- (aq) + H_2(aq)$
C) $OH^- (aq) + 2H^+(aq)$
D) no reaction occurs
E) $H_2O_2 (aq)$

12) An aqueous solution contains 0.10 M NaOH. The solution is __________.
A) very dilute
B) highly colored
C) basic
D) neutral
E) acidic

13) Nitric acid is a strong acid. This means that __________.
A) aqueous solutions of HNO₃ contain equal concentrations of $H^+$ (aq) and $OH^-$ (aq)
B) HNO₃ does not dissociate at all when it is dissolved in water
C) HNO₃ dissociates completely to $H^+$ (aq) and $NO_3^-$ (aq) when it dissolves in water
D) HNO₃ produces a gaseous product when it is neutralized
E) HNO₃ cannot be neutralized by a weak base

14) Of the following acids, __________ is not a strong acid.
A) HNO₂
B) H₂SO₄
C) HNO₃
D) HClO₄
E) HCl

15) Of the following, __________ is a weak acid.
A) HF
B) HCl
C) HBr
D) HNO₃
E) HClO₄

16) Which one of the following is the weakest acid?
A) HF (Kₐ = 6.8 x 10⁻⁴)
B) HClO (Kₐ = 3.0 x 10⁻⁸)
C) HNO₂ (Kₐ = 4.5 x 10⁻⁴)
D) HCN (Kₐ = 4.9 x 10⁻¹⁰)
E) Acetic acid (Kₐ = 1.8 x 10⁻⁵)

17) Of the acids in the table below, __________ is the strongest acid.

<table>
<thead>
<tr>
<th>Acid</th>
<th>Kₐ</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOAc</td>
<td>1.8 x 10⁻⁵</td>
</tr>
<tr>
<td>HCHO₂</td>
<td>1.8 x 10⁻⁴</td>
</tr>
<tr>
<td>HClO</td>
<td>3.0 x 10⁻⁸</td>
</tr>
<tr>
<td>HF</td>
<td>6.8 x 10⁻⁴</td>
</tr>
</tbody>
</table>

A) HOAc
B) HCHO₂
C) HClO
D) HF
E) HOAc and HCHO₂

18) The Kₐ of hypochlorous acid (HClO) is 3.0 x 10⁻⁸ at 25.0 °C. What is the % ionization of hypochlorous acid in a 0.015 M aqueous solution of HClO at 25.0 °C? (may use calculator)
A) 4.5 x 10⁻⁸
B) 14
C) 2.1 x 10⁻⁵
D) 0.14
E) 1.4 x 10⁻³

19) In which of the following aqueous solutions does the weak acid exhibit the highest percentage ionization?
A) 0.01 M HC₂H₃O₂ (Kₐ = 1.8 x 10⁻⁵)
B) 0.01 M HNO₂ (Kₐ = 4.5 X 10⁻⁴)
C) 0.01 M HF (Kₐ = 6.8 X 10⁻⁴)
D) 0.01 M HClO (Kₐ = 3.0 X 10⁻⁸)
E) These will all exhibit the same percentage ionization.

20) Which one of the following is a Brønsted-Lowry acid?
A) (CH₃)₃NH⁺
B) CH₃COOH
C) HF
D) HNO₂
E) all of the above

21) Classify the following compounds as weak acids (W) or strong acids (S):
benzoic acid nitric acid acetic acid
A) Weak Weak Weak
B) Strong Strong Strong
C) Strong Weak Weak
D) Weak Strong Strong
E) Weak Strong Weak

22) Classify the following compounds as weak acids (W) or strong acids (S):
hydrocyanic acid hydrofluroic acid phenol
A) Weak Weak Weak
B) Strong Strong Strong
C) Strong Weak Weak
D) Weak Strong Strong
E) Weak Strong Weak

23) Classify the following compounds as weak acids (W) or strong acids (S):
nitrous acid hydrochloric acid hydrofluoric acid
A) Weak Weak Weak
B) Strong Strong Strong
C) Strong Weak Weak
D) Weak Strong Strong
E) Weak Strong Weak

24) Classify the following compounds as weak acids (W) or strong acids (S):
hypochlorous acid perchloric acid chloric acid
A) Weak Strong Strong
B) Strong Strong Strong
C) Strong Weak Weak
D) Weak Weak Weak
E) Weak Strong Weak

25) Ammonia is a __________.
A) weak acid
B) strong base
C) weak base
D) strong acid
26) Using the data in the table, which of the conjugate acids below is the weakest acid?

<table>
<thead>
<tr>
<th>Base</th>
<th>K_b</th>
</tr>
</thead>
<tbody>
<tr>
<td>ClO^-</td>
<td>3.3 x 10^-7</td>
</tr>
<tr>
<td>CO_3^-2</td>
<td>1.8 x 10^-4</td>
</tr>
<tr>
<td>H_2S^-</td>
<td>1.8 x 10^-7</td>
</tr>
<tr>
<td>NH_2CH_3</td>
<td>4.4 x 10^-4</td>
</tr>
</tbody>
</table>

A) HClO  
B) HCO_3^-  
C) H_2S  
D) NH_3CH_3^+  
E) H_2S and HClO

27) Using the data in the table, which of the conjugate acids below is the strongest acid?

<table>
<thead>
<tr>
<th>Base</th>
<th>K_b</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH_3</td>
<td>1.8 x 10^-5</td>
</tr>
<tr>
<td>C_5H_5N</td>
<td>1.7 x 10^-9</td>
</tr>
<tr>
<td>H_2NOH</td>
<td>1.1 x 10^-8</td>
</tr>
<tr>
<td>NH_2CH_3</td>
<td>4.4 x 10^-4</td>
</tr>
</tbody>
</table>

A) NH_4^+  
B) C_5H_5NH^+  
C) H_3NOH^+  
D) NH_3CH_3^+  
E) NH_4^+ and NH_3CH_3^+

28) Using the data in the table, which of the conjugate acids below is the weakest acid?

<table>
<thead>
<tr>
<th>Base</th>
<th>K_b</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH_3</td>
<td>1.8 x 10^-5</td>
</tr>
<tr>
<td>C_5H_5N</td>
<td>1.7 x 10^-9</td>
</tr>
<tr>
<td>H_2NOH</td>
<td>1.1 x 10^-6</td>
</tr>
<tr>
<td>NH_2CH_3</td>
<td>4.4 x 10^-4</td>
</tr>
</tbody>
</table>

A) NH_4^+  
B) C_5H_5NH^+  
C) H_3NOH^+  
D) NH_3CH_3^+  
E) NH_4^+ and NH_3CH_3^+

29) Which of the following ions will act as a weak base in water?
A) OH⁻  
B) Cl⁻  
C) NO₃⁻  
D) ClO⁻  
E) None of the above will act as a weak base in water.

30) Which of the following ions will act as a weak base in water?
A) HS⁻  
B) F⁻  
C) NO₂⁻  
D) ClO⁻  
E) All of the above will act as a weak base in water.

31) Which of the following aqueous solutions has the highest [OH⁻]?
A) a solution with a pH of 3.0  
B) a 1 X 10⁻⁴ solution of HNO₃  
C) a solution with a pOH of 12.0  
D) pure water  
E) a 1 X 10⁻³ solution of NH₄Cl

32) Which of the following aqueous solutions has the lowest [OH⁻]?
A) a solution with a pH of 3.0  
B) a 1 X 10⁻⁴ solution of HNO₃  
C) a solution with a pOH of 12.0  
D) pure water  
E) a 1 X 10⁻³ solution of NH₄Cl

33) An aqueous solution of a particular compound has pH = 2.46. The compound is
A) a weak base  
B) a weak acid  
C) a strong acid  
D) a strong base  
E) a salt

34) Complete the following table for each aqueous solution at 25°C

<table>
<thead>
<tr>
<th>[H₃O⁺]</th>
<th>[OH⁻]</th>
<th>pH</th>
<th>pOH</th>
<th>Acidic or basic</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 x 10⁻⁵</td>
<td>6.25</td>
<td>5.6 x 10⁻²</td>
<td>9.20</td>
<td></td>
</tr>
<tr>
<td>8.7 x 10⁻¹⁰</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

35) What is the [H⁺] when [OH⁻] = 8.1 x 10⁻⁵?
A) 8.1 x 10⁻⁵ M  
B) 1.0 x 10⁻⁷ M  
C) 1.2 x 10⁻¹⁰ M  
D) 3.6 x 10⁻⁶ M  
E) 8.1 x 10⁻⁵ M

36) What is the [H⁺] when [OH⁻] = 3.3 x 10⁻⁹?
37) What is the [H\(^+\)] in a 0.0025 M HCl solution?
   A) 1.0 \times 10^{-7} M   B) 4.0 \times 10^{-12} M   C) 2.5 \times 10^{-3} M   D) 3.6 \times 10^{-5} M   E) need more info

38) What is the [OH\(^-\)] in a 0.0050 M HCl solution?
   A) 5.0 \times 10^{-3} M   B) 1.0 M   C) 1.0 \times 10^{-7} M   D) 6.6 \times 10^{-5} M   E) 2.0 \times 10^{-12} M

39) A solution in which [H\(^+\)] = 10^{-8} has a pH of ___ and is ________.
   A) 8, acidic   B) 6, basic   C) -6, basic   D) -8, neutral   E) 8, basic

40) What is the pH of a 0.00030 M HNO\(_3\) solution?
   A) 8.11   B) 2.22   C) 3.52   D) 4.48   E) none of these

41) What is the pH of a 0.0060 M KOH solution?
   A) 5.12   B) 2.22   C) 11.72   D) 8.88   E) 7.00

42) A sample of lemon juice is found to have a pH of 2.55. What is the [H\(^+\)] concentration of the juice?
   A) 0.0035 M   B) 0.0028 M   C) 11.6 M   D) 0.0080 M   E) 355 M

43) A sample of milk is found to have a pH of 6.60. What is the OH\(^-\) concentration of the milk?
   A) 2.5 \times 10^{-21} M   B) 1.0 \times 10^{-7} M   C) 5.0 \times 10^{-7} M   D) 4.0 \times 10^{-8} M   E) 2.5 \times 10^{-7} M
May use the calculator for the following problems:

44) What is the conjugate acid of \( \text{NH}_3 \)?
   A) \( \text{NH}_3 \)  B) \( \text{NH}_2^+ \)  C) \( \text{NH}_3^+ \)  D) \( \text{NH}_4^+ \)  E) \( \text{NH}_4\text{OH} \)

45) The conjugate base of \( \text{HSO}_4^- \) is \_________.
   A) \( \text{OH}^- \)  B) \( \text{H}_2\text{SO}_4 \)  C) \( \text{SO}_4^{2-} \)  D) \( \text{HSO}_4^+ \)  E) \( \text{H}_3\text{SO}_4^+ \)

46) The conjugate acid of \( \text{HSO}_4^- \) is \_________.
   A) \( \text{SO}_4^{2-} \)  B) \( \text{H}_2\text{SO}_4 \)  C) \( \text{HSO}_4^+ \)  D) \( \text{H}^+ \)  E) \( \text{HSO}_3^+ \)

47) What is the conjugate base of \( \text{OH}^- \)?
   A) \( \text{O}_2 \)  B) \( \text{O}^- \)  C) \( \text{H}_2\text{O} \)  D) \( \text{O}^{2-} \)  E) \( \text{H}_3\text{O}^+ \)

48) What is the pH of an aqueous solution at 25.0 °C in which \([\text{H}^+]\) is 0.0025 M?
   A) 3.40  B) 2.60  C) -2.60  D) -3.40  E) 2.25

49) What is the pH of an aqueous solution at 25.0 °C in which \([\text{OH}^-]\) is 0.0025 M?
   A) +2.60  B) -2.60  C) +11.4  D) -11.4  E) -2.25

50) What is the pH of an aqueous solution at 25.0 °C that contains \(3.98 \times 10^{-9}\) hydronium ion?
   A) 8.400  B) 5.600  C) 9.000  D) 3.980  E) 7.000

51) What is the pH of an aqueous solution at 25.0 °C that contains \(3.98 \times 10^{-9}\) hydroxide ion?
   A) 8.40  B) 5.60  C) 9.00  D) 3.98  E) 7.00

52) What is the concentration (in M) of hydronium ions in a solution at 25.0 °C with pH = 4.282?
   A) 4.28  B) 9.71  C) \(1.92 \times 10^{-10}\)  D) \(5.22 \times 10^{-5}\)  E) \(1.66 \times 10^{4}\)

53) What is the concentration (in M) of hydroxide ions in a solution at 25.0 °C with pH = 4.282?
   A) 4.28  B) 9.72  C) \(1.91 \times 10^{-10}\)  D) \(5.22 \times 10^{-5}\)  E) \(1.66 \times 10^{4}\)

54) Calculate the pOH of a solution at 25.0 °C that contains \(1.94 \times 10^{-10}\) hydronium ions.
   A) 1.94  B) 4.29  C) 7.00  D) 14.0  E) 9.71

55) Calculate the concentration (in M) of hydronium ions in a solution at 25.0 °C with a pOH of 4.223.
   A) \(5.98 \times 10^{-5}\)  B) \(1.67 \times 10^{-10}\)  C) \(1.67 \times 10^{4}\)  D) \(5.99 \times 10^{-19}\)  E) \(1.00 \times 10^{-7}\)

56) What is the pH of a 0.015 M aqueous solution of barium hydroxide?
   A) 12.48  B) 12.25  C) 1.82  D) 10.41  E) 1.52

57) What is the pOH of a 0.0150 M solution of barium hydroxide?
   A) 12.2  B) 12.5  C) 1.52  D) 1.82  E) 10.4

58) An aqueous solution contains 0.100 M NaOH at 25.0 °C. The pH of the solution is
   A) 0.100  B) 1.00  C) 13.00  D) 7.00  E) -1.00
Dissociation of Weak acids and Bases, poly-protic acid dissociation, hydrolysis of salts, oxy-acids

59) HZ is a weak acid. An aqueous solution of HZ is prepared by dissolving 0.020 mol of HZ in sufficient water to yield 1.0 L of solution. The pH of the solution was 4.93 at 25.0 °C. The $K_a$ of HZ is __________.
   A) 1.2 X 10^-5  B) 6.9 X 10^-9  C) 1.4 X 10^-10  D) 9.9 X 10^-2  E) 2.8 X 10^-12

60) The pH of a 0.55 M aqueous solution of hypobromous acid, HOBr, at 25.0 °C is 4.48. What is the value of $K_a$ for HOBr?
   A) 2.0 X 10^-9  B) 1.1 X 10^-9  C) 6.0 X 10^-5  D) 3.3 X 10^-5  E) 3.0 X 10^4

61) A 0.15 M aqueous solution of the weak acid HA at 25.0 °C has a pH of 5.35. The value of $K_a$ for HA is __________.
   A) 3.0 X 10^-5  B) 1.8 X 10^-5  C) 7.1 X 10^-9  D) 1.3 X 10^-10  E) 3.3 X 10^-4

62) The $K_a$ of hypochlorous acid (HOCl) is 3.0 X 10^-8 at 25.0 °C. Calculate the pH of a 0.0385 M hypochlorous acid solution.
   A) 1.41  B) 8.94  C) 4.47  D) 7.52  E) -1.41

63) The $K_a$ of hypochlorous acid (HOCl) is 3.0 X 10^-8. What is the pH at 25.0 °C of an aqueous solution that is 0.0200 M in HOCl?
   A) +2.45  B) -2.45  C) -9.22  D) +9.22  E) +4.61

64) The $K_a$ of hydrofluoric acid (HF) at 25.0 °C is 6.8 X 10^-4. What is the pH of a 0.35 M aqueous solution of HF?
   A) 3.25  B) 1.81  C) 3.64  D) 0.46  E) 1.22

65) The $K_a$ of hydrazoic acid (HN3) is 1.9 X 10^-5 at 25.0 °C. What is the pH of a 0.35 M aqueous solution of HN3?
   A) 1.14  B) 2.41  C) 5.23  D) 2.59  E) -2.46

66) The acid-dissociation constants of sulfurous acid (H2SO3) are $K_{a1} = 1.7 X 10^-2$ and $K_{a2} = 6.4 X 10^-8$ at 25.0 °C. Calculate the pH of a 0.163 M aqueous solution of sulfurous acid.
   A) 4.53  B) 1.30  C) 1.86  D) 6.21  E) 1.93

67) The acid-dissociation constants of phosphoric acid (H3PO4) are $K_{a1} = 7.5 X 10^-3$, $K_{a2} = 6.2 X 10^-8$ and $K_{a3} = 4.2 X 10^-13$ at 25.0 °C. What is the pH of a 2.5 M aqueous solution of phosphoric acid?
   A) 1.82  B) 0.40  C) 2.51  D) 0.88  E) 0.13

68) The pH of a 0.10 M solution of a weak base is 9.82. What is the $K_b$ for this base?
   A) 2.1 X 10^-4  B) 4.4 X 10^-8  C) 8.8 X 10^-8  D) 6.6 X 10^-4  E) 2.0 X 10^-5

69) Calculate the pH of a 0.500 M aqueous solution of NH3. The $K_b$ of NH3 is 1.77 X 10^-5 is
   A) 8.95  B) 11.47  C) 2.52  D) 5.05  E) 3.01

70) Determine the pH of a 0.35 M aqueous solution of CH3NH2 (methylamine). The $K_b$ of methylamine is 4.4 X 10^-4
   A) 10.00  B) 3.86  C) 12.09  D) 1.96  E) 13.24
71) An aqueous solution contains 0.050 M of methylamine. The concentration of hydroxide ion in this solution is ________ M. \( K_b \) for methylamine is \( 4.4 \times 10^{-4} \).  
A) 0.050  
B) \( 2.2 \times 10^{-5} \)  
C) \( 2.9 \times 10^{-3} \)  
D) \( 4.5 \times 10^{-3} \)  
E) \( 4.7 \times 10^{-3} \)

72) The acid-dissociation constant, \( K_a \), for gallic acid is \( 4.57 \times 10^{-3} \). What is the base-dissociation constant, \( K_b \), for the gallate ion?  
A) \( 4.5 \times 10^{-3} \)  
B) \( 2.19 \times 10^{-12} \)  
C) \( 5.43 \times 10^{-5} \)  
D) \( 7.81 \times 10^{-6} \)  
E) \( 2.91 \times 10^{-2} \)

73) The base-dissociation constant, \( K_b \), for pyridine, \( C_5H_5N \), is \( 1.4 \times 10^{-9} \). The acid-dissociation constant, \( K_a \), for the pyridinium ion, \( C_5H_5NH^+ \) is __________.  
A) \( 1.0 \times 10^{-7} \)  
B) \( 1.4 \times 10^{-23} \)  
C) \( 7.1 \times 10^{-4} \)  
D) \( 1.4 \times 10^{-5} \)  
E) \( 7.1 \times 10^{-6} \)

74) The \( K_a \) for HCN is \( 4.9 \times 10^{-10} \). What is the value of \( K_b \) for \( CN^- \)?  
A) \( 2.0 X 10^{-5} \)  
B) \( 4.0 X 10^{-6} \)  
C) \( 4.9 X 10^{-4} \)  
D) \( 4.9 X 10^{-24} \)  
E) \( 2.0 X 10^{9} \)

75) \( K_a \) for HF is \( 7.0 \times 10^{-4} \). \( K_b \) for the fluoride ion is __________.  
A) \( 2.0 \times 10^{-8} \)  
B) \( 1.4 \times 10^{-11} \)  
C) \( 7.0 \times 10^{-18} \)  
D) \( 7.0 \times 10^{-4} \)  
E) \( 1.4 \times 10^{3} \)

76) Calculate the pOH of a 0.0827 M aqueous sodium cyanide solution at 25.0 °C. \( K_b \) for \( CN^- \) is \( 4.49 \times 10^{-10} \).  
A) 9.33  
B) 10.00  
C) 5.20  
D) 1.17  
E) 8.89

77) Determine the pH of a 0.15 M aqueous solution of KF. For hydrofluoric acid, \( K_a = 7.0 \times 10^{-4} \).  
A) 12.01  
B) 5.85  
C) 8.17  
D) 2.32  
E) 6.68

78) Calculate the pH of 0.726 M anilinium hydrochloride (\( C_6H_5NH_3Cl \)) solution in water, given that \( K_b \) for aniline is \( 3.83 \times 10^{-4} \).  
A) 1.77  
B) 12.2  
C) 5.36  
D) 8.64  
E) 12.4

79) \( K_b \) for \( NH_3 \) is \( 1.8 \times 10^{-5} \). What is the pH of a 0.35 M aqueous solution of \( NH_4Cl \) at 25.0 °C?  
A) 9.76  
B) 4.35  
C) 9.11  
D) 4.86  
E) 11.23

80) The \( K_a \) for formic acid (\( HCO_2H \)) is \( 1.8 \times 10^{-4} \). What is the pH of a 0.35 M aqueous solution of sodium formate (\( NaHCO_2 \))?  
A) 11.64  
B) 5.42  
C) 3.39  
D) 8.64  
E) 4.26

81) \( K_a \) for HCN is \( 4.9 \times 10^{-10} \). What is the pH of a 0.068 M aqueous solution of sodium cyanide?  
A) 0.74  
B) 2.96  
C) 11.07  
D) 13.24  
E) 7.00

82) \( K_a \) for HX is \( 7.5 \times 10^{-12} \). What is the pH of a 0.15 M aqueous solution of \( NaX \)?  
A) 7.97  
B) 1.96  
C) 6.00  
D) 8.04  
E) 12.10

83) The pH of a 0.15 M aqueous solution of \( NaZ \) (the sodium salt of \( HZ \)) is 10.7. What is the \( K_a \) for \( HZ \)?  
A) \( 1.6 \times 10^{-6} \)  
B) \( 6.0 \times 10^{-9} \)  
C) \( 8.9 \times 10^{-4} \)  
D) \( 1.3 \times 10^{-12} \)  
E) \( 3.3 \times 10^{-8} \)

84) What is the concentration of \( OCl^- \) in a 0.60 M solution of HOCl? \( K_a = 3.1 \times 10^{-8} \).  
A) \( 1.8 \times 10^{-4} \) M  
B) \( 7.1 \times 10^{-11} \) M  
C) 0.40 M  
D) \( 1.4 \times 10^{-4} \) M  
E) \( 1.1 \times 10^{-4} \) M
85) What is the pH of a 0.50 M solution of NaNO₂? For HNO₂, $K_a = 4.5 \times 10^{-4}$.
   A) 12.18   B) 5.48   C) 1.82   D) 8.52   E) 7.00

86) What is the pH of a 1.0 M solution of NaOCl? For HOCl, $K_a = 3.1 \times 10^{-8}$.
   A) 10.75   B) 3.25   C) 3.75   D) 10.25   E) 7.00

87) What is the pH of a 1.0 $\times 10^{-2}$ molar solution of HCN? (For HCN, $K_a = 4.0 \times 10^{-10}$)
   A) 10   B) Between 7 and 10   C) 7   D) Between 4 and 7   E) 4

88) What is the pH of a 0.020 M solution of hydrosulfuric acid, a diprotic acid?
   $K_{a1} = 1.1 \times 10^{-7}$ $K_{a2} = 1.0 \times 10^{-14}$
   A) 7.00   B) 9.67   C) 7.84   D) 4.33   E) 3.05

89) What is the concentration of CO₃²⁻ in a 0.010 M solution of carbonic acid? The relevant equilibria are,
   $H_2CO_3 \leftrightarrow H^+ + HCO_3^-$ $K_{a1} = 4.3 \times 10^{-7}$
   $HCO_3^- \leftrightarrow H^+ + CO_3^{2-}$ $K_{a2} = 5.6 \times 10^{-11}$
   A) 6.6 $\times 10^{-5}$ M   B) 5.6 $\times 10^{-11}$ M   C) 6.7 $\times 10^{-11}$ M   D) 7.5 $\times 10^{-7}$ M   E) 7.9 $\times 10^{-7}$ M

90) What is the S²⁻ concentration in a saturated solution (0.10 M) of H₂S, in which the pH has been adjusted to 6.00 by the addition of HCl? For H₂S, $K_{a1} = 1.1 \times 10^{-7}$ and $K_{a2} = 1.0 \times 10^{-14}$.
   A) 1.1 $\times 10^{-16}$ M   B) 1.1 $\times 10^{-10}$ M   C) 1.0 $\times 10^{-2}$ M   D) 3.2 $\times 10^{-8}$ M   E) 3.2 $\times 10^{-6}$ M

91) Of the following substances an aqueous solution of _____ will form basic solution.
   NH₄Cl, Cu(NO₃)₂, K₂CO₃, NaF
   A. NH₄Cl, Cu(NO₃)₂  B. K₂CO₃, NH₄Cl  C. NaF only  D. NaF, K₂CO₃  E. NH₄Cl only

92) A 0.1M aqueous solution of _____ will have a pH of 7.0 at 25°C.
   A. NaOCl  B. KCl  C. NH₄Cl  D. Ca(OAc)₂  E. None of these
93) A 0.1M solution of ____ has a pH of 7.0
   A. Na₂S
   B. KF
   C. NaNO₃
   D. NH₄Cl
   E. NaF

94) An Aqueous solution of _______will produce a basic solution.
   A. NH₄ClO₄
   B. KBr
   C. NaCl
   D. Na₂CO₃
   E. NaHCO₃

95) Which of the following salts will result in a basic solution when it is dissolved in water?
   A) KCl
   B) NH₄I
   C) NaCN
   D) MgBr₂
   E) none of these

96) Of the following which is the strongest acid?
   A) HIO
   B) HIO₄
   C) HIO₂
   D) HIO₃
   E) all nearly the same

97) of the following which is the strongest acid?
   A) CH₃COOH
   B) ClCH₂COOH
   C) Cl₂CHCOOH
   D) Cl₃CCOOH
   E) BrCH₂COOH

98) which of the following is the strongest?
   A) H₂SO₄
   B) HSO₄⁻
   C) H₂SO₃
   D) H₂SeO₄
   E) HSO₃⁻

99) Which of the following is the strongest?
   A) HClO
B) HF  
C) HBr  
D) HI  
E) HCl

**Conceptual Questions: No calculator**

1) Write the name and formula for the conjugate bases of the following.  
   A) HNO$_2$  
   B) H$_2$SO$_4$  
   C) H$_2$PO$_4^-$  
   D) HF  
   E) CH$_3$COOH

2) For each of the following predict whether an aqueous solution would be acidic, basic or neutral?  
   A) Sodium nitrate NaNO$_3$  
   B) Ammonium iodide NH$_4$I  
   C) Sodium bicarbonate NaHCO$_3$  
   D) Ammonium cyanide NH$_4$CN  
   E) Sodium hypochlorite NaOCl  
   F) Potassium acetate KCH$_3$CO$_2$

3) Complete the Brønsted-Lowry equilibria, label the components acid or base and pair up the conjugate acid base pairs.  
   A) HSO$_4^-$ + H$_2$O →  
   B) NH$_3$ + H$_2$O →  
   C) CN$^- + H_2O$ →  
   D) H$^- + H_2O$ →  
   E) HClO$_4 + H_2O$ →

4) In the laboratory, H$_2$ (g) can be produced by adding which of the following to 1M HCl( aq)?  
   I. 1M NH$_3$  
   II. Zn(s)  
   III. NaHCO$_3$(s)  
   A) I only  
   B) II only  
   C) III only  
   D) I and II only  
   E) I, II and III

5) 2NH$_3$ ↔ NH$_4^+$ + NH$_2^-$ In liquid ammonia, the reaction represented above occurs. In the reaction, NH$_4^+$ acts as  
   A) a catalyst  
   B) both an acid and base  
   C) the conjugate acid of NH$_3$  
   D) the reducing agent  
   E) the oxidizing agent
6) At 25°C, aqueous solution with a pH of 8 have a hydroxide ion concentration, \([\text{OH}^-]\), of
A) \(1 \times 10^{-14}\) M
B) \(1 \times 10^{-8}\) M
C) \(1 \times 10^{-6}\) M
D) 1 M
E) 8 M

7) How can 100 ml sodium hydroxide solution with a pH of 13 be converted to a sodium hydroxide solution of pH 12?
A) By diluting the solution with distilled water to a total volume of 108 ml
B) by diluting the solution with distilled water to a total volume of 200mL
C) by diluting to a total volume of 1.00L
D) By adding 100mL of 0.10M HCl
E) By adding 100mL of 0.01M NaOH

8) The pH of a solution prepared by the addition of 10 mL of 0.002M KOH (aq) to 10mL of distilled water is close to
A) 12
B) 11
C) 10
D) 4
E) 3

9) In solution, which of the following has the greatest \([\text{H}_3\text{O}^+]\) ?
A) HCN
B) HNO_3
C) H_2O
D) OH^-
E) CH_3OH

10) Which of the following is not true for a solution at 25°C that has a hydroxide concentration of \(1.0 \times 10^{-6}\) M?
A) \(\text{K}_w = 1 \times 10^{-14}\)
B) the solution is acidic
C) The solution is basic
D) \([\text{H}^+] = 1 \times 10^{-6}\)M
E) the pOH is 6.0

11) Equal volumes of two solutions of pH 3 and pH 4 are mixed. The pH of the resulting solution will be
A) 7
B) 3.5
C) 2.96
D) 3.26
E) 3.5
12) The pH of 1.0 x10^-8 M solution of HCL in water is
   A) 8
   B) -8
   C) between 7 and 8
   D) between 6 and 7
   E) between 8 and 9

13) Which of the following will occur if a 0.1M solution of a weak acid is diluted to 0.01 M at constant temperature?
   A) [H+] will decrease to 0.01M
   B) pH will decrease
   C) percentage ionization will increase
   D) Ka will increase
   E) nothing will happen

14) Which of the following ions is the strongest Lewis acid?
   A) Na+
   B) Cl-
   C) CH3COO-
   D) Mg2+
   E) Al3+

15) Each of the following can act as both a Brönsted acid and a Brönsted base EXCEPT
   A) HCO3-
   B) H2PO4-
   C) NH4+
   D) H2O
   E) HS-

16) Which, if any, of the following species is in the greatest concentration in a 0.100-molar solution of H2SO4 in water?
   A) H2SO4 molecules
   B) H3O+ ions
   C) HSO4- ions
   D) SO42- ions
   E) All species are in equilibrium and therefore have the same concentrations
17) $\text{HSO}_4^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{SO}_4^{2-}$

In the equilibrium represented above, the species that act as bases include which of the following?

I. $\text{HSO}_4^-$
II. $\text{H}_2\text{O}$
III. $\text{SO}_4^{2-}$

A) II only  
B) III only  
C) I and II  
D) I and III  
E) II and III

18) Which of the following acids can be oxidized to form a stronger acid?

A) $\text{H}_3\text{PO}_4$  
B) $\text{HNO}_3$  
C) $\text{H}_2\text{CO}_3$  
D) $\text{H}_3\text{BO}_3$  
E) $\text{H}_2\text{SO}_3$

19) The reaction represented below has an equilibrium constant equal to $3.7 \times 10^4$. Which of the following can be concluded from this information?

$\text{HC}_2\text{H}_3\text{O}_2(aq) + \text{CN}^-(aq) \rightleftharpoons \text{HCN}(aq) + \text{C}_2\text{H}_3\text{O}_2^-(aq)$

A) $\text{CN}^-(aq)$ is a stronger base than $\text{C}_2\text{H}_3\text{O}_2^- (aq)$  
B) $\text{HCN}(aq)$ is a stronger acid than $\text{C}_2\text{H}_3\text{O}_2^- (aq)$  
C) The conjugate base of $\text{CN}^-(aq)$ is $\text{C}_2\text{H}_3\text{O}_2^- (aq)$  
D) The equilibrium constant will increase with an increase in temperature.  
E) The pH of a solution containing equimolar amounts of $\text{CN}^-(aq)$ and $\text{C}_2\text{H}_3\text{O}_2^- (aq)$ is 7.0.

20) When a 0.1M solutions of HF, HCl, KF and KCl are arranged in order of increasing pH which order is correct?

A) HF, HCl, KF, KCl  
B) HCl, HF, KF, KCl  
C) HCl, HF, KCl, KF  
D) HF, HCl, KCl, KF  
E) KCl, KF, HF, HCl

21) Which is not a conjugate acid/base pair?

A) $\text{H}_2\text{CO}_3$ and $\text{CO}_3^{2-}$  
B) $\text{HSO}_4^-$ and $\text{SO}_4^{2-}$  
C) $\text{H}_2\text{PO}_4^-$ and $\text{HPO}_4^{2-}$  
D) $\text{H}_3\text{O}^+$ and $\text{H}_2\text{O}$  
E) $\text{HNO}_3$ and $\text{NO}_3^-$
22) What is the [OH⁻] in an aqueous solution which has a pH = 11

A) 1.0 x 10⁻³
B) 1.0 x 10⁻⁴
C) 4.0 x 10⁻¹¹
D) 1.0 x 10⁻²
E) 1.0 x 10³
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**Explanation for some of the above answers in the table:**

85) \( \text{NO}_2^- + \text{H}_2\text{O} \leftrightarrow \text{HNO}_2 + \text{OH}^- \)

\[
\begin{array}{ccc}
0.5 & 0 & 0 \\
-x & +x & +x \\
0.5-x & x & x \\
\end{array}
\]

\[K_b = \frac{K_w}{K_a} = \frac{[\text{HNO}_2][\text{OH}]^-}{[\text{NO}_2^-]} = x^2 / 0.5 = 2.22 \times 10^{-11}\]

\[\text{pH} = 14 - \text{pOH} = 8.52\]

88) Only the first dissociation is significant so only \( K_{a1} \) is needed

89) From the first dissociation, \( [\text{H}^+] = [\text{HCO}_3^-] \). The second dissociation does not change this much. \( K_{a2} = \frac{[\text{H}^+][\text{CO}_3^{2-}]}{[\text{HCO}_3^-]} \). But \( [\text{H}^+] = [\text{HCO}_3^-] \) and cancel each other out. 

So \( K_{a2} = [\text{CO}_3^{2-}] = 5.6 \times 10^{-11} \)

90) Combine the two dissociations

\( \text{H}_2\text{S} \leftrightarrow \text{H}^+ + \text{HS}^- \)

\( \text{HS}^- \leftrightarrow \text{H}^+ + \text{S}^{2-} \)

\( \text{H}_2\text{S} \leftrightarrow 2\text{H}^+ + \text{S}^{2-} \)
\[ K = K_{a1} \times K_{a2} \quad 1.1 \times 10^{-21} = [H^+]^2[S^{2-}] \]
\[
\frac{[S^{2-}]}{[H_2S]} = k[H_2S] / [H^+]^2 = 1.1 \times 10^{-10}
\]

Conceptual questions:

1)
A) \( \text{NO}_2^- \) nitrite
B) \( \text{HSO}_4^- \) hydrogen sulfate
C) \( \text{HPO}_4^{2-} \) hydrogen phosphate
D) \( F^- \) fluoride
E) \( \text{CH}_3\text{COO}^- \) acetate

2)
A) Neutral
B) Acidic
C) Basic
D) Neutral
E) Basic
F) Basic

3)
A) (A) \( \text{HSO}_4^- \) + (B) \( \text{H}_2\text{O} \) → (CB) \( \text{SO}_4^{2-} \) + (CA) \( \text{H}_3\text{O}^+ \)
B) (B) \( \text{NH}_3 \) + (A) \( \text{H}_2\text{O} \) → (CA) \( \text{NH}_4^+ \) + (CB) \( \text{OH}^- \)
C) (B) \( \text{CN}^- \) + (A) \( \text{H}_2\text{O} \) → (CA) \( \text{HCN} \) + (CB) \( \text{OH}^- \)
D) (B) \( \text{H}^+ \) + (A) \( \text{H}_2\text{O} \) → (CA) \( \text{H}_2 \) + (CB) \( \text{OH}^- \)
E) (A) \( \text{HClO}_4 \) + (B) \( \text{H}_2\text{O} \) → (CB) \( \text{ClO}_4^- \) + (CA) \( \text{H}_3\text{O}^+ \)
Free Response Questions:

1) The overall dissociation of oxalic acid, H2C2O4, is represented below. The overall dissociation constant is also indicated.

\[ H_2C_2O_4 \leftrightarrow 2 H^+ + H_2C_2O_4^{2-} \quad K = 3.78 \times 10^{-6} \]

(a) Give the equations representing the first and second dissociations of oxalic acid.
(b) Calculate the value of the first dissociation constant, \( K_1 \), for oxalic acid if the value of the second dissociation constant, \( K_2 \), is \( 6.40 \times 10^{-5} \).
(c) To a 0.015 molar solution of oxalic acid, a strong acid is added until the pH is 0.5. Calculate the \([C_2O_4^{2-}]\) in the resulting solution. (Assume the change in volume is negligible.)
(d) Calculate the value of the equilibrium constant, \( K_b \), for the reaction that occurs when solid \( Na_2C_2O_4 \) is dissolved in water. (Do later)

2) H3PO2, H3PO3, and H3PO4 are monoprotic, diprotic and triprotic acids, respectively, and they are about equal strong acids.
HClO2, HClO3, and HClO4 are all monoprotic acids, but HClO2 is a weaker acid than HClO3 which is weaker than HClO4. Account for:
(a) The fact that the molecules of the three phosphorus acids can provide different numbers of protons.
(b) The fact that the three chlorine acids differ in strengths.

3) The value of the ionization constant, \( K_a \), for hypochlorous acid, HOCl, is \( 3.1 \times 10^{-8} \).

(a) Calculate the hydronium ion concentration of a 0.050 molar solution of HOCl.
(b) Calculate the concentration of hydronium ion in a solution prepared by mixing equal volumes of 0.050 molar HOCl and 0.020 molar sodium hypochlorite, NaOCl.
(c) A solution is prepared by the disproportionation reaction below. (Do later)
\[ Cl_2 + H_2O \rightarrow HCl + HOCl \]
Calculate the pH of the solution if enough chlorine is added to water to make the concentration of HOCl equal to 0.0040 molar.

4) Methylamine CH3NH2, is a weak base that ionizes in solution as shown by the following equation.

\[ CH_3NH_2 + H_2O \leftrightarrow CH_3NH_3^{+} + OH^- \]

(a) At 25°C the percentage ionization in a 0.160 molar solution of CH3NH2 is 4.7%. Calculate \([OH^-]\), \([CH_3NH_3^{+}]\), \([CH_3NH_2]\), \([H_3O^+]\), and the pH of a 0.160 molar solution of CH3NH2 at 25°C.
(b) Calculate the value for \( K_b \), the ionization constant for CH3NH2, at 25°C.

5) The acid ionization constant, \( K_a \), for propanoic acid, C2H5COOH, is \( 1.3 \times 10^{-5} \).

(a) Calculate the hydrogen ion concentration, \([H^+]\), in a 0.20-molar solution of propanoic acid.
(b) Calculate the percentage of propanoic acid molecules that are ionized in the solution in (a).
(c) What is the ratio of the concentration of propanoate ion, C2H5COO-, to that of propanoic acid in a buffer solution with a pH of 5.20?

6) In water, hydrazoic acid, HN3, is a weak acid that has an equilibrium constant, \( K_a \), equal to \( 2.8 \times 10^{-5} \) at 25°C. A 0.300 L sample of a 0.050M solution of the acid is prepared.

(a) Write the expression for the equilibrium constant, \( K_a \), for hydrazoic acid.
(b) Calculate the pH of this solution at 25°C.
7) \[ \text{NH}_3(aq) + \text{H}_2\text{O}(l) \leftrightarrow \text{NH}_4^+(aq) + \text{OH}^-(aq) \]
\[ \text{NH}_3(aq) + \text{H}_2\text{O}(l) \leftrightarrow \text{NH}_4^+(aq) + \text{OH}^-(aq) \]

In aqueous solution, ammonia reacts as represented above. In 0.0180 M NH\(_3\)(aq) at 25ºC, the hydroxide ion concentration, [OH\(^-\)] is 5.60 \times 10^{-4} M. In answering the following, assume that temperature is constant at 25ºC and that volumes are additive.

(a) Write the equilibrium-constant expression for the reaction represented above.
(b) Determine the pH of 0.0180 M NH\(_3\)(aq).
(c) Determine the value of the base ionization constant, \(K_b\), of NH\(_3\)(aq).
(d) Determine the percent ionization of NH\(_3\) in 0.0180 M NH\(_3\)(aq).

8) \[ \text{C}_6\text{H}_5\text{NH}_2(aq) + \text{H}_2\text{O}(aq) \leftrightarrow \text{C}_6\text{H}_5\text{NH}_3^+(aq) + \text{OH}^-(aq) \]

Aniline, a weak base, reacts with water according to the reaction represented above.

(a) Write the equilibrium constant expression, \(K_b\), for the reaction represented above.
(b) A sample of aniline is dissolved in water to produce 25.0 mL of a 0.10 M solution. The pH of the solution is 8.82. Calculate the equilibrium constant, \(K_b\), for this reaction.
Answers:

1. a) \[ \text{H}_2\text{C}_2\text{O}_4^- \leftrightarrow \text{H}^+ + \text{HC}_2\text{O}_4^- \] (eq. constant = \( K_1 \))
   \[ \text{HC}_2\text{O}_4^- \leftrightarrow \text{H}^+ + \text{C}_2\text{O}_4^{2-} \] (eq. constant = \( K_2 \))

   b) \[ \text{H}_2\text{C}_2\text{O}_4 \rightarrow \text{H}^+ + \text{HC}_2\text{O}_4^- \ K_1 \]
   \[ \text{HC}_2\text{O}_4^- \rightarrow \text{H}^+ + \text{C}_2\text{O}_4^{2-} \ K_2 \]
   \( K = K_1 \times K_2 \)
   \( K_1 = K/K_2 \)
   \[ = 3.78 \times 10^{-6}/6.40 \times 10^{-5} = 5.91 \times 10^{-2} \]

   c) \[ K = [\text{H}^+]^2 [\text{C}_2\text{O}_4^{2-}] \]
   \[ = 3.78 \times 10^{-6} = (0.316)^2 (x) / (0.015) \]

   \[ [\text{H}_2\text{C}_2\text{O}_4] \]
   \[ X = 5.68 \times 10^{-7} \text{ M} \]

   d) \[ \text{C}_2\text{O}_4^{2-} \ + \text{H}_2\text{O} \leftrightarrow \text{HC}_2\text{O}_4^- \ + \text{OH}^- \]
   \( K_b = K_w/K_a \)
   \[ 1.0 \times 10^{-14}/6.40 \times 10^{-5} = 1.56 \times 10^{-10} \]

2. (a) The structure for the three acids are as follows:

   H \[ \text{P} \]
   H \[ \text{O} \]
   O \[ \text{O} \]
   H \[ \text{H} \]

   The hydrogen atom(s) bonded directly to the phosphorus atom is/are not acidic in aqueous solution; only those hydrogen atoms bonded to the oxygen atoms can be released as protons.

   (b) The acid strength is successively greater as the number of oxygen atoms increases because the very electronegative oxygen atoms are able to draw electrons away from the chlorine atom and the O-H bond. This effect is more important as the number of attached oxygen atoms increases. This means that a proton is most readily produced by the molecule with the largest number of attached oxygen atoms.

3. (a) \[ \text{HOCl} + \text{H}_2\text{O} \leftrightarrow \text{H}_3\text{O}^+ + \text{OCl}^- \]
   \[ 3.2 \times 10^{-8} = [\text{H}_3\text{O}^+][\text{OCl}^-] = X^2 \]

   \[ [\text{HOCl}] = (0.050 - X) \]

   \[ X = [\text{H}_3\text{O}^+] = 4.0 \times 10^{-5} \text{ M} \]

   (b) \[ \text{HOCl} + \text{H}_2\text{O} \leftrightarrow \text{H}_3\text{O}^+ + \text{OCl}^- \]  
   \[ [\text{H}_3\text{O}^+][0.020 + X] \]

   \[ 3.1 \times 10^{-8} \quad X \ll 0.010 \]

   \[ [0.020 - X] \]

   \[ X = [\text{H}_3\text{O}^+] = 8.0 \times 10^{-8} \text{ M} \]

   (c) \[ \text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HCl} + \text{HOCl} \]

   \[ [\text{HOCl}] = [\text{HCl}] = 0.0040 \text{ M} \]

   HCl as principal source of \( \text{H}_3\text{O}^+ \)

   \[ \text{pH} = -\log[\text{H}_3\text{O}^+] = 2.40 \]

4. (a) \[ \text{CH}_3\text{NH}_2; 0.160 \text{ M} \times 4.7\% = 7.5 \times 10^{-3} \text{ M ionizing} \]

   \[ (0.160 \text{ M} - 0.0075 \text{ M}) = 0.152 \text{ M at equilibrium} \]

   \[ [\text{CH}_3\text{NH}_3^+] = [\text{OH}^-] = 7.5 \times 10^{-3} \text{ M} \]
\[ [H_3O^+] = K_w \]
\[
\frac{7.5 \times 10^{-5}}{1.3 \times 10^{-12} \ M} = \text{pH = -log} \ [H_3O^+] = 11.89
\]

(b) \[ K_b = \frac{[CH_3NH_3^+][OH^-]}{[CH_3NH_2]} \]
\[
\frac{(7.5 \times 10^{-3})^2}{3.7 \times 10^{-4}} = \frac{0.152}{[CH_3NH_2]} = \frac{1.3 \times 10^{-12}}{[CH_3NH_2]} = 3.7 \times 10^{-4}
\]

5. (a) \[ K_a = \frac{[H^+][C_2H_5COO^-]}{[C_2H_5COO]} = \frac{X}{[C_2H_5COO]} = \frac{0.20 - X}{X} = 0.20 \]
\[
\frac{[C_2H_5COOH]}{X} = \frac{1.3 \times 10^{-5}}{2.1} \]
\[
\frac{[C_2H_5COOH]}{[C_2H_5COOH]} = \frac{1}{1} = 1.6 \times 10^{-3} \text{ M} = [H^+]
\]

(b) From (a), \( x = \text{amount of acid that ionized, therefore} \)
\[ \frac{1.6 \times 10^{-3}}{0.20} \times (100) = 0.80\% \text{ ionized} \]

(c) At \( \text{pH} = 5.20 \) \[ [H^+] = -\log (5.20) = 6.31 \times 10^{-6} \text{ M} \]
\[ \frac{(6.31 \times 10^{-6})[C_2H_5COO]}{[C_2H_5COOH]} = K_a = 1.3 \times 10^{-5} \]
\[
\frac{[C_2H_5COOH]}{[C_2H_5COOH]} = \frac{2.1}{1} = \frac{[C_2H_5COOH]}{[C_2H_5COOH]}
\]

6. a) \[ K_a = \frac{[H^+][N_3^-]}{[HN_3]} \]

(b) \[ [H^+] = [N_3^-] = x \]
\[ 2.8 \times 10^{-5} = x^2/0.050; x = 1.2 \times 10^{-3} \text{ M} \]
\[ \text{pH = -log} \ [H^+] = 2.92 \]

7. a) \[ K_b = \frac{[NH_4^+][OH^-]}{[NH_3]} \]

(b) \[ \text{pOH} = -\log (5.6 \times 10^{-4}) = 3.252 \]
\[ \text{pH} = 14 - 3.252 = 10.748 \]

(c) \[ K_b = (5.6 \times 10^{-4})^2/(0.0180 - 5.6 \times 10^{-4}) = 1.80 \times 10^{-5} \]

(d) \[ (5.6 \times 10^{-4}/0.0180)100 = 3.11\% \]

8. a) \[ K_b = \frac{[C_6H_5NH_3^+] [OH^-]}{[C_6H_5NH_2][H_2O]} \]

(b) \[ \text{pH} = 8.82 \]
\[ \text{pOH} = 14 - 8.82 = 5.18 \]
\[ [OH^-] = 10^{-5.18} = 6.61 \times 10^{-6} \]
\[ [C_6H_5NH_3^+] = [OH^-] = 6.61 \times 10^{-6} \]
\[ K_b = \frac{[C_6H_5NH_3^+][OH^-]}{[C_6H_5NH_2]} = 6.61 \times 10^{-6}/0.10 = 4.4 \times 10^{-10} \]