Chapter 17
THE CHEMISTRY OF ACIDS AND BASES

17-1. Under the Brønsted concept of acids and bases, a base is:
(a) a proton donor (b) a proton acceptor
(c) a hydroxide donor (d) an electron pair donor

17-2. Under the Brønsted concept of acids and bases, an acid is:
(a) a proton donor (b) a proton acceptor
(c) an electron pair donor (d) an electron pair acceptor

17-3. Under the Lewis concept of acids and bases, a base is:
(a) a proton donor (b) a proton acceptor
(c) an electron pair acceptor (d) an electron pair donor

17-4. Under the Lewis concept of acids and bases, an acid is:
(a) a proton donor (b) a proton acceptor
(c) an electron pair donor (d) an electron pair acceptor

17-5. Which of the following is NOT an acid-base conjugate pair?
(a) HCN and CN\(^-\)  
(b) \(H_2O\) and \(OH^-\)
(c) \(H_2S\) and \(OH^-\)  
(d) \(NH_4^+\) and \(NH_3\)

17-6. Which of the following is NOT an acid-base conjugate pair?
(a) HClO and Cl\(^-\)  
(b) \(HNO_2\) and \(NO_2^-\)
(c) HF and F\(^-\)  
(d) \(H_2CO_3\) and \(HCO_3^-\)

17-7. Knowing that HF is a stronger acid than \(H_3CCOOH\), determine, if possible, in which direction the following equilibrium lies.
\[HF(aq) + H_3CCOO^-(aq) \rightleftharpoons F^-(aq) + H_3CCOOH(aq)\]
(a) equilibrium lies to the left  
(b) equilibrium lies to the right
(c) equilibrium is perfectly balanced left and right  
(d) cannot be determined

17-8. Knowing that \(H_2S\) is a stronger acid than HCN, determine, if possible, in which direction the following equilibrium lies.
\[HCN(aq) + HS^-(aq) \rightleftharpoons CN^-(aq) + H_2S(aq)\]
(a) equilibrium lies to the left  
(b) equilibrium lies to the right
(c) equilibrium is perfectly balanced left and right  
(d) cannot be determined
17-9. The $\text{HSO}_4^-$ ion is a stronger acid than $\text{HNO}_2^-$. Determine, if possible, in which direction the following equilibrium lies.

$$\text{HSO}_4^-(aq) + \text{NO}_2^-(aq) \rightleftharpoons \text{SO}_4^{2-}(aq) + \text{HNO}_2(aq)$$

(a) equilibrium lies to the left  
(b) equilibrium lies to the right  
(c) equilibrium is perfectly balanced left and right  
(d) cannot be determined

17-10. Knowing that $\text{H}_2\text{S}$ is a stronger acid than $\text{HS}^-$, determine, if possible, in which direction the following equilibrium lies.

$$2 \text{ HS}^-(aq) \rightleftharpoons \text{S}^{2-}(aq) + \text{H}_2\text{S(aq)}$$

(a) equilibrium lies to the left  
(b) equilibrium lies to the right  
(c) equilibrium is perfectly balanced left and right

17-11. At 50 °C the water ionization constant, $K_w$, is $5.48 \times 10^{-14}$. What is $[\text{H}_3\text{O}^+]$ in neutral water at 50 °C?

(a) $1.00 \times 10^{-7}$ M  
(b) $2.34 \times 10^{-7}$ M  
(c) $5.48 \times 10^{-7}$ M  
(d) $2.74 \times 10^{-7}$ M

17-12. At 10 °C the water ionization constant, $K_w$, is $2.9 \times 10^{-15}$. What is $[\text{H}_3\text{O}^+]$ in neutral water at 10 °C?

(a) $4.44 \times 10^{-6}$ M  
(b) $1.00 \times 10^{-7}$ M  
(c) $1.70 \times 10^{-7}$ M  
(d) $5.39 \times 10^{-8}$ M

17-13. We have a 0.00100 M solution of NaOH at 25 °C. What is $[\text{H}_3\text{O}^+]$ in this solution?

(a) $1.00 \times 10^{-3}$ M  
(b) $1.00 \times 10^{-11}$ M  
(c) $1.00 \times 10^{-7}$ M  
(d) 7.00 M

17-14. We add 0.535 g of NaOH to 100.0 mL of water at 25 °C. What is $[\text{H}_3\text{O}^+]$ in this solution?

(a) 0.134 M  
(b) $1.34 \times 10^{13}$ M  
(c) $7.48 \times 10^{-14}$ M  
(d) $6.87 \times 10^{-12}$ M

17-15. We dilute 1.00 mL of 1.00 M HCl solution to 100.0 mL. What is $[\text{OH}^-]$ in this solution at 25 °C?

(a) $1.00 \times 10^{12}$ M  
(b) 0.010 M  
(c) $7.00 \times 10^{-4}$ M  
(d) $1.00 \times 10^{-12}$ M

17-16. We have a $5.43 \times 10^{-4}$ M solution of HNO$_3$ at 25 °C. What is $[\text{OH}^-]$ in this solution?

(a) $1.84 \times 10^{-11}$ M  
(b) $5.43 \times 10^{-10}$ M  
(c) $5.43 \times 10^{-4}$ M  
(d) $3.67 \times 10^{-8}$ M

17-17. We have 500. mL of a solution that contains 0.0854 g of NaOH. What is the pH of this solution at 25 °C?

(a) 2.36  
(b) 11.63  
(c) 2.67  
(d) 11.33
17-18. We have 300. mL of a solution that contains 0.0128 g of KOH. What is the pH of this solution at 25 °C?
   (a) 3.64  (b) 3.12  
   (c) 10.88 (d) 10.36

17-19. We have a 4.63 x 10^{-4} M solution of HCl. What is the pH of this solution at 25 °C?
   (a) 3.33  (b) 10.67  
   (c) 4.00  (d) 4.63

17-20. We have a 0.45 M solution of HNO₃. What is the pH of this solution at 25 °C?
   (a) -0.35 (b) 3.47  
   (c) 10.53 (d) 0.35

17-21. We have a 5.82 x 10^{-10} M solution of HCl. What is the pH of this solution at 25 °C?
   (a) 4.76  (b) 9.23  
   (c) 7.00  (d) 2.45

17-22. Concentrated HCl is 12 M. What is the pH of concentrated HCl at 25 °C?
   (a) 1.08  (b) -1.08  
   (c) 12.00 (d) 1.55

BEGIN MATERIAL ON WEAK ACIDS AND BASES

17-23. What is [H₃O⁺] in a 0.10 M solution of HCN at 25 °C? (Kₐ for HCN = 4.0 x 10^{-10})
       (a) 1.58 x 10^{-9} M  (b) 2.00 x 10^{-5} M 
       (c) 6.32 x 10^{-6} M  (d) 4.00 x 10^{-11} M

17-24. What is [H₃O⁺] in a 0.034 M solution of HF at 25 °C? (Kₐ for HF = 7.2 x 10^{-4})
       (a) 4.60 x 10^{-3} M  (b) 4.95 x 10^{-3} M 
       (c) 0.034 M  (d) 0.027 M

17-25. What is the pH of a 0.350 M solution of CH₃COOH at 25 °C? (Kₐ for CH₃COOH = 1.8 x 10^{-5})
       (a) 7.00  (b) 11.4  
       (c) 0.0025 (d) 2.60

17-26. What is the pH of a 0.155 M solution of H₂S at 25 °C? (Kₐ for H₂S =1.00 x 10^{-7})
       (a) 13.39 (b) 3.90  
       (c) 3.50  (d) 2.88

17-27. What is the pH of a 0.00335 M solution of HNO₂ at 25 °C? (Kₐ for HNO₂ = 4.5 x 10^{-4})
       (a) 2.91  (b) 4.50  
       (c) 2.22  (d) 2.99

17-28. What is [OH⁻] in a 0.10 M solution of NaCN at 25 °C? (Kₐ for CN⁻ = 2.5 x 10^{-5})
       (a) 5.00 x 10^{-3} M  (b) 6.37 x 10^{-12} M 
       (c) 1.57 x 10^{-3} M  (d) 4.67 x 10^{-5} M
17-29. What is $[\text{OH}^-]$ in a 0.050 M solution of $\text{NH}_3$ at 25 °C? ($K_b \text{NH}_3 = 1.8 \times 10^{-5}$)
(a) $4.24 \times 10^{-3}$ M  
(b) $6.86 \times 10^{-12}$ M  
(c) $9.40 \times 10^{-4}$ M  
(d) 0.22 M

17-30. What is the pH of a 0.52 M solution of $\text{NaCH}_3\text{COO}$ at 25 °C? ($K_b$ for $\text{CH}_3\text{COO}^- = 5.6 \times 10^{-10}$)
(a) 9.23  
(b) 4.77  
(c) 9.37  
(d) 10.21

17-31. What is the pH of a 0.144 M solution of $\text{NaF}$ at 25 °C? ($K_b$ for $\text{F}^- = 1.4 \times 10^{-11}$)
(a) 8.15  
(b) 5.84  
(c) 9.12  
(d) 7.00

17-32. What is the pOH of a 0.338 M solution of $\text{NaClO}$ at 25 °C? ($K_b$ for $\text{ClO}^- = 2.9 \times 10^{-7}$)
(a) 3.27  
(b) 3.50  
(c) 10.73  
(d) 10.50

17-33. We add 12.0 g of $\text{NaCN}$ to 500. mL of water at 25 °C. What is the pH of the solution? ($K_b$ for $\text{CN}^- = 2.5 \times 10^{-5}$)
(a) 2.46  
(b) 5.83  
(c) 11.5  
(d) 12.8

17-34. A 0.20 M solution of an acid, HA, has a pH of 3.82 at 25 °C. What is $K_a$ for this acid?
(a) $7.56 \times 10^{-4}$  
(b) $2.29 \times 10^{-8}$  
(c) $4.46 \times 10^{-5}$  
(d) $1.15 \times 10^{-7}$

17-35. A 0.040 M solution of an acid, HA, has a pH of 3.02 at 25 °C. What is $K_a$ for this acid?
(a) $2.28 \times 10^{-5}$  
(b) $2.39 \times 10^{-2}$  
(c) $5.68 \times 10^{-4}$  
(d) $2.34 \times 10^{-5}$

17-36. A 0.020 M solution of an acid, HA, has a pH of 2.70 at 25 °C. What is $K_a$ for this acid?
(a) $2.21 \times 10^{-4}$  
(b) $4.55 \times 10^{-8}$  
(c) $1.99 \times 10^{-4}$  
(d) $2.00 \times 10^{-3}$

17-37. A 0.045 M solution of a base, B, has a pH of 9.20 at 25 °C. What is $K_b$ for this base?
(a) $8.85 \times 10^{-18}$  
(b) $5.58 \times 10^{-9}$  
(c) $1.40 \times 10^{-8}$  
(d) $3.56 \times 10^{-5}$

17-38. We make a 0.10 M solution of the diprotic acid, $\text{H}_2\text{CO}_3$, at 25 °C. What is $[\text{CO}_3^{2-}]$ in the solution? ($K_{a1} = 4.2 \times 10^{-7}$ and $K_{a2} = 4.8 \times 10^{-11}$)
(a) $4.2 \times 10^{-7}$ M  
(b) $2.0 \times 10^{-4}$ M  
(c) $4.8 \times 10^{-11}$ M  
(d) $2.2 \times 10^{-6}$ M
17-39. We make a 0.20 M solution of the diprotic acid, \( \text{H}_2\text{S} \), at 25 °C. What is \([\text{S}^{2-}]\) in the solution? \((K_{a1} = 1.0 \times 10^{-7} \text{ and } K_{a2} = 1.3 \times 10^{-13})\)

(a) \(1.3 \times 10^{-13} \text{ M}\)  
(b) \(1.6 \times 10^{-7} \text{ M}\)  
(c) \(1.0 \times 10^{-7} \text{ M}\)  
(d) \(1.4 \times 10^{-4} \text{ M}\)

17-40. Water cannot function as which one of the following?

(a) a Brønsted acid  
(b) a Brønsted base  
(c) a Lewis acid  
(d) a Lewis base

QUESTIONS ON FORMATION CONSTANTS

17-41. We place 0.00010 moles of \( \text{NiCl}_2 \), \( \text{CdCl}_2 \), \( \text{ZnCl}_2 \), and \( \text{CuCl}_2 \) in 1.00 L of a 0.10 M \( \text{NH}_3 \) solution. Which of these metal ions is lowest in concentration in the solution?

\[K_f \text{ for } [\text{Ni(NH}_3)_4]^{2+} = 5.6 \times 10^8\]  
\[K_f \text{ for } [\text{Cd(NH}_3)_4]^{2+} = 1.0 \times 10^7\]  
\[K_f \text{ for } [\text{Cu(NH}_3)_4]^{2+} = 6.8 \times 10^{12}\]  
\[K_f \text{ for } [\text{Zn(NH}_3)_4]^{2+} = 2.9 \times 10^9\]

(a) \(\text{Ni}^{2+}\)  
(b) \(\text{Cd}^{2+}\)  
(c) \(\text{Cu}^{2+}\)  
(d) \(\text{Zn}^{2+}\)

17-42. Calculate \([\text{Cd}^{2+}]\) in a solution that was originally 0.01 M \(\text{Cd}^{2+}\) and 2.0 M \(\text{NH}_3\). \((K_f \text{ for } [\text{Cd(NH}_3)_4]^{2+} = 1.0 \times 10^7)\)

(a) \(0.01 \text{ M}\)  
(b) \(4.6 \times 10^{-6} \text{ M}\)  
(c) \(8.2 \times 10^{-8} \text{ M}\)  
(d) \(6.8 \times 10^{-11} \text{ M}\)

17-43. Calculate \([\text{Ni}^{2+}]\) in a solution that was originally 0.10 M \(\text{Ni}^{2+}\) and 2.0 M \(\text{NH}_3\). \((K_f \text{ for } [\text{Ni(NH}_3)_4]^{2+} = 5.6 \times 10^8)\)

(a) \(2.7 \times 10^{-10} \text{ M}\)  
(b) \(0.10 \text{ M}\)  
(c) \(1.60 \text{ M}\)  
(d) \(8.7 \times 10^{-6} \text{ M}\)

17-44. Calculate \([\text{Cu}^{2+}]\) in a solution that was originally 0.10 M \(\text{Cu}^{2+}\) and 1.0 M \(\text{NH}_3\). \((K_f \text{ for } [\text{Cu(NH}_3)_4]^{2+} = 6.8 \times 10^{12})\)

(a) \(6.8 \times 10^{-12} \text{ M}\)  
(b) \(1.1 \times 10^{-12} \text{ M}\)  
(c) \(0.60 \text{ M}\)  
(d) \(3.2 \times 10^3 \text{ M}\)

17-45. We make up 0.10 M solutions of \([\text{Cd(CN)}_4]^{2-}\), \([\text{Ni(CN)}_4]^{2-}\), \([\text{Ag(CN)}_2]^-\), and \([\text{Fe(CN)}_6]^{2-}\). Which of the following metal ions is highest in concentration?

\[K_f \text{ for } [\text{Cd(CN)}_4]^{2-} = 1.3 \times 10^{17}\]  
\[K_f \text{ for } [\text{Ni(CN)}_4]^{2-} = 1.0 \times 10^{31}\]  
\[K_f \text{ for } [\text{Ag(CN)}_2]^- = 5.6 \times 10^{18}\]  
\[K_f \text{ for } [\text{Fe(CN)}_6]^{2-} = 7.7 \times 10^{36}\]

(a) \(\text{Cd}^{2+}\)  
(b) \(\text{Ni}^{2+}\)  
(c) \(\text{Ag}^+\)  
(d) \(\text{Fe}^{2+}\)
17-46. We make up 0.10 M solutions of \([\text{Cd(CN)}_4]^{2-}\), \([\text{Ni(CN)}_4]^{2-}\), \([\text{Ag(CN)}_2]^{-}\), and \([\text{Fe(CN)}_6]^{2-}\). Which of the following metal ions is lowest in concentration?

- \(\text{K}_f \text{ for } [\text{Cd(CN)}_4]^{2-} = 1.3 \times 10^{17}\)
- \(\text{K}_f \text{ for } [\text{Ni(CN)}_4]^{2-} = 1.0 \times 10^{31}\)
- \(\text{K}_f \text{ for } [\text{Ag(CN)}_2]^{-} = 5.6 \times 10^{18}\)
- \(\text{K}_f \text{ for } [\text{Fe(CN)}_6]^{2-} = 7.7 \times 10^{36}\)

(a) \(\text{Cd}^{2+}\)  
(b) \(\text{Ni}^{2+}\)  
(c) \(\text{Ag}^{+}\)  
(d) \(\text{Fe}^{2+}\)

17-47. Given the following reaction

\[\text{HCN(aq)} + \text{NH}_3(aq) \rightarrow \text{NH}_4^+(aq) + \text{CN}^-(aq)\]

The Brønsted acid on the left is

(a) \(\text{HCN}\)  
(b) \(\text{NH}_3\)

and its conjugate base is

(a) \(\text{NH}_4^+\)  
(b) \(\text{CN}^-\)

The ammonium ion would be classified as a Brønsted

(a) acid  
(b) base

17-48. You are given 0.1 M aqueous solutions of the compounds below. In each case, tell whether the solution will have a pH of 7, a pH less than 7, or a pH greater than 7.

<table>
<thead>
<tr>
<th>Substance</th>
<th>pH of Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) (\text{H}_3\text{PO}_4)</td>
<td>(=7)</td>
</tr>
<tr>
<td>(ii) (\text{K}_2\text{CO}_3)</td>
<td>(=7)</td>
</tr>
<tr>
<td>(iii) (\text{NaHSO}_4)</td>
<td>(=7)</td>
</tr>
<tr>
<td>(iv) (\text{Al(NO}_3)_3)</td>
<td>(=7)</td>
</tr>
<tr>
<td>(v) (\text{KNO}_3)</td>
<td>(=7)</td>
</tr>
<tr>
<td>(vi) (\text{Mg(C}_2\text{H}_3\text{O}_2)_2)</td>
<td>(=7)</td>
</tr>
</tbody>
</table>

17-49. The molecule HOCl is both a weak Brønsted acid and an oxidizing agent. As an acid it gives the base OCl\(^-\) on ionization.

\[\text{HOCl(aq)} + \text{H}_2\text{O}(l) \rightleftharpoons \text{OCl}^-(aq) + \text{H}_3\text{O}^+(aq)\]

(i) If the pH of a 0.015 M solution of the acid is 4.64, what is the concentration of the hypochlorite ion, OCl\(^-\), in solution?

(a) \(4.37 \times 10^{-4}\)  
(b) \(2.29 \times 10^{-5}\)  
(c) \(4.37 \times 10^{4}\)  
(d) \(4.38 \times 10^{10}\)

(ii) What is the value of \(K_a\) for the acid?

(a) \(2.30 \times 10^{-5}\)  
(b) \(5.25 \times 10^{-10}\)  
(c) \(1.53 \times 10^{-3}\)  
(d) \(3.50 \times 10^{-8}\)
17-50. Pyridine, an organic molecule, is a very common weak base.
\[ \text{C}_5\text{H}_5\text{N(aq)} + \text{H}_2\text{O(l)} \rightleftharpoons \text{C}_5\text{H}_5\text{NH}^+(aq) + \text{OH}^-(aq) \]
Assume you have a 0.0213 M aqueous solution of pyridine, C\textsubscript{5}H\textsubscript{5}N. The K\textsubscript{b} value for the compound is 1.5 x 10\textsuperscript{-9}.
(i) What is the concentration of OH\textsuperscript{-} in the solution?
(a) 2.13 x 10\textsuperscript{-2} M (b) 5.65 x 10\textsuperscript{-6} M
(c) 1.77 x 10\textsuperscript{-9} M (d) 3.20 x 10\textsuperscript{-11} M
(ii) What is the pH of the solution?
(a) 12.33 (b) 8.75
(c) 5.25 (d) 10.50

17-51. The molecule phenol is a weak Brønsted acid often used in disinfectants. As an acid it gives the base C\textsubscript{6}H\textsubscript{5}O\textsuperscript{-} on ionization.
\[ \text{C}_6\text{H}_5\text{OH(aq)} + \text{H}_2\text{O(l)} \rightleftharpoons \text{C}_6\text{H}_5\text{O}^-(aq) + \text{H}_3\text{O}^+(aq) \]
(i) If the pH of a 0.015 M solution of the acid is 5.86, what is the concentration of the hydronium ion, H\textsubscript{3}O\textsuperscript{+}, in solution?
(a) 1.50 x 10\textsuperscript{-1} (b) 7.24 x 10\textsuperscript{-9}
(c) 1.38 x 10\textsuperscript{-6} (d) 5.86 x 10\textsuperscript{-6}
(ii) What is the value of K\textsubscript{a} for the acid?
(a) 1.50 (b) 1.3 x 10\textsuperscript{-10}
(c) 2.29 x 10\textsuperscript{-9} (d) 9.20 x 10\textsuperscript{-5}

17-52. For each solution below, tell if the pH is less than 7, equal to 7, or greater than 7.

<table>
<thead>
<tr>
<th>SOLUTION</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) 0.10 M HNO\textsubscript{3}</td>
<td></td>
</tr>
<tr>
<td>(ii) 0.012 M KOH</td>
<td></td>
</tr>
<tr>
<td>(iii) 0.15 M acetic acid</td>
<td></td>
</tr>
<tr>
<td>(iv) 0.56 M Na\textsubscript{2}CO\textsubscript{3}</td>
<td></td>
</tr>
<tr>
<td>(v) 0.45 M KBr</td>
<td></td>
</tr>
<tr>
<td>(vi) 0.15 M (NH\textsubscript{4})\textsubscript{2}S</td>
<td></td>
</tr>
</tbody>
</table>

17-53. What are the pH and the ion concentrations in a solution of 0.0015 M NaOH?

<table>
<thead>
<tr>
<th>pH</th>
<th>[OH\textsuperscript{-}]</th>
<th>[H\textsubscript{3}O\textsuperscript{+}]</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) 11.18</td>
<td>6.7 x 10\textsuperscript{-3}</td>
<td>1.5 x 10\textsuperscript{-12}</td>
</tr>
<tr>
<td>(b) 2.82</td>
<td>1.5 x 10\textsuperscript{-3}</td>
<td>6.7 x 10\textsuperscript{-12}</td>
</tr>
<tr>
<td>(c) 11.18</td>
<td>1.5 x 10\textsuperscript{-3}</td>
<td>6.7 x 10\textsuperscript{-12}</td>
</tr>
<tr>
<td>(d) 1.50</td>
<td>3.16 x 10\textsuperscript{-13}</td>
<td>3.16 x 10\textsuperscript{-2}</td>
</tr>
</tbody>
</table>
17-54. What are the pH and ion concentrations in a solution of 0.10 M sodium formate, NaCHO₂⁻? \( K_b \) for the formate ion, HCO₂⁻ is \( 5.6 \times 10^{-11} \).

<table>
<thead>
<tr>
<th>pH</th>
<th>[Na⁺]</th>
<th>[CHO₂⁻]</th>
<th>[OH⁻]</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>5.63</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>(b)</td>
<td>8.37</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>(c)</td>
<td>8.22</td>
<td>0.050</td>
<td>0.050</td>
</tr>
<tr>
<td>(d)</td>
<td>5.63</td>
<td>0.10</td>
<td>0.10</td>
</tr>
</tbody>
</table>

17-55. If you have a 0.15 M solution of Na₂CO₃, what are the concentrations of H₃O⁺ and OH⁻ and what is the pH of the solution? \( K_b \) for CO₃²⁻ is \( 2.1 \times 10^{-4} \).

<table>
<thead>
<tr>
<th>[H₃O⁺]</th>
<th>[OH⁻]</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>5.61 x 10⁻³</td>
<td>1.78 x 10⁻¹²</td>
</tr>
<tr>
<td>(b)</td>
<td>1.78 x 10⁻¹²</td>
<td>5.61 x 10⁻³</td>
</tr>
<tr>
<td>(c)</td>
<td>5.61 x 10⁻³</td>
<td>1.78 x 10⁻¹²</td>
</tr>
<tr>
<td>(d)</td>
<td>1.78 x 10⁻¹²</td>
<td>5.61 x 10⁻³</td>
</tr>
</tbody>
</table>

17-56. The pH of a solution made by dissolving 0.588 g of the weak organic acid phenol, C₆H₅OH, in 500. mL of water is 5.90. What is the value of \( K_a \) for the acid?

\[
C_6H_5OH(aq) + H_2O(l) \rightleftharpoons C_6H_5O^-(aq) + H_3O^+(aq)
\]

<table>
<thead>
<tr>
<th>([H_3O^+])</th>
<th>([OH^-])</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) 5.0 x 10⁻¹⁵</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) 2.5 x 10⁻¹⁰</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) 1.0 x 10⁻⁴</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) 1.3 x 10⁻¹⁰</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ANSWERS — CHAPTER 17

1. b 11. b 21. c
2. a 12. d 22. b
3. d 13. b 23. c
4. d 14. c 24. a
5. c 15. d 25. d
6. a 16. a 26. b
7. b 17. b 27. d
8. a 18. c 28. c
9. b 19. a 29. c
10. a 20. d 30. a
31. a 41. c 51. c, b
32. b 42. d 52. <7, >7, <7, >7, =7, >7
33. c 43. a 53. c
34. d 44. b 54. b
35. d 45. a 55. b
36. a 46. b 56. d
37. b 47. a, b, a
38. c 48. <7, >7, <7, <7, =7, >7
39. a 49. b, d
40. c 50. b, b