Section 8.2: Strong and Weak Acids and Bases

Tutorial 1 Practice, page 502

1. $$K_b = \frac{K_w}{K_a}$$
$$= \frac{1.0\times10^{-14}}{5.8\times10^{-10}}$$
$$K_b = 1.7\times10^{-5}$$

2. $$K_a = \frac{K_w}{K_b}$$
$$= \frac{1.0\times10^{-14}}{1.5\times10^{-11}}$$
$$K_a = 6.7\times10^{-4}$$

Tutorial 2 Practice, page 505

1. pH + pOH = 14
pOH = 14 – pH
= 14 – 4
pOH = 4

2. pH + pOH = 14.00
pH = 14.00 – pOH
= 14.00 – 8.47
pH = 5.53

3. pH + pOH = 14.00
pH = 14.00 – pOH
= 14.00 – 2.41
pH = 11.59

Tutorial 3 Practice, page 508

1. Given: $[H^+(aq)] = 1.8 \times 10^{-9}$ mol/L
Required: pH
Analysis: $pH = -\log[H^+(aq)]$
Solution: $pH = -\log(1.8 \times 10^{-9})$
$= 8.74$
Statement: The solution has a pH of 8.74

2. Given: pH = 2.5
Required: $[H^+(aq)]$
Analysis: $[H^+(aq)] = 10^{-pH}$
Solution: $[H^+(aq)] = 10^{-2.5}$
$= 3.2 \times 10^{-3}$
Statement: $[H^+(aq)] = 3.2 \times 10^{-3}$ mol/L

3. Given: $[OH^- (aq)] = 3.2 \times 10^{-4}$ mol/L
Required: pOH
Analysis: $pOH = -\log[OH^-(aq)]$
Solution: $pOH = -\log(3.2 \times 10^{-4})$
$= 3.49$
Statement: The solution has a pOH of 3.49
4. Given: $[OH^-(aq)] = 1.0$ mol/L
Required: pOH, pH
Analysis: $pOH = -\log[OH^-(aq)]$
Solution: $pOH = -\log(1.0)$
$= 0$
$pH = 14 - pOH = 14$
Statement: The solution has a pOH of 0.00 and a pH of 14.00

Research This: Hazardous to Your Teeth, page 508

A. Answers may vary. Sample answer: Cola beverage; sample pH approximately 2.5
B. Sample answer: Tooth erosion occurs due to the increased solubility of hydroxyapatite at low pH, which removes the hydroxyapatite from tooth enamel.
C. Answers may vary. Student answer should consider health benefits of the selected food and health costs due to tooth erosion in making a recommendation.
D. Answers may vary.

Section 8.2 Questions, page 509

1. $H_2O < H_2S < HC_2H_3O_2 < H_3O^+ < HCl$
2. $Cl^- < F^- < NO_2^- < CN^-$
3. $K_b = \dfrac{K_w}{K_a}$

(a) $K_b = \dfrac{1.0\times10^{-14}}{1.8\times10^{-4}} = 5.6\times10^{-11}$

(b) $K_b = \dfrac{1.0\times10^{-14}}{4.4\times10^{-7}} = 2.3\times10^{-8}$

(c) $K_b = \dfrac{1.0\times10^{-14}}{3.8\times10^{-8}} = 2.9\times10^{-7}$

(d) $K_b = \dfrac{1.0\times10^{-14}}{5.8\times10^{-10}} = 1.7\times10^{-5}$

4. $K_a = \dfrac{K_w}{K_b}$

(a) $K_a = \dfrac{1.0\times10^{-14}}{1.7\times10^{-9}} = 5.9\times10^{-6}$

(b) $K_a = \dfrac{1.0\times10^{-14}}{1.7\times10^{-6}} = 5.9\times10^{-9}$

(c) $K_a = \dfrac{1.0\times10^{-14}}{7.5\times10^{-7}} = 1.3\times10^{-8}$

(d) $K_a = \dfrac{1.0\times10^{-14}}{9.6\times10^{-4}} = 1.0\times10^{-11}$

5. $[H^+(aq)]\ [OH^-\ (aq)] = 1.00 \times 10^{-14}$

If $[H^+(aq)] > 1.0\times 10^{-7}$, the solution is acidic.

If $[H^+(aq)] < 1.0 \times 10^{-7}$, the solution is basic.

(a) $[H^+(aq)]$: 1.0×10^{-9} mol/L; basic

(b) $[OH^-(aq)]$: 1.0×10^{-15} mol/L; acidic

(c) $[OH^-(aq)]$: 2.0×10^{-8} mol/L; acidic

(d) $[H^+(aq)]$: 1.3×10^{-4} mol/L; acidic

(e) $[OH^-(aq)]$: 1.4×10^{-1} mol/L; basic

(f) $[H^+(aq)]$: 8.3×10^{-9} mol/L; basic

6. Given: pH

Required: $[H^+(aq)]$, $[OH^-\ (aq)]$

Analysis: $[H^+(aq)] = 10^{-pH}$

$$[OH^-(aq)] = \frac{1.0\times10^{-14}}{[H^+]}$$

(a) $[H^+(aq)]$: 5.9×10^{-4} mol/L; $[OH^-(aq)]$: 1.7×10^{-11} mol/L

(b) $[H^+(aq)]$: 3.8×10^{-14} mol/L; $[OH^-(aq)]$: 2.6×10^{-1} mol/L

(c) $[H^+(aq)]$: 6.0×10^{-3} mol/L; $[OH^-(aq)]$: 1.7×10^{-12} mol/L

(d) $[H^+(aq)]$: 1.1×10^{-9} mol/L; $[OH^-(aq)]$: 8.9×10^{-6} mol/L

7. (a) Given: $[H^+(aq)] = 6.2 \times 10^{-11}$ mol/L

Required: pH

Analysis: $pH = -\log[H^+(aq)]$

Solution: $pH = -\log(6.2 \times 10^{-11})$
$= 10.21$

Statement: The solution has a pH of 10.21.

(b) Given: $[OH^-(aq)]$: 7.1×10^{-14} mol/L

Required: pH

Analysis: $[H^+(aq)] = \dfrac{1.0\times10^{-14}}{[OH^-]}$

$pH = -\log[H^+(aq)]$

Solution: $[H^+(aq)] = \dfrac{1.0\times10^{-14}}{7.1\times10^{-14}} = 1.41\times10^{-1}$ mol/L

$pH = -\log(1.41 \times 10^{-1})$
$= 0.85$

Statement: The solution has a pH of 0.85.

(c) Given: pOH = 4.98

Required: pH

Analysis: pH = 14.00 − pOH
Solution: pH = 14.00 – 4.98
Statement: The solution has a pH of 9.02.

8. (a) Given: $[OH^-(aq)] = 3.1 \times 10^{-4}$ mol/L
Required: pOH
Analysis: $pOH = -\log[OH^-(aq)]$
Solution: $pOH = -\log(3.1 \times 10^{-4})$
$= 3.51$
Statement: The solution has a pOH of 3.51.

(b) Given: $[H^+(aq)] = –1.0 \times 10^{-7}$ mol/L
Required: pOH
Analysis: $[OH^-(aq)] = \dfrac{1.0\times10^{-14}}{[H^+]}$
$pOH = -\log[OH^-(aq)]$
Solution: $[OH^-(aq)] = 1.0 \times 10^{-14}/1.0 \times 10^{-7} = 1.0 \times 10^{-7}$
$pOH = -\log(1.0 \times 10^{-7})$
$= 7.00$
Statement: The solution has a pOH of 7.00.

(c) Given: pH = 3.84
Required: pOH
Analysis: pOH = 14.00 − pH
Solution: pH = 14.00 – 3.84
=10.16
Statement: The solution has a pOH of 10.16.

9. $[H^+(aq)] = 10^{-pH}$
$[OH^-(aq)] = 10^{-pOH}$
$[H^+(aq)]\,[OH^-(aq)] = 1.0 \times 10^{-14}$

(a) $[H^+]$: 1.00×10^{-12} mol/L; $[OH^-]$: 1.0×10^{-2}
(b) $[H^+]$: 2.88×10^{-2} mol/L; $[OH^-]$: 3.5×10^{-13}
(c) $[H^+]$: 1.00×10^{-3} mol/L; $[OH^-]$: 1.0×10^{-11}
(d) $[H^+]$: 4.90×10^{-10} mol/L; $[OH^-]$: 2.0×10^{-5}

10. This statement is not true because it is the concentration of hydrogen ions that makes an acid dangerous, not the strength of the acid. A dilute solution of a strong acid has a low concentration of hydrogen ions.

11. A superacid is an acid that has a greater tendency to donate protons than pure sulfuric acid does. Some superacids are molecules that lose protons easily; others are manufactured by adding sulfur or nitrogen oxides to concentrated sulfuric or nitric acids. They are extremely corrosive and can cause severe skin damage. Superacids are used as catalysts in chemical manufacturing.