

Answers to Chapter 14 Study Questions

1. Fill in the following table:

| $[H^+]$ | $[OH^-]$ | pH | pOH | acid, base or neutral? |
|-------------------------|-------------------------|------|------|------------------------|
| $1.0 \times 10^{-4} M$ | $1.0 \times 10^{-10} M$ | 4.0 | 10.0 | acid |
| $1.0 \times 10^{-7} M$ | $1.0 \times 10^{-7} M$ | 7.0 | 7.0 | neutral |
| $1.0 \times 10^{-12} M$ | $1.0 \times 10^{-2} M$ | 12.0 | 2.0 | base |
| 1.0 M | $1.0 \times 10^{-14} M$ | 0.0 | 14.0 | acid |
| $3.2 \times 10^{-4} M$ | $3.2 \times 10^{-11} M$ | 3.5 | 10.5 | acid |
| $4.6 \times 10^{-3} M$ | $2.2 \times 10^{-12} M$ | 2.3 | 11.7 | acid |
| $1.2 \times 10^{-3} M$ | $8.2 \times 10^{-12} M$ | 2.9 | 11.1 | acid |

2. a) strong, acid, $HNO_3(aq) \rightarrow H^+(aq) + NO_3^-(aq)$ b) weak, acid, $HF(aq) \rightleftharpoons H^+(aq) + F^-(aq)$ c) weak, base, $F^-(aq) + H_2O \rightleftharpoons HF(aq) + OH^-(aq)$ d) amphoteric, acid: $HSO_3^-(aq) \rightleftharpoons H^+(aq) + SO_3^{2-}(aq)$;base: $HSO_3^-(aq) + H_2O \rightleftharpoons H_2SO_3(aq) + OH^-(aq)$ e) strong, base, $KOH(s) \rightarrow K^+(aq) + OH^-(aq)$ 3. a) HCl = strong acid; $[H^+] = \frac{0.010 \text{ mol}}{10.0 \text{ L}} = 1.0 \times 10^{-3} M$; pH = 3.0b) NaOH = strong base; $[NaOH] = \frac{6.0 \text{ g NaOH}}{15.0 \text{ L}} \times \frac{1 \text{ mol NaOH}}{40.0 \text{ g NaOH}} = 0.010 \text{ mol/L} =$ $[OH^-] = [NaOH] = 1.0 \times 10^{-2} M$; $[H^+] = 1.0 \times 10^{-12} M$; pH = 12.0c) HBr = strong acid; $5.0 \text{ mL} = 5.0 \times 10^{-3} \text{ L}$; $V_1 \times M_1 = V_2 \times M_2$ $(5.0 \times 10^{-3} \text{ L}) \times (0.40 \text{ M}) = (20 \text{ L}) \times M_2$; $M_2 = (5.0 \times 10^{-3} \text{ L}) \times (0.40 \text{ M}) / (20 \text{ L})$ $M_2 = 1.0 \times 10^{-4} M = [H^+]$; pH = 4.0.d) $K_a = \frac{[H^+][A^-]}{[HA]}$; $[H^+] = [A^-] = x$; $[HA] \approx 0.10 \text{ M}$; $6.4 \times 10^{-5} = \frac{x^2}{0.10 \text{ M}}$ $x^2 = (6.4 \times 10^{-5})(0.10) = 6.4 \times 10^{-6} \text{ M}$; $x = (6.4 \times 10^{-6})^{1/2} = 2.5 \times 10^{-3}$; pH = 2.6e) $K_b = \frac{[HClO][OH^-]}{[ClO^-]}$; $[HClO] = [OH^-] = x$; $[ClO^-] \approx 0.20 \text{ M}$; $K_a \times K_b = 10^{-14}$; $K_b = \frac{10^{-14}}{K_a(HClO)} = \frac{10^{-14}}{3.5 \times 10^{-8}} = 2.9 \times 10^{-7}$ $K_b = \frac{[HClO][OH^-]}{[ClO^-]}$; $2.9 \times 10^{-7} = \frac{x^2}{0.20 \text{ M}}$; $x^2 = (2.9 \times 10^{-7})(0.20 \text{ M}) = 5.8 \times 10^{-8}$ $x = [OH^-] = (5.8 \times 10^{-8})^{1/2} = 2.4 \times 10^{-4} \text{ M}$; pOH = 3.6; pH = 14.0 - 3.6 = 10.4

f) 0.10 mol H^+ and $0.10 \text{ mol OH}^- \rightarrow 0.10 \text{ mol H}_2\text{O}$; 0.10 mol H^+ remains in 1.0 L .
 $[\text{H}^+] = (0.10 \text{ mol})/(1.0 \text{ L}) = 1.0 \times 10^{-1} \text{ M}$; $\text{pH} = 1.0$

4. a) $\text{H}_2\text{CO}_3(\text{aq}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{HCO}_3^-(\text{aq})$

b) $K_a = \frac{[\text{H}^+][\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]}$

c) $\text{pH} = 3.68$; $[\text{H}^+] = [\text{HCO}_3^-] = 10^{-3.68} = 2.1 \times 10^{-4} \text{ M}$; $[\text{H}_2\text{CO}_3] \approx 0.10 \text{ M}$

$$K_a = \frac{[\text{H}^+][\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]}; K_a = \frac{(2.1 \times 10^{-4})^2}{0.10 \text{ M}} = \frac{(2.1)^2 \times 10^{-8}}{(1.0 \times 10^{-1})} = 4.4 \times 10^{-7}$$

d) $K_a \times K_b = 1.0 \times 10^{-14}$; $K_b = (1.0 \times 10^{-14})/(4.4 \times 10^{-7}) = 2.3 \times 10^{-8}$

5. a) It can be an H^+ acceptor.

b) CH_3COOH

c) $\text{CH}_3\text{COO}^-(\text{aq}) + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COOH}(\text{aq}) + \text{OH}^-(\text{aq})$

6. a) $\text{HNO}_2(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{NO}_2^-(\text{aq}) + \text{H}_2\text{O}$
acid₁ base₂ base₁ acid₂

7. weakest acid \rightarrow strongest acid: $\text{HCN} < \text{HC}_2\text{H}_3\text{O}_2 < \text{HF} < \text{HCl}$
weakest base \rightarrow strongest base: $\text{Cl}^- < \text{F}^- < \text{C}_2\text{H}_3\text{O}_2^- < \text{CN}^-$

8. a) basic

b) acidic (NH_4^+ is an acid, NO_3^- is neutral)

c) neutral

d) basic (Na^+ is neutral; F^- is a weak base)