

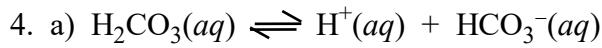
Answers to Chapter 14 Study Questions

1. Fill in the following table:

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

2. a) strong, acid, HNO₃(aq) \rightarrow H⁺(aq) + NO₃⁻(aq)
- b) weak, acid, HF(aq) \rightleftharpoons H⁺(aq) + F⁻(aq)
- c) weak, base, F⁻(aq) + H₂O \rightleftharpoons HF(aq) + OH⁻(aq)
- d) amphoteric, acid: HSO₃⁻(aq) \rightleftharpoons H⁺(aq) + SO₃²⁻(aq);
base: HSO₃⁻(aq) + H₂O \rightleftharpoons H₂SO₃(aq) + OH⁻(aq)
- e) strong, base, KOH(s) \rightarrow K⁺(aq) + OH⁻(aq)
3. a) HCl = strong acid; [H⁺] = $\frac{0.010 \text{ mol}}{10.0 \text{ L}} = 1.0 \times 10^{-3} \text{ M}$; pH = 3.0
- b) 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] = $1.0 \times 10^{-2} \text{ M}$; [H⁺] = $1.0 \times 10^{-12} \text{ M}$; pH = 12.0
- c) HBr = strong acid; 5.0 mL = $5.0 \times 10^{-3} \text{ L}$; V₁ x M₁ = V₂ x M₂
 $(5.0 \times 10^{-3} \text{ L}) \times (0.40 \text{ M}) = (20 \text{ L}) \times M_2$; M₂ = $(5.0 \times 10^{-3} \text{ L}) \times (0.40 \text{ M}) / (20 \text{ L})$
M₂ = $1.0 \times 10^{-4} \text{ M} = [\text{H}^+]$; pH = 4.0.
- d) $K_a = \frac{[\text{H}^+]x[\text{A}^-]}{[\text{HA}]}$; [H⁺] = [A⁻] = x; [HA] \approx 0.10 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 = 2.6
- e) $K_b = \frac{[\text{HClO}][\text{OH}^-]}{[\text{ClO}^-]}$; [HClO] = [OH⁻] = x; [ClO⁻] \approx 0.20 M;
 $K_a \times K_b = 10^{-14}$; $K_b = \frac{10^{-14}}{K_a(\text{HClO})} = \frac{10^{-14}}{3.5 \times 10^{-8}} = 2.9 \times 10^{-7}$
 $K_b = \frac{[\text{HClO}][\text{OH}^-]}{[\text{ClO}^-]}$; $2.9 \times 10^{-7} = \frac{x^2}{0.20 \text{ M}}$; $x^2 = (2.9 \times 10^{-7})(0.20 \text{ M}) = 5.8 \times 10^{-8}$
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.
 $[\text{H}^+] = (0.10 \text{ mol})/(1.0 \text{ L}) = 1.0 \times 10^{-1} \text{ M}$; $\text{pH} = 1.0$



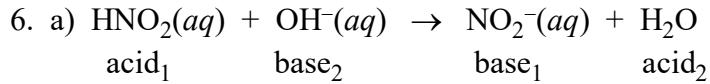
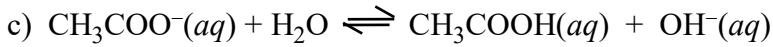
b) $K_a = \frac{[\text{H}^+][\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]}$

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.



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

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)