

## Section 8.1: The Nature of Acids and Bases

### Tutorial 1 Practice, page 492

1. (a)  $\text{HCHO}_2(\text{aq})$  donates a proton, so it is an acid and  $\text{CHO}_2^-(\text{aq})$  is its conjugate base;  $\text{H}_2\text{O}(\text{l})$  accepts a proton, so it is a base and  $\text{H}_3\text{O}^+(\text{aq})$  is its conjugate acid.

(b)  $\text{C}_6\text{H}_5\text{NH}_3^+(\text{aq})$  donates a proton, so it is an acid and  $\text{C}_6\text{H}_5\text{NH}_2(\text{aq})$  is its conjugate base;  $\text{H}_2\text{O}(\text{l})$  accepts a proton, so it is a base and  $\text{H}_3\text{O}^+(\text{aq})$  is its conjugate acid.

(c)  $\text{H}_2\text{CO}_3(\text{aq})$  donates a proton, so it is an acid and  $\text{HCO}_3^-(\text{aq})$  is its conjugate base;  $\text{OH}^-(\text{aq})$  accepts a proton, so it is a base and  $\text{H}_2\text{O}(\text{l})$  is its conjugate acid.

(d)  $\text{HSO}_4^-(\text{aq})$  donates a proton, so it is an acid and  $\text{SO}_4^{2-}(\text{aq})$  is its conjugate base;  $\text{HPO}_4^{2-}(\text{aq})$  accepts a proton, so it is a base and  $\text{H}_2\text{PO}_4^-(\text{aq})$  is its conjugate acid.

(e)  $\text{HCl}(\text{aq})$  donates a proton, so it is an acid and  $\text{Cl}^-(\text{aq})$  is its conjugate base;  $\text{HSO}_4^-(\text{aq})$  accepts a proton, so it is a base and  $\text{H}_2\text{SO}_4(\text{aq})$  is its conjugate acid.

2.  $\text{HSO}_4^-(\text{aq})$  is amphiprotic because it is able to donate a proton and it is able to accept a proton.

### Tutorial 2 Practice, page 493

1.  $\text{HCN}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{CN}^-(\text{aq})$

$$K = \frac{[\text{H}_3\text{O}^+(\text{aq})][\text{CN}^-(\text{aq})]}{[\text{HCN}(\text{aq})]}$$

2.  $\text{HNO}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{NO}_2^-(\text{aq})$

$$K = \frac{[\text{H}_3\text{O}^+(\text{aq})][\text{NO}_2^-(\text{aq})]}{[\text{HNO}_2(\text{aq})]}$$

3.  $\text{HSO}_4^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq})$

$$K = \frac{[\text{H}_3\text{O}^+(\text{aq})][\text{SO}_4^{2-}(\text{aq})]}{[\text{HSO}_4^-(\text{aq})]}$$

### Section 8.1 Questions, page 494

1. (a)  $K_a$  is the acid dissociation constant, which is the ratio of ions to undissociated molecules of acid.

(b) *Amphiprotic* means “able to donate or accept a hydrogen ion.”

(c) A hydronium ion is a water molecule that has accepted a hydrogen ion.

(d) A hydroxide ion is a negative ion consisting of an oxygen atom and a hydrogen ion.

(e) A conjugate acid is a substance formed by accepting a hydrogen ion.

(f) A conjugate base is a substance formed by donating a hydrogen ion.

2. (a) The two concentrations are equal.

(b) The hydrogen ion concentration is greater than the hydroxide ion concentration.

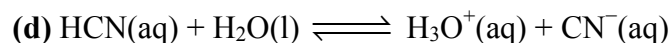
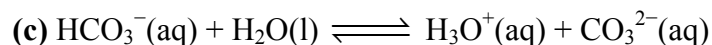
(c) The hydrogen ion concentration is less than the hydroxide ion concentration.

3. (a) An Arrhenius acid forms hydrogen ions in aqueous solution; an Arrhenius base forms hydroxide ions in aqueous solution.

(b) A Brønsted–Lowry acid is a proton donor; a Brønsted–Lowry base is a proton acceptor.

4. (a)  $\text{HF}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{F}^-(\text{aq})$

(b)  $\text{HNO}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{NO}_2^-(\text{aq})$



5.

Substance	Arrhenius theory	Brønsted–Lowry theory
	acid – forms hydronium ion base – forms hydroxide ion	acid – donates a proton base – accepts a proton both – can donate or accept a proton
$\text{NH}_4^+(\text{aq})$	acid	acid
$\text{NH}_3(\text{aq})$	acid	both
$\text{H}_2\text{O}(\text{l})$	both	both
$\text{C}_2\text{H}_3\text{O}_2^-(\text{aq})$	neither	base
$\text{H}_3\text{PO}_4(\text{aq})$	acid	acid
$\text{Ca}(\text{OH})_2(\text{aq})$	base	base
$\text{HCl}(\text{aq})$	acid	acid
$\text{H}_3\text{O}^+(\text{aq})$	acid	acid
$\text{HC}_2\text{H}_3\text{O}_2(\text{aq})$	acid	acid
$\text{H}_2\text{PO}_4^-(\text{aq})$	acid	both

6. (a) acid:  $\text{HNO}_2(\text{aq})$ ; base:  $\text{H}_2\text{O}(\text{l})$ ; conjugate acid:  $\text{H}_3\text{O}^+(\text{aq})$ ; conjugate base:  $\text{NO}_2^-(\text{aq})$

(b) acid:  $\text{H}_2\text{O}$ ; base:  $\text{NH}_3(\text{aq})$ ; conjugate acid:  $\text{NH}_4^+$ ; conjugate base:  $\text{OH}^-$

7. (a)  $\text{H}_3\text{PO}_4(\text{aq}) + \text{NH}_3(\text{aq}) \rightleftharpoons \text{H}_2\text{PO}_4^-(\text{aq}) + \text{NH}_4^+(\text{aq})$

acid:  $\text{H}_3\text{PO}_4(\text{aq})$ ; base:  $\text{NH}_3(\text{aq})$ ; conjugate acid:  $\text{H}_2\text{PO}_4^-(\text{aq})$ ; conjugate base:  $\text{NH}_4^+(\text{aq})$   
amphiprotic entity:  $\text{H}_2\text{PO}_4^-(\text{aq})$ ,  $\text{NH}_3$

(b)  $\text{HCO}_2\text{H}(\text{aq}) + \text{CN}^-(\text{aq}) \rightleftharpoons \text{HCN}(\text{aq}) + \text{CHO}_2^-(\text{aq})$

acid:  $\text{HCO}_2\text{H}(\text{aq})$ ; base:  $\text{CN}^-(\text{aq})$ ; conjugate acid:  $\text{HCN}(\text{aq})$ ; conjugate base:  $\text{CHO}_2^-(\text{aq})$

8. (a) 
$$K_a = \frac{[\text{H}^+(\text{aq})][\text{F}^-(\text{aq})]}{[\text{HF}(\text{aq})]}$$

(b) 
$$K_a = \frac{[\text{H}^+(\text{aq})][\text{CO}_3^{2-}(\text{aq})]}{[\text{HCO}_3^-(\text{aq})]}$$

(c) 
$$K_a = \frac{[\text{H}^+(\text{aq})][\text{C}_4\text{H}_7\text{O}_2^-(\text{aq})]}{[\text{HC}_4\text{H}_7\text{O}_2(\text{aq})]}$$

9. (a)  $\text{HCO}_2\text{H}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{CHO}_2^-(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$

acid:  $\text{HCO}_2\text{H}(\text{aq})$ ; base:  $\text{H}_2\text{O}(\text{l})$ ; conjugate acid:  $\text{H}_3\text{O}^+(\text{aq})$ ; conjugate base:  $\text{CHO}_2^-(\text{aq})$

(b)  $\text{C}_{17}\text{H}_{23}\text{NO}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{C}_{17}\text{H}_{24}\text{NO}_3^+(\text{aq}) + \text{OH}^-(\text{aq})$

acid:  $\text{H}_2\text{O}(\text{l})$ ; base:  $\text{C}_{17}\text{H}_{23}\text{NO}_3(\text{aq})$ ; conjugate acid:  $\text{C}_{17}\text{H}_{24}\text{NO}_3^+(\text{aq})$ ;  
conjugate base:  $\text{OH}^-(\text{aq})$

(c)  $\text{HCO}_3^-(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_2\text{CO}_3(\text{aq}) + \text{OH}^-(\text{aq})$

acid:  $\text{H}_2\text{O}(\text{l})$ ; base:  $\text{NaHCO}_3(\text{s})$ ; conjugate acid:  $\text{HCO}_3^+(\text{aq})$ ; conjugate base:  $\text{OH}^-(\text{aq})$

10. I disagree, because any substance that donates a proton can be considered a Brønsted–Lowry acid even if it does not form a hydronium ion.