Section 8.1: The Nature of Acids and Bases

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1. (a) $HCHO_2$(aq) donates a proton, so it is an acid and CHO_2^- (aq) is its conjugate base; H_2O(l) accepts a proton, so it is a base and H_3O^+(aq) is its conjugate acid.
(b) $C_6H_5NH_3^+$(aq) donates a proton, so it is an acid and $C_6H_5NH_2$(aq) is its conjugate base; H_2O(l) accepts a proton, so it is a base and H_3O^+(aq) is its conjugate acid.
(c) H_2CO_3(aq) donates a proton, so it is an acid and HCO_3^-(aq) is its conjugate base; OH^-(aq) accepts a proton, so it is a base and H_2O(l) is its conjugate acid.
(d) HSO_4^-(aq) donates a proton, so it is an acid and SO_4^{2-}(aq) is its conjugate base; HPO_4^{2-}(aq) accepts a proton, so it is a base and $H_2PO_4^-$(aq) is its conjugate acid.
(e) HCl(aq) donates a proton, so it is an acid and Cl^-(aq) is its conjugate base; HSO_4^-(aq) accepts a proton, so it is a base and H_2SO_4(aq) is its conjugate acid.
2. HSO_4^-(aq) is amphiprotic because it is able to donate a proton and it is able to accept a proton.

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1. $HCN(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CN^-(aq)$

$$K = \frac{[H_3O^+(aq)][CN^-(aq)]}{[HCN(aq)]}$$

2. $HNO_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + NO_2^-(aq)$

$$K = \frac{[H_3O^+(aq)][NO_2^-(aq)]}{[HNO_2(aq)]}$$

3. $HSO_4^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + SO_4^{2-}(aq)$

$$K = \frac{[H_3O^+(aq)][SO_4^{2-}(aq)]}{[HSO_4^-(aq)]}$$

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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) $HF(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + F^-(aq)$
(b) $HNO_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + NO_2^-(aq)$

(c) $HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CO_3^{2-}(aq)$

(d) $HCN(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CN^-(aq)$

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
$NH_4^+(aq)$	acid	acid
$NH_3(aq)$	acid	both
$H_2O(l)$	both	both
$C_2H_3O_2^-(aq)$	neither	base
$H_3PO_4(aq)$	acid	acid
$Ca(OH)_2(aq)$	base	base
$HCl(aq)$	acid	acid
$H_3O^+(aq)$	acid	acid
$HC_2H_3O_2(aq)$	acid	acid
$H_2PO_4^-(aq)$	acid	both

6. (a) acid: $HNO_2(aq)$; base: $H_2O(l)$; conjugate acid: $H_3O^+(aq)$; conjugate base: $NO_2^-(aq)$
(b) acid: H_2O; base: $NH_3(aq)$; conjugate acid: NH_4^+; conjugate base: OH^-
7. (a) $H_3PO_4(aq) + NH_3(aq) \rightleftharpoons H_2PO_4^-(aq) + NH_4^+(aq)$
acid: $H_3PO_4(aq)$; base: $NH_3(aq)$; conjugate acid: $H_2PO_4^-(aq)$; conjugate base: $NH_4^+(aq)$
amphiprotic entity: $H_2PO_4^-(aq)$, NH_3
(b) $HCO_2H(aq) + CN^-(aq) \rightleftharpoons HCN(aq) + CHO_2^-(aq)$
acid: $HCO_2H(aq)$; base: $CN^-(aq)$; conjugate acid: $HCN(aq)$; conjugate base: $CHO_2^-(aq)$

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

(b) $K_a = \dfrac{[H^+(aq)][CO_3^{2-}(aq)]}{[HCO_3^-(aq)]}$

(c) $K_a = \dfrac{[H^+(aq)][C_4H_7O_2^-(aq)]}{[HC_4H_7O_2(aq)]}$

9. (a) $HCO_2H(aq) + H_2O(l) \rightleftharpoons CHO_2^-(aq) + H_3O^+(aq)$
acid: $HCO_2H(aq)$; base: $H_2O(l)$; conjugate acid: $H_3O^+(aq)$; conjugate base: $CHO_2^-(aq)$

(b) $C_{17}H_{23}NO_3(aq) + H_2O(l) \rightleftharpoons C_{17}H_{24}NO_3^+(aq) + OH^-(aq)$
acid: $H_2O(l)$; base: $C_{17}H_{23}NO_3(aq)$; conjugate acid: $C_{17}H_{24}NO_3^+$ (aq);
conjugate base: $OH^-(aq)$

(c) $HCO_3^-(s) + H_2O(l) \rightleftharpoons H_2CO_3(aq) + OH^-(aq)$
acid: $H_2O(l)$; base: $NaHCO_3(s)$; conjugate acid: $HCO_3^+(aq)$; conjugate base: $OH^-(aq)$
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.