Hydrolysis of Salts and Reactions of Acids and Bases

Example 1

Determining the Acidic or Basic Nature of Salts

Determine whether aqueous solutions of the following salts are acidic, basic, or neutral:

(a) KBr

(b) $NaHCO_3$

(c) NH_4Cl

(d) Na_2HPO_4

(e) NH_4F

Solution

Consider each of the ions separately in terms of its effect on the pH of the solution, as shown here:

(a) The K^+ cation and the Br^- anion are both spectators, since they are the cation of a strong base (KOH) and the anion of a strong acid (HBr), respectively. The solution is neutral.

(b) The Na^+ cation is a spectator, and will not affect the pH of the solution; while the HCO_3^- anion is amphiprotic, it could either behave as an acid or a base. The K_a of HCO_3^- is 4.7×10^{-11}, so the K_b of its conjugate base is $\frac{1.0 \times 10^{-14}}{4.3 \times 10^{-7}} = 2.3 \times 10^{-8}$.

Since $K_b >> K_a$, the solution is basic.

(c) The NH_4^+ ion is acidic and the Cl^- ion is a spectator. The solution will be acidic.

(d) The Na^+ ion is a spectator, while the HPO_4^{2-} ion is amphiprotic, with a K_a of 4.2×10^{-13} so that the K_b of its conjugate base is $\frac{1.0 \times 10^{-14}}{6.2 \times 10^{-8}} = 1.6 \times 10^{-7}$.
Because $K_b >> K_a$, the solution is basic.

(e) The NH_4^+ ion is listed as being acidic, and the F^- ion is listed as a base, so we must directly compare the K_a and the K_b of the two ions. K_a of NH_4^+ is 5.6×10^{-10}, which seems very small, yet the K_b of F^- is 1.4×10^{-11}, so the solution is acidic, since $K_a > K_b$.

Try yourself

Determine whether aqueous solutions of the following salts are acidic, basic, or neutral:

(a) K_2CO_3

(b) $CaCl_2$

(c) KH_2PO_4

(d) $(NH_4)_2CO_3$

(e) $AlBr_3$

Salts of strong acids and strong bases:

Formula	Strong Acid	Strong Base
NaCl	HCl	NaOH
KCl	HCl	KOH
$NaNO_3$	HNO_3	NaOH
KNO_3	HNO_3	KOH
Na_2SO_4	H_2SO_4	NaOH
K_2SO_4	H_2SO_4	KOH

Salts of strong acids and weak bases:

Formula	Strong Acid	Weak Base
NH_4Cl	HCl	NH_4OH
$FeCl_3$	HCl	$Fe(OH)_3$
$PbNO_3$	HNO_3	PbOH
$CuSO_4$	H_2SO_4	$Cu(OH)_2$

Salts of weak acids and weak bases:

Formula	Weak Acid	Weak Base
CH_3COONH_4	CH_3COOH	NH_4OH
$HCOONH_4$	HCOOH	NH_4OH
$(NH_4)_2CO_3$	H_2CO_3	NH_4OH

Describe each as an acid, base, neutral salt, acidic salt, or basic salt. For each salt write a parent acid-base formation equation, dissociation equation, and hydrolysis equation (only for acidic and basic salts). For acids and bases write an equation to show how each reacts with water.

1. NH_3 _____

_____

2. KCl _____ _____

_____

_____

3. HNO_3 _____

_____

4. $NaHCO_3$ _____

_____

_____

_____

5. RbOH _____

_____

6. $AlCl_3$ _____

_____

_____

_____

7. $H_2C_2O_4$_____

_____

8. NaC_6H_5O _____

_____

_____

_____

9. $Co(NO_3)_3$ _____

_____

_____

_____

10. Na_2CO_3 _____

_____

_____

_____

Hydrolysis of Salts and Reactions of Acids and Bases

Describe each as an acid, base, neutral salt, acidic salt, or basic salt. For each salt write a dissociation equation and hydrolysis equation (only for acidic and basic salts). For acids and bases write an equation to show how each reacts with water.

1. NH_3 _____

_____

2. NaCl _____ _____

_____

3. HCl _____

_____

4. NaCN _____

_____

5. NaOH _____

6. $FeCl_3$ _____

7. HF _____

8. $LiHCO_3$ _____

9. $Fe(NO_3)_3$ _____

10. $MgCO_3$ _____

11. H_2S _____

12. HF _____

13. CaI_2 _____

14. $Mg(OH)_2$ _____

_____

15. $Ba(OH)_2$ _____

_____

16. Describe why Tums ($CaCO_3$) neutralizes stomach acid.

17. Describe why $Mg(OH)_2$ is used in Milk of Magnesia as an antacid instead of NaOH.

ANSWERS

WS # 1 Hydrolysis of Salts and Reactions of Acids and Bases

Describe each as an acid, base, neutral salt, acidic salt, or basic salt. For each salt write a parent acid-base formation equation, dissociation equation, and hydrolysis equation (only for

acidic and basic salts). For acids and bases write an equation to show how each reacts with water.

1. NH_3 **weak base**

$NH_3 + H_2O \rightleftarrows NH_4^+ + OH^-$

2. KCl **neutral salt**

$HCl + KOH \rightarrow KCl + H_2O$

$KCl \rightarrow K^+ + Cl^-$

3. HNO_3 **strong acid**

$HNO_3 + H_2O \rightarrow H_3O^+ + NO_3^-$

4. **$NaHCO_3$** **basic salt**

$H_2CO_3 + NaOH \rightarrow NaHCO_3 + H_2O$

$NaHCO \rightarrow Na^+ + HCO_3^-$

$HCO_3^- + H_2O \rightleftarrows H_2CO_3 + OH^-$

5. RbOH **strong base**

$RbOH \rightarrow Rb^+ + OH^-$

6. $AlCl_3$ **acid salt**

$3HCl + Al(OH)_3 \rightarrow AlCl_3 + 3H_2O$

$AlCl_3 \rightarrow Al^{+3} + 3Cl^-$

$Al(H_2O)_6^{3+} \rightleftarrows Al(H_2O)_5(OH)^{2+} + H^+$

7. $H_2C_2O_4$ **weak acid**

$H_2C_2O_4 + H_2O \rightleftarrows H_3O^+ + HC_2O_4^-$

8. NaC_6H_5O **basic salt**

$C_6H_5OH + NaOH \rightarrow NaC_6H_5O + H_2O$

$NaC_6H_5O \rightarrow Na^+ + C_6H_5O^-$

$C_6H_5O^- + H_2O \rightleftarrows C_6H_5OH + OH^-$

9. $Co(NO_3)_3$ **acid salt**

$3HNO_3 + Co(OH)_3 \rightarrow Co(NO_3)_3 + 3H_2O$

$Co(NO_3)_3 \rightarrow Co^{+3} + 3NO_3^-$

$Co(H_2O)_6^{3+} \rightleftarrows Co(H_2O)_5(OH)^{2+} + H^+$

10. Na_2CO_3 **basic salt**

$H_2CO_3 + 2NaOH \rightarrow Na_2CO_3 + 2H_2O$

$Na_2CO_3 \rightarrow 2Na^+ + CO_3^{-2}$

$CO_3^{-2} + H_2O \rightleftarrows HCO_3^- + OH^-$

WS # 2 Hydrolysis of Salts and Reactions of Acids and Bases

Describe each as an acid, base, neutral salt, acidic salt, or basic salt. For each salt write a parent acid-base formation equation, dissociation equation, and hydrolysis equation (only for

acidic and basic salts). For acids and bases write an equation to show how each reacts with water.

1. NH_3 **weak base**

$NH_3 + H_2O \rightleftarrows NH_4^+ + OH^-$

2. NaCl **neutral salt**

$NaCl \rightarrow Na^+ + Cl^-$

3. HCl **strong acid**

$HCl + H_2O \rightarrow H_3O^+ + Cl^-$

4. NaCN **basic salt**

$NaCN \rightarrow Na^+ + CN^-$

$CN^- + H_2O \rightleftarrows HCN + OH^-$

5. NaOH **strong base**

$NaOH \rightarrow Na^+ + OH^-$

6. $FeCl_3$ **acid salt**

$FeCl_3 \rightarrow Fe^{+3} + 3Cl^-$

$Fe(H_2O)_6^{3+} \rightleftarrows Fe(H_2O)_5(OH)^{2+} + H^+$

7. HF **weak acid**

$HF + H_2O \rightleftarrows H_3O^+ + F^-$

8. $LiHCO_3$ **basic salt**

$LiHCO_3 \rightarrow Li^+ + HCO_3^-$

$HCO_3^- + H_2O \rightleftarrows H_2CO_3 + OH^-$

9. $Fe(NO_3)_3$ **acid salt**

$Fe(NO_3)_3 \rightarrow Fe^{+3} + 3NO_3^-$

$Fe(H_2O)_6^{3+} \rightleftarrows Fe(H_2O)_5(OH)^{2+} + H^+$

10. $MgCO_3$ **basic salt**

$MgCO_3 \rightarrow Mg^{+2} + CO_3^{-2}$

$CO_3^{-2} + H_2O \rightleftarrows HCO_3^- + OH^-$

11. H_2S **weak acid**

$H_2S + H_2O \rightleftarrows H_3O^+ + HS^-$

12. HF **weak acid**

$HF + H_2O \rightleftarrows H_3O^+ + F^-$

13. CaI_2 **neutral salt**

$CaI_2 \rightarrow Ca^{+2} + 2I^-$

14. $Mg(OH)_2$ **weak base**

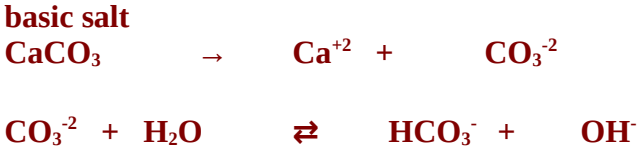
$Mg(OH)_2 \rightleftarrows Mg^{+2} + 2OH^-$

15. $Ba(OH)_2$ **strong base**

$Ba(OH)_2 \rightarrow Ba^{+2} + 2OH^-$

16. Describe why Tums ($CaCO_3$) neutralizes stomach acid. **It is a weak base and will neutralize acid.**

basic salt



17. Describe why $Mg(OH)_2$ is used in Milk of Magnesia as an antacid instead of NaOH.
$Mg(OH)_2$ is weak base and releases OH^- slowly, whereas NaOH is a strong base which releases OH^- in high concentrations which is corrosive.