Le Chatelier's principle

If the conditions of a system at equilibrium are changed, the system moves in such a way as to oppose the effects of that change.

$$a + b \overset{K}{\longleftrightarrow} c + d$$

Precipitation Reactions

Mix $CaCl_2$ and Na_2CO_3 in water – what happens?

soluble soluble

$$Ca^{2+}(aq) + 2Cl^-(aq) + 2Na^+(aq) + CO_3^{2-}(aq) \longrightarrow 2Cl^-(aq) + 2Na^+(aq) + CaCO_3(s)$$

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$$Ca^{2+}(aq) + CO_3^{2-}(aq) \longrightarrow CaCO_3(s)$$

Precipitation Reactions

Mix $CaCl_2$ and Na_2CO_3 in water – what happens?

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Net Ionic Equation

$$Ca^{2+}(aq) + CO_3^{2-}(aq) \longrightarrow CaCO_3(s)$$

Precipitation Reactions

Mix $CaCl_2$ and Na_2CO_3 in water – what happens?

soluble soluble

$$Ca^{2+}(aq) + 2Cl^-(aq) + 2Na^+(aq) + CO_3^{2-}(aq) \longrightarrow 2Cl^-(aq) + 2Na^+(aq) + CaCO_3(s)$$

Precipitation ***drives*** this rxn forward

Net Ionic Equation

$$Ca^{2+}(aq) + CO_3^{2-}(aq) \longrightarrow CaCO_3(s)$$

Acid-Base Chemistry

$$\underset{\text{hydrochloric acid}}{HCl(aq)} + \underset{\text{sodium hydroxide}}{NaOH(aq)} \longrightarrow \underset{\text{water}}{H_2O(\ell)} + \underset{\text{sodium chloride}}{NaCl(aq)}$$

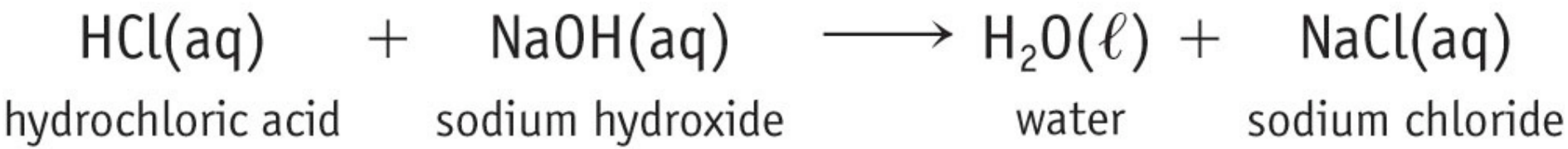
$$\underbrace{H_3O^+(aq) + Cl^-(aq)}_{\text{from HCl(aq)}} + \underbrace{Na^+(aq) + OH^-(aq)}_{\text{from NaOH(aq)}} \longrightarrow \underset{\text{water}}{2\,H_2O(\ell)} + \underbrace{Na^+(aq) + Cl^-(aq)}_{\text{from salt}}$$

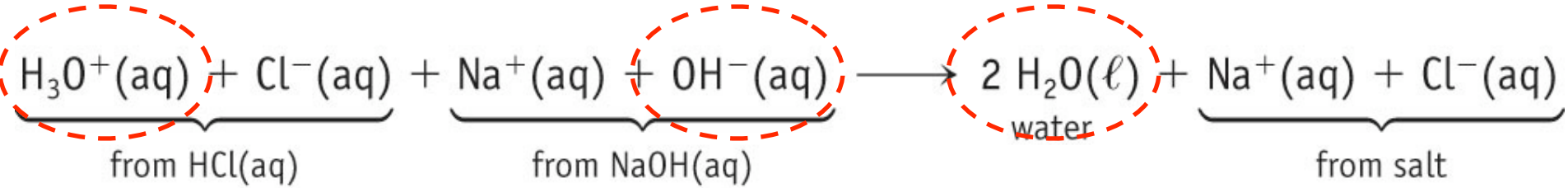
Acid-Base Chemistry

$$\underset{\text{hydrochloric acid}}{HCl(aq)} + \underset{\text{sodium hydroxide}}{NaOH(aq)} \longrightarrow \underset{\text{water}}{H_2O(\ell)} + \underset{\text{sodium chloride}}{NaCl(aq)}$$

$$\underbrace{H_3O^+(aq) + Cl^-(aq)}_{\text{from HCl(aq)}} + \underbrace{Na^+(aq) + OH^-(aq)}_{\text{from NaOH(aq)}} \longrightarrow \underbrace{2\,H_2O(\ell)}_{\text{water}} + \underbrace{Na^+(aq) + Cl^-(aq)}_{\text{from salt}}$$

Acid-Base Chemistry





Net Ionic Equation

$H_3O^+ (aq) + OH^- (aq) \longrightarrow 2\ H_2O\ (l)$

Acid-Base Chemistry

$$\underset{\text{hydrochloric acid}}{HCl(aq)} + \underset{\text{sodium hydroxide}}{NaOH(aq)} \longrightarrow \underset{\text{water}}{H_2O(\ell)} + \underset{\text{sodium chloride}}{NaCl(aq)}$$

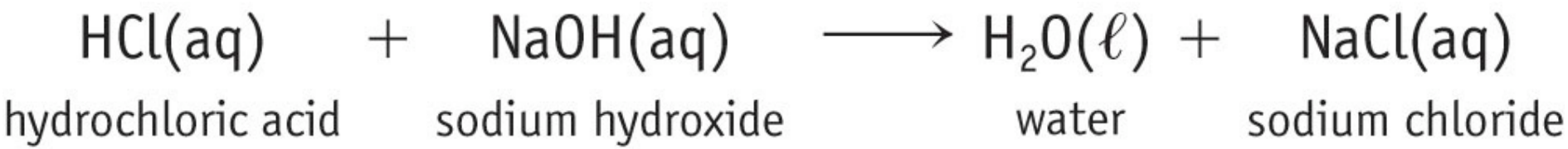
$$\underbrace{H_3O^+(aq) + Cl^-(aq)}_{\text{from HCl(aq)}} + \underbrace{Na^+(aq) + OH^-(aq)}_{\text{from NaOH(aq)}} \longrightarrow \underbrace{2\,H_2O(\ell)}_{\text{water}} + \underbrace{Na^+(aq) + Cl^-(aq)}_{\text{from salt}}$$

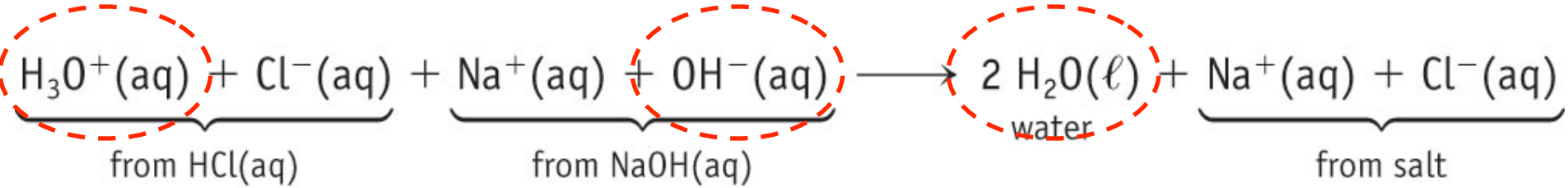
Net Ionic Equation

$$H_3O^+\,(aq) + OH^-\,(aq) \longrightarrow 2\,H_2O\,(l)$$

Acid-base reactions can ***drive*** reactions forward

Acid-Base Chemistry





Acid-base neutralization ***drives*** this rxn forward

Net Ionic Equation

$H_3O^+ (aq) + OH^- (aq) \longrightarrow 2\ H_2O\ (l)$

Acid-base reactions can ***drive*** reactions forward

TABLE 3.3 Gas-Forming Reactions

Metal carbonate or bicarbonate + acid → metal salt + $CO_2(g)$ + $H_2O(\ell)$

$Na_2CO_3(aq) + 2\ HCl(aq) \rightarrow 2\ NaCl(aq) + CO_2(g) + H_2O(\ell)$

$2Na^+(aq) + 2Cl^-(aq) + 2H^+(aq) + CO_3^{2-}(aq)$

$\rightarrow H_2O(l) + CO_2(g) + 2Na^+(aq) + 2Cl^-(aq)$

Table 3-3, p. 140

TABLE 3.3 Gas-Forming Reactions

Metal carbonate or bicarbonate + acid → metal salt + $CO_2(g)$ + $H_2O(\ell)$

$Na_2CO_3(aq) + 2\ HCl(aq) \rightarrow 2\ NaCl(aq) + CO_2(g) + H_2O(\ell)$

$2Na^+(aq) + 2Cl^-(aq) + 2H^+(aq) + CO_3^{2-}(aq)$

$\rightarrow H_2O(l) + CO_2(g) + 2Na^+(aq) + 2Cl^-(aq)$

Table 3-3, p. 140

TABLE 3.3 Gas-Forming Reactions

Metal carbonate or bicarbonate + acid → metal salt + $CO_2(g)$ + $H_2O(\ell)$

$Na_2CO_3(aq) + 2\ HCl(aq) \rightarrow 2\ NaCl(aq) + CO_2(g) + H_2O(\ell)$

$2Na^+(aq) + 2Cl^-(aq) + 2H^+(aq) + CO_3^{2-}(aq)$

$\rightarrow H_2O(l) + CO_2(g) + 2Na^+(aq) + 2Cl^-(aq)$

$2H^+(aq) + CO_3^{2-}(aq)$

$\rightarrow$

$H^+(aq) + OH^-(aq) + CO_2(aq) \rightarrow H_2O(l) + CO_2(g)$

Table 3-3, p. 140

TABLE 3.3 Gas-Forming Reactions

Metal carbonate or bicarbonate + acid → metal salt + $CO_2(g)$ + $H_2O(\ell)$

$Na_2CO_3(aq) + 2\ HCl(aq) \rightarrow 2\ NaCl(aq) + CO_2(g) + H_2O(\ell)$

$2Na^+(aq) + 2Cl^-(aq) + 2H^+(aq) + CO_3^{2-}(aq)$

$\rightarrow H_2O(l) + CO_2(g) + 2Na^+(aq) + 2Cl^-(aq)$

$2H^+(aq) + CO_3^{2-}(aq)$

$\rightarrow$

$H^+(aq) + OH^-(aq) + CO_2(aq) \rightarrow H_2O(l) + CO_2(g)$

Acid-base neutralization *and*
gas evolution ***drive*** this rxn forward

Table 3-3, p. 140

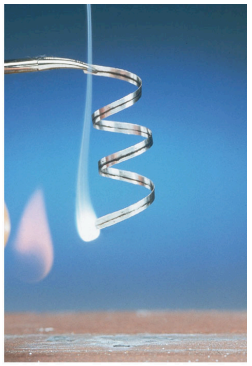
Oxidation-Reduction

(b)

Fig. 3-17, p. 142

Mg combines with oxygen and is oxidized.

(has its electrons stolen)



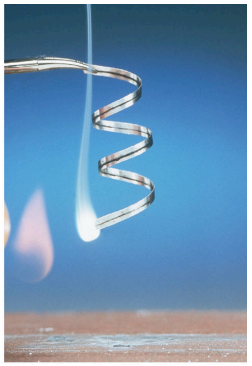
(b)

$$2\,Mg(s) + O_2(g) \longrightarrow 2\,MgO(s)$$

O_2 is the oxidizing agent

Mg combines with oxygen and is oxidized.

(has its electrons stolen)



(b)

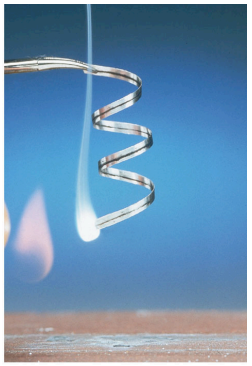
$$2\,Mg(s) + O_2(g) \longrightarrow 2\,MgO(s)$$

0

O_2 is the oxidizing agent

Mg combines with oxygen and is oxidized.

(has its electrons stolen)



(b)

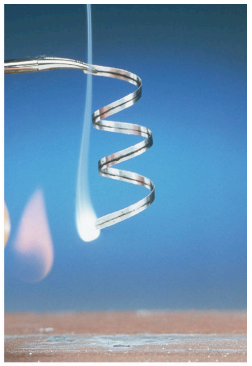
$$2\,Mg(s) + O_2(g) \longrightarrow 2\,MgO(s)$$

0 0

O_2 is the oxidizing agent

Mg combines with oxygen and is oxidized.

(has its electrons stolen)



(b)

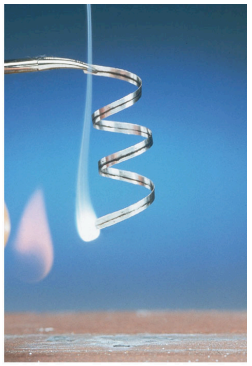
$$2\,Mg(s) + O_2(g) \longrightarrow 2\,MgO(s)$$

0 0 +2

O_2 is the oxidizing agent

Mg combines with oxygen and is oxidized.

(has its electrons stolen)



(b)

$$2\,Mg(s) + O_2(g) \longrightarrow 2\,MgO(s)$$

0 0 +2 -2

O_2 is the oxidizing agent

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule
Halogen, F_2, Cl_2, Br_2, or I_2	Halide ion, F^-, Cl^-, Br^-, or I^-	M, metals such as Na, K, Fe, and Al	M^{n+}, metal ions such as Na^+, K^+, Fe^{2+} or Fe^{3+}, and Al^{3+}
HNO_3, nitric acid	Nitrogen oxides* such as NO and NO_2	C, carbon (used to reduce metal oxides)	CO and CO_2
$Cr_2O_7^{2-}$, dichromate ion	Cr^{3+}, chromium(III) ion (in acid solution)		
MnO_4^-, permanganate ion	Mn^{2+}, manganese(II) ion (in acid solution)		

* NO is produced with dilute HNO_3, whereas NO_2 is a product of concentrated acid.

TABLE 3.4 Common Oxidizing and Reducing Agents

want to steal electrons

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule
Halogen, F_2, Cl_2, Br_2, or I_2	Halide ion, F^-, Cl^-, Br^-, or I^-	M, metals such as Na, K, Fe, and Al	M^{n+}, metal ions such as Na^+, K^+, Fe^{2+} or Fe^{3+}, and Al^{3+}
HNO_3, nitric acid	Nitrogen oxides* such as NO and NO_2	C, carbon (used to reduce metal oxides)	CO and CO_2
$Cr_2O_7^{2-}$, dichromate ion	Cr^{3+}, chromium(III) ion (in acid solution)		
MnO_4^-, permanganate ion	Mn^{2+}, manganese(II) ion (in acid solution)		

* NO is produced with dilute HNO_3, whereas NO_2 is a product of concentrated acid.

TABLE 3.4 Common Oxidizing and Reducing Agents

want to steal electrons

readily give up electrons

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule
Halogen, F_2, Cl_2, Br_2, or I_2	Halide ion, F^-, Cl^-, Br^-, or I^-	M, metals such as Na, K, Fe, and Al	M^{n+}, metal ions such as Na^+, K^+, Fe^{2+} or Fe^{3+}, and Al^{3+}
HNO_3, nitric acid	Nitrogen oxides* such as NO and NO_2	C, carbon (used to reduce metal oxides)	CO and CO_2
$Cr_2O_7^{2-}$, dichromate ion	Cr^{3+}, chromium(III) ion (in acid solution)		
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Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule

Oxidizing agent

Table 3-4, p. 146

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule

Oxidizing agent

Gets reduced

Table 3-4, p. 146

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule

Oxidizing agent

Gets reduced

At the expense of the other

Table 3-4, p. 146

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule

Oxidizing agent

Gets reduced

At the expense of the other

Oxidizing **agent**

Table 3-4, p. 146

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Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule

Oxidizing agent

Gets reduced

At the expense of the other

Reducing agent

Oxidizing **agent**

Table 3-4, p. 146

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Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule

Oxidizing agent

Gets reduced

At the expense of the other

Reducing agent

Gets oxidized

Oxidizing **agent**

Table 3-4, p. 146

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule

Oxidizing agent

Gets reduced

At the expense of the other

Reducing agent

Gets oxidized

At the expense of the other

Oxidizing **agent**

Table 3-4, p. 146

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule

Oxidizing agent

Gets reduced

At the expense of the other

Reducing agent

Gets oxidized

At the expense of the other

Oxidizing **agent**

Reducing **agent**

Table 3-4, p. 146

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule

0

Table 3-4, p. 146

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule

0 -2

Table 3-4, p. 146

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule

0 -2 0

Table 3-4, p. 146

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule
0	-2	0	+1

Table 3-4, p. 146

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Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
O_2, oxygen	O^{2-}, oxide ion or O combined in H_2O	H_2, hydrogen	$H^+(aq)$, hydrogen ion or H combined in H_2O or other molecule

0 **-2** **0** **+1**

Need 2 H per O

Table 3-4, p. 146

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
Halogen, F_2, Cl_2, Br_2, or I_2	Halide ion, F^-, Cl^-, Br^-, or I^-	M, metals such as Na, K, Fe, and Al	M^{n+}, metal ions such as Na^+, K^+, Fe^{2+} or Fe^{3+}, and Al^{3+}

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
Halogen, F_2, Cl_2, Br_2, or I_2	Halide ion, F^-, Cl^-, Br^-, or I^-	M, metals such as Na, K, Fe, and Al	M^{n+}, metal ions such as Na^+, K^+, Fe^{2+} or Fe^{3+}, and Al^{3+}

0

Table 3-4, p. 146

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
Halogen, F_2, Cl_2, Br_2, or I_2	Halide ion, F^-, Cl^-, Br^-, or I^-	M, metals such as Na, K, Fe, and Al	M^{n+}, metal ions such as Na^+, K^+, Fe^{2+} or Fe^{3+}, and Al^{3+}

0 -1

Table 3-4, p. 146

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
Halogen, F_2, Cl_2, Br_2, or I_2	Halide ion, F^-, Cl^-, Br^-, or I^-	M, metals such as Na, K, Fe, and Al	M^{n+}, metal ions such as Na^+, K^+, Fe^{2+} or Fe^{3+}, and Al^{3+}

0 -1 0

Table 3-4, p. 146

TABLE 3.4 Common Oxidizing and Reducing Agents

Oxidizing Agent	Reaction Product	Reducing Agent	Reaction Product
Halogen, F_2, Cl_2, Br_2, or I_2	Halide ion, F^-, Cl^-, Br^-, or I^-	M, metals such as Na, K, Fe, and Al	M^{n+}, metal ions such as Na^+, K^+, Fe^{2+} or Fe^{3+}, and Al^{3+}
0	-1	0	+n

Table 3-4, p. 146

Oxidation number of Cu changes from 0 to +2. Cu is oxidized to Cu^{2+} and is the reducing agent.

$$Cu(s) + 2\,NO_3^-(aq) + 4\,H_3O^+(aq) \longrightarrow Cu^{2+}(aq) + 2\,NO_2(g) + 6\,H_2O(\ell)$$

N in NO_3^- changes from +5 to +4 in NO_2. NO_3^- is reduced to NO_2 and is the oxidizing agent.

TABLE 3.5 Recognizing Oxidation-Reduction Reactions

	Oxidation	Reduction
In terms of oxidation number	Increase in oxidation number of an atom	Decrease in oxidation number of an atom
In terms of electrons	Loss of electrons by an atom	Gain of electrons by an atom
In terms of oxygen	Gain of one or more O atoms	Loss of one or more O atoms

TABLE 3.5 Recognizing Oxidation-Reduction Reactions

	Oxidation	Reduction
In terms of oxidation number	Increase in oxidation number of an atom	Decrease in oxidation number of an atom
In terms of electrons	Loss of electrons by an atom	Gain of electrons by an atom
In terms of oxygen	Gain of one or more O atoms	Loss of one or more O atoms

Summary

Summary

$$Ca^{2+}\,(aq) + CO_3^{2-}\,(aq) \longrightarrow CaCO_3\,(s)$$

Summary

Net Ionic Equation

$$Ca^{2+}\,(aq) + CO_3^{2-}\,(aq) \longrightarrow CaCO_3\,(s)$$

Summary

Net Ionic Equation

Precipitation

$$Ca^{2+}\,(aq) + CO_3^{2-}\,(aq) \longrightarrow CaCO_3\,(s)$$

$$H_3O^{+}\,(aq) + OH^{-}\,(aq) \longrightarrow 2\,H_2O\,(l)$$

Summary

Net Ionic Equation

Precipitation

Ca^{2+} (aq) + CO_3^{2-} (aq) $\longrightarrow$ $CaCO_3$ (s)

Acid-Base

H_3O^+ (aq) + OH^- (aq) $\longrightarrow$ 2 H_2O (l)

Summary

Net Ionic Equation

Precipitation

$Ca^{2+}(aq) + CO_3^{2-}(aq) \longrightarrow CaCO_3(s)$

Acid-Base

$H_3O^+(aq) + OH^-(aq) \longrightarrow 2\,H_2O(l)$

Summary

Net Ionic Equation

Precipitation

$Ca^{2+}(aq) + CO_3^{2-}(aq) \longrightarrow CaCO_3(s)$

Acid-Base

$H_3O^+(aq) + OH^-(aq) \longrightarrow 2\,H_2O(l)$

0 0

Summary

Net Ionic Equation

Precipitation

$Ca^{2+}(aq) + CO_3^{2-}(aq) \longrightarrow CaCO_3(s)$

Acid-Base

$H_3O^+(aq) + OH^-(aq) \longrightarrow 2\,H_2O(l)$

0 **0** **+2**

Summary

Net Ionic Equation

Precipitation

$Ca^{2+}(aq) + CO_3^{2-}(aq) \longrightarrow CaCO_3(s)$

Acid-Base

$H_3O^+(aq) + OH^-(aq) \longrightarrow 2\,H_2O(l)$

$2\,Mg(s) + O_2(g) \longrightarrow 2\,MgO(s)$

0 0 +2 -2

Summary

Net Ionic Equation

Precipitation

$Ca^{2+}(aq) + CO_3^{2-}(aq) \longrightarrow CaCO_3(s)$

Acid-Base

$H_3O^+(aq) + OH^-(aq) \longrightarrow 2\,H_2O(l)$

Oxidation-Reduction

$2\,Mg(s) + O_2(g) \longrightarrow 2\,MgO(s)$

0 0 +2 -2

Which is the reducing agent?

(1) (2)

$$Cu\ (s) + 2\ AgNO_3\ (aq) \rightarrow Cu(NO_3)_2\ (aq) + 2\ Ag\ (s)$$

Which is the reducing agent?

$$Cu\ (s) + 2\ AgNO_3\ (aq) \rightarrow Cu(NO_3)_2\ (aq) + 2\ Ag\ (s)$$

$$Cu\ (s) + 2\ Ag^{+}\ (aq) + 2\ NO_3^{-}\ (aq) \rightarrow Cu^{2+}\ (aq) + 2\ NO_3^{-}\ (aq) + 2\ Ag\ (s)$$

Which is the reducing agent?

$$Cu\ (s) + 2\ AgNO_3\ (aq) \rightarrow Cu(NO_3)_2\ (aq) + 2\ Ag\ (s)$$

$$Cu\ (s) + 2\ Ag^+\ (aq) + 2\ NO_3^-\ (aq) \rightarrow Cu^{2+}\ (aq) + 2\ NO_3^-\ (aq) + 2\ Ag\ (s)$$

0 **+2**

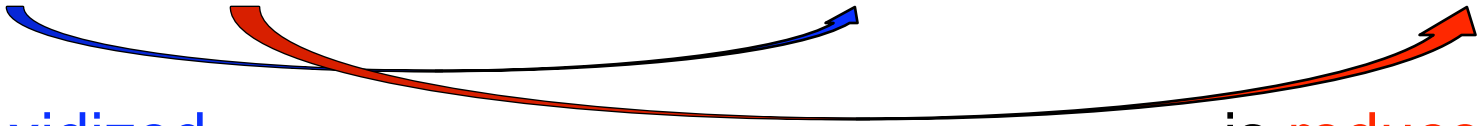
is oxidized
(reducing agent)

Which is the reducing agent?

$$Cu\ (s) + 2\ AgNO_3\ (aq) \rightarrow Cu(NO_3)_2\ (aq) + 2\ Ag\ (s)$$

$$Cu\ (s) + 2\ Ag^+\ (aq) + 2\ NO_3^-\ (aq) \rightarrow Cu^{2+}\ (aq) + 2\ NO_3^-\ (aq) + 2\ Ag\ (s)$$

0 **+1** **+2** **0**



is oxidized
(reducing agent)

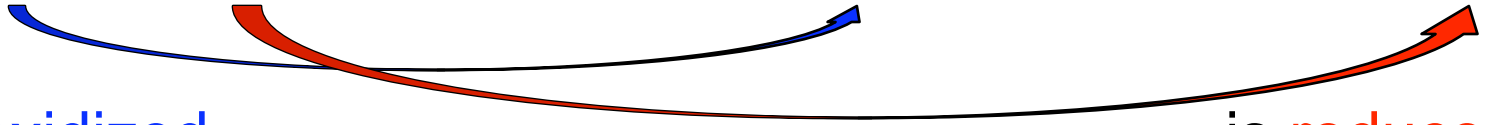
is reduced
(oxidizing agent)

Which is the reducing agent?

$$Cu\ (s) + 2\ AgNO_3\ (aq) \rightarrow Cu(NO_3)_2\ (aq) + 2\ Ag\ (s)$$

$$Cu\ (s) + 2\ Ag^+\ (aq) + 2\ NO_3^-\ (aq) \rightarrow Cu^{2+}\ (aq) + 2\ NO_3^-\ (aq) + 2\ Ag\ (s)$$

0 **+1** **-1** **+2** **-1** **0**



is oxidized
(reducing agent)

spectator

is reduced
(oxidizing agent)

Which is the reducing agent?

(1) (2)

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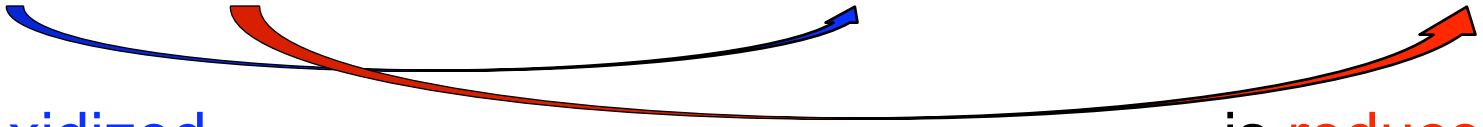

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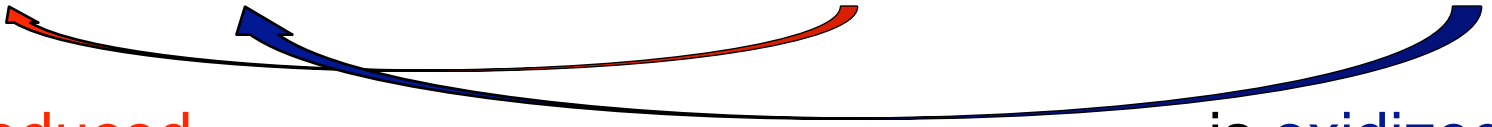

is reduced
(oxidizing agent)

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(reducing agent)

Fig. 3-21, p. 148

Exercise 3-13, p. 148

Which is the oxidizing agent?

(1) (2) (3)

$$3\ CH_3CH_2OH(aq) + 2\ Cr_2O_7^{2-}(aq) + 16\ H_3O^+(aq) \longrightarrow$$

ethanol

dichromate ion; orange-red

$$3\ CH_3CO_2H(aq) + 4\ Cr^{3+}(aq) + 27\ H_2O(\ell)$$

acetic acid

chromium(III) ion; green

Fig. 3-21, p. 148

Exercise 3-13, p. 148

Which is the oxidizing agent?

(1) (2) (3)

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