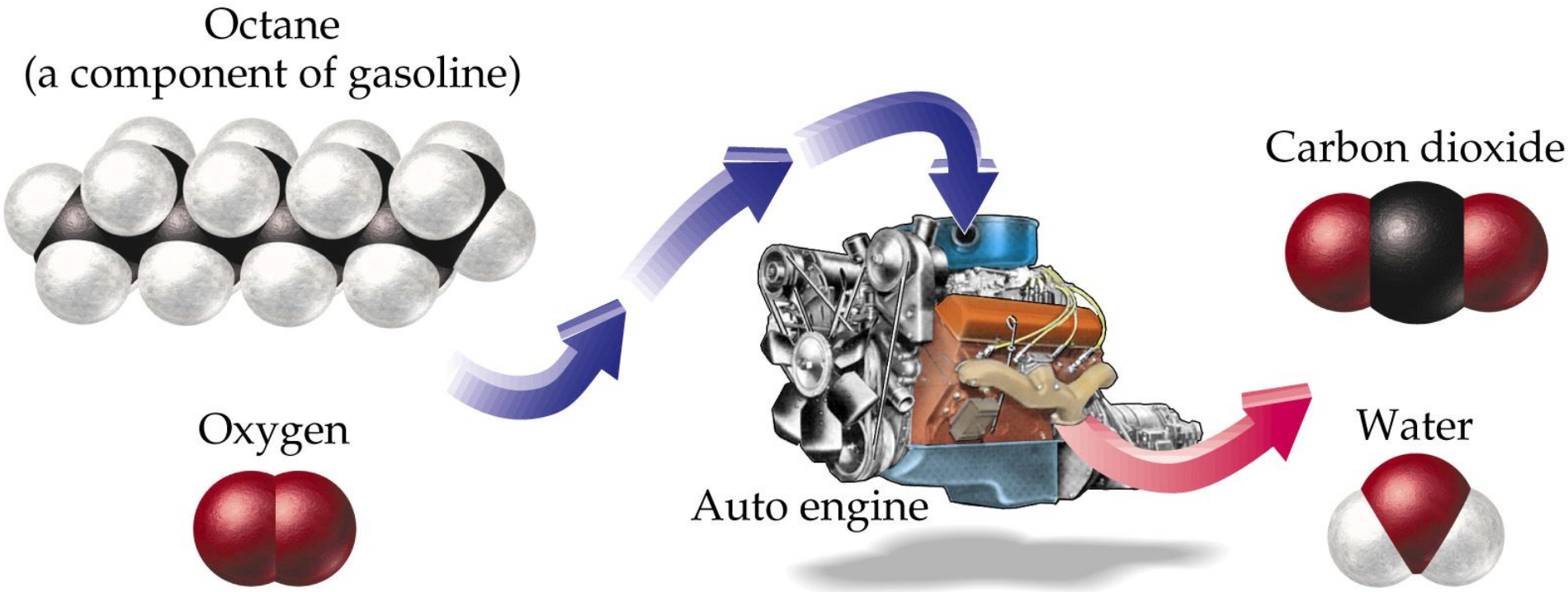
Chapter 8

Chemical Equations



Chemical Reactions

- Chemical reactions are processes in which one set of chemicals are converted to a new set of chemicals

- Chemical reactions are described by chemical equations.

Evidence for Chemical Reactions

- A gas is produced.
- A precipitate is formed.
- A permanent color change is observed.
- An energy change occurs.

(a) (b) (c)

Law of Conservation of Mass

- In an ordinary chemical reaction, the total mass of reacting substances is equal to the total mass of products formed.

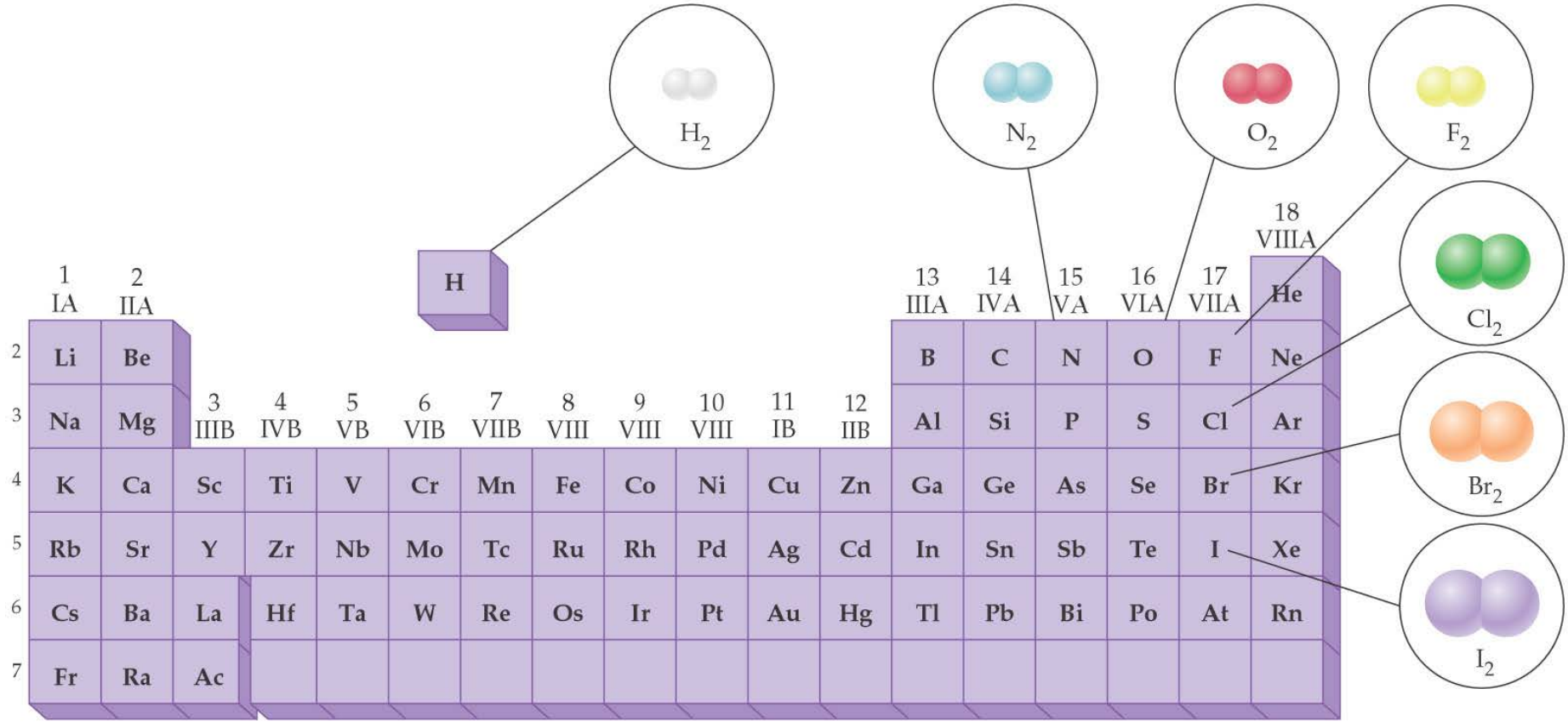
Chemical Equations

- $N_2\,(g) + 3\,H_2\,(g) \rightarrow 2\,NH_3\,(g)$
- must be balanced to satisfy Law of conservation of mass
- State Designations
  - (g) gas
  - (l) liquid
  - (s) solid
  - (aq) aqueous

- Copper(II) oxide reacts with ammonia (NH_3) to yield copper, nitrogen gas, and water.

- Write a balanced equation for this reaction.

Diatomic Elements



- Lead(II) nitrate reacts with potassium chromate to form lead(II) chromate (yellow ppt.) and potassium nitrate.

- Hydrochloric acid reacts with sodium carbonate to form carbon dioxide, sodium chloride, and water

- Zinc metal reacts with hydrochloric acid to produce zinc chloride and hydrogen gas.

- Potassium chlorate when heated, decomposes to form potassium chloride and oxygen gas.

- Hexane(C_6H_{14}) burns in oxygen gas to form carbon dioxide and water.

- Vinegar(acetic acid) reacts with baking soda (sodium bicarbonate) to produce carbon dioxide gas, sodium acetate, and water.

- Ammonia reacts with oxygen gas to form nitrogen monoxide and water.

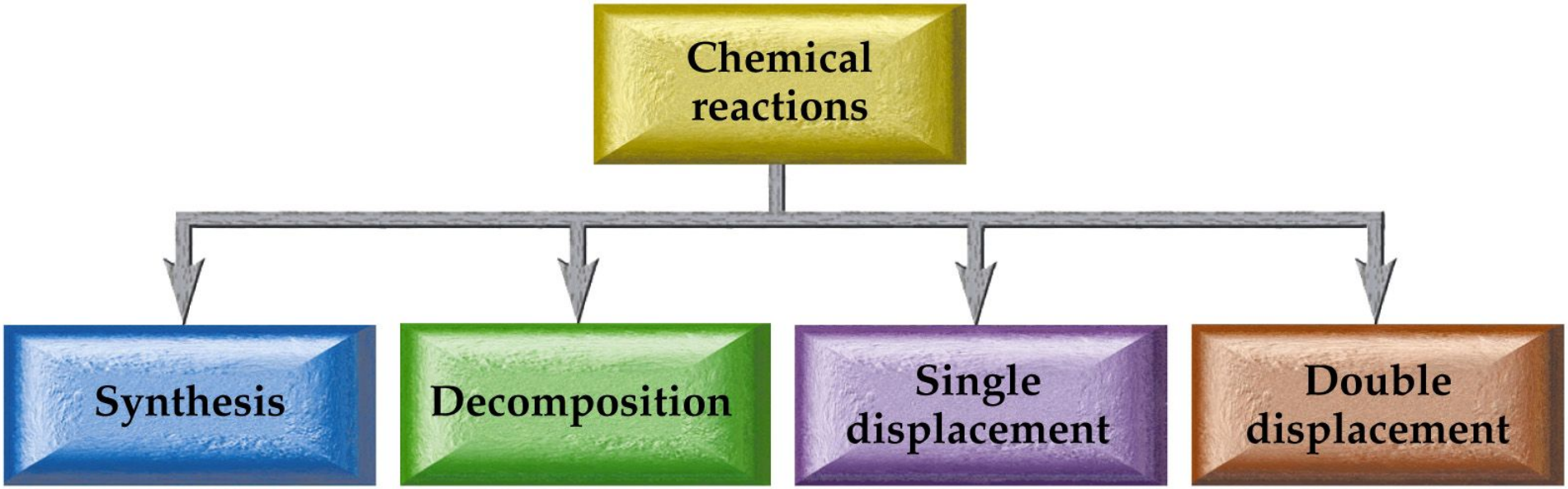
- Iron(III) chloride reacts with ammonium hydroxide to form iron(III) hydroxide (brown ppt.) and ammonium chloride.

- Barium hydroxide and ammonium chloride react to form ammonia (NH_3), water, and barium chloride.

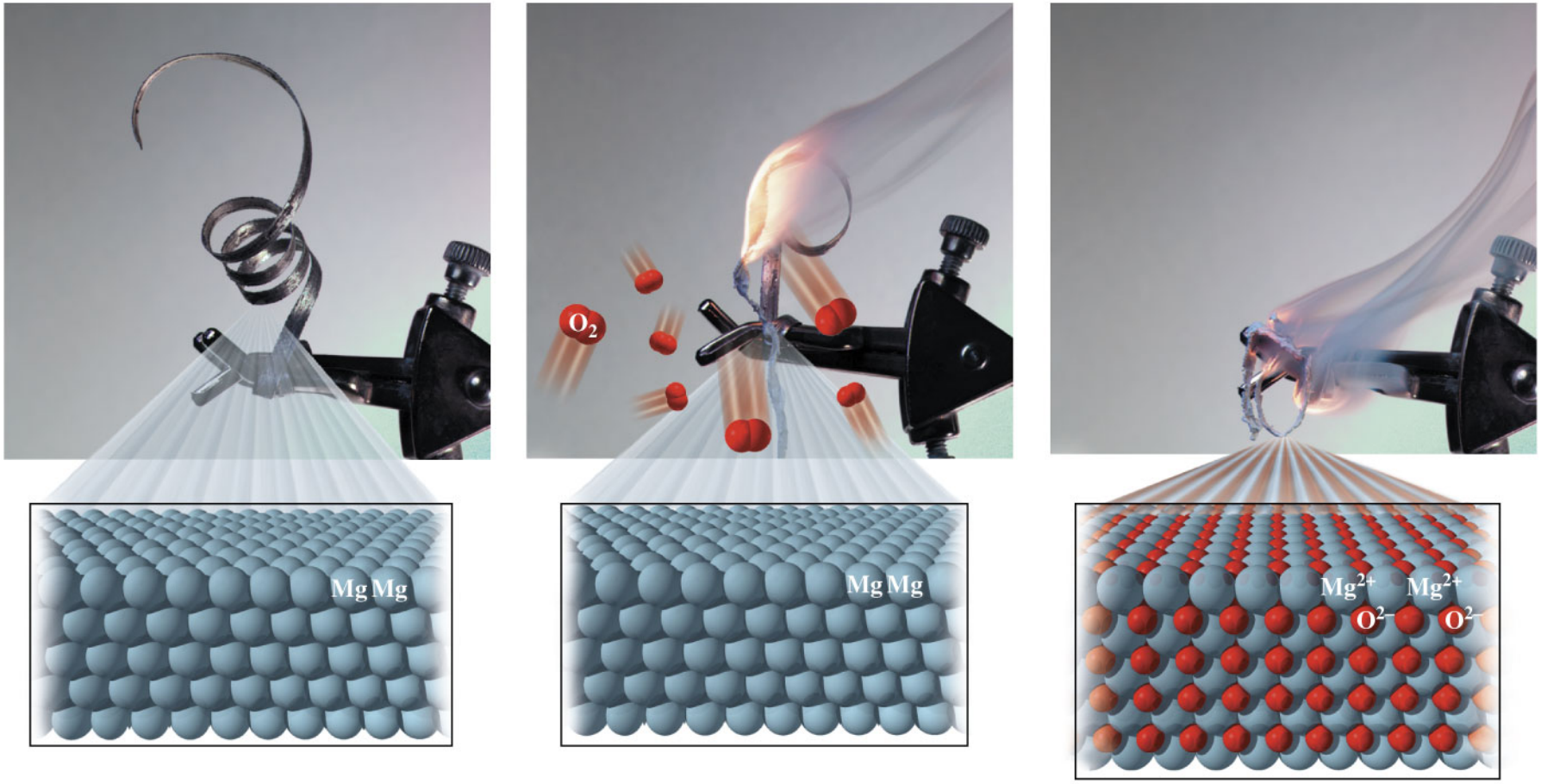
Some more examples

- $N_2 + H_2 \longrightarrow NH_3$
- $Be_2C + H_2O \longrightarrow Be(OH)_2 + CH_4$
- $HCl + CaCO_3 \longrightarrow CaCl_2 + H_2O + CO_2$
- $C_2H_6 + O_2 \longrightarrow CO_2 + H_2O$

Classifying Reactions by what Atoms Do



Combination Reaction

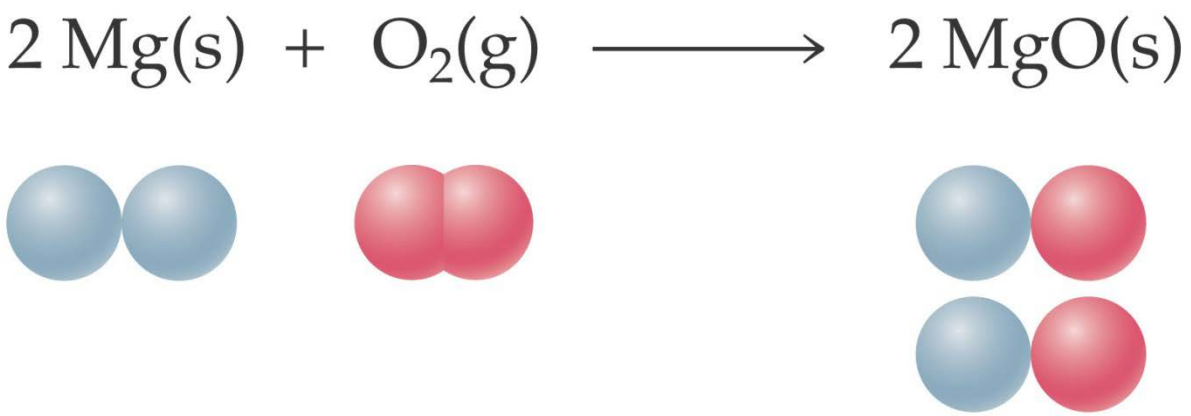


$$2Mg(s) + O_2(g) \xrightarrow{\Delta} 2MgO(s)$$

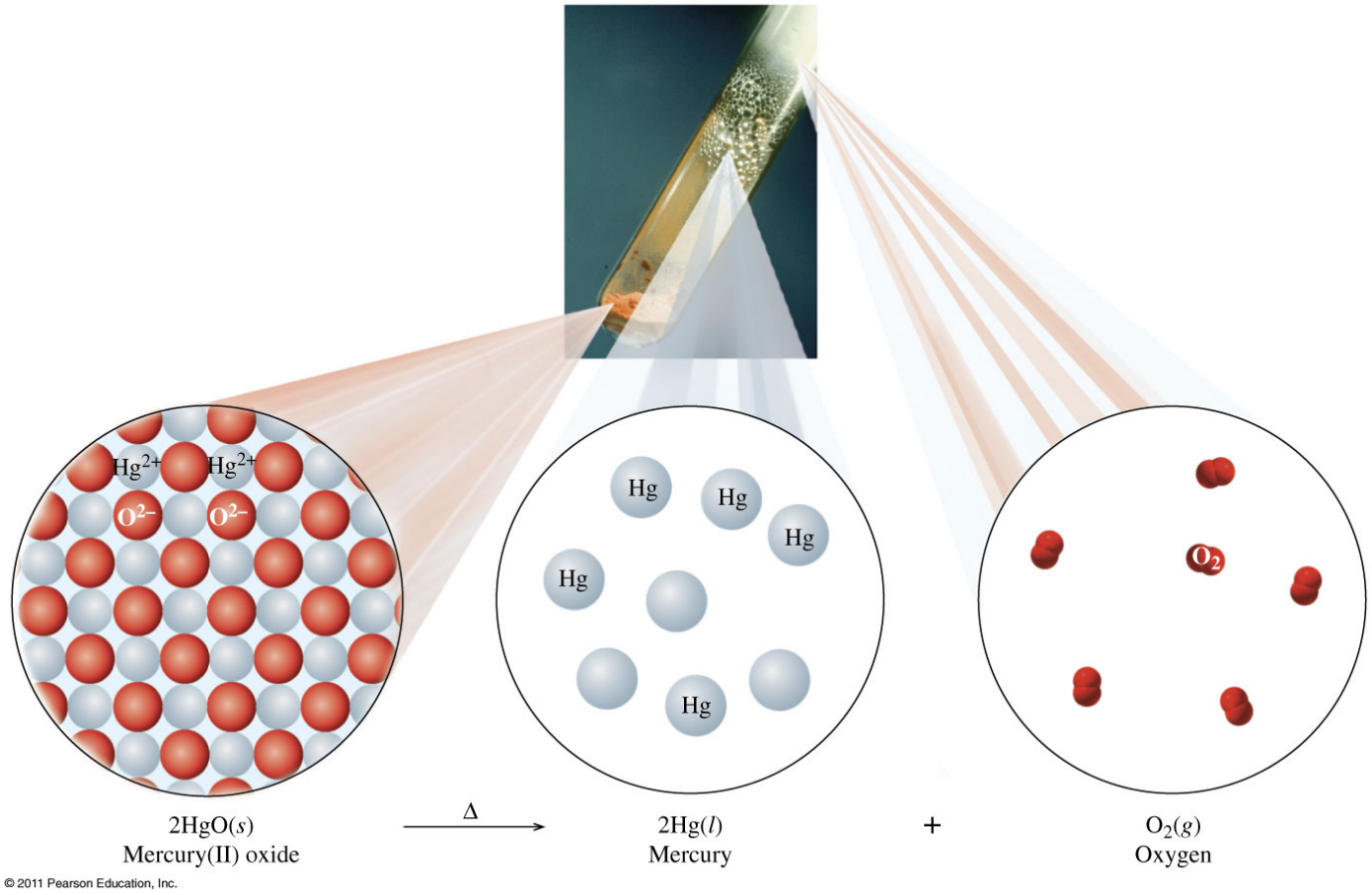
Magnesium + Oxygen → Magnesium oxide

Classifying Reactions by what Atoms Do

- Combination/Synthesis
- $A + Z \longrightarrow AZ$

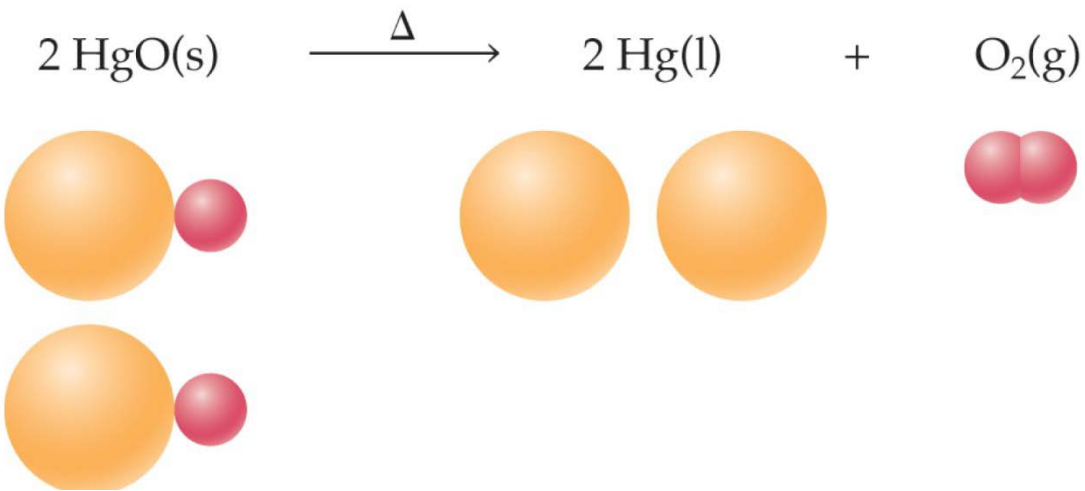


Decomposition

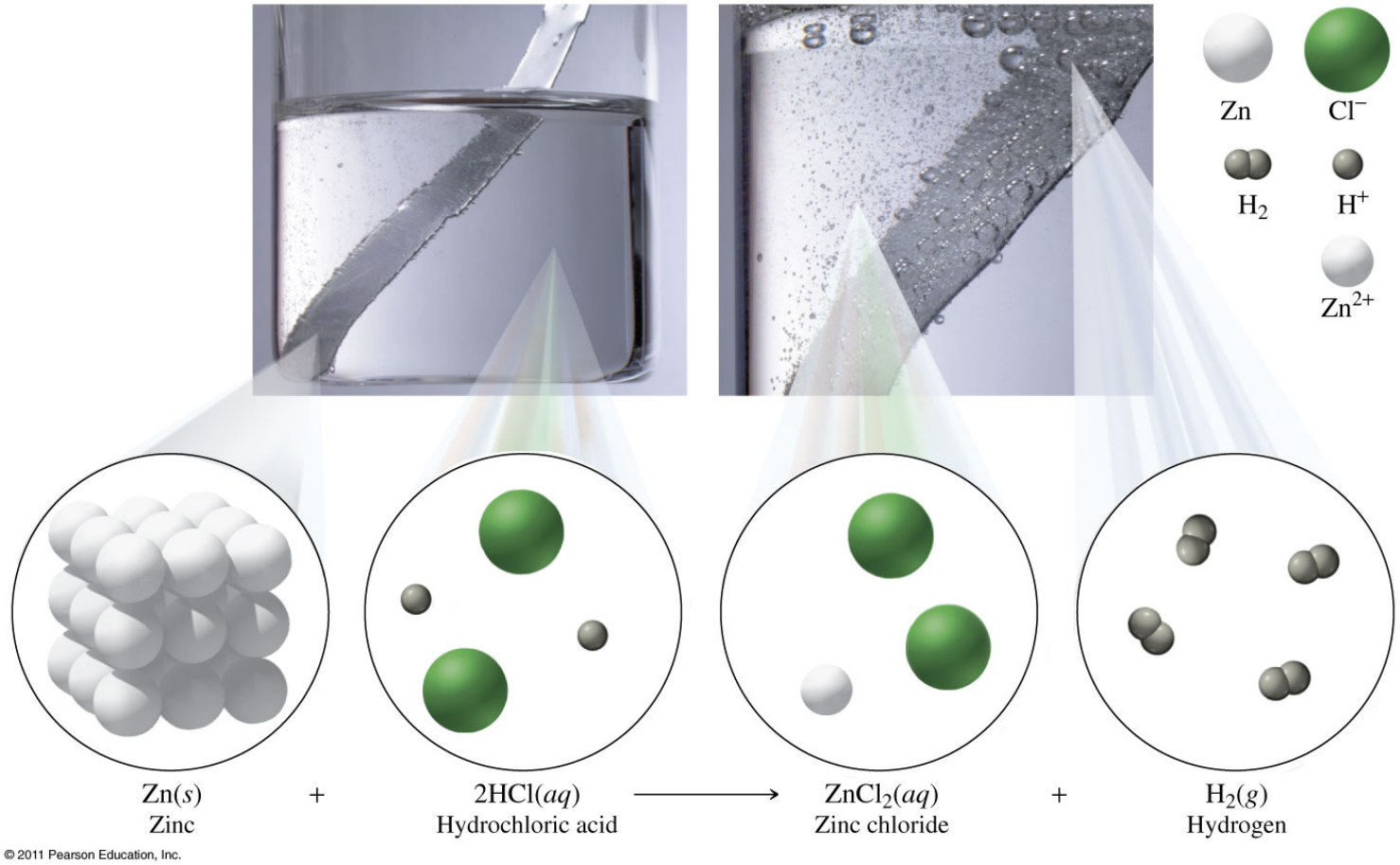


Classifying Reactions by what Atoms Do

- Decomposition
- $AZ \longrightarrow A + Z$

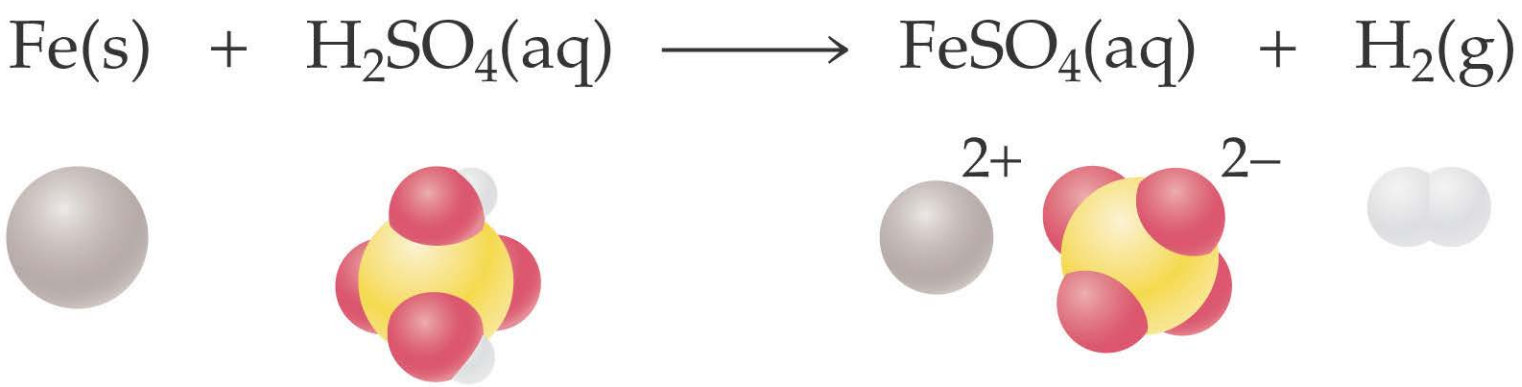


Single Replacement



Classifying Reactions by what Atoms Do

- Single Displacement
  - ➢ $A + BZ \longrightarrow AZ + B$



Predicting Reactions

Single Displacement

(AKA Single Replacement)

TABLE 4.3 A Partial Activity Series of the Elements

	Oxidation Reaction	
Strongly reducing	$Li \rightarrow Li^+ + e^-$	These elements react rapidly with aqueous H^+ ions (acid) or with liquid H_2O to release H_2 gas.
	$K \rightarrow K^+ + e^-$	
	$Ba \rightarrow Ba^{2+} + 2\,e^-$	
	$Ca \rightarrow Ca^{2+} + 2\,e^-$	
	$Na \rightarrow Na^+ + e^-$	
	$Mg \rightarrow Mg^{2+} + 2\,e^-$	These elements react with aqueous H^+ ions or with steam to release H_2 gas.
	$Al \rightarrow Al^{3+} + 3\,e^-$	
	$Mn \rightarrow Mn^{2+} + 2\,e^-$	
	$Zn \rightarrow Zn^{2+} + 2\,e^-$	
	$Cr \rightarrow Cr^{3+} + 3\,e^-$	
	$Fe \rightarrow Fe^{2+} + 2\,e^-$	
	$Co \rightarrow Co^{2+} + 2\,e^-$	These elements react with aqueous H^+ ions to release H_2 gas.
	$Ni \rightarrow Ni^{2+} + 2\,e^-$	
	$Sn \rightarrow Sn^{2+} + 2\,e^-$	
	$\mathbf{H_2 \rightarrow 2\,H^+ + 2\,e^-}$	
	$Cu \rightarrow Cu^{2+} + 2\,e^-$	These elements do not react with aqueous H^+ ions to release H_2.
	$Ag \rightarrow Ag^+ + e^-$	
	$Hg \rightarrow Hg^{2+} + 2\,e^-$	
	$Pt \rightarrow Pt^{2+} + 2\,e^-$	
Weakly reducing	$Au \rightarrow Au^{3+} + 3\,e^-$	

$Cu + AgNO_3 \rightarrow$

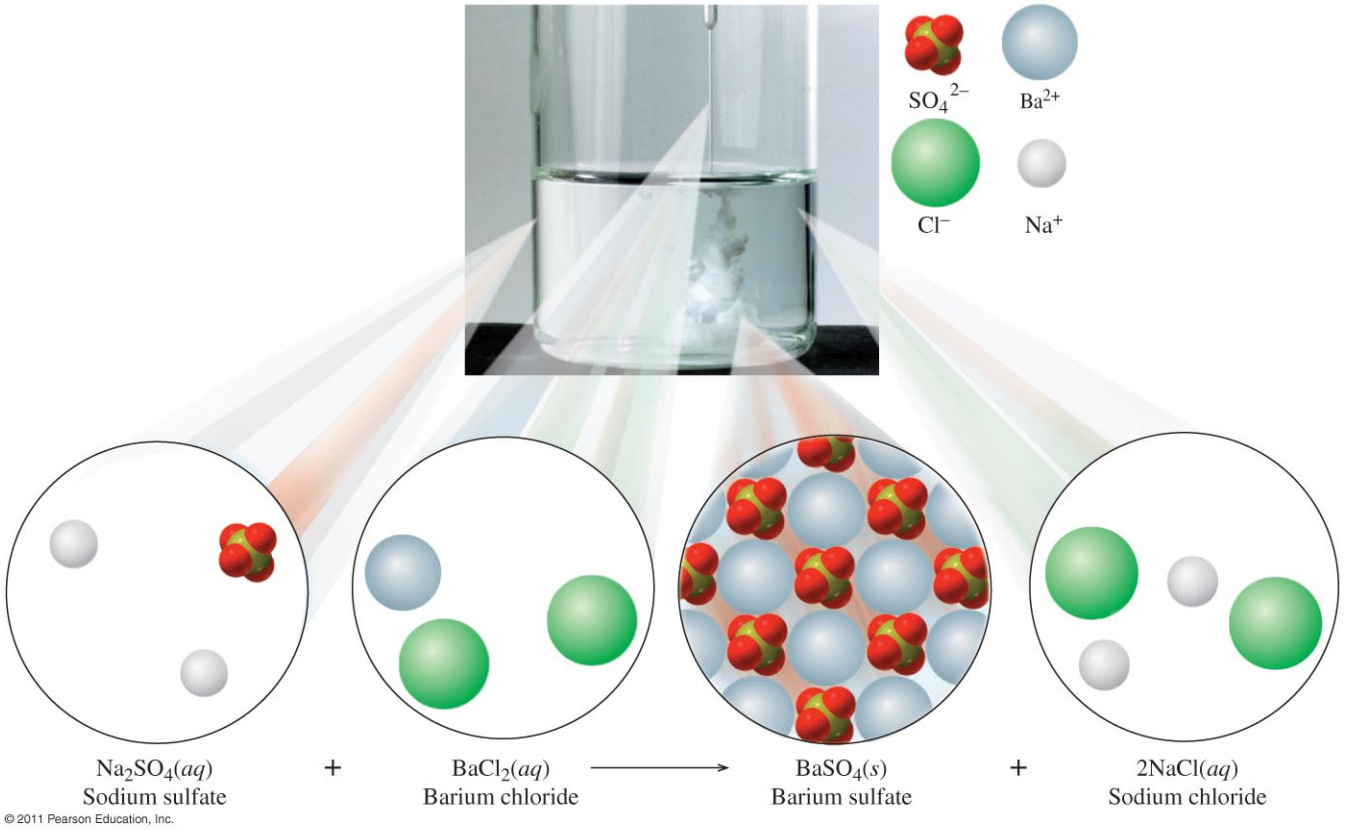
$Cr + NiCl_2 \rightarrow$

$Cr + Zn(NO_3)_2 \rightarrow$

$Zn + HCl \rightarrow$

$Fe + HCl \rightarrow$

Double Displacement



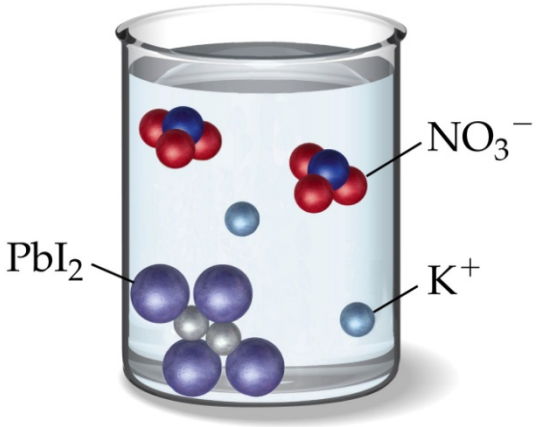
Classifying Reactions by what Atoms Do

- Double displacement
  - $AX + BZ \longrightarrow AZ + BX$
- Neutralization (special type of double displacement reaction)
  - $HX + BOH \longrightarrow BX + H_2O$

Predicting Reactions
Double Displacement

Original compounds → *Potentially insoluble products*

$KI(aq) + Pb(NO_3)_2(aq) \rightarrow KNO_3 + PbI_2$



$PbI_2(s)$ and $KNO_3(aq)$

$$Na_2S + ZnCl_2 \rightarrow$$

$$Na_2S + ZnCl_2 \rightarrow 2\ NaCl + ZnS(s)$$

$$Mg(NO_3)_2 + NaOH \rightarrow$$

$$Mg(NO_3)_2 + 2\ NaOH \rightarrow Mg(OH)_2(s) + 2\ NaNO_3$$

$AgNO_3 + Na_2SO_4 \rightarrow$

- $AgNO_3 + Na_2SO_4 \rightarrow$ NR

$$K_2CO_3 + HCl \rightarrow$$

$K_2CO_3 + 2\ HCl \rightarrow (H_2CO_3 + 2\ KCl)$

$\rightarrow H_2O + CO_2 + 2\ KCl$

$NH_4Cl + KOH \rightarrow$

$NH_4Cl + KOH \rightarrow (NH_4OH + KCl) \rightarrow$

$NH_3 + HOH + KCl$

$$HNO_3 + NaC_2H_3O_2 \rightarrow$$

$$HNO_3(aq) + NaC_2H_3O_2(aq)$$

$$\rightarrow HC_2H_3O_2(aq) + NaNO_3(aq)$$

$HClO_4 + NaOH \rightarrow$

$HClO_4 + NaOH \rightarrow H_2O(l) + NaClO_4$