

## CHAPTER 6

# Chemical Reactions: An Introduction

## CHAPTER ANSWERS

1. The types of evidence for a chemical reaction mentioned in the text are a change in color, formation of a solid, evolution of a gas, and absorption or evolution of heat. Other bits of evidence that might also be observed include appearance or disappearance of a characteristic odor or separation of the reaction mixture into layers of visibly different composition.
2. Most of these products contain a peroxide, which decomposes releasing oxygen gas.
3. The fact that the material in the drain that did *not* dissolve in water dissolves when the drain cleaner is added suggests that rather than simple dissolving, the material in the drain has undergone a chemical change that makes it soluble. You may also have noticed that the drain cleaner evolved *heat* when added to the drain; evolution or absorption of heat is also often a sign of a chemical reaction.
4. Bubbling takes place as the hydrogen peroxide chemically decomposes into water and oxygen gas.
5. The container of a flashlight battery usually consists of zinc, which is one of the substances involved in the chemical reaction in the battery that generates the electricity. The fact that the zinc decays until the battery leaks is a sign that a chemical reaction has taken place.
6. The two components are both liquids, but harden to a solid when combined. There is also heat evolved during the reaction.
7. A and B are the reactants; C and D are the products; the arrow indicates that a reaction takes place.
8. atoms
9. the same as
10. the same
11. The physical state is included because it helps us visualize the reaction taking place (for example, if a solid forms when two liquids are mixed together, that is very significant). The physical state is also included because it may influence some measured properties of the reaction. For example, if water vapor is formed in a reaction, a different quantity of energy may be involved than if liquid water were formed (See Chapter 10.). We indicate the physical states as follows: (*s*), solid; (*l*), liquid; (*g*), gas; (*aq*) aqueous solution.
12. water
13.  $\text{Zn}(s) + \text{HCl}(aq) \rightarrow \text{ZnCl}_2(aq) + \text{H}_2(g)$
14.  $\text{H}_2\text{O}_2(aq) \rightarrow \text{H}_2(g) + \text{O}_2(g)$
15.  $\text{H}_2(g) + \text{O}_2(g) \rightarrow \text{H}_2\text{O}(g)$

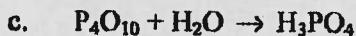
16.  $\text{AgNO}_3(\text{aq}) + \text{HCl}(\text{aq}) \rightarrow \text{AgCl}(\text{s}) + \text{HNO}_3(\text{aq})$   
 $\text{Pb}(\text{NO}_3)_2(\text{aq}) + \text{HCl}(\text{aq}) \rightarrow \text{PbCl}_2(\text{s}) + \text{HNO}_3(\text{aq})$
17.  $\text{Ag}(\text{s}) + \text{HNO}_3(\text{aq}) \rightarrow \text{AgNO}_3(\text{aq}) + \text{NO}(\text{g}) + \text{H}_2(\text{g})$
18.  $\text{C}_3\text{H}_8(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$   
 $\text{C}_3\text{H}_8(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g})$
19.  $\text{B}_2\text{O}_3(\text{s}) + \text{Mg}(\text{s}) \rightarrow \text{B}(\text{g}) + \text{MgO}(\text{s})$
20.  $\text{CaCO}_3(\text{s}) + \text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
21.  $\text{P}_4(\text{s}) + \text{Cl}_2(\text{g}) \rightarrow \text{PCl}_3(\text{s})$
22.  $\text{SiO}_2(\text{s}) + \text{C}(\text{s}) \rightarrow \text{Si}(\text{s}) + \text{CO}(\text{g})$
23.  $\text{NH}_4\text{NO}_3(\text{s}) \rightarrow \text{N}_2\text{O}(\text{g}) + \text{H}_2\text{O}(\text{g})$
24.  $\text{H}_2\text{S}(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{SO}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$
25.  $\text{C}_2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$
26.  $\text{SO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{SO}_3(\text{aq})$   
 $\text{SO}_3(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{SO}_4(\text{aq})$
27.  $\text{BaO}(\text{s}) + \text{Al}(\text{s}) \rightarrow \text{Ba}(\text{s}) + \text{Al}_2\text{O}_3(\text{s})$   
 $\text{CaO}(\text{s}) + \text{Al}(\text{s}) \rightarrow \text{Ca}(\text{s}) + \text{Al}_2\text{O}_3(\text{s})$   
 $\text{SrO}(\text{s}) + \text{Al}(\text{s}) \rightarrow \text{Sr}(\text{s}) + \text{Al}_2\text{O}_3(\text{s})$
28.  $\text{NO}(\text{g}) + \text{O}_3(\text{g}) \rightarrow \text{NO}_2(\text{g}) + \text{O}_2(\text{g})$
29.  $\text{CH}_4(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow \text{CCl}_4(\text{l}) + \text{HCl}(\text{g})$
30.  $\text{NH}_3(\text{g}) + \text{HNO}_3(\text{aq}) \rightarrow \text{NH}_4\text{NO}_3(\text{s})$
31.  $\text{CaO}(\text{s}) + \text{H}_2\text{O}(\text{g}) \rightarrow \text{Ca}(\text{OH})_2(\text{s})$
32.  $\text{Xe}(\text{g}) + \text{F}_2(\text{g}) \rightarrow \text{XeF}_4(\text{s})$
33.  $\text{NH}_4\text{NO}_3(\text{s}) \rightarrow \text{N}_2(\text{g}) + \text{O}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$
34.  $\text{NH}_4\text{Cl}(\text{s}) + \text{NaOH}(\text{s}) \xrightarrow{\text{heat}} \text{NH}_3(\text{g}) + \text{H}_2\text{O}(\text{g}) + \text{NaCl}(\text{s})$
35. The subscripts in a formula really define what compound is present since the subscripts represent in what proportions the elements combine to form the compound. Changing the subscripts would be changing the identity of the compound.
36. whole numbers
- 37.
- a.  $\text{FeCl}_3 + \text{KOH} \rightarrow \text{Fe(OH)}_3 + \text{KCl}$   
Balance chlorine:  $\text{FeCl}_3 + \text{KOH} \rightarrow \text{Fe(OH)}_3 + 3\text{KCl}$   
Balance potassium:  $\text{FeCl}_3 + 3\text{KOH} \rightarrow \text{Fe(OH)}_3 + 3\text{KCl}$   
Balanced equation:  $\text{FeCl}_3(\text{aq}) + 3\text{KOH}(\text{aq}) \rightarrow \text{Fe(OH)}_3(\text{s}) + 3\text{KCl}(\text{aq})$



Balance iodine:  $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 + 2\text{KI} \rightarrow \text{PbI}_2 + \text{KC}_2\text{H}_3\text{O}_2$

Balance potassium:  $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 + 2\text{KI} \rightarrow \text{PbI}_2 + 2\text{KC}_2\text{H}_3\text{O}_2$

Balanced equation:  $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2(aq) + 2\text{KI}(aq) \rightarrow \text{PbI}_2(s) + \text{KC}_2\text{H}_3\text{O}_2(aq)$



Balance phosphorus:  $\text{P}_4\text{O}_{10} + \text{H}_2\text{O} \rightarrow 4\text{H}_3\text{PO}_4$

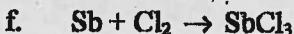
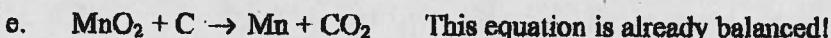
Balance hydrogen:  $\text{P}_4\text{O}_{10} + 6\text{H}_2\text{O} \rightarrow 4\text{H}_3\text{PO}_4$

Balanced equation:  $\text{P}_4\text{O}_{10}(s) + 6\text{H}_2\text{O}(l) \rightarrow 4\text{H}_3\text{PO}_4(aq)$



Balance lithium:  $\text{Li}_2\text{O} + \text{H}_2\text{O} \rightarrow 2\text{LiOH}$

Balanced equation:  $\text{Li}_2\text{O}(s) + \text{H}_2\text{O}(l) \rightarrow 2\text{LiOH}(aq)$

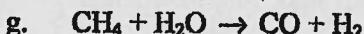


This equation is more difficult to balance than it may appear. The problem arises in the fact that there are two Cl atoms on the left side of the equation, whereas there are three Cl atoms on the right side of the equation. To balance the chlorine atoms, we need to know the smallest whole number into which both two and three divide. This number is six: we need to adjust the coefficients of  $\text{Cl}_2$  and  $\text{SbCl}_3$  so that there will be six chlorine atoms on each side of the equation.

Balance chlorine:  $\text{Sb} + 3\text{Cl}_2 \rightarrow 2\text{SbCl}_3$

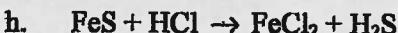
Balance antimony:  $2\text{Sb} + 3\text{Cl}_2 \rightarrow 2\text{SbCl}_3$

Balanced equation:  $2\text{Sb}(s) + 3\text{Cl}_2(g) \rightarrow 2\text{SbCl}_3(s)$



Balance hydrogen:  $\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + 3\text{H}_2$

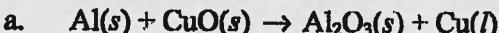
Balanced equation:  $\text{CH}_4(g) + \text{H}_2\text{O}(g) \rightarrow \text{CO}(g) + 3\text{H}_2(g)$



Balance chlorine:  $\text{FeS} + 2\text{HCl} \rightarrow \text{FeCl}_2 + \text{H}_2\text{S}$

Balanced equation:  $\text{FeS}(s) + 2\text{HCl}(aq) \rightarrow \text{FeCl}_2(aq) + \text{H}_2\text{S}(g)$

38.



balance Al:  $2\text{Al}(s) + \text{CuO}(s) \rightarrow \text{Al}_2\text{O}_3(s) + \text{Cu}(l)$

balance O:  $2\text{Al}(s) + 3\text{CuO}(s) \rightarrow \text{Al}_2\text{O}_3(s) + \text{Cu}(l)$

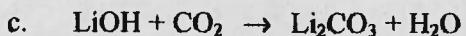
balance Cu:  $2\text{Al}(s) + 3\text{CuO}(s) \rightarrow \text{Al}_2\text{O}_3(s) + 3\text{Cu}(l)$

balanced equation:  $2\text{Al}(s) + 3\text{CuO}(s) \rightarrow \text{Al}_2\text{O}_3(s) + 3\text{Cu}(l)$

- b.  $S_8(s) + F_2(g) \rightarrow SF_6(g)$   
 balance sulfur:  $S_8(s) + F_2(g) \rightarrow 8SF_6(g)$   
 balance fluorine:  $S_8(s) + 24F_2(g) \rightarrow 8SF_6(g)$   
 balanced equation:  $S_8(s) + 24F_2(g) \rightarrow 8SF_6(g)$
- c.  $Xe(g) + F_2(g) \rightarrow XeF_6(s)$   
 balance fluorine:  $Xe(g) + 3F_2(g) \rightarrow XeF_6(s)$   
 balanced equation:  $Xe(g) + 3F_2(g) \rightarrow XeF_6(s)$
- d.  $NH_4Cl(g) + KOH(s) \rightarrow NH_3(g) + H_2O(g) + KCl(s)$   
 The equation is already balanced.
- e.  $SiC(s) + Cl_2(g) \rightarrow SiCl_4(l) + C(s)$   
 balance chlorine:  $SiC(s) + 2Cl_2(g) \rightarrow SiCl_4(l) + C(s)$   
 balanced equation:  $SiC(s) + 2Cl_2(g) \rightarrow SiCl_4(l) + C(s)$
- f.  $K_2O(s) + H_2O(l) \rightarrow KOH(aq)$   
 balance potassium:  $K_2O(s) + H_2O(l) \rightarrow 2KOH(aq)$   
 balanced equation:  $K_2O(s) + H_2O(l) \rightarrow 2KOH(aq)$
- g.  $N_2O_5(g) + H_2O(l) \rightarrow HNO_3(aq)$   
 balance nitrogen:  $N_2O_5(g) + H_2O(l) \rightarrow 2HNO_3(aq)$   
 balanced equation:  $N_2O_5(g) + H_2O(l) \rightarrow 2HNO_3(aq)$
- h.  $H_2S(g) + Cl_2(g) \rightarrow S_8(s) + HCl(g)$   
 balance sulfur:  $8H_2S(g) + Cl_2(g) \rightarrow S_8(s) + HCl(g)$   
 balance hydrogen:  $8H_2S(g) + 8Cl_2(g) \rightarrow S_8(s) + 16HCl(g)$   
 balanced equation:  $8H_2S(g) + 8Cl_2(g) \rightarrow S_8(s) + 16HCl(g)$

39.

- a.  $Br_2 + KI \rightarrow I_2 + KBr$   
 Balance bromine:  $Br_2 + KI \rightarrow I_2 + 2KBr$   
 Balance iodine:  $Br_2 + 2KI \rightarrow I_2 + 2KBr$   
 Balanced equation:  $Br_2(g) + 2KI(aq) \rightarrow I_2(s) + 2KBr(aq)$
- b.  $K_2O_2 + H_2O \rightarrow KOH + O_2$   
 Balance hydrogen:  $K_2O_2 + H_2O \rightarrow 2KOH + O_2$   
 Balance oxygen:  $K_2O_2 + H_2O \rightarrow 2KOH + \frac{1}{2}O_2$   
 Convert to whole numbers:  $2K_2O_2 + 2H_2O \rightarrow 4KOH + O_2$   
 Balanced equation:  $2K_2O_2(s) + 2H_2O(l) \rightarrow 4KOH(aq) + O_2(g)$



Balance lithium:  $2\text{LiOH} + \text{CO}_2 \rightarrow \text{Li}_2\text{CO}_3 + \text{H}_2\text{O}$

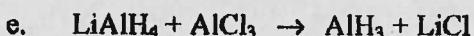
Balanced equation:  $2\text{LiOH}(s) + \text{CO}_2(g) \rightarrow \text{Li}_2\text{CO}_3(s) + \text{H}_2\text{O}(l)$



Balance potassium:  $\text{K}_2\text{CO}_3 + \text{HNO}_3 \rightarrow 2\text{KNO}_3 + \text{H}_2\text{O} + \text{CO}_2$

Balance nitrate ion:  $\text{K}_2\text{CO}_3 + 2\text{HNO}_3 \rightarrow 2\text{KNO}_3 + \text{H}_2\text{O} + \text{CO}_2$

Balanced equat.:  $\text{K}_2\text{CO}_3(s) + 2\text{HNO}_3(aq) \rightarrow 2\text{KNO}_3(aq) + \text{H}_2\text{O}(l) + \text{CO}_2(g)$

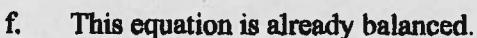


We have an interesting situation here. There are four hydrogen atoms on the left side of the equation, but only three hydrogen atoms on the right side. The smallest number that is divisible by both four and three is 12. So the simplest way to begin balancing this equation is to take care of the hydrogen atoms so that there are 12 on each side.

Balance hydrogen:  $3\text{LiAlH}_4 + \text{AlCl}_3 \rightarrow 4\text{AlH}_3 + \text{LiCl}$

Balance lithium:  $3\text{LiAlH}_4 + \text{AlCl}_3 \rightarrow 4\text{AlH}_3 + 3\text{LiCl}$

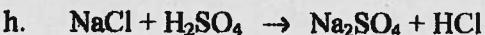
Balanced equation:  $3\text{LiAlH}_4(s) + \text{AlCl}_3(s) \rightarrow 4\text{AlH}_3(s) + 3\text{LiCl}(s)$



Balance oxygen:  $\text{Na}_2\text{SO}_4 + \text{C} \rightarrow \text{Na}_2\text{S} + 2\text{CO}_2$

Balance carbon:  $\text{Na}_2\text{SO}_4 + 2\text{C} \rightarrow \text{Na}_2\text{S} + 2\text{CO}_2$

Balanced equation:  $\text{Na}_2\text{SO}_4(s) + 2\text{C}(s) \rightarrow \text{Na}_2\text{S}(s) + 2\text{CO}_2(g)$

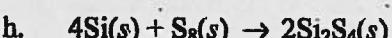
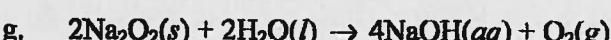
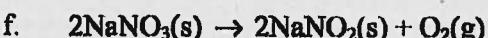
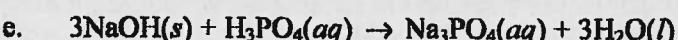
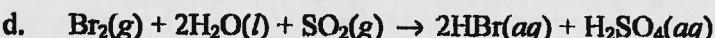
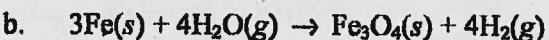
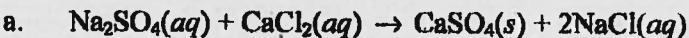


Balance sodium:  $2\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{HCl}$

Balance chlorine:  $2\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{HCl}$

Balanced equation:  $2\text{NaCl}(s) + \text{H}_2\text{SO}_4(l) \rightarrow \text{Na}_2\text{SO}_4(s) + 2\text{HCl}(g)$

40.



41.

- $2\text{Li}(s) + \text{Cl}_2(g) \rightarrow 2\text{LiCl}(s)$
- $3\text{Ba}(s) + \text{N}_2(g) \rightarrow \text{Ba}_3\text{N}_2(s)$
- $2\text{NaHCO}_3(s) \rightarrow \text{Na}_2\text{CO}_3(s) + \text{CO}_2(g) + \text{H}_2\text{O}(g)$
- $2\text{Al}(s) + 6\text{HCl}(aq) \rightarrow 2\text{AlCl}_3(aq) + 3\text{H}_2(g)$
- $2\text{NiS}(s) + 3\text{O}_2(g) \rightarrow 2\text{NiO}(s) + 2\text{SO}_2(g)$
- $\text{CaH}_2(s) + 2\text{H}_2\text{O}(l) \rightarrow \text{Ca}(\text{OH})_2(s) + 2\text{H}_2(g)$
- $2\text{H}_2(g) + \text{CO}(g) \rightarrow \text{CH}_3\text{OH}(l)$
- $2\text{B}_2\text{O}_3(s) + 6\text{C}(s) \rightarrow \text{B}_4\text{C}_3(s) + 3\text{CO}_2(g)$

42.

- $4\text{NaCl}(s) + 2\text{SO}_2(g) + 2\text{H}_2\text{O}(g) + \text{O}_2(g) \rightarrow 2\text{Na}_2\text{SO}_4(s) + 4\text{HCl}(g)$
- $3\text{Br}_2(l) + \text{I}_2(s) \rightarrow 2\text{IBr}_3(s)$
- $\text{Ca}(s) + 2\text{H}_2\text{O}(g) \rightarrow \text{Ca}(\text{OH})_2(aq) + \text{H}_2(g)$
- $2\text{BF}_3(g) + 3\text{H}_2\text{O}(g) \rightarrow \text{B}_2\text{O}_3(s) + 6\text{HF}(g)$
- $\text{SO}_2(g) + 2\text{Cl}_2(g) \rightarrow \text{SOCl}_2(l) + \text{Cl}_2\text{O}(g)$
- $\text{Li}_2\text{O}(s) + \text{H}_2\text{O}(l) \rightarrow 2\text{LiOH}(aq)$
- $\text{Mg}(s) + \text{CuO}(s) \rightarrow \text{MgO}(s) + \text{Cu}(l)$
- $\text{Fe}_3\text{O}_4(s) + 4\text{H}_2(g) \rightarrow 3\text{Fe}(l) + 4\text{H}_2\text{O}(g)$

43.

- $4\text{KO}_2(s) + 6\text{H}_2\text{O}(l) \rightarrow 4\text{KOH}(aq) + \text{O}_2(g) + 4\text{H}_2\text{O}_2(aq)$
- $\text{Fe}_2\text{O}_3(s) + 6\text{HNO}_3(aq) \rightarrow 2\text{Fe}(\text{NO}_3)_3(aq) + 3\text{H}_2\text{O}(l)$
- $4\text{NH}_3(g) + 5\text{O}_2(g) \rightarrow 4\text{NO}(g) + 6\text{H}_2\text{O}(g)$
- $\text{PCl}_5(l) + 4\text{H}_2\text{O}(l) \rightarrow \text{H}_3\text{PO}_4(aq) + 5\text{HCl}(g)$
- $\text{C}_2\text{H}_5\text{OH}(l) + 3\text{O}_2(g) \rightarrow 2\text{CO}_2(g) + 3\text{H}_2\text{O}(l)$
- $2\text{CaO}(s) + 5\text{C}(s) \rightarrow 2\text{CaC}_2(s) + \text{CO}_2(g)$
- $2\text{MoS}_2(s) + 7\text{O}_2(g) \rightarrow 2\text{MoO}_3(s) + 4\text{SO}_2(g)$
- $\text{FeCO}_3(s) + \text{H}_2\text{CO}_3(aq) \rightarrow \text{Fe}(\text{HCO}_3)_2(aq)$

44.

- $\text{Ba}(\text{NO}_3)_2(aq) + \text{Na}_2\text{CrO}_4(aq) \rightarrow \text{BaCrO}_4(s) + 2\text{NaNO}_3(aq)$
- $\text{PbCl}_2(aq) + \text{K}_2\text{SO}_4(aq) \rightarrow \text{PbSO}_4(s) + 2\text{KCl}(aq)$
- $\text{C}_2\text{H}_5\text{OH}(l) + 3\text{O}_2(g) \rightarrow 2\text{CO}_2(g) + 3\text{H}_2\text{O}(l)$
- $\text{CaC}_2(s) + 2\text{H}_2\text{O}(l) \rightarrow \text{Ca}(\text{OH})_2(s) + \text{C}_2\text{H}_2(g)$
- $\text{Sr}(s) + 2\text{HNO}_3(aq) \rightarrow \text{Sr}(\text{NO}_3)_2(aq) + \text{H}_2(g)$

- f.  $\text{BaO}_2(s) + \text{H}_2\text{SO}_4(aq) \rightarrow \text{BaSO}_4(s) + \text{H}_2\text{O}_2(aq)$
- g.  $2\text{AsI}_3(s) \rightarrow 2\text{As}(s) + 3\text{I}_2(s)$
- h.  $2\text{CuSO}_4(aq) + 4\text{KI}(s) \rightarrow 2\text{CuI}(s) + \text{I}_2(s) + 2\text{K}_2\text{SO}_4(aq)$
45.  $\text{C}_2\text{H}_2(g) + \text{O}_2(g) \rightarrow \text{CO}_2(g) + \text{H}_2\text{O}(g)$
46.  $\text{Na}(s) + \text{O}_2(g) \rightarrow \text{Na}_2\text{O}_2(s)$   
 $\text{Na}_2\text{O}_2(s) + \text{H}_2\text{O}(l) \rightarrow \text{NaOH}(aq) + \text{O}_2(g)$
47.  $\text{KNO}_3(s) + \text{C}(s) \rightarrow \text{K}_2\text{CO}_3(s) + \text{CO}(g) + \text{N}_2(g)$
48.  $\text{C}_{12}\text{H}_{22}\text{O}_{11}(aq) + \text{H}_2\text{O}(l) \rightarrow 4\text{C}_2\text{H}_5\text{OH}(aq) + 4\text{CO}_2(g)$
49.  $2\text{H}_2(g) + \text{CO}(g) \rightarrow \text{CH}_3\text{OH}(l)$
50.  $2\text{Al}_2\text{O}_3(s) + 3\text{C}(s) \rightarrow 4\text{Al}(s) + 3\text{CO}_2(g)$
51.  $\text{Fe}_3\text{O}_4(s) + 4\text{H}_2(g) \rightarrow 3\text{Fe}(s) + 4\text{H}_2\text{O}(g)$   
 $\text{Fe}_3\text{O}_4(s) + 4\text{CO}(g) \rightarrow 3\text{Fe}(s) + 4\text{CO}_2(g)$
52.  $2\text{Li}(s) + \text{S}(s) \rightarrow \text{Li}_2\text{S}(s)$   
 $2\text{Na}(s) + \text{S}(s) \rightarrow \text{Na}_2\text{S}(s)$   
 $2\text{K}(s) + \text{S}(s) \rightarrow \text{K}_2\text{S}(s)$   
 $2\text{Rb}(s) + \text{S}(s) \rightarrow \text{Rb}_2\text{S}(s)$   
 $2\text{Cs}(s) + \text{S}(s) \rightarrow \text{Cs}_2\text{S}(s)$   
 $2\text{Fr}(s) + \text{S}(s) \rightarrow \text{Fr}_2\text{S}(s)$
53.  $\text{Fe}(s) + \text{O}_2(g) \rightarrow \text{FeO}(s)$   
 $\text{Fe}(s) + \text{O}_2(g) \rightarrow \text{Fe}_2\text{O}_3(s)$
54.  $\text{BaO}_2(s) + \text{H}_2\text{O}(l) \rightarrow \text{BaO}(s) + \text{H}_2\text{O}_2(aq)$
55.  $4\text{B}(s) + 3\text{O}_2(g) \rightarrow 2\text{B}_2\text{O}_3(s)$   
 $\text{B}_2\text{O}_3(s) + 3\text{H}_2\text{O}(l) \rightarrow 2\text{B}(\text{OH})_3(s)$
56.  $2\text{KClO}_3(s) \rightarrow 2\text{KCl}(s) + 3\text{O}_2(g)$
57.  $2\text{H}_2\text{O}_2(aq) \rightarrow 2\text{H}_2\text{O}(g) + \text{O}_2(g)$
58.  $\text{NH}_3(g) + \text{HCl}(g) \rightarrow \text{NH}_4\text{Cl}(s)$
59.  $\text{CaSiO}_3(s) + 6\text{HF}(g) \rightarrow \text{CaF}_2(aq) + \text{SiF}_4(g) + 3\text{H}_2\text{O}(l)$
60. The senses we call "odor" and "taste" are really chemical reactions of the receptors in our body with molecules in the food we are eating. The fact that the receptors no longer detect the "fishy" odor or taste suggests that adding the lemon juice or vinegar has changed the nature of the amines in the fish.
61. Many over-the-counter antacids contain either carbonate ion ( $\text{CO}_3^{2-}$ ) or hydrogen carbonate ion ( $\text{HCO}_3^-$ ). When either of these encounter stomach acid (primarily HCl), carbon dioxide gas is released.
62.  $\text{Fe}(s) + \text{S}(s) \rightarrow \text{FeS}(s)$

63.  $\text{Na}(s) + \text{Cl}_2(g) \rightarrow \text{NaCl}(s)$
64.  $\text{K}_2\text{CrO}_4(aq) + \text{BaCl}_2(aq) \rightarrow \text{BaCrO}_4(s) + 2\text{KCl}(aq)$
65.  $\text{H}_2\text{S}(g) + \text{Pb}(\text{NO}_3)_2(aq) \rightarrow \text{PbS}(s) + \text{HNO}_3(aq)$
66.  $2\text{NaCl}(aq) + 2\text{H}_2\text{O}(l) \rightarrow 2\text{NaOH}(aq) + \text{H}_2(g) + \text{Cl}_2(g)$   
 $2\text{NaBr}(aq) + 2\text{H}_2\text{O}(l) \rightarrow 2\text{NaOH}(aq) + \text{H}_2(g) + \text{Br}_2(g)$   
 $2\text{NaI}(aq) + 2\text{H}_2\text{O}(l) \rightarrow 2\text{NaOH}(aq) + \text{H}_2(g) + \text{I}_2(g)$
67.  $\text{Mg}(s) + \text{O}_2(g) \rightarrow \text{MgO}(s)$
68.  $\text{CaC}_2(s) + 2\text{H}_2\text{O}(l) \rightarrow \text{Ca}(\text{OH})_2(s) + \text{C}_2\text{H}_2(g)$
69.  $\text{P}_4(s) + \text{O}_2(g) \rightarrow \text{P}_4\text{O}_{10}(s)$
70.  $\text{CuO}(s) + \text{H}_2\text{SO}_4(aq) \rightarrow \text{CuSO}_4(aq) + \text{H}_2\text{O}(l)$
71.  $\text{PbS}(s) + \text{O}_2(g) \rightarrow \text{PbO}(s) + \text{SO}_2(g)$
72.  $\text{Na}_2\text{SO}_3(aq) + \text{S}(s) \rightarrow \text{Na}_2\text{S}_2\text{O}_3(aq)$
- 73.
- a.  $\text{Cl}_2(g) + 2\text{KBr}(aq) \rightarrow \text{Br}_2(l) + 2\text{KCl}(aq)$
  - b.  $4\text{Cr}(s) + 3\text{O}_2(g) \rightarrow 2\text{Cr}_2\text{O}_3(s)$
  - c.  $\text{P}_4(s) + 6\text{H}_2(g) \rightarrow 4\text{PH}_3(g)$
  - d.  $2\text{Al}(s) + 3\text{H}_2\text{SO}_4(aq) \rightarrow \text{Al}_2(\text{SO}_4)_3(aq) + 3\text{H}_2(g)$
  - e.  $\text{PCl}_3(l) + 3\text{H}_2\text{O}(l) \rightarrow \text{H}_3\text{PO}_3(aq) + 3\text{HCl}(aq)$
  - f.  $2\text{SO}_2(g) + \text{O}_2(g) \rightarrow 2\text{SO}_3(g)$
  - g.  $\text{C}_7\text{H}_{16}(l) + 11\text{O}_2(g) \rightarrow 7\text{CO}_2(g) + 8\text{H}_2\text{O}(g)$
  - h.  $2\text{C}_2\text{H}_6(g) + 7\text{O}_2(g) \rightarrow 4\text{CO}_2(g) + 6\text{H}_2\text{O}(g)$
- 74.
- a.  $\text{Cl}_2(g) + 2\text{KI}(aq) \rightarrow 2\text{KCl}(aq) + \text{I}_2(s)$
  - b.  $\text{CaC}_2(s) + 2\text{H}_2\text{O}(l) \rightarrow \text{Ca}(\text{OH})_2(s) + \text{C}_2\text{H}_2(g)$
  - c.  $2\text{NaCl}(s) + \text{H}_2\text{SO}_4(l) \rightarrow \text{Na}_2\text{SO}_4(s) + 2\text{HCl}(g)$
  - d.  $\text{CaF}_2(s) + \text{H}_2\text{SO}_4(l) \rightarrow \text{CaSO}_4(s) + 2\text{HF}(g)$
  - e.  $\text{K}_2\text{CO}_3(s) \rightarrow \text{K}_2\text{O}(s) + \text{CO}_2(g)$
  - f.  $3\text{BaO}(s) + 2\text{Al}(s) \rightarrow \text{Al}_2\text{O}_3(s) + 3\text{Ba}(s)$
  - g.  $2\text{Al}(s) + 3\text{F}_2(g) \rightarrow 2\text{AlF}_3(s)$
  - h.  $\text{CS}_2(g) + 3\text{Cl}_2(g) \rightarrow \text{CCl}_4(l) + \text{S}_2\text{Cl}_2(g)$
- 75.
- a.  $\text{SiCl}_4(l) + 2\text{Mg}(s) \rightarrow \text{Si}(s) + 2\text{MgCl}_2(s)$
  - b.  $2\text{NO}(g) + \text{Cl}_2(g) \rightarrow 2\text{NOCl}(g)$
  - c.  $3\text{MnO}_2(s) + 4\text{Al}(s) \rightarrow 3\text{Mn}(s) + 2\text{Al}_2\text{O}_3(s)$

- d.  $16\text{Cr}(s) + 3\text{S}_8(s) \rightarrow 8\text{Cr}_2\text{S}_3(s)$
- e.  $4\text{NH}_3(g) + 3\text{F}_2(g) \rightarrow 3\text{NH}_4\text{F}(s) + \text{NF}_3(g)$
- f.  $\text{Ag}_2\text{S}(s) + \text{H}_2(g) \rightarrow 2\text{Ag}(s) + \text{H}_2\text{S}(g)$
- g.  $3\text{O}_2(g) \rightarrow 2\text{O}_3(g)$
- h.  $8\text{Na}_2\text{SO}_3(aq) + \text{S}_8(s) \rightarrow 8\text{Na}_2\text{S}_2\text{O}_3(aq)$
- 76.
- a.  $\text{Pb}(\text{NO}_3)_2(aq) + \text{K}_2\text{CrO}_4(aq) \rightarrow \text{PbCrO}_4(s) + 2\text{KNO}_3(aq)$
- b.  $\text{BaCl}_2(aq) + \text{Na}_2\text{SO}_4(aq) \rightarrow \text{BaSO}_4(s) + 2\text{NaCl}(aq)$
- c.  $2\text{CH}_3\text{OH}(l) + 3\text{O}_2(g) \rightarrow 2\text{CO}_2(g) + 4\text{H}_2\text{O}(g)$
- d.  $\text{Na}_2\text{CO}_3(aq) + \text{S}(s) + \text{SO}_2(g) \rightarrow \text{CO}_2(g) + \text{Na}_2\text{S}_2\text{O}_3(aq)$
- e.  $\text{Cu}(s) + 2\text{H}_2\text{SO}_4(aq) \rightarrow \text{CuSO}_4(aq) + \text{SO}_2(g) + 2\text{H}_2\text{O}(l)$
- f.  $\text{MnO}_2(s) + 4\text{HCl}(aq) \rightarrow \text{MnCl}_2(aq) + \text{Cl}_2(g) + 2\text{H}_2\text{O}(l)$
- g.  $\text{As}_2\text{O}_3(s) + 6\text{KI}(aq) + 6\text{HCl}(aq) \rightarrow 2\text{AsI}_3(s) + 6\text{KCl}(aq) + 3\text{H}_2\text{O}(l)$
- h.  $2\text{Na}_2\text{S}_2\text{O}_3(aq) + \text{I}_2(aq) \rightarrow \text{Na}_2\text{S}_4\text{O}_6(aq) + 2\text{NaI}(aq)$