

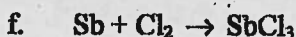
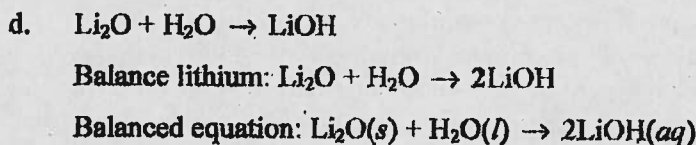
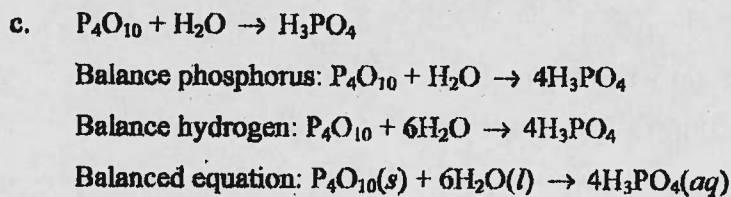
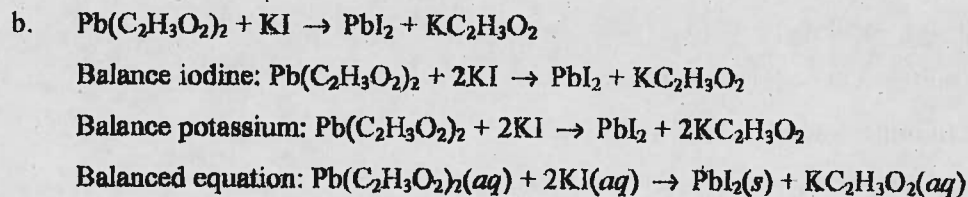
CHAPTER 6

Chemical Reactions: An Introduction

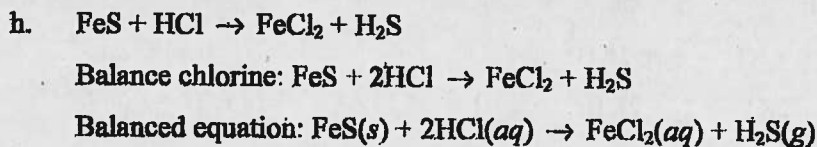
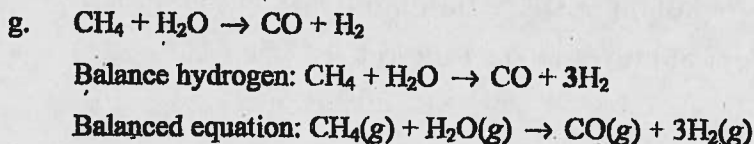
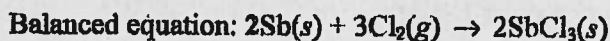
CHAPTER ANSWERS

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. $\text{H}_2(g) + \text{O}_2(g) \rightarrow \text{H}_2\text{O}(g)$

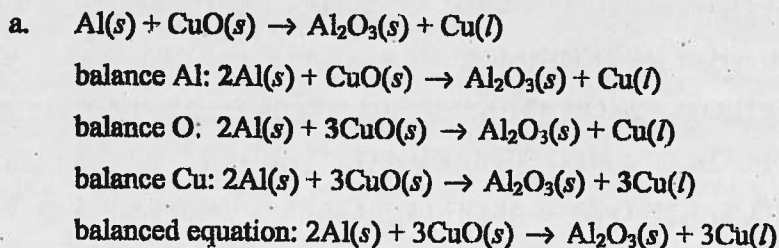
16. $\text{AgNO}_3(aq) + \text{HCl}(aq) \rightarrow \text{AgCl}(s) + \text{HNO}_3(aq)$
 $\text{Pb}(\text{NO}_3)_2(aq) + \text{HCl}(aq) \rightarrow \text{PbCl}_2(s) + \text{HNO}_3(aq)$
17. $\text{Ag}(s) + \text{HNO}_3(aq) \rightarrow \text{AgNO}_3(aq) + \text{NO}(g) + \text{H}_2(g)$
18. $\text{C}_3\text{H}_8(g) + \text{O}_2(g) \rightarrow \text{CO}_2(g) + \text{H}_2\text{O}(g)$
 $\text{C}_3\text{H}_3(g) + \text{O}_2(g) \rightarrow \text{CO}(g) + \text{H}_2\text{O}(g)$
19. $\text{B}_2\text{O}_3(s) + \text{Mg}(s) \rightarrow \text{B}(g) + \text{MgO}(s)$
20. $\text{CaCO}_3(s) + \text{HCl}(aq) \rightarrow \text{CaCl}_2(aq) + \text{H}_2\text{O}(l) + \text{CO}_2(g)$
21. $\text{P}_4(s) + \text{Cl}_2(g) \rightarrow \text{PCl}_3(s)$
22. $\text{SiO}_2(s) + \text{C}(s) \rightarrow \text{Si}(s) + \text{CO}(g)$
23. $\text{NH}_4\text{NO}_3(s) \rightarrow \text{N}_2\text{O}(g) + \text{H}_2\text{O}(g)$
24. $\text{H}_2\text{S}(g) + \text{O}_2(g) \rightarrow \text{SO}_2(g) + \text{H}_2\text{O}(g)$
25. $\text{C}_2\text{H}_2(g) + \text{O}_2(g) \rightarrow \text{CO}_2(g) + \text{H}_2\text{O}(g)$
26. $\text{SO}_2(g) + \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{SO}_3(aq)$
 $\text{SO}_3(g) + \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{SO}_4(aq)$
27. $\text{BaO}(s) + \text{Al}(s) \rightarrow \text{Ba}(s) + \text{Al}_2\text{O}_3(s)$
 $\text{CaO}(s) + \text{Al}(s) \rightarrow \text{Ca}(s) + \text{Al}_2\text{O}_3(s)$
 $\text{SrO}(s) + \text{Al}(s) \rightarrow \text{Sr}(s) + \text{Al}_2\text{O}_3(s)$
28. $\text{NO}(g) + \text{O}_3(g) \rightarrow \text{NO}_2(g) + \text{O}_2(g)$
29. $\text{CH}_4(g) + \text{Cl}_2(g) \rightarrow \text{CCl}_4(l) + \text{HCl}(g)$
30. $\text{NH}_3(g) + \text{HNO}_3(aq) \rightarrow \text{NH}_4\text{NO}_3(s)$
31. $\text{CaO}(s) + \text{H}_2\text{O}(g) \rightarrow \text{Ca}(\text{OH})_2(s)$
32. $\text{Xe}(g) + \text{F}_2(g) \rightarrow \text{XeF}_4(s)$
33. $\text{NH}_4\text{NO}_3(s) \rightarrow \text{N}_2(g) + \text{O}_2(g) + \text{H}_2\text{O}(g)$
34. $\text{NH}_4\text{Cl}(s) + \text{NaOH}(s) \xrightarrow{\text{heat}} \text{NH}_3(g) + \text{H}_2\text{O}(g) + \text{NaCl}(s)$
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. $\text{FeCl}_3 + \text{KOH} \rightarrow \text{Fe}(\text{OH})_3 + \text{KCl}$
 Balance chlorine: $\text{FeCl}_3 + \text{KOH} \rightarrow \text{Fe}(\text{OH})_3 + 3\text{KCl}$
 Balance potassium: $\text{FeCl}_3 + 3\text{KOH} \rightarrow \text{Fe}(\text{OH})_3 + 3\text{KCl}$
 Balanced equation: $\text{FeCl}_3(aq) + 3\text{KOH}(aq) \rightarrow \text{Fe}(\text{OH})_3(s) + 3\text{KCl}(aq)$

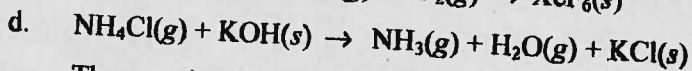
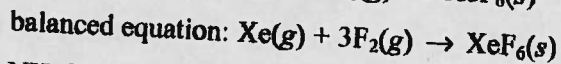
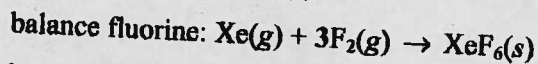
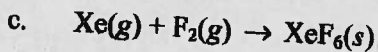
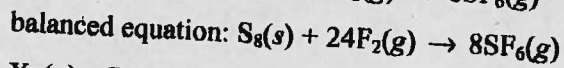
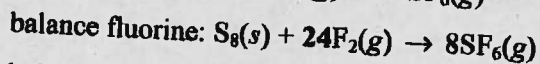
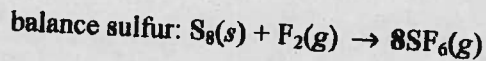
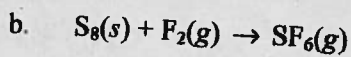


This equation is more difficult to balance than it may appear. The problem arises in the fact that there are two Cl atoms on the left side of the equation, whereas there are three Cl atoms on the right side of the equation. To balance the chlorine atoms, we need to know the smallest whole number into which both two and three divide. This number is six: we need to adjust the coefficients of Cl_2 and SbCl_3 so that there will be six chlorine atoms on each side of the equation.

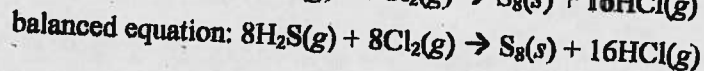
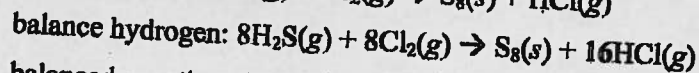
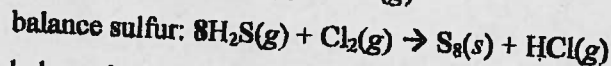
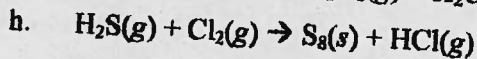
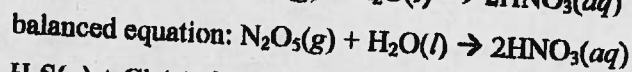
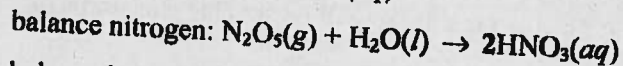
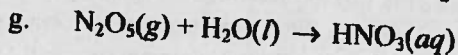
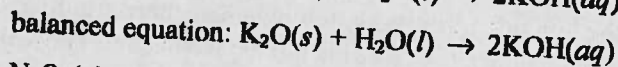
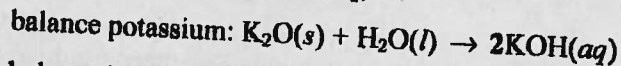
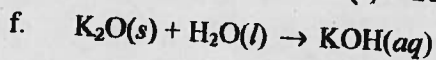
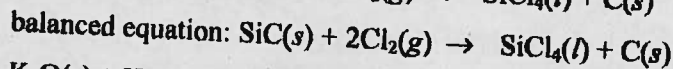
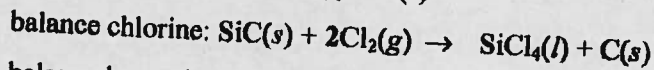
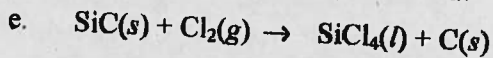


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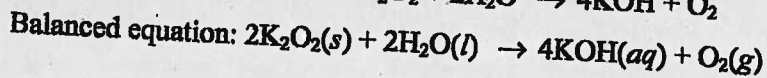
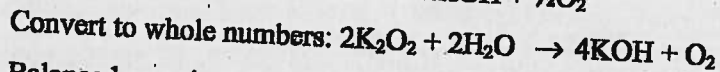
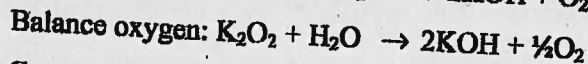
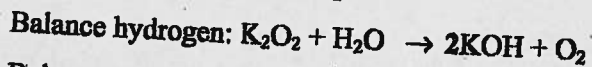
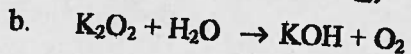
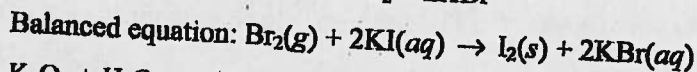
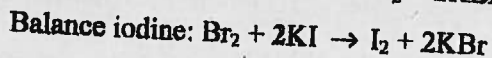
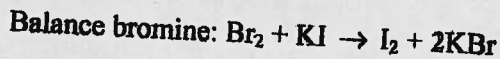
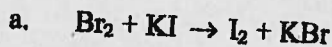


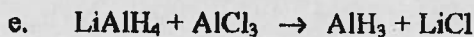
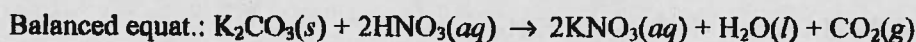
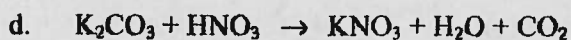
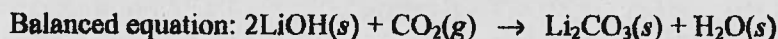
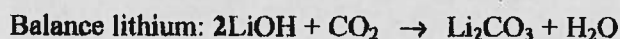
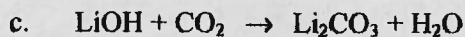


The equation is already balanced.

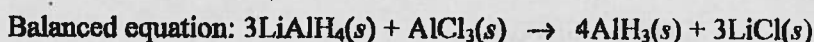
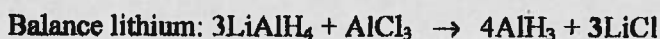
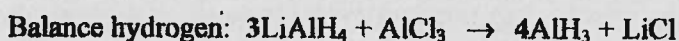


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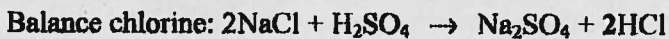
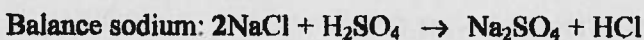
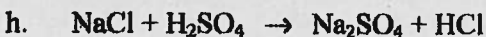
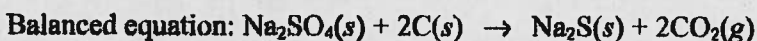
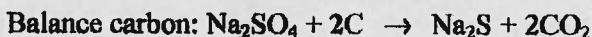
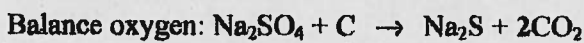




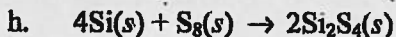
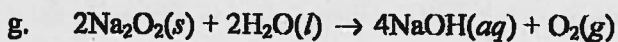
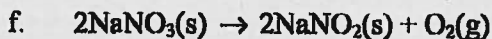
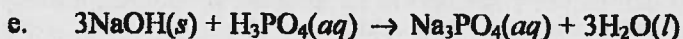
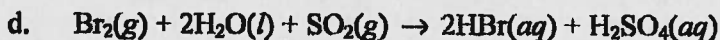
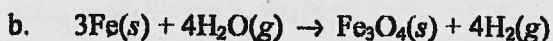
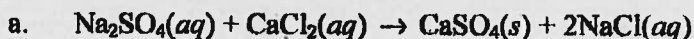
We have an interesting situation here. There are four hydrogen atoms on the left side of the equation, but only three hydrogen atoms on the right side. The smallest number that is divisible by both four and three is 12. So the simplest way to begin balancing this equation is to take care of the hydrogen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



f. This equation is already balanced.



40.



41.

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

42.

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

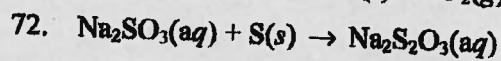
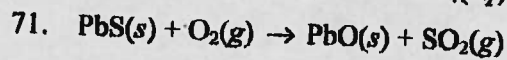
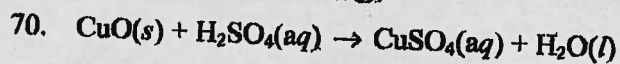
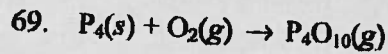
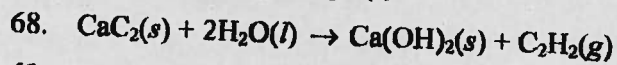
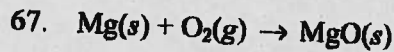
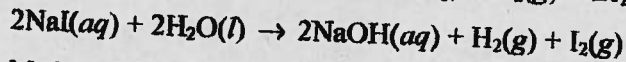
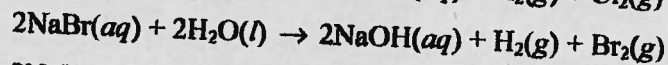
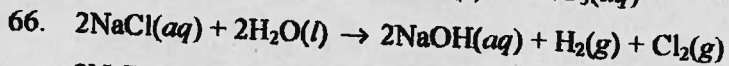
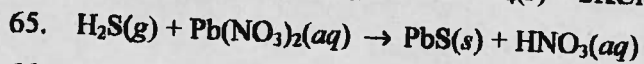
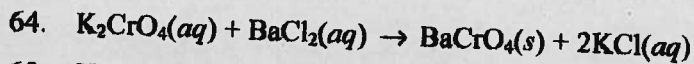
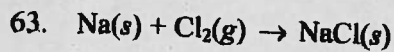
43.

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

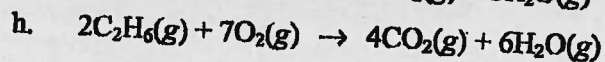
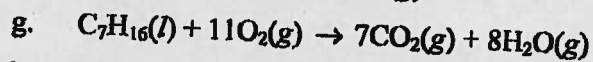
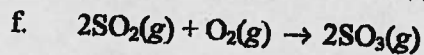
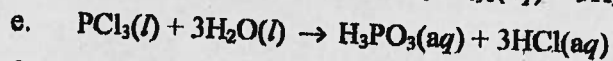
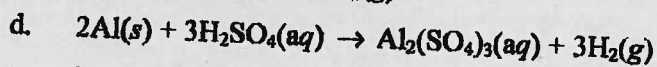
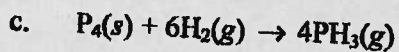
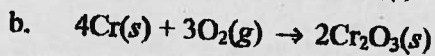
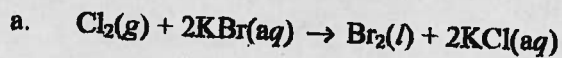
44.

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

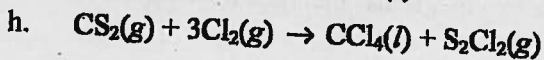
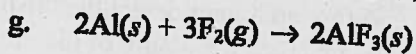
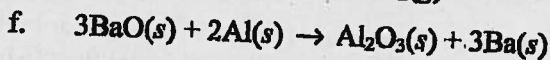
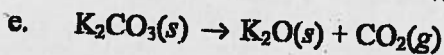
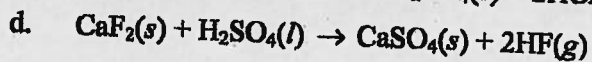
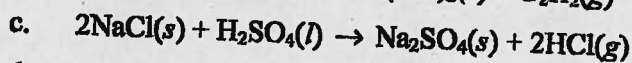
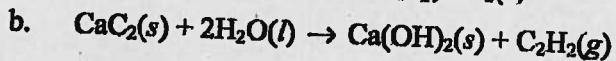
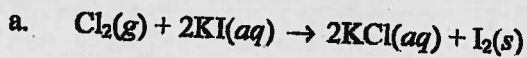
- f. $\text{BaO}_2(s) + \text{H}_2\text{SO}_4(aq) \rightarrow \text{BaSO}_4(s) + \text{H}_2\text{O}_2(aq)$
- g. $2\text{AsI}_3(s) \rightarrow 2\text{As}(s) + 3\text{I}_2(s)$
- h. $2\text{CuSO}_4(aq) + 4\text{KI}(s) \rightarrow 2\text{CuI}(s) + \text{I}_2(s) + 2\text{K}_2\text{SO}_4(aq)$
45. $\text{C}_2\text{H}_2(g) + \text{O}_2(g) \rightarrow \text{CO}_2(g) + \text{H}_2\text{O}(g)$
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 (CO_3^{2-}) or hydrogen carbonate ion (HCO_3^-). When either of these encounter stomach acid (primarily HCl), carbon dioxide gas is released.
62. $\text{Fe}(s) + \text{S}(s) \rightarrow \text{FeS}(s)$



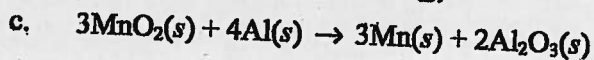
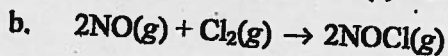
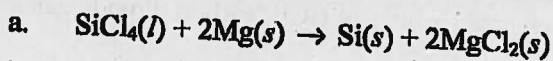
73.



74.



75.



- 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. $2\text{Na}_2\text{S}_2\text{O}_3(aq) + \text{I}_2(aq) \rightarrow \text{Na}_2\text{S}_4\text{O}_6(aq) + 2\text{NaI}(aq)$