11 Study Guide

BIG IDEA REACTIONS

The law of conservation of mass states that mass is neither created nor destroyed. In order to show that mass is conserved during a reaction, a chemical equation must be balanced. The general types of chemical reactions are combination, decomposition, single-replacement, double-replacement, and combustion reactions. Net ionic equations show only those particles involved in the reaction.

11.1 Describing Chemical Reactions

- To write a skeleton equation, write the formulas for the reactants to the left of the yields sign and the formulas for the products to the right.
- After writing the skeleton equation, use coefficients to balance the equation so that it obeys the law of conservation of mass.

- chemical equation (348)
- skeleton equation (348)
- catalyst (348)
- coefficient (350)
- balanced equation (350)

11.2 Types of Chemical Reactions

- The five general types of reactions are combination, decomposition, single-replacement, double-replacement, and combustion.
- The number of elements and/or compounds reacting is a good indicator of possible reaction type and, thus, possible products.
- In a combination reaction, there is always a single product.
- A decomposition reaction involves the breakdown of a single compound into two or more simpler substances.
- In a single-replacement reaction, both the reactants and the products are an element and a compound.
- A double-replacement reaction generally takes place between two ionic compounds in aqueous solution.
- A combustion reaction always involves oxygen as a reactant.

- combination reaction (356)
- decomposition reaction (358)
- single-replacement reaction (360)
- activity series (360)
- double-replacement reaction (362)
- combustion reaction (363)

11.3 Reactions in Aqueous Solution

- A net ionic equation shows only those particles involved in the reaction and is balanced with respect to mass and charge.
- By using the general rules for solubility of ionic compounds, you can predict the formation of a precipitate.

- complete ionic equation (370)
- spectator ion (370)
- net ionic equation (370)

Performance Tasks

IDENTIFYING REACTIONS Provide students with the reactants only of a series of reactions. Have students write balanced equations to complete each reaction and identify the type of reaction. Students should explain the reasoning behind each classification.

CORAL REEFS Explain that limestone is sedimentary rock formed from the exoskeletons of marine corals. Have students research the formation of these exoskeletons and write a report on the chemical processes involved. Reports should include balanced complete and net ionic equations representing the precipitation reactions responsible.

Evaluate

Review and Assessment Materials

WALK-THRU TUTORIALS Each of the Skills Tune-Up problems on the following page has an animated step-by-step tutorial that explains the problem-solving strategy in detail.

PROBLEM SETS Have students practice solving more chemical reaction problems by using the Chapter 11 Online Problem Set.

MATH SKILLS REVIEW Have struggling students practice solving algebraic equations by using the MathXL learning module.

VIRTUAL LABS Have students complete a virtual lab as an in-class or take-home assignment to help reinforce the concepts involved in writing and balancing chemical equations.

Study Tip

Encourage students to use physical models to clarify concepts. For example, for balancing chemical equations or classifying a reaction according to its type, physical models of atoms can aid visual learners. Molecular model kits, foam balls, gumdrops, or modeling clay can be used to represent different types of atoms.

SKILLS TUNE-UP

Evaluate

Skills Review

Example and sample practice problems related to balancing chemical equations can be found on the following pages:

LESSON 11.1 Writing a Skeleton Equation—page 349; Balancing a Chemical Equation—pages 352 and 353

LESSON 11.2 Writing Equations for Combination and Decomposition Reactions—page 359; Writing the Equation for Single-Replacement Reactions— page 361; Writing Equations for Double-Replacement Reactions—page 363; Writing Equations for Combustion Reactions—page 365

LESSON 11.3 Writing and Balancing Net Ionic Equations—pages 371 and 373

Skills Tune-Up: Balancing Chemical Equations

Problem	❶ Analyze	❷ Solve
Write the balanced equation for the following reaction: $C_2H_4 + O_2 \longrightarrow$	The reactants are a hydrocarbon and oxygen. The hydrocarbon tells you that the products must be CO_2 and H_2O. The oxygen tells you that this is a combustion reaction.	First write a skeleton equation. $C_2H_4 + O_2 \longrightarrow CO_2 + H_2O$ (unbalanced) Balance the C atoms and the H atoms first. $C_2H_4 + O_2 \longrightarrow 2CO_2 + 2H_2O$ (unbalanced) Balance the O atoms next. $C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$ (balanced)
Write the balanced equation for the following reaction: $Al + Cu(NO_3)_2 \longrightarrow$ A subscript in a polyatomic ion moves with the ion. So the 3 in NO_3 stays with the ion. But the subscript 2 is there only to balance the charges. It's not part of the ion and doesn't move with it.	$Cu(NO_3)_2$ is an ionic compound, and Al is an element. This is a single-replacement reaction. Check Table 11.2 to be sure a reaction will take place.	First write a skeleton equation. $Al + Cu(NO_3)_2 \longrightarrow Al(NO_3)_3 + Cu$ (unbalanced) Balance the equation. $2Al + 3Cu(NO_3)_2 \longrightarrow 2Al(NO_3)_3 + 3Cu$ (balanced)
Write the balanced equation for the following reaction: $Na(OH)(aq) + Ba(NO_3)_2(aq) \longrightarrow$ Use the solubility rules in Table 11.3 to identify the precipitate formed.	Both reactants are ionic compounds, so this is a double-replacement reaction. In a double-replacement reaction, two compounds exchange positive ions. They often produce a gas, a precipitate, or another molecular compound such as water.	Write the reactants, showing each as dissociated free ions. $Na^+(aq) + OH^-(aq) + Ba^{2+}(aq) + 2NO_3^-(aq) \longrightarrow$ Look at the possible new pairings of cation and anion that give an insoluble substance. Of the two possible combinations, $Na(NO)_3$ is soluble and $Ba(OH)_2$ is insoluble. Balance the equation. $2NaOH(aq) + Ba(NO_3)_2(aq) \longrightarrow 2(NaNO)_3(aq) + Ba(OH)_2(s)$ (balanced)

Focus on ELL

5 ASSESS UNDERSTANDING Use a variety of informal assessments to help monitor students' progress in this chapter. Include various types of learning assignments, based on each student's language proficiency.

BEGINNING: LOW/HIGH Have students use diagrams to answer questions or describe reactions.

INTERMEDIATE

LOW Ask students to create a song or poem that demonstrates their knowledge of the five different types of chemical reactions.

HIGH Use the students' participation in the labs to assess their ability to demonstrate understanding.

ADVANCED: LOW/HIGH Include questions from previous lessons as part of assessments so that students can retain information.

11 Assessment

* Solutions appear in Appendix E

Lesson by Lesson

11.1 Describing Chemical Reactions

34. Identify the reactants and products in each chemical reaction.

a. Hydrogen gas and sodium hydroxide are formed when sodium is dropped into water.

b. In photosynthesis, carbon dioxide and water react to form oxygen gas and glucose.

35. Write sentences that completely describe each of the chemical reactions shown in these skeleton equations.

a. $NH_3(g) + O_2(g) \xrightarrow{Pt} NO(g) + H_2O(g)$

b. $H_2SO_4(aq) + BaCl_2(aq) \longrightarrow BaSO_4(s) + HCl(aq)$

c. $N_2O_3(g) + H_2O(l) \longrightarrow HNO_2(aq)$

36. The equation for the formation of water from its elements, $H_2(g) + O_2(g) \longrightarrow H_2O(l)$, can be "balanced" by changing the formula of the product to H_2O_2. Explain why this is incorrect.

***37.** Balance the following equations:

a. $PbO_2(s) \longrightarrow PbO(s) + O_2(g)$

b. $Fe(OH)_3(s) \longrightarrow Fe_2O_3(s) + H_2O(s)$

c. $(NH_4)_2CO_3(s) \longrightarrow NH_3(g) + H_2O(g) + CO_2(g)$

d. $CaCl_2(aq) + H_2SO_4(aq) \longrightarrow CaSO_4(s) + HCl(aq)$

11.2 Types of Chemical Reactions

***38.** Write balanced chemical equations for the following combination reactions:

a. $Mg(s) + O_2(g) \longrightarrow$

b. $P(s) + O_2(g) \longrightarrow$ diphosphorus pentoxide

c. $Ca(s) + S(s) \longrightarrow$

39. Write a balanced chemical equation for each decomposition reaction.

a. $Ag_2O(s) \xrightarrow{\Delta}$

b. ammonium nitrate $\xrightarrow{\Delta}$ dinitrogen monoxide + water

40. Use the activity series of metals to write a balanced chemical equation for each single-replacement reaction.

a. $Au(s) + KNO_3(aq) \longrightarrow$

b. $Zn(s) + AgNO_3(aq) \longrightarrow$

c. $Al(s) + H_2SO_4(aq) \longrightarrow$

41. Write a balanced equation for each of the following double-replacement reactions:

a. $H_2C_2O_4(aq) + KOH(aq) \longrightarrow$

b. $CdBr_2(aq) + Na_2S(aq) \longrightarrow$ (Cadmium sulfide is a precipitate.)

42. Write a balanced equation for the complete combustion of each compound.

a. butene (C_4H_8) **b.** propanal (C_3H_6O)

43. Balance each equation and identify its type.

a. $Hf(s) + N_2(g) \longrightarrow Hf_3N_4(s)$

b. $Mg(s) + H_2SO_4(aq) \longrightarrow MgSO_4(aq) + H_2(g)$

c. $C_2H_6(g) + O_2(g) \longrightarrow CO_2(g) + H_2O(g)$

d. $Pb(NO_3)_2(aq) + NaI(aq) \longrightarrow PbI_2(s) + NaNO_3(aq)$

44. What is a distinguishing feature of every decomposition reaction?

11.3 Reactions in Aqueous Solution

45. What is a spectator ion?

***46.** Write a balanced net ionic equation for the following reactions:

a. $HCl(aq) + Ca(OH)_2(aq) \longrightarrow$

b. $AgNO_3(aq) + AlCl_3(aq) \longrightarrow$ (Silver chloride is a precipitate.)

47. Complete each equation and then write a net ionic equation.

a. $Al(s) + H_2SO_4(aq) \longrightarrow$

b. $HCl(aq) + Ba(OH)_2(aq) \longrightarrow$

c. $Au(s) + HCl(aq) \longrightarrow$

Understand Concepts

48. Write a balanced chemical equation for each reaction. Use the necessary symbols from Table 11.1 to describe the reaction completely.

a. Bubbling chlorine gas through a solution of potassium iodide gives elemental iodine and a solution of potassium chloride.

b. Bubbles of hydrogen gas and aqueous iron(III) chloride are produced when metallic iron is dropped into hydrochloric acid.

c. Solid tetraphosphorus decaoxide reacts with water to produce phosphoric acid.

ASSESSMENT

Evaluate

Answers

LESSON 11.1

34. **a.** reactants: sodium and water; products: hydrogen and sodium hydroxide

b. reactants: carbon dioxide and water; products: oxygen and glucose

35. **a.** Gaseous ammonia and oxygen react in the presence of a platinum catalyst to produce nitrogen monoxide gas and water vapor.

b. Aqueous solutions of sulfuric acid and barium chloride are mixed to produce a precipitate of barium sulfate and aqueous hydrochloric acid.

c. The gas dinitrogen trioxide reacts with water to produce an aqueous solution of nitrous acid.

36. A formula is a unique identifier of a substance. A different formula would indicate a different substance, not the one that is taking part in the reaction you are trying to balance.

37. **a.** $2PbO_2(s) \rightarrow 2PbO(s) + O_2(g)$

b. $2Fe(OH)_3(s) \rightarrow Fe_2O_3(s) + 3H_2O(l)$

c. $(NH_4)_2CO_3(s) \rightarrow 2NH_3(g) + H_2O(g) + CO_2(g)$

d. $CaCl_2(aq) + H_2SO_4(aq) \rightarrow CaSO_4(s) + 2HCl(aq)$

LESSON 11.2

38. **a.** $2Mg(s) + O_2(g) \rightarrow 2MgO(g)$

b. $4P(s) + 5O_2(g) \rightarrow 2P_2O_5(s)$

c. $Ca(s) + S(s) \rightarrow CaS(s)$

39. **a.** $2Ag_2O \xrightarrow{\Delta} 4Ag + O_2$

b. $NH_4NO_3 \xrightarrow{\Delta} N_2O + 2H_2O$

40. **a.** no reaction

b. $Zn(s) + 2AgNO_3(aq) \rightarrow Zn(NO_3)_2(aq) + 2Ag(s)$

c. $2Al(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$

41. **a.** $H_2C_2O_4(aq) + 2KOH(aq) \rightarrow K_2C_2O_4(aq) + 2H_2O(l)$

b. $CdBr_2(aq) + Na_2S(aq) \rightarrow CdS(s) + 2NaBr(aq)$

42. **a.** $C_4H_8(g) + 6O_2(g) \rightarrow 4CO_2(g) + 4H_2O(g)$

b. $C_3H_6O(l) + 4O_2(g) \rightarrow 3CO_2(g) + 3H_2O(g)$

43. **a.** $3Hf(s) + 2N_2(g) \rightarrow Hf_3N_4(s)$; combination

b. $Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$; single replacement

c. $2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$; combustion

d. $Pb(NO_3)_2(aq) + 2NaI(aq) \rightarrow PbI_2(s) + 2NaNO_3(aq)$; double replacement

44. a single reactant

LESSON 11.3

45. an ion that does not participate in the reaction

46. **a.** $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

b. $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

47. **a.** $2Al(s) + 6H^+(aq) \rightarrow 2Al^{3+}(aq) + 3H_2(g)$

b. $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

c. no reaction

UNDERSTAND CONCEPTS

48. **a.** $Cl_2(g) + 2KI(aq) \rightarrow I_2(aq) + 2KCl(aq)$

b. $2Fe(s) + 6HCl(aq) \rightarrow 2FeCl_3(aq) + 3H_2(g)$

c. $P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)$

ASSESSMENT

Evaluate

Answers

49. **a.** $Cl_2 + 2NaI \rightarrow 2NaCl + I_2$
b. $2NH_3 \rightarrow N_2 + 3H_2$
c. $4Na + O_2 \rightarrow 2Na_2O$

50. **a.** $ZnS(aq) + H_2SO_4(aq) \rightarrow H_2S(g) + ZnSO_4(aq)$
b. $NaOH(aq) + HNO_3(aq) \rightarrow H_2O(l) + NaNO_3(aq)$
c. $2KF(aq) + Ca(NO_3)_2(aq) \rightarrow CaF_2(s) + 2KNO_3(aq)$

51. **a.** $Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$
b. $H_2(g) + Br_2(g) \rightarrow 2HBr(g)$
c. $Cl_2O_7(l) + H_2O(l) \rightarrow 2HClO_4(aq)$

52. **a.** $Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$
b. no reaction
c. $Br_2(l) + BaI_2(aq) \rightarrow BaBr_2(aq) + I_2(aq)$

53. **a.** tube A
b. $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$
single-replacement

54. **a.** $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$
b. $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
c. $HC_2H_3O_2 + 2O_2 \rightarrow 2CO_2 + 2H_2O$

55. **a.** $2Al_2O_3 \xrightarrow{\text{energy}} 4Al + 3O_2$
b. $Sn(OH)_4 \xrightarrow{\Delta} SnO_2 + 2H_2O$
c. $Ag_2CO_3 \xrightarrow{\Delta} Ag_2O + CO_2$

56. **a.** $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$
b. $S^{2-}(aq) + 2H^+(aq) \rightarrow H_2S(g)$
c. $3OH^-(aq) + Fe^{3+}(aq) \rightarrow Fe(OH)_3(s)$

57. **a.** CdS(s)
b. $Na^+(aq)$ and $NO_3^-(aq)$
c. $Cd^{2+}(aq) + S^{2-}(aq) \rightarrow CdS(s)$

THINK CRITICALLY

58. **a.** (1) combination
(2) single-replacement
(3) combustion
(4) double-replacement
b. (1) $2Al(s) + 3Br_2(l) \rightarrow 2AlBr_3(s)$
(2) $Cu(s) + 2AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2Ag(s)$
(3) $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$
(4) $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$

49. Each equation is incorrect. Find the errors, then rewrite and balance each equation.
a. $Cl_2 + NaI \longrightarrow NaCl_2 + I$
b. $NH_3 \longrightarrow N + H_3$
c. $Na + O_2 \longrightarrow NaO_2$

50. Write balanced chemical equations for these double-replacement reactions that occur in aqueous solution.
a. Zinc sulfide is added to sulfuric acid.
b. Sodium hydroxide reacts with nitric acid.
c. Solutions of potassium fluoride and calcium nitrate are mixed.

***51.** Write a balanced chemical equation for each combination reaction.
a. sodium oxide + water
b. hydrogen + bromine
c. dichlorine heptoxide + water

52. Write a balanced chemical equation for each single-replacement reaction that takes place in aqueous solution. Write "no reaction" if a reaction does not occur.
a. Steel wool (iron) is placed in sulfuric acid.
b. Mercury is poured into an aqueous solution of zinc nitrate.
c. Bromine reacts with aqueous barium iodide.

***53.** Pieces of sodium and magnesium are dropped into separate water-filled test tubes (A and B). There is vigorous bubbling in Tube A but not in Tube B.
a. Which tube contains the sodium metal?
b. Write an equation for the reaction in the tube containing the sodium metal. What type of reaction is occurring in this tube?

54. Write a balanced equation for the complete combustion of each compound. Assume that the products are carbon dioxide and water.
a. octane (C_8H_{18})
b. glucose ($C_6H_{12}O_6$)
c. ethanoic acid ($HC_2H_3O_2$)

55. Write balanced chemical equations for these decomposition reactions.
a. Aluminum is obtained from aluminum oxide with the addition of a large amount of electrical energy.
b. Heating tin(IV) hydroxide gives tin(IV) oxide and water.
c. Silver carbonate decomposes into silver oxide and carbon dioxide when it is heated.

56. Write a balanced net ionic equation for each reaction. The product that is not ionized is given.
a. $H_2C_2O_4 + KOH \longrightarrow [H_2O]$
b. $Na_2S + HCl \longrightarrow [H_2S]$
c. $NaOH + Fe(NO_3)_3 \longrightarrow [Fe(OH_3)]$

***57.** A yellow precipitate formed when aqueous solutions of sodium sulfide and cadmium nitrate were mixed in a beaker.
a. Write the formula of the yellow precipitate.
b. Identify the spectator ions in the solution.
c. Write the net ionic equation for the reaction.

Think Critically

58. **Interpret Photos** The photos show various types of reactions.

(1) 
(2) 
(3) 
(4) 

(1) Aluminum reacting with bromine

(2) The reaction of copper with aqueous silver nitrate

(3) Propane (C_3H_8) reacting with oxygen

(4) The reaction of lead(II) nitrate with potassium iodide

a. Identify each type of reaction.
b. Write the equation for each type of reaction.

59. Write a balanced chemical equation for each reaction. Classify each by type.

a. Sodium iodide reacts with phosphoric acid.
b. Potassium oxide reacts with water.
c. Heating sulfuric acid produces water, oxygen, and sulfur dioxide.
d. Aluminum reacts with sulfuric acid.
e. Pentane (C_5H_{12}) reacts with oxygen.

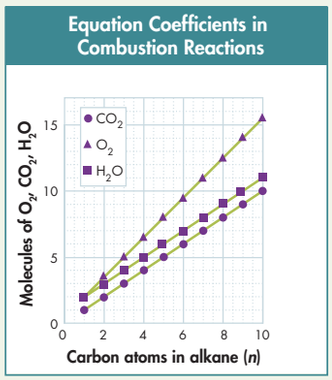
***60.** When pale yellow chlorine gas is bubbled through a clear, colorless solution of sodium iodide, the solution turns brown.

a. What type of reaction is taking place?
b. Write the net ionic equation.

Enrichment

61. Interpret Graphs Alkanes are hydrocarbon molecules that have the general formula C_nH_{2n+2}. The graph shows the number of oxygen, carbon dioxide, and water molecules needed to balance the equations for the complete combustion of every alkane having from one to ten carbon atoms.

$C_nH_{2n+2} + \_\_\_ O_2 \longrightarrow \_\_\_ CO_2 + \_\_\_ H_2O$



a. Use the graph to write balanced equations for the combustion of C_5H_{12} and C_9H_{20}.
b. Extrapolate the graph and write balanced equations for the combustion of $C_{12}H_{26}$ and $C_{17}H_{36}$.
c. The coefficient for O_2 in the general equation is as follows:

$$n + \frac{n+1}{2}$$

What are the coefficients for CO_2 and H_2O?

***62. Apply Concepts** Fill in the missing reactant, and then balance each equation.

a. $K(s) + \_\_\_\_ \longrightarrow KOH(aq) + H_2(g)$
b. $C_2H_5OH(l) + \_\_\_\_ \longrightarrow CO_2(g) + H_2O(g)$
c. $Bi(NO_3)_3(aq) + \_\_\_\_ \longrightarrow Bi_2S_3(s) + HNO_3(aq)$
d. $Al(s) + \_\_\_\_ \longrightarrow AlBr_3(s)$

Write About Science

63. Apply Concepts Research organisms such as fireflies and jellyfish that use bioluminescence, including information on the discovery of green fluorescent protein (GFP). In a pamphlet or poster, explain how bioluminescence works and how each organism uses it.

64. Observe Make a list of five chemical reactions that happen in your kitchen. Describe and name each reaction on your list.

***65. Relate Cause and Effect** Why is smoking not permitted near an oxygen source? What would happen if a match were struck in a room filled with oxygen?

CHEMYSTERY

Order in the Lab

Chemicals should not be stored in alphabetical order because some chemicals that will react if mixed could end up next to each other. For example, acids should not be stored near cyanides, sulfides and other chemicals that produce toxic gases when combined. Acids should also not be stored near bases or active metals. Reactions between acids and bases produce heat. Acids and active metals react to produce gases and heat. Acids and flammables should have separate, dedicated storage areas.

66. Connect to the BIGIDEA Should sulfuric acid be stored next to sodium hydroxide? Explain your answer. If they should not be stored next to each other, write a balanced chemical equation to support your answer.

ASSESSMENT

CHEMYSTERY

APPLY CONCEPTS After students have read through the CHEMystery, call on volunteers to write chemical equations for reactions involving the chemicals that Maria rearranged. **Ask** What gaseous product would form by reacting sulfuric acid with sodium cyanide? *(hydrogen cyanide, HCN)* **Ask** What gaseous product would form from the reaction of sulfuric acid and sodium sulfide? *(hydrogen sulfide, H_2S)* Explain that both HCN and H_2S are gases that can be lethal if inhaled. Because sulfuric acid is a liquid, a very serious situation would have occurred in the lab if a spill occurred while it was stored next to either Na_2S or NaCN.

CHEMYSTERY ANSWERS

66. BIGIDEA No; NaOH is a base, and bases should not be stored next to acids because reactions between these two classes of chemicals generate heat.
$H_2SO_4(aq) + 2NaOH(s) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

Answers

59. a. $3NaI + H_3PO_4 \rightarrow 3HI + Na_3PO_4$; double-replacement
b. $K_2O + H_2O \rightarrow 2KOH$; combination
c. $2H_2SO_4 \xrightarrow{\Delta} 2H_2O + O_2 + 2SO_2$; decomposition
d. $2Al + 3H_2SO_4 \rightarrow 3H_2 + Al_2(SO_4)_3$; single-replacement
e. $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$; combustion

60. a. single-replacement
b. $Cl_2(g) + 2I^-(aq) \rightarrow I_2(aq) + 2Cl^-(aq)$

ENRICHMENT

61. a. $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$
$C_9H_{20} + 14O_2 \rightarrow 9CO_2 + 10H_2O$
b. $2C_{12}H_{26} + 37O_2 \rightarrow 24CO_2 + 26H_2O$
$C_{17}H_{36} + 26O_2 \rightarrow 17CO_2 + 18H_2O$
c. $n = CO_2$; $(n + 1) = H_2O$

62. a. $2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$
b. $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$
c. $2Bi(NO_3)_3(aq) + 3H_2S(g) \rightarrow Bi_2S_3(s) + 6HNO_3(aq)$
d. $2Al(s) + 3Br_2(l) \rightarrow 2AlBr_3(s)$

WRITE ABOUT SCIENCE

63. Answers will vary, but should indicate an understanding that bioluminescence is a combination reaction that requires a catalyst, and produces an oxidized protein and light.

64. Answers will vary, but should include examples and descriptions of combination, decomposition, single-replacement, double-replacement, and combustion reactions.

65. Answers will vary, but should indicate an understanding that as the oxygen concentration in a combustion reaction increases, the more rapidly the reaction will proceed and the more likely combustion be complete. A fire in an oxygen-filled room will spread much more rapidly and cause significantly more damage than in a room with the concentration of oxygen found in air.

Cumulative Review

67. **a.** water
b. water vapor in the air
c. physical change

68. Element: gold; compounds: sodium chloride, ice with water; homogeneous mixtures, salt water, air; heterogeneous mixture: salt and sand; substance: sodium chloride, gold, water with ice

69. 36.6 kg

70. 22 protons, 28 neutrons, and 22 electrons

71. **a.** $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$
b. $1s^2 2s^2 2p^6 3s^2 3p^6$
c. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$
d. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$

72. Electronegativity is the tendency for an atom to attract bonded electrons to itself. Electronegativity values increase from left to right in a period.

73. **a.** incorrect; KBr
b. correct
c. incorrect; Ca_3N_2
d. correct

74. **a.** K_2CrO_4
b. $NaHSO_3$
c. permanganic acid
d. potassium oxalate

75. **a.** 2.41 mol
b. 6.91×10^{-2} mol
c. 0.934 mol
d. 7.09 mol

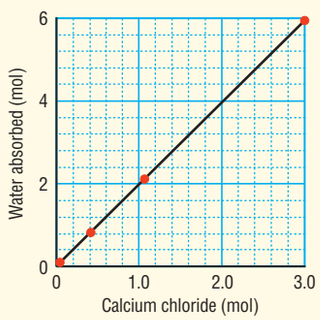
76. **a.** compound 1: $FeSO_4$, compound 2: $FeSO_3$
b. $FeSO_4$, iron(II) sulfate; $FeSO_3$, iron(III) sulfite

77. $C_8H_{10}O_2N_4$

78. **a.**

$CaCl_2$ (mol)	H_2O (mol)
a. 0.156	e. 0.312
b. 0.439	f. 0.878
c. 1.12	g. 2.24
d. 3.03	h. 6.06

b.



c. Two molecules of water.

Cumulative Review

67. When you take a glass of cold liquid outside on a warm, humid day, drops of liquid soon form on the outside of the glass.
a. What is the liquid?
b. Where did the liquid come from?
c. Did a chemical or physical change occur?

68. Classify each of the following as an element, a compound, a homogeneous mixture, a heterogeneous mixture, or a substance. Some may fit in more than one category.
a. salt water
b. sodium chloride
c. air
d. salt and sand
e. gold
f. water with ice

69. A block of ice measures 25.0 cm × 42.0 cm × 38.0 cm. What is the mass of the ice in kilograms? The density of ice is 0.917 g/cm^3.

***70.** List the number of protons, neutrons, and electrons in this isotope of titanium: $^{50}_{22}Ti$.

71. Write electron configurations for the following ions.
a. Sr^{2+} **b.** S^{2-} **c.** Ga^{3+} **d.** Cu^{+}

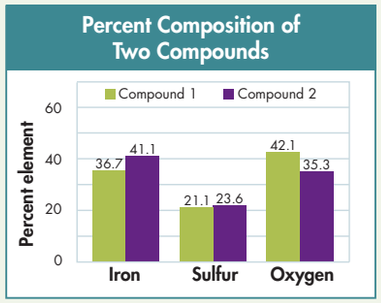
72. Explain what is meant by *electronegativity*. How do electronegativity values change across a row of representative elements?

73. Are any of the following formulas for ionic compounds incorrect? If so, write the correct formulas.
a. K_2Br **b.** Na_2S **c.** CaN_2 **d.** Al_2O_3

***74.** Give the name or formula for the following compounds:
a. potassium chromate
b. sodium hydrogen sulfite
c. $HMnO_4$
d. $K_2C_2O_4$

75. Calculate the number of moles in each substance.
a. 54.0 L of nitrogen dioxide (at STP)
b. 1.68 g of magnesium ions
c. 69.6 g of sodium hypochlorite
d. 4.27×10^{24} molecules of carbon monoxide

76. The graph shows the percent composition of two different compounds formed by the elements iron, oxygen, and sulfur.



a. Using the data on the graphs, calculate the empirical formula of each compound.
b. Name each compound.

***77.** Many coffees and colas contain the stimulant caffeine. The percent composition of caffeine is 49.5% C, 5.20% H, 16.5% O, and 28.9% N. What is the molecular formula of caffeine if its molar mass is 194.1 g/mol?

78. Calcium chloride ($CaCl_2$) is a white solid used as a drying agent. The maximum amount of water absorbed by different quantities of $CaCl_2$ is given in the table below.

$CaCl_2$ (g)	$CaCl_2$ (mol)	H_2O (g)	H_2O (mol)
17.3	a._____	5.62	e._____
48.8	b._____	15.8	f._____
124	c._____	40.3	g._____
337	d._____	109	h._____

a. Complete the table.
b. Plot the moles of water absorbed (*y*-axis) versus the moles of $CaCl_2$.
c. Based on your graph, how many molecules of water does each formula unit of $CaCl_2$ absorb?

If You Have Trouble With . . .

Question	67	68	69	70	71	72	73	74	75	76	77	78
See Chapter	2	2	3	4	5	6	7	9	10	10	10	10