6. A reactant is a substance preset at the outset of a chemical reaction that is consumed during the reaction. They appear on the left side of a chemical equation.
   A product is a substance formed in a chemical reaction that appears on the right side of a chemical equation.
7. solids: (s); liquids: (l); gases: (g); aqueous solutions: (aq)
8. The addition of heat is symbolized in a chemical equation by placing a Δ above the arrow. The addition of light energy is symbolized in a chemical equation by placing an hν above the arrow.
9. The law of nature that underpins the concept of a balanced chemical equation is the law of conservation of matter, which states that matter is neither created nor destroyed.
10. A stoichiometric coefficient is a number placed in front of a species that balances a chemical equation.
11. PART A: $4\ Al(s) + 3\ O_2(g) \rightarrow 2\ Al_2O_3(s)$

    PART B: $N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$

    PART C: $2\ C_6H_6(l) + 15\ O_2(g) \rightarrow 6\ H_2O(l) + 12\ CO_2(g)$
12. PART A: $CaC_2(s) + 2\ H_2O(l) \rightarrow Ca(OH)_2(s) + C_2H_2(g)$

    PART B: $(NH_4)_2Cr_2O_7(s) \rightarrow Cr_2O_3(s) + N_2(g) + 4\ H_2O(g)$

    PART C: $4\ CH_3NH_2(g) + 9\ O_2(g) \rightarrow 4\ CO_2(g) + 2N_2(g) + 10\ H_2O(g)$
13. $2\ C_3H_6N_6O_6 + 3\ O_2 \rightarrow 6\ H_2O + 6\ CO_2 + 6\ N_2$
14. $3\ CaO + Al_2O_3 + 6\ H_2O \rightarrow Ca_3Al_2(OH)_{12}$
15. $C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$
16. PART A: $Ca_3(PO_4)_2(s) + 2\ H_2SO_4(aq) \rightarrow Ca(H_2PO_4)_2(aq) + 2\ CaSO_4(s)$

    PART B: $2\ NaBH_4(s) + H_2SO_4(aq) \rightarrow B_2H_6(g) + 2\ H_2(g) + Na_2SO_4(aq)$

    PART C: $WO_3(s) + 3\ H_2(g) \rightarrow W(s) + 3\ H_2O(l)$

    PART D: $(NH_4)_2Cr_2O_7(s) \rightarrow N_2(g) + 4\ H_2O(g) + Cr_2O_3(s)$

PART A: $\mathrm{N_2}(g) + 3\ \mathrm{H_2}(g) \rightarrow 2\ \mathrm{NH_3}(g)$

PART B: $2\ \mathrm{H_2}(g) + \mathrm{CO}(g) \rightarrow \mathrm{CH_3OH}(l)$

17. PART C: $2\ \mathrm{S}(s) + 3\ \mathrm{O_2}(g) + 2\ \mathrm{H_2O}(l) \rightarrow 2\ \mathrm{H_2SO_4}(l)$
18. $\mathrm{B_2H_6} + 3\ \mathrm{O_2} \rightarrow \mathrm{B_2O_3} + 3\ \mathrm{H_2O}$
19. $3\ \mathrm{SiCl_4} + 16\ \mathrm{NH_3} \rightarrow \mathrm{Si_3N_4} + 12\ \mathrm{NH_4Cl}$
20.
21. A solution is a homogeneous mixture of two or more substances in a single phase. A solute is the minor component of a solution. A solvent is the component present in the greatest amount in any solution.
22. A saturated solution is a solution that contains the maximum amount of a solute that will dissolve in a solvent at a specific temperature.
23. A concentrated solution is a solution in which many solute particles are present. A dilute solution is a solution in which few particles are present.
24. PART A: strong electrolyte; PART B: strong electrolyte; PART C: nonelectrolyte; PART D: strong electrolyte

PART A: $\mathrm{K^+}$ and $\mathrm{OH^-}$ ions

PART B: $\mathrm{K^+}$ and $\mathrm{SO_4^{2-}}$ ions

PART C: $\mathrm{Li^+}$ and $\mathrm{NO_3^-}$ ions

25. PART D: $\mathrm{NH_4^+}$ and $\mathrm{SO_4^{2-}}$ ions

PART A: soluble: $\mathrm{Na^+}$ and $\mathrm{CO_3^{2-}}$ are produced

PART B: insoluble

PART C: insoluble

26. PART D: soluble: $\mathrm{Ba^{2+}}$ and $\mathrm{Br^-}$ are produced
27. 1.4 L
28. (A) 26.6 g NH4NO3; (B) 1.2×10^2 g product
29.
30. A spectator ion is an ion that is present in a solution but that does not participate in a chemical reaction.

31. A total ionic equation shows all ions and molecules present in solution, whereas a net ionic equation has the spectator ions removed.

PART A:

balanced equation: $(NH_4)_2CO_3(aq) + Cu(NO_3)_2(aq) \rightarrow CuCO_3(s) + 2\ NH_4NO_3(aq)$ net ionic equation: $Cu^+(aq) + CO_3^{2-}(aq) \rightarrow CuCO_3(s)$

PART B:

balanced equation: $Pb(OH)_2(s) + 2\ HCl(aq) \rightarrow PbCl_2(s) + 2\ H_2O(l)$

net ionic equation: $Pb(OH)_2(s) + 2\ H^+(aq) + 2\ Cl^-(aq) \rightarrow PbCl(s) + H_2O(l)$

PART C:

balanced equation: $BaCO_3(s) + 2\ HCl(aq) \rightarrow BaCl_2(aq) + H_2O(l) + CO_2(g)$

net ionic equation: $BaCO_3(s) + 2\ H^+(aq) \rightarrow Ba^{2+}(aq) + H_2O(l) + CO_2(g)$

PART D:

balanced equation: $2\ CH_3CO_2H(aq) + Ni(OH)_2(s) \rightarrow Ni(CH_3CO_2)_2(aq) + 2\ H_2O(l)$

net ionic equation: $H^+(aq) + Ni(OH)_2(s) \rightarrow Ni^{2+}(aq) + 2\ H_2O(l)$

32.

PART A:

balanced equation: $Zn(s) + 2\ HCl(aq) \rightarrow H_2(g) + ZnCl_2(aq)$

net ionic equation: $Zn(s) + 2\ H^+(aq) \rightarrow H_2(g) + Zn^{2+}(aq)$

PART B:

balanced equation: $Mg(OH)_2(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + 2\ H_2O(l)$

net ionic equation: $Mg(OH)_2(s) + 2\ H^+(aq) \rightarrow Mg^{2+}(aq) + 2\ H_2O(l)$

PART C:

balanced equation: $2\ HNO_3(aq) + CaCO_3(s) \rightarrow Ca(NO_3)_2(aq) + H_2O(l) + CO_2(g)$

net ionic equation: $2\ H^+(aq) + CaCO_3(s) \rightarrow Ca^{2+}(aq) + H_2O(l) + CO_2(g)$

PART D:

balanced equation: $3\ (NH_4)_2S(aq) + 2\ FeCl_3(aq) \rightarrow 6\ NH_4Cl(aq) + Fe_2S_3(s)$

net ionic equation: $2\ Fe^{3+}(aq) + 3\ S^{2-}(aq) \rightarrow Fe_2S_3(s)$

33.

balanced equation: $CO_2(g) + Ca(OH)_2(aq) \rightarrow CaCO_3(s) + H_2O(l)$

complete ionic equation: $CO_2(g) + Ca^{2+}(aq) + 2\ OH^-(aq) \rightarrow CaCO_3(s) + H_2O(l)$

net ionic equation: $CO_2(g) + Ca^{2+}(aq) + 2\ OH^-(aq) \rightarrow CaCO_3(s) + H_2O(l)$

34.

35. A mole is an Avogadro constant (6.022×10^23) number of particles. This quantity is defined as the number of carbon atoms in exactly 12 grams of carbon-12. Thus,

one mole of a substance has a mass in grams numerically equal to the mass of one particle of that substance in atomic mass units.

36. (A) 1.93×10^24 atom Ar; (B) 7.8×10^11 marbles; (C) 2×10^30 molecule H2O; (D) 4.59×10^6 basketballs
37. 7.8×10^19 cm3 and 7.8×10^16 L
38.
39. (A) 159.688 g/mol; (B) 117.160 g/mol; (C) 176.1238 g/mol
40. (A) 342.2956 g/mol; (B) 44.0128 g/mol; (C) 286.4504 g/mol
41. (A) M(PbS) = 239.3 g/mol; %Pb = 86.60%; %S = 13.40%;
    (B) M(C2H6) = 30.0688 g/mol; %C = 79.8881%; %H = 20.1119%;
    (C) M(CH3COOH) = 60.0518 g/mol; %C = 40.0011%; %H = 6.7315%; %O = 53.2852%;
    (D) M(NH4NO3) = 80.0432 g/mol; %N = 34.9979%; %H = 5.0368%; %O = 59.9654%;
42. 65.0099 g/mol
43. (A) 262.8578 g/mol; (B) 78.0446 g/mol; (C) 92.0110 g/mol
44. (A) 192.50 g/mol; (B) 264.0369 g/mol; (C) 233.193 g/mol
45.
46. 2.2×10^2 g O3
47. (A) 67 g Al; (B) 0.0698 g Fe; (C) 0.60 g Ca; (D) 1.32×10^4 g Ne
48. (A) 844 g C2H3Cl; (B) 4.12×10^3 g C18H27NO3; (C) 3.84×10^3 g C18H36O2
49. (A) 1.577 mol C7H5N3O6; (B) 1.35 mol CH3NO2; (C) 7.56 mol C3H6N6O6
50. 0.36 mol NO2
51. 6.8×10^13 molecule CO2
52. 8.22×10^23 atom H
53. 4.29×10^24 atom O
54. 2.39 g H2C2O4
55. (A) 4.7×10^22 molecule O2; (B) 2.8×10^24 molecule O2; (C) 6.8×10^25 molecule O2
56. B5H7
57. Empirical: C8H8O3; molecular: C8H8O3
58. (A) NaC5H8NO4; (B) ZrSiO4; (C) C5H7N
59. (A) %mol Cu = 40% (one significant digit); %mol Al = 60% (one significant digit);
    (B) %wt NiO = 38% (two significant digits); %wt MgO = 62% (two significant digits);
    (C) %mol MgO = 50% (one significant digit); %mol FeO = 50% (one significant digit)
60. %mol Al2O3 = 5.5%; %mol Cu = 94.5%
61. (A) 5.8 M HCl; (B) 4.2 M NaOH; (C) 3.41 M KCl; (D) 0.71 M NaNO3

PART A: $0.0269\ \mathrm{M}\ \mathrm{Co}^{3+}$ and $0.0807\ \mathrm{M}\ \mathrm{Cl}^{-}$

PART B: $0.0219\ \mathrm{M}\ \mathrm{Ni}^{3+}$ and $0.0329\ \mathrm{M}\ \mathrm{SO}_4^{2-}$

PART C: $0.0313\ \mathrm{M}\ \mathrm{Na}^{+}$ and $0.0313\ \mathrm{M}\ \mathrm{MnO}_4^{-}$

PART D: $0.0206\ \mathrm{M}\ \mathrm{Fe}^{2+}$ and $0.0412\ \mathrm{M}\ \mathrm{Br}^{-}$

62.

63. (A) 0.16 mol H2SO4; (B) 8.3×10^-3 mol KNO3; (C) 0.11 mol NH3; (D) 0.027 mol NaF
64. (A) 1.42 g HBr; (B) 1.71×10^4 g Na2CO3; (C) 8.7 g CH3COOH; (D) 0.011 g H2SO3
65. (A) 0.74 M; (B) 0.0646 M; (C) 4.9×10^-3 M; (D) 0.294 M
66. (A) 1.5 L; (B) 0.128 L; (C) 2.2 mL; (D) 0.066 mL
67. 0.208 L
68. 0.0593 M Mg2+ and 1.89×10^4 gal