Chapter 5, Calculations and the Chemical Equation

1. How many iron atoms are present in one mole of iron?
   Ans. \(6.02 \times 10^{23}\) atoms

2. How many grams of sulfur are found in 0.150 mol of sulfur? [Use atomic weight: S, 32.06 amu]
   Ans. 4.81 g

3. How many moles of sulfur are found in \(1.81 \times 10^{24}\) atoms of sulfur? [Use atomic weight: S, 32.06 amu]
   Ans. 3.01 mol

4. How many atoms are present in a 7.31 g sample of copper? [Use atomic weight: Cu, 63.55 amu]
   Ans. \(6.93 \times 10^{22}\) atoms

5. What is the mass, in grams, of 1.79 mol of helium, the gas commonly used to fill party balloons and lighter-than-air ships? [Use atomic weight: He, 4.00 amu]
   Ans. 7.16 g

6. An iodine sample contains \(2.91 \times 10^{22}\) atoms of iodine. What is its mass in grams? [Use atomic weight: I, 126.9 amu]
   Ans. 6.13 g

7. Give the symbol(s) needed to show the smallest unit of nitrogen as it is normally found in nature.
   Ans. N\(_2\)

8. When a solid compound is described as a "hydrate", what does this mean?
   Ans. The compound contains water molecules in its structure.

9. What is the difference in meaning between "2O" and "O\(_2\)" when they occur in chemical equations?
   Ans. 2O means 2 separate atoms of oxygen, not combined in the form of a molecule. O\(_2\) means a molecule of oxygen, i.e. two atoms bonded to each other.

10. 6.022 \(\times\) \(10^{23}\) molecules of a covalent compound is equal to how many moles of that compound?
    Ans. 1 mol

11. What is the mass, in grams, of one mole of diatomic hydrogen? [Use molar mass: H, 1.0 g/mol]
    Ans. 2.0 g

12. How many molecules of water are there in 5.00 mol of water?
    Ans. \(3.01 \times 10^{24}\) molecules

13. If one atom of oxygen weighs 16.00 amu, what will one mole of oxygen (O\(_2\)) weigh?
    Ans. 32.00 g
14. Dinitrogen monoxide or laughing gas (N\textsubscript{2}O) is used as a dental anesthetic and as an aerosol propellant. How many moles of N\textsubscript{2}O are present in 12.6 g of the compound? [Use atomic weights: N, 14.01 amu, O, 16.00 amu]

Ans. 0.286 mol

15. Dinitrogen monoxide or laughing gas (N\textsubscript{2}O) is used as a dental anesthetic and as an aerosol propellant. How many molecules of N\textsubscript{2}O are present in 12.6 g of the compound? [Use atomic weights: N, 14.01 amu, O, 16.00 amu]

Ans. \(1.72 \times 10^{23}\) molecules

16. What law states that matter cannot be gained or lost during a chemical reaction?

Ans. law of conservation of mass

17. What does the symbol "(aq)", often found in chemical equations, mean?

Ans. The reactant or product to which this applies is aqueous, i.e. dissolved in water.

18. In chemical equations, what are the meanings of the symbols s, l and g, used in parentheses?

Ans. s = solid; l = liquid; g = gas

19. Balance the following equation: \(\text{Ca(s)} + \text{HCl(g)} \rightarrow \text{CaCl}_2(s) + \text{H}_2(g)\)

Ans. \(\text{Ca(s)} + 2\text{HCl(g)} \rightarrow \text{CaCl}_2(s) + \text{H}_2(g)\)

20. Balance the following equation: \(\text{Mg(OH)}_2(s) + \text{HCl(g)} \rightarrow \text{MgCl}_2(s) + \text{H}_2\text{O(l)}\)

Ans. \(\text{Mg(OH)}_2(s) + 2\text{HCl(g)} \rightarrow \text{MgCl}_2(s) + 2\text{H}_2\text{O(l)}\)

21. Balance the following equation: \(\text{Na(s)} + \text{Cl}_2(g) \rightarrow \text{NaCl(s)}\)

Ans. \(2\text{Na(s)} + \text{Cl}_2(g) \rightarrow 2\text{NaCl(s)}\)

22. Balance the equation for the combustion of octane, a component of gasoline, using smallest whole number coefficients: \(\text{C}_8\text{H}_{18}(l) + \text{O}_2(g) \rightarrow \text{CO}_2(g) + \text{H}_2\text{O(l)}\)

Ans. \(2\text{C}_8\text{H}_{18}(l) + 25\text{O}_2(g) \rightarrow 16\text{CO}_2(g) + 18\text{H}_2\text{O(l)}\)

23. Balance the equation for the complete oxidation of glucose (C\textsubscript{6}H\textsubscript{12}O\textsubscript{6}), an important metabolic process: \(\text{C}_6\text{H}_12\text{O}_6(l) + \text{O}_2(g) \rightarrow \text{CO}_2(g) + \text{H}_2\text{O(l)}\)

Ans. \(\text{C}_6\text{H}_12\text{O}_6(l) + 6\text{O}_2(g) \rightarrow 6\text{CO}_2(g) + 6\text{H}_2\text{O(l)}\)

24. How many moles of hydrogen gas are needed to react with oxygen to form two moles of water? \(2\text{H}_2(g) + \text{O}_2(g) \rightarrow 2\text{H}_2\text{O(l)}\)

Ans. 2 mol

25. How many moles of oxygen gas are needed to react with hydrogen to form one mole of water? \(2\text{H}_2(g) + \text{O}_2(g) \rightarrow 2\text{H}_2\text{O(l)}\)

Ans. 0.5 mol
Chapter 5, Calculations and the Chemical Equation

26. How many grams of sodium hydroxide will react with 73.00 g of aqueous HCl? [Use formula weights: NaOH, 39.99 amu; HCl, 36.45 amu]
   \[
   \text{NaOH(aq) + HCl(aq)} \rightarrow \text{NaCl(aq) + H}_2\text{O(l)}
   \]
   Ans. 80.09 g

27. Calculate the number of grams of oxygen that must react with 46.85 g of \( \text{C}_3\text{H}_8 \) to produce only carbon dioxide and water. [Use atomic weights: C, 12.01 amu; H, 1.01 amu; O, 16.00 amu]
   Ans. 169.9 g

28. Iron reacts with oxygen to form iron(III) oxide (Fe\(_2\)O\(_3\)). How many grams of product will be formed from 5.00 grams of Fe? [Use atomic weights: Fe, 55.85 amu; O, 16.00 amu]
   Ans. 7.15 g

29. Glucose (\( \text{C}_6\text{H}_{12}\text{O}_6 \)) is an important energy-rich compound, produced by photosynthesis: 6\( \text{CO}_2(g) \) + 6\( \text{H}_2\text{O}(l) \) → \( \text{C}_6\text{H}_{12}\text{O}_6(l) \) + 6\( \text{O}_2(g) \) What mass of glucose, in grams, can be produced from 2.61 mol of \( \text{CO}_2 \) and the necessary water? [Use atomic weights: H, 1.01 amu; C, 12.01; O, 16.00]
   Ans. 78.4 g

30. Explain what is meant by the term "limiting reactant" in a chemical reaction.
   Ans. If the amount of one reactant at the start of reaction is less than that required to react completely with the other reactants, according to the balanced equation, it is the limiting reactant.

31. Magnesium hydroxide (Mg(OH)\(_2\)), as "Milk of Magnesia" can be used to neutralize excess stomach acid, represented by HCl(aq):
   \[
   \text{Mg(OH)}_2(s) + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2(\text{aq}) + 2\text{H}_2\text{O(l)}
   \]
   When 5.00 g each of Mg(OH)\(_2\) and HCl are combined, which is the limiting reactant, and what mass of MgCl\(_2\) can be produced? [Use atomic weights: H, 1.01 amu; O, 16.00 amu; Mg, 24.31 amu; Cl, 35.45 amu]
   Ans. HCl is limiting reactant; 6.53 g of MgCl\(_2\) can be produced.

32. To convert a given number of moles into the number of atoms, you would multiply by which of the following factors?
   A. 6.02 \times 10^{23} \text{ atoms/1 mol}
   B. 1 \text{ mol/6.02} \times 10^{23} \text{ atoms}
   C. 1.66 \times 10^{-24} \text{ atoms/1 mol}
   D. 1 \text{ mol/1.66} \times 10^{-24} \text{ atoms}
   E. molar mass
   Ans. A
33. To convert from a given mass in grams to the number of moles, you would multiply by which of the following factors?
A. \(1/\text{Avogadro's number}\)
B. \(\text{Avogadro's number}/1\)
C. molar mass/1
D. \(1/\text{molar mass}\)
E. \(\text{Avogadro's number}/\text{molar mass}\)

Ans. D

34. To convert from a given number of atoms to the number of moles, you would multiply by which of the following factors?
A. \(\text{Avogadro's number}/1\)
B. \(1/\text{Avogadro's number}\)
C. \(1/\text{molar mass}\)
D. molar mass/1
E. \(\text{Avogadro's number}/\text{molar mass}\)

Ans. B

35. To convert from a given number of grams to the number of atoms, you would multiply by which of the following factors?
A. \(\text{Avogadro's number}/1\)
B. \(1/\text{Avogadro's number}\)
C. \(1/\text{molar mass}\)
D. molar mass/1
E. \(\text{Avogadro's number}/\text{molar mass}\)

Ans. E

36. The average mass of one atom of iron is 55.85 amu. What is the mass of Avogadro's number of atoms?
A. 55.85 centigrams
B. 55.85 g
C. 55.85 kg
D. 55.85 atoms
E. 55.85 formula units

Ans. B

37. What is the weight, in grams, of one mole of hydrogen atoms? [Use atomic weight: H, 1.01 amu]
A. 1.01 g
B. 2.02 g
C. 2.52 g
D. \(6.02 \times 10^{23}\) g
E. \(1.81 \times 10^{24}\) g

Ans. A
38. How many grams of sulfur make up 3.01 mol of sulfur? [Use atomic weight: S, 32.06 amu]

A. 1.81 x 10^24 g
B. 32.06 g
C. 3.01 g
D. 0.150 g
E. 96.5 g

Ans. E

39. How many moles are there in one ounce (28.4 g) of pure gold? [Use atomic weight: Au, 197.0 amu]

A. 1.97 x 10^2 mol
B. 6.94 mol
C. 0.144 mol
D. 0.0721 mol
E. 5.08 x 10^-3 mol

Ans. C

40. How many atoms of sulfur are present in 155 g of sulfur? [Use atomic weight: S, 32.06 amu]

A. 2.91 x 10^24 atoms
B. 6.02 x 10^23 atoms
C. 3.01 x 10^23 atoms
D. 2.91 x 10^23 atoms
E. 2.01 x 10^23 atoms

Ans. A

41. How many iron atoms are present in 3.01 mol of iron?

A. 1.81 x 10^23
B. 6.02 x 10^23
C. 3.01 x 10^23
D. 1.81 x 10^24
E. 58.5

Ans. D

42. What is the formula weight of carbon dioxide? [Use atomic weights: C, 12.01 amu; O, 16.00 amu]

A. 28.01 amu
B. 28.01 g
C. 44.01 amu
D. 44.01 g
E. 44.01 mol

Ans. C
Chapter 5, Calculations and the Chemical Equation

43. Aspirin is the common name for acetylsalicylic acid, C₉H₈O₄. A tablet has 0.325 g of aspirin. How many moles is this? [Use formula weight: aspirin, 180.2 amu]

A. 1.80 × 10⁻⁶ mol  
B. 1.80 × 10⁻³ mol  
C. 0.554 mol  
D. 554 mol  
E. 1.96 × 10²³ mol

Ans. B

44. How many grams are there in 0.0200 mol of nicotine, a yellow liquid? [Use formula weight: nicotine, 162.2 amu]

A. 1.23 × 10⁻⁴ g  
B. 0.308 g  
C. 3.24 g  
D. 32.4 g  
E. 8.11 × 10³ g

Ans. C

45. How many molecules are there in 0.0200 mol of nicotine, a yellow liquid?

A. 0.0400 molecules  
B. 1.20 × 10²² molecules  
C. 2.41 × 10²² molecules  
D. 6.02 × 10²³ molecules  
E. 1.20 × 10²³ molecules

Ans. B

46. How many molecules are there in 0.325 g of aspirin? [Use formula weight: aspirin, 180.2 amu]

A. 1.09 × 10²¹ molecules  
B. 2.17 × 10²¹ molecules  
C. 1.96 × 10²³ molecules  
D. 3.91 × 10²³ molecules  
E. 1.85 × 10²⁴ molecules

Ans. A

47. What number will be found in front of "Al" when the following equation is balanced with smallest whole number coefficients?  
Al(s) + O₂(g) → Al₂O₃(s)

A. 1  
B. 2  
C. 3  
D. 4  
E. 8

Ans. D
48. How many moles of HCl can be formed when 2 mol of hydrogen gas react
with chlorine? \(\text{H}_2(g) + \text{Cl}_2(g) \rightarrow \text{HCl}(g)\) (unbalanced)

A. 0.5 mol B. 1 mol C. 2 mol D. 4 mol E. 8 mol

Ans. D

49. Which of the choices is the correctly balanced form of the following
equation?
\(\text{C}_6\text{H}_{14}(l) + \text{O}_2(g) \rightarrow \text{CO}_2(g) + \text{H}_2\text{O}(l)\)

A. \(\text{C}_6\text{H}_{14}(l) + 13\text{O}_2(g) \rightarrow 6\text{CO}_2(g) + 7\text{H}_2\text{O}(l)\)
B. \(\text{C}_6\text{H}_{14}(l) + 19\text{O}_2(g) \rightarrow 6\text{CO}_2(g) + 7\text{H}_2\text{O}(l)\)
C. \(\text{C}_6\text{H}_{14}(l) + 19\text{O}_2(g) \rightarrow 6\text{CO}_2(g) + 7\text{H}_2\text{O}(l)\)
D. \(2\text{C}_6\text{H}_{14}(l) + 19\text{O}_2(g) \rightarrow 12\text{CO}_2(g) + 14\text{H}_2\text{O}(l)\)
E. \(\text{C}_{12}\text{H}_{28}(l) + 38\text{O}_2(g) \rightarrow 12\text{CO}_2(g) + 14\text{H}_2\text{O}(l)\)

Ans. D

50. How many moles of hydrogen gas are needed to react with oxygen to form
one mole of water? \(2\text{H}_2(g) + \text{O}_2(g) \rightarrow 2\text{H}_2\text{O}(l)\)

A. 0.5 mol B. 1 mol C. 2 mol D. 4 mol E. 6 mol

Ans. B

51. Calculate the mass in grams of oxygen needed to react with 1.000 mol of
\(\text{C}_3\text{H}_8\) to form carbon dioxide and water. [Use atomic weight: O, 16.00 amu]
\(\text{C}_3\text{H}_8(g) + \text{O}_2(g) \rightarrow \text{CO}_2(g) + \text{H}_2\text{O}(l)\) (unbalanced)

A. 80.0 g B. 32.00 g C. 40.0 g D. 320.0 g E. 160.0 g

Ans. E

52. Iron reacts with oxygen to form iron(III) oxide (\(\text{Fe}_2\text{O}_3\)). How many grams
of product will be formed from 125.5 g of \(\text{Fe}\)? [Use atomic weights: \(\text{Fe}, 55.85 \text{ amu}; \text{O, 16.00 amu}\)]

A. 59.8 g B. 179.4 g C. 89.7 g D. 358.5 g E. 159.7 g

Ans. B

53. Consider the hypothetical reaction: \(3\text{A}_2 + 2\text{B} \rightarrow \text{C} + 2\text{D}\) How many moles of
\(\text{D}\) can be formed from 5.0 mol of \(\text{A}_2\) and excess \(\text{B}\)?

A. 1.7 mol B. 3.3 mol C. 6.7 mol D. 7.5 mol E. 10. mol

Ans. B

54. T F One atomic mass unit is the same as one gram.

Ans. F

55. T F The smallest complete unit of iron is an atom of iron.

Ans. T
Chapter 5, Calculations and the Chemical Equation

56. T  F  One mole of iron atoms contains $6.02 \times 10^{23}$ molecules.
   Ans. F

57. T  F  The formula weight of a compound is calculated by adding together the number of atoms that make it up.
   Ans. F

58. T  F  Strictly speaking, it is incorrect to use the term "molecular weight" in referring to ionic compounds.
   Ans. T

59. T  F  One mole of Ca$_3$(PO$_4$)$_2$ contains $6.02 \times 10^{23}$ atoms of calcium.
   Ans. F

60. T  F  One mole of oxygen gas contains $6.02 \times 10^{23}$ molecules.
   Ans. T

61. T  F  The formula weight of water is equal to 18.02 g.
   Ans. F

62. T  F  If the atomic weight of hydrogen is 1.01 amu, a mole of H$_2$ will weigh 1.01 g.
   Ans. F

63. T  F  One gram of gold (atomic weight 197 amu) contains more atoms than one gram of copper (atomic weight 63.55 amu).
   Ans. F

64. T  F  One mole of H$_2$O contains a total of $6.02 \times 10^{23}$ atoms.
   Ans. F

65. T  F  The law of conservation of mass states that matter cannot be gained or lost during a chemical reaction.
   Ans. T

66. T  F  The symbol $\Delta$, above or below the reaction arrow in an equation, indicates that heating is needed for the reaction to take place.
   Ans. T

67. T  F  Counting the number of moles on both the reactant and product sides of an equation is the first step in balancing the equation.
   Ans. F

68. T  F  In a correctly balanced equation, the number of moles of reactants and the number of moles of products may differ.
   Ans. T

69. T  F  The term "dynamic equilibrium" is used to describe the condition of a reaction when one of the reactants has been completely used up.
   Ans. F
Chapter 5, Calculations and the Chemical Equation

70. T F 0.5 mol of oxygen gas can react with hydrogen gas to form 1.0 mol of water.

Ans. T