Knowledge

For each question, select the best answer from the four alternatives.

1. Which of the following is an example of using quantitative analysis? (6.1) K/U
   (a) The wind is coming from the west and has a speed of 1.5 m/s.
   (b) Both cirrus and cumulonimbus clouds are present.
   (c) In summer, land masses near the Great Lakes often experience humid weather.
   (d) A thunderstorm is moving from west to east across Ontario.

2. How might a lab technician measure the amount of sodium chloride present in processed lunch meat? (6.1, 6.2) K/U
   (a) qualitative analysis only
   (b) quantitative analysis only
   (c) both qualitative analysis and quantitative analysis
   (d) neither qualitative analysis nor quantitative analysis

3. What is the base unit for the amount of a substance? (6.3) K/U
   (a) gram
   (b) molecule
   (c) Avogadro's constant
   (d) mole

4. Which isotope is the standard chosen to define the mole? (6.3) K/U
   (a) hydrogen-2
   (b) carbon-12
   (c) carbon-14
   (d) oxygen-16

5. What is the mass, in grams, of a mole of any element? (6.4) K/U
   (a) the atomic number of the element
   (b) the mass of one atom of the element
   (c) the atomic mass of the element
   (d) the mass of one molecule of the element

6. A student knows he has 2.5 mol of iron. He also knows Avogadro's constant. What must he do to these two numbers to find the number of iron atoms in the sample? (6.5) K/U
   (a) Add them.
   (b) Subtract them.
   (c) Multiply them.
   (d) Divide them.

7. What concept can be used to explain why each water molecule contains 2 hydrogen atoms and 1 oxygen atom? (6.6) K/U
   (a) the law of definite proportions
   (b) percentage composition
   (c) determination of molar mass
   (d) the comparison of an empirical formula and a molecular formula

8. $MgBr_2$ is an ionic compound. What type of chemical formula is $MgBr_2$? (6.7, 6.9) K/U
   (a) a molecular formula only
   (b) an empirical formula only
   (c) both a molecular and an empirical formula
   (d) neither a molecular nor an empirical formula

9. The formula for the compound hydrogen peroxide is H_2O_2. Which type of chemical formula is H_2O_2? (6.7, 6.9) K/U
   (a) a molecular formula only
   (b) an empirical formula only
   (c) both a molecular and an empirical formula
   (d) neither a molecular nor an empirical formula

Match each term on the left with the appropriate formula(s) on the right. You can use each term on the right more than once.

10. (a) molecular formula   (i) $MgCl_2$
    (b) empirical formula   (ii) $C_6H_{12}O_6$
    (c) formula unit   (iii) CH
                (iv) CH_4 (6.7, 6.9) K/U

Indicate whether each statement is true or false. If you think the statement is false, rewrite it to make it true.

11. Qualitative analysis is used to measure the amount of a substance present. (6.1) K/U

12. The presence of cocaine on banknotes can be determined by qualitative analysis. (6.1, 6.8) K/U

13. The mole is the base unit for the amount of something. (6.3) K/U

14. The value commonly used for Avogadro's constant is 6.02×10^{23}. (6.3) K/U

15. The unit used for molar mass is grams, g. (6.4) K/U

16. The number of entities in a sample can be found by multiplying the mass of the sample by Avogadro's constant. (6.5) K/U

17. Percentage composition is the percentage, by number, of each element in a compound. (6.6) K/U

18. A molecular formula is found by multiplying all the subscripts of an empirical formula by the same whole number. (6.7, 6.9) K/U

19. The formula $C_4H_8O_2$ is an empirical formula. (6.9) `K/U`

Write a short answer to each question.

20. Classify each of the following statements as an example of qualitative analysis or an example of quantitative analysis. (6.1) `K/U`
    (a) A leaf is green.
    (b) A board is 4.6 cm long.

21. Classify each of the following as a tool used in qualitative analysis or a tool used in quantitative analysis: (6.1) `K/U`
    (a) a graduated cylinder
    (b) your eyes

22. (a) How can you use the molar mass of iron and Avogadro's constant to find the mass of a single iron atom?
    (b) Use your answer to Part (a) to find the mass of a single iron atom. (6.3, 6.4) `K/U` `T/I`

23. (a) Explain how to multiply two numbers that are written in scientific notation.
    (b) Multiply 2.4×10^{14} and 4.6×10^4. (6.3) `K/U`

24. What is the result when 5.34×10^5 is divided by 3.56×10^7? (6.3) `K/U`

Understanding

25. Bromine and mercury are the only two elements that are liquid at room temperature. One mole of mercury is in a sealed container, and one mole of bromine is in an identical sealed container. (6.3) `K/U`
    (a) A balance is used to determine the mass of each liquid and its container. The mass of the container is subtracted from the mass of the liquid and the container to find the mass of the liquid. How do the masses of the mercury and the bromine compare?
    (b) The volumes of the liquids are compared by measuring the depth of the liquids in the containers. How do the volumes of the two liquids compare? Explain your answer.

26. (a) Explain why the mass of 1 mol of zinc differs from the mass of 1 mol of sulfur.
    (b) How do the masses compare? (6.3) `K/U`

27. What is the molar mass of aluminum? Include correct units. (6.4) `K/U`

28. What is the molar mass of each of the following? (6.4) `K/U` `T/I`
    (a) oxygen atom (O)
    (b) oxygen gas (O_2)
    (c) ozone (O_3)

29. (a) How do you find the molar mass of a hydrate?
    (b) Find the molar mass of cobalt chloride hexahydrate, $CoCl_2 \cdot 6H_2O$. (6.4) `T/I`

30. Explain how finding the molar mass of a molecular compound differs from finding the molar mass of an ionic compound. Use examples in your explanation. (6.4) `K/U` `C`

31. (a) What is the molar mass of potassium permanganate, $KMnO_4$?
    (b) How many moles of potassium permanganate are in 258 g of the compound? (6.4) `K/U` `T/I`

32. How many grams of iron are in 2.7 mol of iron? (6.4) `T/I`

33. Calculate the mass of copper(II) nitrate, $Cu(NO_3)_2$, in 4.5 mol of the compound. (6.4) `T/I`

34. How many atoms are in 0.68 mol of silicon? (6.5) `T/I`

35. (a) Find the number of molecules in 1.4 mol of ethane, C_2H_6.
    (b) How many atoms are in the same amount of ethane? (6.5) `T/I`

36. The mass of a sample of pure water is 4.56 g. What is the amount of water in the sample? (6.5) `T/I`

37. What is percentage composition? Provide an example in your explanation. (6.6) `K/U`

38. A sample of methane, CH_4, contains 7.50 g of carbon. The total mass of the sample is 10.0 g. Carbon atoms make up what percentage by mass of methane? (6.6) `T/I`

39. What is the percentage composition of magnesium chloride, $MgCl_2$? (6.6) `T/I`

40. In your own words, describe the law of definite proportions. (6.6) `K/U`

41. A sample of potassium nitrate, KNO_3, contains 78.2 g of potassium, 28.0 g of nitrogen, and 96.0 g of oxygen. Find the percentage composition of potassium nitrate. (6.6) `T/I`

42. A 24.9 g sample of aluminum bromide, $AlBr_3$, contains 2.52 g of aluminum.
    (a) What mass of bromine is in the sample?
    (b) Find the percentage composition of aluminum bromide. (6.6) `T/I`

43. What is the percentage composition of hydrogen sulfide, H_2S? (6.6) `T/I`

44. How does finding the percentage composition of a compound differ from finding the percentage composition of a mixture? Use examples in your explanation. (6.6) `K/U`

45. Could the empirical formula of potassium fluoride be K_2F_2? Explain. (6.7) `K/U`

46. Find the empirical formula of a compound that has a percentage composition of 23.6 % potassium and 76.4 % iodine. (6.7) `T/I`

47. A compound contains 74.2 % sodium. The rest of the compound is oxygen. (6.7) T/I

    (a) What percentage of the compound is oxygen?

    (b) What is the empirical formula of the compound?

48. A compound contains 20.2 % phosphorus and 10.4 % oxygen. The rest of the compound is chlorine. What is the empirical formula of this compound? (6.7) T/I

49. What is the molecular formula of a compound that has a molar mass of 92.0 g/mol and an empirical formula of NO_2? (6.9) T/I

50. A compound has a molar mass of 208.5 g/mol. Its percentage composition is 14.9 % phosphorus and 85.1 % chlorine. What is the molecular formula of the compound? (6.9) T/I

Analysis and Application

51. A student is determining the effect of differing quantities of fertilizer on the growth of bean plants. (6.1) K/U T/I A

    (a) Describe one way the student can use qualitative analysis in his experiment.

    (b) Explain how quantitative analysis is important to the results of this experiment.

52. A student knows that some acids react with metals, releasing bubbles of hydrogen gas. She is observing what happens when magnesium and copper are placed into hydrochloric acid. She analyzes the results using the amount of hydrogen gas released by the reaction between the acid and each metal. (6.1) K/U T/I C A

    (a) How might she describe the results qualitatively?

    (b) How might she describe the results quantitatively?

53. Classify each of the following tools as being most useful in quantitative analysis or qualitative analysis: (6.1) K/U A

    (a) a metric ruler

    (b) a balance

    (c) an eye

    (d) the skin on a finger

    (e) a measuring cup

54. The average adult human circulatory system contains approximately 3.00×10^{13} red blood cells. How many moles of red blood cells does this represent? (6.3) T/I A

55. Measurements made in space are usually so large that they are expressed in scientific notation. For example, the Large Magellanic Cloud is a galaxy that is located 1.63×10^5 light years from Earth. One light year is approximately 9.5×10^{12} km, which is the distance light travels in a year. Determine the approximate distance of the Large Magellanic Cloud from Earth, in kilometres. (6.3) T/I A

56. Some systems that purify water in pools and spas use chlorine, and some use bromine. One mole of chlorine reacts in the same way as one mole of bromine. Assume you need to add 1 mol of chlorine to one pool and 1 mol of bromine to another pool. How would the mass of chlorine added compare to the mass of bromine added? Explain. (6.3) T/I C A

57. A problem in a homework assignment refers to the molar mass of bromine. One student says that the molar mass of bromine is 79.9 g/mol. Another student says that the molar mass of bromine is 159.8 g/mol. (6.4) K/U T/I C A

    (a) If no other information is known, how might either student be correct?

    (b) What else do you need to know to determine which of the two molar masses is correct for bromine?

58. Pentane has the chemical formula C_5H_{12} and is used in some refrigerants. Methylbutane also has the chemical formula C_5H_{12}, and it is used along with liquid nitrogen in situations requiring extremely low temperatures. (6.4, 6.9) K/U A

    (a) Explain how one chemical formula can represent two or more compounds with different properties.

    (b) How do the molar masses of these two compounds compare?

59. Magnesium sulfate, $MgSO_4$, forms several different hydrates. One of the hydrates has a molar mass of 246.4 g/mol. Another hydrate has a molar mass of 210.4 g/mol. What are the chemical formulas for the two hydrates? (6.4) K/U T/I

60. Aluminum oxide, Al_2O_3, is quite common in Earth's crust. If the compound is accompanied by very small concentrations of other elements, the result might be a colourful gemstone. For example, a ruby is aluminum oxide with a small quantity of chromium in it. A sapphire is aluminum oxide that contains very small quantities of iron or titanium. (6.4) T/I A

    (a) What mass of aluminum oxide is in 2.70 mol of the compound?

    (b) What amount of aluminum oxide is in 67.5 g of the compound?

61. Ethyne (acetylene), C_2H_2, produces a high-temperature flame when it burns. As a result, it is often used in welding. (6.4) K/U T/I A

    (a) How many moles of ethyne are in a tank that contains 526 g of the gas?

    (b) If a welding tank is filled with 25.7 mol of ethyne, what mass of the gas does the tank contain?

62. Nitric acid, HNO_3, is used to produce many products, such as fertilizers and explosives. It also dissolves certain metals, such as gold, that do not dissolve in other chemicals. How many atoms are in 1.25 mol of nitric acid? (6.5) T/I A

63. Some air pollutants oxidize in air to form other pollutants. (6.5) T/I A

(a) The gas sulfur dioxide, SO_2, oxidizes to form another gas, sulfur trioxide, SO_3. How many oxygen atoms are present in 3.20 g of sulfur trioxide?

(b) At high temperatures, nitrogen gas oxidizes to form nitrogen monoxide, NO. This compound further oxidizes to form nitrogen dioxide, NO_2. How many oxygen atoms are present in 2.50 g of NO_2?

64. Acid rain remains a problem in Canada. It damages vegetation, pollutes water, and reacts with stone and other materials. However, government regulations and concerned individuals and industries have reduced the occurrence of acid rain in recent years. One way acid rain forms is by the dissolving of the gas sulfur trioxide, SO_3, in rainwater, forming sulfuric acid, H_2SO_4. (6.5) K/U T/I A

(a) How many molecules of sulfur trioxide are in 5.2 g of the gas?

(b) What is the total number of atoms in 254 g of sulfuric acid?

65. Iron pyrite, FeS_2, is sometimes called "fool's gold" because it looks like gold. A 24.3 g sample of pyrite contains 11.3 g of iron. What percentage of pyrite, by mass, is made up of iron? (6.6) T/I A

66. Ethanol, C_2H_5OH, forms when grains such as corn or wheat undergo the process of fermentation. As a result, ethanol is sometimes called grain alcohol. Ethanol is sometimes added to gasoline as a fuel. Adding it to gasoline helps conserve petroleum, which is a non-renewable resource. What is the percentage composition of ethanol? (6.6) K/U T/I A

67. Magnesium hydroxide, $Mg(OH)_2$, is a common antacid and is also used in deodorants. The percentage of magnesium in one sample of magnesium hydroxide is 41.7 %. How does the law of definite proportions help you determine the percentage of magnesium in a different sample of the same compound? (6.6) K/U T/I

68. One possible product of the reaction of iron with oxygen is iron(III) oxide, Fe_2O_3. This reaction is used in some heat packs because it releases thermal energy. Suppose the iron(III) oxide produced in one heat pack contains 5.58 g of iron and 2.40 g of oxygen. What is the percentage composition of Fe_2O_3? (6.6) T/I A

69. Marble and limestone are common building materials. The major component of marble and limestone is calcium carbonate, $CaCO_3$. One slab of marble that a sculptor wants to use to make a sculpture has a mass of 245 kg. This piece of marble contains 98.1 kg of calcium and 29.4 kg of carbon. What is the percentage composition of calcium carbonate? (6.6) T/I A

70. Tetraphosphorus trisulfide, P_4S_3, requires little energy to burn. As a result, it is one of the ingredients commonly used in match heads so that they burn readily. What is the percentage composition of tetraphosphorus trisulfide? (6.6) K/U T/I A

71. List two examples of each of the following:

(a) a molecular formula that is also an empirical formula

(b) a molecular formula that is not an empirical formula (6.7, 6.9) K/U

72. In determining the empirical formula of a compound from its percentage composition, Rosa chose to use a 25 g sample of the compound. Mark told her that she had to use a 100.0 g sample. (6.7) K/U T/I C

(a) Was Mark correct?

(b) Explain your answer to Part (a).

73. Magnesium sulfide is formed when magnesium powder reacts with the sulfur in molten steel to purify the steel. Magnesium sulfide contains 43.1 % magnesium, and the remainder of the compound is sulfur. (6.7) K/U T/I A

(a) What percentage of magnesium sulfide is sulfur?

(b) What is the empirical formula for magnesium sulfide?

74. Calcium chloride is sometimes used on icy roads instead of sodium chloride. Calcium chloride melts snow and ice better than an equal amount of sodium chloride does. Calcium chloride is 36.1 % calcium. The rest of the compound is chlorine. What is the empirical formula for calcium chloride? (6.7) K/U T/I A

75. Photosynthesis is the process by which green plants produce glucose and oxygen from water and carbon dioxide in the presence of sunlight and chlorophyll. Glucose contains 40.0 % carbon and 6.67 % hydrogen, by mass. The remainder of the compound is oxygen. (6.7) K/U T/I A

(a) What percentage of glucose is oxygen?

(b) What is the empirical formula of glucose?

76. Oxalic acid is a weak acid sometimes used to clean or bleach materials. It is especially effective in removing rust. Oxalic acid has a molar mass of 90.0 g/mol. It contains 2.20 % hydrogen and 26.7 % carbon. The rest of the compound is made up of oxygen. (6.7, 6.9) **K/U** **T/I** **A**
    (a) What percentage of oxalic acid is made up of oxygen?
    (b) What is the empirical formula for oxalic acid?
    (c) What is its molecular formula?

77. Phosphorus and oxygen form several different compounds when they react with each other. One of these compounds is a strong dehydrating agent because it removes water from other materials, forming phosphoric acid. This compound has a molar mass of 285 g/mol and an empirical formula of P_2O_5. What is the molecular formula for this compound? (6.9) **T/I** **A**

Evaluation

78. With a partner, debate which you think is more important to medical research, qualitative analysis or quantitative analysis. Provide specific justification for your side, accompanied by examples. Recognize that both types of analysis have value. (6.1) **T/I** **C** **A**

79. Ammonia is important in making many products, including fertilizers and cleaning products. Assume you work for a manufacturer that makes ammonia from hydrogen and nitrogen gases. You are in charge of ordering all the raw materials for the manufacturing process. (6.3) **K/U** **T/I** **C** **A**
    (a) Why do you need to know how much hydrogen reacts with each mole of nitrogen to make ammonia?
    (b) 1 mol of nitrogen reacts with 3 mol of hydrogen to make ammonia. What amount of nitrogen would you order to react with 270 mol of hydrogen?
    (c) How many kilograms of hydrogen do you need to order if you are ordering 840 kg of nitrogen, assuming that none of either compound is left over?

80. Recall the procedure for finding the number of entities in a sample if the amount is known. (6.5) **K/U** **T/I** **C**
    (a) What additional information do you need to know to use this procedure to find the amount of a substance if the number of entities is known?
    (b) Briefly explain how to find the number of moles of carbon dioxide when 1.9×10^{24} molecules of carbon dioxide are present.

(c) How would this explanation change if you knew the number of oxygen atoms present instead of the number of carbon dioxide molecules?

81. A chemical formula can be a molecular formula or an empirical formula, or it can show a formula unit. Which two of these types of formulas cannot both apply to the same compound? Explain, using examples. (6.7, 6.9) **K/U** **T/I** **C** **A**

82. A student made the statement that any chemical formula for an ionic compound must be an empirical formula and cannot be a molecular formula. Evaluate that statement. Use at least two examples in your evaluation. (6.7, 6.9) **K/U** **T/I** **C** **A**

Reflect on Your Learning

83. Choose a product that you use every day. **K/U** **T/I** **C** **A**
    (a) How might qualitative analysis be used in the manufacturing of this product?
    (b) How might quantitative analysis be helpful in its production?

84. Recall that measurements of length can have different units, depending on what is measured. For example, the height of a door is probably written using units of metres, road distances are likely to be expressed as kilometres, and the length of an insect might have units of millimetres or centimetres. Units used to describe the amount of something can also use prefixes to make the unit best express the number of moles present. **K/U** **C** **A**
    (a) Describe a situation in which an amount would likely be expressed in millimoles (mmol).
    (b) When might it be most convenient to express an amount in kilomoles (kmol)?

85. Visual representations can be helpful in performing calculations that require more than one step. **K/U** **T/I** **C** **A**
    (a) Draw a concept map that shows the sequence of steps in finding the number of entities in a sample of a substance if you know the mass of the substance.
    (b) Draw another concept map that you could use to find a molecular formula if you know molar mass and percentage composition.

86. (a) A ream contains 500 pieces of paper. Suppose you are asked to find the number of reams of paper when you know the number of sheets of paper present. How is this problem similar to finding the number of moles present when you know the number of entities present and Avogadro's constant?

(b) A gross contains 144 items. Suppose you are asked to find the number of pencils present in 4.5 gross of pencils. How is this problem similar to finding the number of entities present if you know the number of moles and Avogadro's constant? K/U T/I C A

Research ⊕ GO TO NELSON SCIENCE

87. Glucose is the type of sugar found in your blood. Fructose is a sugar found in fruit and certain other foods. Use the molecular and structural formulas of these sugars to show how they are similar and how they are different. T/I C A

88. The compound ethene is commonly known as ethylene. Ethylene is the organic compound produced in the greatest quantity in Canada as well as worldwide. T/I C A
    (a) Find the molecular and empirical formulas for ethylene.
    (b) Name at least three other compounds that have the same empirical formula as ethylene.
    (c) How do the uses of these compounds compare to the uses of ethylene?

89. The procedures used to produce ethene (ethylene) in Canada vary from year to year and place to place. T/I C A
    (a) Investigate how ethene is produced.
    (b) The mass of ethene produced is usually measured in tonnes. Convert 200.0 t of ethene to kilograms.
    (c) What amount of ethene is 200.0 t? Why might it be more convenient to report the amount of ethene produced in units of kilomoles instead of moles?

90. The term *empirical* is used in instances other than in *empirical formula*. T/I A
    (a) What is meant by the term *empirical*?
    (b) How does this definition help explain what an empirical formula is?

91. Most of the dietary salt taken into the human body comes from food that is processed. T/I A
    (a) Which two elements are in salt? Which of these elements is listed on a food label to reflect the amount of salt in the product?
    (b) Use the Internet and other resources to find information on the amount of sodium present in a food that can be purchased unprocessed (fresh or frozen) or processed (dried, canned, or boxed). Compare the amount of sodium present in both forms of the food.
    (c) How does the recommended daily intake of sodium for a person change as the person ages?
    (d) What is meant by a low-sodium food and a no-sodium food?

92. Currency contaminated with drugs and diseases has been found worldwide.
    (a) Use the Internet and other resources to research what potential solution to the problem was developed by Australia in the late 1980s.
    (b) Examine a mass spectrum of heroin. How does heroin's mass spectrum differ from the mass spectrum of cocaine? Using the mass spectrum, find the molecular mass of heroin. T/I A