STUDENT SOLUTION GUIDE

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Chemistry 2e.

Chemistry 2e **1: Essential Ideas** **1.1: Chemistry in Context**

1. Explain how you could experimentally determine whether the outside temperature is higher or lower than 0 °C (32 °F) without using a thermometer.

Solution
Place a glass of water outside. It will freeze if the temperature is below 0 °C.

3. Identify each of the following statements as being most similar to a hypothesis, a law, or a theory. Explain your reasoning.
(a) The pressure of a sample of gas is directly proportional to the temperature of the gas.
(b) Matter consists of tiny particles that can combine in specific ratios to form substances with specific properties.
(c) At a higher temperature, solids (such as salt or sugar) will dissolve better in water.

Solution
(a) law (states a consistently observed phenomenon, can be used for prediction); (b) theory (a widely accepted explanation of the behavior of matter); (c) hypothesis (a tentative explanation, can be investigated by experimentation)

5. Identify each of the underlined items as a part of either the macroscopic domain, the microscopic domain, or the symbolic domain of chemistry. For those in the symbolic domain, indicate whether they are symbols for a macroscopic or a microscopic feature.
(a) A certain molecule contains one H atom and one Cl atom.
(b) Copper wire has a density of about 8 g/cm^3.
(c) The bottle contains 15 grams of Ni powder.
(d) A sulfur molecule is composed of eight sulfur atoms.

Solution
(a) symbolic, microscopic; (b) macroscopic; (c) symbolic, macroscopic; (d) microscopic

7. The amount of heat required to melt 2 lbs of ice is twice the amount of heat required to melt 1 lb of ice. Is this observation a macroscopic or microscopic description of chemical behavior? Explain your answer.

Solution
Macroscopic. The heat required is determined from macroscopic properties.

Chemistry 2e
1: Essential Ideas
1.2: Phases and Classification of Matter

9. What properties distinguish solids from liquids? Liquids from gases? Solids from gases?

Solution

Liquids can change their shape (flow); solids can't. Gases can undergo large volume changes as pressure changes; liquids do not. Gases flow and change volume; solids do not.

11. How does a homogeneous mixture differ from a pure substance? How are they similar?

Solution

The mixture can have a variety of compositions; a pure substance has a definite composition. Both have the same composition from point to point.

13. How do molecules of elements and molecules of compounds differ? In what ways are they similar?

Solution

Molecules of elements contain only one type of atom; molecules of compounds contain two or more types of atoms. They are similar in that both are comprised of two or more atoms chemically bonded together.

15. Many of the items you purchase are mixtures of pure compounds. Select three of these commercial products and prepare a list of the ingredients that are pure compounds.

Solution

Answers will vary. Sample answer: Gatorade contains water, sugar, dextrose, citric acid, salt, sodium chloride, monopotassium phosphate, and sucrose acetate isobutyrate.

17. Classify each of the following as an element, a compound, or a mixture:
(a) iron
(b) oxygen
(c) mercury oxide
(d) pancake syrup
(e) carbon dioxide
(f) a substance composed of molecules each of which contains one hydrogen atom and one chlorine atom
(g) baking soda
(h) baking powder

Solution

(a) element; (b) element; (c) compound; (d) mixture; (e) compound; (f) compound; (g) compound; (h) mixture

19. How are the molecules in oxygen gas, the molecules in hydrogen gas, and water molecules similar? How do they differ?

Solution

In each case, a molecule consists of two or more combined atoms. They differ in that the types of atoms change from one substance to the next.

21. Prepare a list of the principal chemicals consumed and produced during the operation of an automobile.

Solution

Gasoline (a mixture of compounds), oxygen, and to a lesser extent, nitrogen are consumed. Carbon dioxide and water are the principal products. Carbon monoxide and nitrogen oxides are produced in lesser amounts.

23. When elemental iron corrodes it combines with oxygen in the air to ultimately form red brown iron(III) oxide called rust. (a) If a shiny iron nail with an initial mass of 23.2 g is weighed after being coated in a layer of rust, would you expect the mass to have increased, decreased, or remained the same? Explain. (b) If the mass of the iron nail increases to 24.1 g, what mass of oxygen combined with the iron?

Solution

(a) Increased as it would have combined with oxygen in the air thus increasing the amount of matter and therefore the mass. (b) 24.1 g – 23.2 g = 0.9 g

25. Yeast converts glucose to ethanol and carbon dioxide during anaerobic fermentation as depicted in the simple chemical equation below:

$$\text{glucose} \longrightarrow \text{ethanol} + \text{carbon dioxide}$$

(a) If 200.0 g of glucose is fully converted, what will be the total mass of ethanol and carbon dioxide produced?

(b) If the fermentation is carried out in an open container, would you expect the mass of the container and contents after fermentation to be less than, greater than, or the same as the mass of the container and contents before fermentation? Explain.

(c) If 97.7 g of carbon dioxide is produced, what mass of ethanol is produced?

Solution

(a) 200.0 g; (b) The mass of the container and contents would decrease as carbon dioxide is a gaseous product and would leave the container. (c) 200.0 g – 97.7 g = 102.3 g

Chemistry 2e
1: Essential Ideas
1.3: Physical and Chemical Properties

27. Classify each of the following changes as physical or chemical:
(a) condensation of steam
(b) burning of gasoline
(c) souring of milk
(d) dissolving of sugar in water
(e) melting of gold

Solution
(a) physical; (b) chemical; (c) chemical; (d) physical; (e) physical

29. The volume of a sample of oxygen gas changed from 10 mL to 11 mL as the temperature changed. Is this a chemical or physical change?

Solution
physical

31. Explain the difference between extensive properties and intensive properties.

Solution
The value of an extensive property depends upon the amount of matter being considered, whereas the value of an intensive property is the same regardless of the amount of matter being considered.

33. The density (d) of a substance is an intensive property that is defined as the ratio of its mass (m) to its volume (V).

$$\text{density} = \frac{\text{mass}}{\text{volume}} \qquad d = \frac{m}{V}$$

Considering that mass and volume are both extensive properties, explain why their ratio, density, is intensive.

Solution
Being extensive properties, both mass and volume are directly proportional to the amount of substance under study. Dividing one extensive property by another will in effect “cancel” this dependence on amount, yielding a ratio that is independent of amount (an intensive property).

Chemistry 2e
1: Essential Ideas
1.4: Measurements

35. Is a meter about an inch, a foot, a yard, or a mile?

Solution
about a yard

37. Indicate the SI base units or derived units that are appropriate for the following measurements:
(a) the mass of the moon
(b) the distance from Dallas to Oklahoma City
(c) the speed of sound
(d) the density of air
(e) the temperature at which alcohol boils
(f) the area of the state of Delaware
(g) the volume of a flu shot or a measles vaccination

Solution
(a) kilograms; (b) meters; (c) meters/second; (d) kilograms/cubic meter; (e) kelvin; (f) square meters; (g) cubic meters

39. Give the name of the prefix and the quantity indicated by the following symbols that are used with SI base units.
(a) c
(b) d
(c) G
(d) k
(e) m
(f) n
(g) p
(h) T

Solution
(a) centi-, $\times 10^{-2}$; (b) deci-, $\times 10^{-1}$; (c) Giga-, $\times 10^{9}$; (d) kilo-, $\times 10^{3}$; (e) milli-, $\times 10^{-3}$; (f) nano-, $\times 10^{-9}$; (g) pico-, $\times 10^{-12}$; (h) tera-, $\times 10^{12}$

41. Visit https://www.simbucket.com/density/ and click the “turn fluid into water” button to adjust the density of liquid in the beaker to 1.00 g/mL.
(a) Use the water displacement approach to measure the mass and volume of the unknown material (select the green block with question marks).
(b) Use the measured mass and volume data from step (a) to calculate the density of the unknown material.
(c) Assuming this material is a copper-containing gemstone, identify its three most likely identities by comparing the measured density to the values tabulated at https://www.ajsgem.com/articles/gemstone-density-definitive-guide.html.

Solution
(a) m = 18.58 g, V = 5.7 mL. (b) d = 3.3 g/mL (c) dioptase (copper cyclosilicate, d = 3.28-3.31 g/mL); malachite (basic copper carbonate, d = 3.25-4.10 g/mL); Paraiba tourmaline (sodium lithium boron silicate with copper, d = 2.82-3.32 g/mL)

43. Visit https://www.simbucket.com/density/ and click the “turn fluid into water” button to adjust the density of liquid in the beaker to 1.00 g/mL. Change the block material to foam, and then wait patiently until the foam block stops bobbing up and down in the water.
(a) The foam block should be floating on the surface of the water (that is, only partially submerged). What is the volume of water displaced?
(b) Use the water volume from part (a) and the density of water (1.0 g/mL) to calculate the mass of water displaced.
(c) Remove and weigh the foam block. How does the block’s mass compare the mass of displaced water from part (b)?

Solution
(a) displaced water volume = 2.8 mL; (b) displaced water mass = 2.8 g; (c) The block mass is 2.76 g, essentially equal to the mass of displaced water (2.8 g) and consistent with Archimedes’ principle of buoyancy.

Chemistry 2e
1: Essential Ideas
1.5: Measurement Uncertainty, Accuracy, and Precision

45. Express each of the following numbers in exponential notation with correct significant figures:
(a) 704
(b) 0.03344
(c) 547.9
(d) 22086
(e) 1000.00
(f) 0.0000000651
(g) 0.007157

Solution
(a) 7.04×10^2; (b) 3.344×10^{-2}; (c) 5.479×10^2; (d) 2.2086×10^4; (e) 1.00000×10^3; (f) 6.51×10^{-8}; (g) 7.157×10^{-3}

47. Indicate whether each of the following can be determined exactly or must be measured with some degree of uncertainty:
(a) the number of seconds in an hour
(b) the number of pages in this book
(c) the number of grams in your weight
(d) the number of grams in 3 kilograms
(e) the volume of water you drink in one day
(f) the distance from San Francisco to Kansas City

Solution
(a) exact; (b) exact; (c) uncertain; (d) exact; (e) uncertain; (f) uncertain

49. How many significant figures are contained in each of the following measurements?
(a) 53 cm
(b) 2.05×10^8 m
(c) 86,002 J
(d) 9.740×10^4 m/s
(e) 10.0613 m^3
(f) 0.17 g/mL
(g) 0.88400 s

Solution
(a) two; (b) three; (c) five; (d) four; (e) six; (f) two; (g) five

51. Round off each of the following numbers to two significant figures:
(a) 0.436
(b) 9.000
(c) 27.2
(d) 135
(e) 1.497×10^{-3}
(f) 0.445

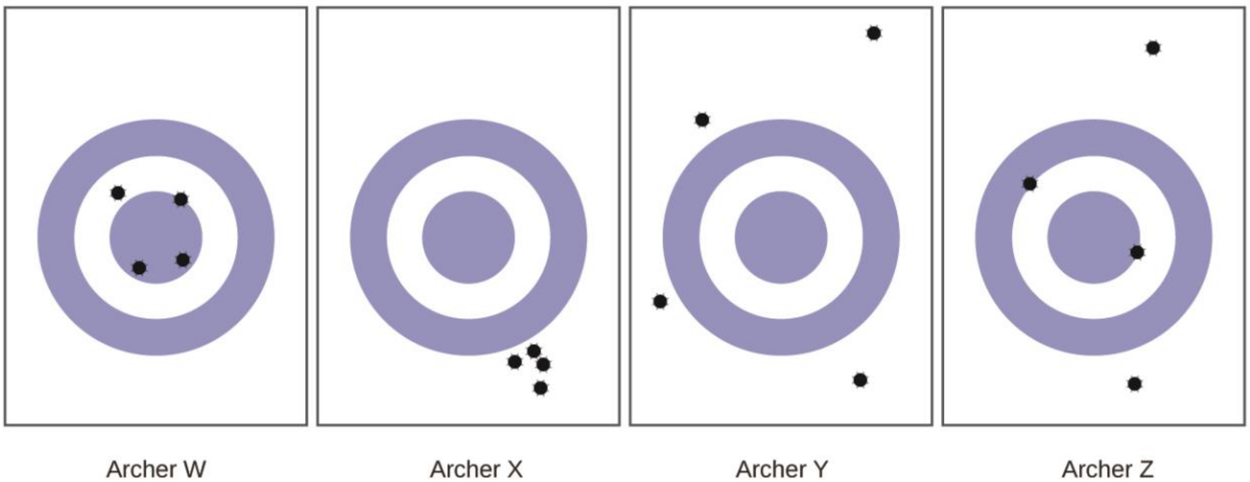
Solution
(a) 0.44; (b) 9.0; (c) 27; (d) 140; (e) 1.5×10^{-3}; (f) 0.44

53. Perform the following calculations and report each answer with the correct number of significant figures.

(a) 628×342
(b) $(5.63 \times 10^2) \times (7.4 \times 10^3)$
(c) $\frac{28.0}{13.483}$
(d) 8119×0.000023
(e) 14.98 + 27,340 + 84.7593
(f) 42.7 + 0.259

Solution
(a) 2.15×10^5; (b) 4.2×10^6; (c) 2.08; (d) 0.19; (e) 27,440; (f) 43.0

55. Consider the results of the archery contest shown in this figure.
(a) Which archer is most precise?
(b) Which archer is most accurate?
(c) Who is both least precise and least accurate?



Solution
(a) Archer X; (b) Archer W; (c) Archer Y

Chemistry 2e
1: Essential Ideas
1.6: Mathematical Treatment of Measurement Results

57. Write conversion factors (as ratios) for the number of:
(a) yards in 1 meter
(b) liters in 1 liquid quart
(c) pounds in 1 kilogram

Solution

(a) $\frac{1.0936 \text{ yd}}{1 \text{ m}}$; (b) $\frac{0.94635 \text{ L}}{1 \text{ qt}}$; (c) $\frac{2.2046 \text{ lb}}{1 \text{ kg}}$

59. The label on a soft drink bottle gives the volume in two units: 2.0 L and 67.6 fl oz. Use this information to derive a conversion factor between the English and metric units. How many significant figures can you justify in your conversion factor?

Solution

Divide the total number of liters by the total number of fluid ounces.

0.030 L = 1 fl oz

$$\frac{2.0 \text{ L}}{67.6 \text{ fl oz}} = \frac{0.030 \text{ L}}{1 \text{ fl oz}}$$

Only two significant figures are justified.

61. Soccer is played with a round ball having a circumference between 27 and 28 in. and a weight between 14 and 16 oz. What are these specifications in units of centimeters and grams?

Solution

68–71 cm; 400–450 g

63. How many milliliters of a soft drink are contained in a 12.0-oz can?

Solution

355 mL

65. The diameter of a red blood cell is about 3×10^{-4} in. What is its diameter in centimeters?

Solution

8×10^{-4} cm

67. Is a 197-lb weight lifter light enough to compete in a class limited to those weighing 90 kg or less?

Solution

yes; weight = 89.4 kg

69. Many medical laboratory tests are run using 5.0 μL blood serum. What is this volume in milliliters?

Solution

5.0×10^{-3} mL

71. Use scientific (exponential) notation to express the following quantities in terms of the SI base units in Table1.3:
(a) 0.13 g
(b) 232 Gg
(c) 5.23 pm
(d) 86.3 mg
(e) 37.6 cm
(f) 54 μm

(g) 1 Ts
(h) 27 ps
(i) 0.15 mK

Solution

(a) 1.3×10^{-4} kg; (b) 2.32×10^{8} kg; (c) 5.23×10^{-12} m; (d) 8.63×10^{-5} kg; (e) 3.76×10^{-1} m; (f) 5.4×10^{-5} m; (g) 1×10^{12} s; (h) $2.\ 7 \times 10^{-11}$ s; (i) $l.5 \times 10^{-4}$ K

73. Gasoline is sold by the liter in many countries. How many liters are required to fill a 12.0-gal gas tank?

Solution

45.4 L

75. A long ton is defined as exactly 2240 lb. What is this mass in kilograms?

Solution

$$2240\ \cancel{\text{lb}}\ \text{(exactly)} \times \frac{0.45359\ \text{kg}}{1\ \cancel{\text{lb}}} = 1016.0\ \text{kg} = 1.0160 \times 10^{3}\ \text{kg}$$

77. Make the conversion indicated in each of the following:
(a) the length of a soccer field, 120 m (three significant figures), to feet
(b) the height of Mt. Kilimanjaro, at 19,565 ft the highest mountain in Africa, to kilometers
(c) the area of an 8.5×11-inch sheet of paper in cm^2
(d) the displacement volume of an automobile engine, 161 $in.^3$, to liters
(e) the estimated mass of the atmosphere, 5.6×10^{15} tons, to kilograms
(f) the mass of a bushel of rye, 32.0 lb, to kilograms
(g) the mass of a 5.00-grain aspirin tablet to milligrams (1 grain = 0.00229 oz)

Solution

(a) $120\ \cancel{\text{m}} \times \frac{1.0936\ \cancel{\text{yd}}}{1\ \cancel{\text{m}}} \times \frac{3\ \text{ft}}{1\ \cancel{\text{yd}}} = 394\ \text{ft}$

(b) $19{,}565\ \cancel{\text{ft}} \times \frac{12\ \cancel{\text{in.}}}{1\ \cancel{\text{ft}}} \times \frac{2.54\ \cancel{\text{cm}}}{1\ \cancel{\text{in.}}} \times \frac{1\ \cancel{\text{m}}}{100\ \cancel{\text{cm}}} \times \frac{1\ \text{km}}{1000\ \cancel{\text{m}}} = 5.9634\ \text{km}$

(c) $8.5\ \text{in.} \times 11\ \text{in.} = 93.5\ \cancel{\text{in.}^2} \times \frac{(2.54\ \text{cm})^2}{(1\ \cancel{\text{in.}})^2} = 6.0 \times 10^{2}$

(d) $161\ \cancel{\text{in.}^3} \times \left(\frac{2.54\ \cancel{\text{cm}}}{1\ \cancel{\text{in.}}}\right)^3 \times \frac{1\ \text{L}}{1000\ \cancel{\text{cm}^3}} = 2.64\ \text{L}$

(e) $5.6 \times 10^{15}\ \cancel{\text{short tons}} \times 907.185\ \text{kg}/\cancel{\text{short tons}} = 5.1 \times 10^{18}\ \text{kg}$

(f) $32.0\ \cancel{\text{lb}} \times \frac{0.45359\ \text{kg}}{1\ \cancel{\text{lb}}} = 14.5\ \text{kg}$

(g) $5.00\ \cancel{\text{grain}} \times \frac{0.00229\ \cancel{\text{oz}}}{1\ \cancel{\text{grain}}} \times \frac{28.349\ \text{g}}{1\ \cancel{\text{oz}}} = 0.324\ \text{g}$

$0.411\ \cancel{\text{g}} \times \frac{1000\ \text{mg}}{1\ \cancel{\text{g}}} = 324\ \text{mg}$

79. A chemist's 50-Trillion Angstrom Run (see Exercise 78) would be an archeologist's 10,900 cubit run. How long is one cubit in meters and in feet? ($1\ \text{Å} = 1 \times 10^{-8}\ \text{cm}$)

Solution

$$5.0 \times \frac{10^3\ \text{m}}{10{,}900\ \text{cubit}} = 0.46\ \text{m/cubit or 1 cubit} = 0.46\ \text{m}$$

$$\frac{5000\ \text{m}}{10{,}900\ \text{cubit}} \times \frac{1\ \text{yd}}{0.9744\ \text{m}} \times 3\ \text{ft/yd} = 1.5\ \text{ft/cubit}$$

81. As an instructor is preparing for an experiment, he requires 225 g phosphoric acid. The only container readily available is a 150-mL Erlenmeyer flask. Is it large enough to contain the acid, whose density is 1.83 g/mL?

Solution

Yes, the acid's volume is 123 mL.

83. A chemistry student is 159 cm tall and weighs 45.8 kg. What is her height in inches and weight in pounds?

Solution

62.6 in (about 5 ft 3 in.) and 101 lb

85. Solve these problems about lumber dimensions.

(a) To describe to a European how houses are constructed in the US, the dimensions of “two-by-four” lumber must be converted into metric units. The thickness × width × length dimensions are 1.50 in. × 3.50 in. × 8.00 ft in the US. What are the dimensions in cm × cm × m?

(b) This lumber can be used as vertical studs, which are typically placed 16.0 in. apart. What is that distance in centimeters?

Solution

(a) 3.81 cm × 8.89 cm × 2.44 m; (b) 40.6 cm

87. Calculate the density of aluminum if 27.6 cm^3 has a mass of 74.6 g.

Solution

2.70 g/cm^3

89. Calculate these masses.

(a) What is the mass of 6.00 cm^3 of mercury, density = 13.5939 g/cm^3?

(b) What is the mass of 25.0 mL octane, density = 0.702 g/cm^3?

Solution

(a) 81.6 g; (b) 17.6 g

91. Calculate these volumes.

(a) What is the volume of 25 g iodine, density = 4.93 g/cm^3?

(b) What is the volume of 3.28 g gaseous hydrogen, density = 0.089 g/L?

Solution

(a) 5.1 mL; (b) 37 L

93. Convert the boiling temperature of gold, 2966 °C, into degrees Fahrenheit and kelvin.

Solution

5371 °F, 3239 K

95. Convert the temperature of the coldest area in a freezer, –10 °F, to degrees Celsius and kelvin.

Solution

–23 °C, 250 K

97. Convert the boiling temperature of liquid ammonia, –28.1 °F, into degrees Celsius and kelvin.

Solution

–33.4 °C, 239.8 K

99. The weather in Europe was unusually warm during the summer of 1995. The TV news reported temperatures as high as 45 °C. What was the temperature on the Fahrenheit scale?

Solution
113 °F