

FIRST EDITION

SOLUTIONS MANUAL TO CHEMISTRY

A Fundamental Overview of Essential Principles

David R. Khan
and Jason C. Yarbrough



SNEAK PREVIEW

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SOLUTIONS MANUAL TO

**Chemistry: A Fundamental
Overview of Essential Principles**

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The Basics of Chemistry

CHAPTER 1

KEY CONCEPTS

- Matter
- Scientific Method
- Scientific Laws and Theories
- Scientific Notation
- Measurement, Units, and Unit Conversions
- Significant Figures
- Density

INTRODUCTION AND SCIENTIFIC METHOD

1. What is Chemistry?

Chemistry is the study of matter, its structure, its properties, and the processes it undergoes.

2. What is the scientific method?

The scientific method is the *systematic* acquisition of knowledge through observation and experiment.

3. What is a hypothesis?

A hypothesis is a tentative or speculative explanation for observations. This becomes the basis for future experiment(s) and observation(s).

4. What is an observation?

An observation is data collected with or without instrumentation. It can be qualitative or quantitative.

5. What is a scientific law?

A scientific law is a summary statement (or mathematical equation) which describes a set of observations and can be used to make predictions about the outcome of future events or experiments.

6. How are observations related to scientific laws?

When specific observations are made consistently and are always the same, such a set of observations can result in the formulation of a *scientific law*.

7. What is a theory?

A theory is a model which describes the underlying explanations of all observations. Theories are at the height of scientific knowledge. They are models of how the world works, which are supported by large bodies of experimental data and can be used to predict entirely new observations across a wide range of phenomena.

8. What is the difference between a law and a theory? Which one is more powerful?

A theory is a model which describes the underlying explanations of all observations. A law is a summary of past observations which carries no explanation for itself or its predictions.

9. Classify each of the following as an observation, hypothesis, scientific law, or theory:

- a. A sample of dry ice sublimates at room temperature.

Observation

- b. Two samples of water were acquired from two different sources within North America and found to contain the same ratio of Oxygen to Hydrogen according to mass.

Observation

- c. All samples of a given compound will exhibit the same ratio of constituent elements according to mass.

Law

- d. Matter is composed of tiny indestructible particles called atoms. They combine in simple integer ratios to form compounds.

Theory

10. Classify each of the following as an observation, hypothesis, scientific law, or theory:
- a. Wood is burned inside a closed system. Following this reaction, the total mass of the system was measured and found to be the same as before the reaction.

Observation

- b. During chemical processes, all matter is conserved; it is neither created nor destroyed.

Law

- c. The temperature of a sample of nitrogen gas is increased by a factor of two and the pressure of the gas is measured and found to be twice the original pressure.

Observation

- d. The pressure of gases is directly proportional to their absolute temperature, holding all other variables constant.

Law

SCIENTIFIC NOTATION

11. Convert each of the following to scientific notation:

- | | |
|-----------------|-------------------------|
| a. 1101 | 1.101×10^3 |
| b. 0.031 | 3.1×10^{-2} |
| c. 456 | 4.56×10^2 |
| d. 0.0000033456 | 3.3456×10^{-6} |
| e. 23,901,000 | 2.3901×10^7 |

12. Convert each of the following to scientific notation:

- | | |
|--------------------------|-------------------------|
| a. 2,398,800,000,000,000 | 2.3988×10^{18} |
| b. 0.00000000002319 | 2.319×10^{-11} |
| c. 1320 | 1.32×10^3 |
| d. 12,110,000,000,000 | 1.211×10^{13} |
| e. 0.0000061901 | 6.1901×10^{-6} |

13. Convert each of the following to scientific notation:

- | | |
|-------------------|-------------------------|
| a. 1,198,000 | 1.198×10^6 |
| b. 19,630,000,000 | 1.963×10^{10} |
| c. 0.0000058897 | 5.8897×10^{-6} |
| d. 0.0008536 | 8.536×10^{-4} |
| e. 0.078991 | 7.8991×10^{-2} |

14. Convert each of the following to scientific notation:

- | | |
|------------------|-------------------------|
| a. 999 | 9.99×10^2 |
| b. 832210 | 8.3221×10^5 |
| c. 0.004572 | 4.572×10^{-3} |
| d. 0.00000055598 | 5.5598×10^{-7} |
| e. 0.00034299 | 3.4299×10^{-4} |

15. Convert each of the following to standard notation:

- | | |
|-----------------------------|------------------|
| a. 2.31×10^4 | 23,100 |
| b. 2.31×10^{-4} | 0.000231 |
| c. 3.0317×10^{10} | 30,317,000,000 |
| d. 3.0317×10^{-10} | 0.00000000030317 |
| e. 9.13×10^{-7} | 0.000000913 |

16. Convert each of the following to standard notation:

- | | |
|----------------------------|-----------------------------|
| a. 4.21×10^6 | 4,210,000 |
| b. 7.343×10^{-2} | 0.07343 |
| c. 3.339×10^{-16} | 0.00000000000000003339 |
| d. 9.9×10^{-20} | 0.000000000000000000099 |
| e. 9.9×10^{20} | 990,000,000,000,000,000,000 |

17. Convert each of the following to standard notation:

- | | |
|---------------------------|----------------|
| a. 6.98×10^{-5} | 0.0000698 |
| b. 6.98×10^{-10} | 0.000000000698 |
| c. 6.98×10^5 | 698,000 |
| d. 7.11×10^2 | 711 |
| e. 7.11×10^{-2} | 0.0711 |

18. Convert each of the following to standard notation:

- | | |
|----------------------------|-----------------------------|
| a. 1.49×10^2 | 149 |
| b. 5.26×10^{-8} | 0.000000526 |
| c. 6.022×10^{23} | 602,200,000,000,000,000,000 |
| d. 1.602×10^{-19} | 0.0000000000000000001602 |
| e. 2.18×10^{-18} | 0.00000000000000000218 |

19. Determine the greatest of each of the following pairs:

- | |
|--|
| a. 6.626×10^{-34} and 6.626×10^{-43} |
| b. 2.18×10^{-18} and 6.626×10^{18} |
| c. 6.626×10^{-2} and 6.626×10^{-4} |
| d. 4.132×10^{10} and 4.133×10^{10} |
| e. 1.21×10^3 and 1.45×10^2 |

20. Determine the greatest of each of the following pairs:

- | |
|--|
| a. 5.64×10^{-13} and 5.64×10^{-31} |
| b. 7.12×10^{-14} and 7.12×10^{14} |
| c. 3.91×10^{-7} and 3.91×10^{-4} |
| d. 2.172×10^3 and 2.173×10^3 |
| e. 2.27×10^3 and 9.65×10^2 |

21. Complete the following table:

	Standard Notation	Scientific Notation
a.	12,001	1.2001×10^4
b.	0.000000452	4.52×10^{-7}
c.	0.000231	2.31×10^{-4}
d.	0.00000000000933	9.33×10^{-12}
e.	100	1×10^2

22. Complete the following table:

	Standard Notation	Scientific Notation
a.	0.0001299	1.299×10^{-4}
b.	45,200,000	4.52×10^7
c.	45,120,000,000	4.512×10^{10}
d.	8,571,000	8.571×10^6
e.	0.00001	1×10^{-5}

UNITS OF MEASUREMENT AND DENSITY

23. What is a unit of measurement?

A unit is a generally accepted *quantity* which is used to accurately and reproducibly report experimental measurements.

24. Name the base units of measurement for length, mass, volume, and time in the SI system.

Length – meter

Mass – kilogram

Volume – cubic meters

Time – seconds

25. What is meant by the term *derived unit*? Give two examples.

These are units which result from multiplication or division of simpler base units. Two such examples are volume (m^3) or density (g/ml).

26. What are prefix multipliers and how are they used?

Prefix multipliers indicate multiplication by powers of 10 and are used to amplify base units into larger or smaller quantities.

27. How many nm are in 1 meter? How many meters are in 1 nm?

$$10^9 \text{ nm} = 1 \text{ m}$$

$$1 \text{ nm} = 10^{-9} \text{ m}$$

28. How many meters are in 1 km? How many kilometers are in 1 m?

$$10^3 \text{ m} = 1 \text{ km}$$

$$1 \text{ m} = 10^{-3} \text{ km}$$

29. How many deciliters are in 1 L? How many liters are in 1 dL?

$$10 \text{ dL} = 1 \text{ L}$$

$$1 \text{ dL} = 0.01 \text{ L}$$

30. How many picoseconds are in 1 s? How many seconds are 1 ps?

$$10^{12} \text{ ps} = 1 \text{ s}$$

$$1 \text{ ps} = 10^{-12} \text{ s}$$

31. Complete the following:

a. $1.20 \times 10^{12} \text{ m} = \underline{1.20} \text{ Tm}$

$$(1.20 \times 10^{12} \text{ m}) \times \frac{1 \text{ Tm}}{10^{12} \text{ m}} = 1.20 \text{ Tm}$$

b. $1.20 \times 10^{-12} \text{ g} = \underline{1.20} \text{ pg}$

$$(1.20 \times 10^{-12} \text{ g}) \times \frac{10^{12} \text{ pg}}{1 \text{ g}} = 1.20 \text{ pg}$$

c. $3.2 \text{ L} = \underline{3.2 \times 10^3} \text{ ml}$

$$(3.2 \text{ L}) \times \frac{10^3 \text{ ml}}{1 \text{ L}} = 3.2 \times 10^3 \text{ ml}$$

d. $8.0 \text{ mg} = \underline{0.80} \text{ cg}$

$$(8.0 \text{ mg}) \times \frac{1 \text{ g}}{10^3 \text{ mg}} \times \frac{10^2 \text{ cg}}{1 \text{ g}} = 0.80 \text{ cg}$$

32. Complete the following:

a. $4.61 \times 10^4 \text{ m} = \underline{4.61 \times 10^6} \text{ cm}$

b. $7.56 \times 10^{-7} \text{ g} = \underline{7.56 \times 10^{-4}} \text{ mg}$

c. $9.3 \text{ L} = \underline{9.3 \times 10^{12}} \text{ pl}$

d. $31.56 \text{ mg} = \underline{3.156 \times 10^{-7}} \text{ kg}$

33. Convert 2.135 L into the following units:

- a. mL – 2.135×10^3 mL
- b. ML – 2.135×10^{-6} ML
- c. kL – 2.135×10^{-3} kL
- d. nL – 2.135×10^9 nL
- e. pL – 2.135×10^{12} pL

34. What is the volume, in m^3 , of an object with the following dimensions? What is this same volume in dm^3 ? What is this volume in L?

Length = 1.0 m

Width = 3.0 m

Height = 7.0 m

$$Volume = 1.0\ m \times 3.0\ m \times 7.0\ m = 21\ m^3$$

$$21\ m^3 \times \left(\frac{10\ dm}{1\ m} \right)^3 = 2.1 \times 10^4\ dm^3$$

$$21\ m^3 \times \left(\frac{100\ cm}{1\ m} \right)^3 \times \frac{1\ ml}{1\ cm^3} \times \frac{1\ L}{1000\ ml} = 2.1 \times 10^4\ L$$

35. What is the volume, in cm^3 , of an object with the following dimensions? What is this same volume in m^3 ? What is this volume in L?

Length = 29 cm

Width = 312 cm

Height = 78 cm

$$Volume = 29\ cm \times 312\ cm \times 78\ cm = 705,744\ cm^3 = 7.1 \times 10^5\ cm^3$$

$$705,744\ cm^3 \times \left(\frac{1\ m}{100\ cm} \right)^3 = 0.705744\ m^3 = 7.1 \times 10^{-1}\ m^3$$

$$705,744\ cm^3 \times \frac{1\ ml}{1\ cm^3} \times \frac{1\ L}{1000\ ml} = 705.744\ L = 7.1 \times 10^2\ L$$

36. If a room measures 3 m by 5 m by 6 m, what is the volume of the room in m^3 , dm^3 , cm^3 , L, and mL?

$$Volume = 3\ m \times 5\ m \times 6\ m = 90\ m^3$$

$$90\ m^3 \times \left(\frac{10\ dm}{1\ m} \right)^3 = 9 \times 10^4\ dm^3$$

$$90\ m^3 \times \left(\frac{100\ cm}{1\ m} \right)^3 = 9 \times 10^7\ cm^3$$

37. Area: Complete the following conversions:

a. $1 \text{ s}^2 = \underline{\hspace{2cm}} \text{ ms}^2$

$$1 \text{ s}^2 \times \left(\frac{1000 \text{ ms}}{1 \text{ s}} \right)^2 = 1,000,000 \text{ ms}^2 = 1 \times 10^6 \text{ ms}^2$$

b. $5.6 \text{ cm}^2 = \underline{\hspace{2cm}} \text{ mm}^2$

$$5.6 \text{ cm}^2 \times \left(\frac{10 \text{ mm}}{1 \text{ cm}} \right)^2 = 560 \text{ mm}^2 = 5.6 \times 10^2 \text{ mm}^2$$

c. $4.8 \text{ mm}^2 = \underline{\hspace{2cm}} \text{ m}^2$

$$4.8 \text{ mm}^2 \times \left(\frac{1 \text{ m}}{1000 \text{ mm}} \right)^2 = 0.0000048 \text{ m}^2 = 4.8 \times 10^{-6} \text{ m}^2$$

d. $78.2 \text{ pm}^2 = \underline{\hspace{2cm}} \text{ nm}^2$

$$78.2 \text{ pm}^2 \times \left(\frac{1 \text{ nm}}{1000 \text{ pm}} \right)^2 = 0.0000782 \text{ nm}^2 = 7.82 \times 10^{-5} \text{ nm}^2$$

e. $21.78 \text{ km}^2 = \underline{\hspace{2cm}} \text{ Tm}^2$

$$21.78 \text{ km}^2 \times \left(\frac{1 \text{ Tm}}{10^9 \text{ km}} \right)^2 = 2.178 \times 10^{-17} \text{ Tm}^2$$

38. Area: Complete the following conversions:

a. $4.91 \times 10^4 \text{ ft}^2 = \underline{\hspace{2cm}} \text{ yd}^2$

$$(4.91 \times 10^4 \text{ ft}^2) \times \left(\frac{1 \text{ yd}}{3 \text{ ft}} \right)^2 = 5.46 \times 10^3 \text{ yd}^2$$

b. $2.89 \times 10^{-2} \text{ m}^2 = \underline{\hspace{2cm}} \text{ cm}^2$

$$(2.89 \times 10^{-2} \text{ m}^2) \times \left(\frac{100 \text{ cm}}{1 \text{ m}} \right)^2 = 2.89 \times 10^2 \text{ cm}^2$$

c. $1.99 \text{ dm}^2 = \underline{\hspace{2cm}} \text{ mm}^2$

$$(1.99 \text{ dm}^2) \times \left(\frac{1 \text{ m}}{10 \text{ dm}} \right)^2 \times \left(\frac{100 \text{ cm}}{1 \text{ m}} \right)^2 = 1.99 \times 10^2 \text{ cm}^2$$

d. $7.32 \text{ Mm}^2 = \underline{\hspace{2cm}} \text{ m}^2$

$$(7.32 \text{ Mm}^2) \times \left(\frac{10^6 \text{ m}}{1 \text{ Mm}} \right)^2 = 7.32 \times 10^{12} \text{ m}^2$$

e. $8.112 \text{ nm}^2 = \underline{\hspace{2cm}} \mu\text{m}^2$

$$(8.112 \text{ nm}^2) \times \left(\frac{1 \text{ m}}{10^9 \text{ nm}} \right)^2 \times \left(\frac{10^6 \mu\text{m}}{1 \text{ m}} \right)^2 = 8.112 \times 10^{-6} \mu\text{m}^2$$

39. Volume: Complete the following conversions:

a. $4.91 \times 10^4 \text{ dm}^3 = \underline{\hspace{2cm}} \text{ L}$

$$(4.91 \times 10^4 \text{ dm}^3) \times \frac{1 \text{ L}}{1 \text{ dm}^3} = 4.91 \times 10^4 \text{ L}$$

b. $4.53 \times 10^{-6} \text{ m}^3 = \underline{\hspace{2cm}} \text{ mm}^3$

$$4.53 \times 10^{-6} \text{ m}^3 \times \left(\frac{10^3 \text{ mm}}{1 \text{ m}} \right)^3 = 4.53 \times 10^3 \text{ mm}^3$$

c. $1.99 \text{ cm}^3 = \underline{\hspace{2cm}} \text{ mL}$

$$1.99 \text{ cm}^3 \times \frac{1 \text{ mL}}{1 \text{ cm}^3} = 1.99 \text{ mL}$$

d. $7.39 \text{ Mm}^3 = \underline{\hspace{2cm}} \text{ m}^3$

$$7.39 \text{ Mm}^3 \times \left(\frac{10^6 \text{ m}}{1 \text{ Mm}} \right)^3 = 7.39 \times 10^{18} \text{ m}^3$$

e. $4.333 \text{ nm}^3 = \underline{\hspace{2cm}} \mu\text{m}^3$

$$4.333 \text{ nm}^3 \times \left(\frac{1 \text{ m}}{10^9 \text{ nm}} \right)^3 \times \left(\frac{10^6 \mu\text{m}}{1 \text{ m}} \right)^3 = 4.333 \times 10^{-9} \text{ m}^3$$

40. Volume: Complete the following conversions:

a. $6.22 \text{ km}^3 = \underline{\hspace{2cm}} \text{ Mm}^3$

$$6.22 \text{ km}^3 \times \left(\frac{10^3 \text{ m}}{1 \text{ km}} \right)^3 \times \left(\frac{1 \text{ Mm}}{10^6 \text{ m}} \right)^3 = 6.22 \times 10^{-9} \text{ Mm}^3$$

b. $9.1 \times 10^3 \text{ mm}^3 = \underline{\hspace{2cm}} \text{ cm}^3$

$$9.1 \times 10^3 \text{ mm}^3 \times \left(\frac{1 \text{ m}}{10^3 \text{ mm}} \right)^3 \times \left(\frac{100 \text{ cm}}{1 \text{ m}} \right)^3 = 9.1 \text{ cm}^3$$

c. $9.1 \times 10^3 \text{ cm}^3 = \underline{\hspace{2cm}} \text{ mm}^3$

$$9.1 \times 10^3 \text{ cm}^3 \times \left(\frac{1 \text{ m}}{10^2 \text{ cm}} \right)^3 \times \left(\frac{10^3 \text{ mm}}{1 \text{ m}} \right)^3 = 9.1 \times 10^6 \text{ mm}^3$$

d. $6.42 \text{ m}^3 = \underline{\hspace{2cm}} \text{ cm}^3$

$$6.42 \text{ m}^3 \times \left(\frac{10^2 \text{ cm}}{1 \text{ m}} \right)^3 = 6.42 \times 10^6 \text{ cm}^3$$

e. $6.112 \text{ pm}^3 = \text{_____} \text{ mm}^3$

$$6.112 \text{ pm}^3 \times \left(\frac{1 \text{ m}}{10^{12} \text{ pm}} \right)^3 \times \left(\frac{10^3 \text{ mm}}{1 \text{ m}} \right)^3 = 6.112 \times 10^{-27} \text{ mm}^3$$

41. If a sample has a mass of 1.356 g and occupies a volume of 1.775 ml, what is its density in g/ml?

$$d = \frac{1.356 \text{ g}}{1.775 \text{ ml}} = 0.7639 \text{ g/ml}$$

42. If a sample of lithium is cut into a cube with each side being 2.00 cm in length, what is the density of lithium if the sample weighs 4.32 g?

$$d = \frac{4.32 \text{ g}}{(2.00 \text{ cm} \times 2.00 \text{ cm} \times 2.00 \text{ cm}) \left(\frac{1 \text{ ml}}{1 \text{ cm}^3} \right)} = 0.540 \text{ g/ml}$$

43. If a sample has a mass of 4.13 g and occupies a volume of 3.780 ml, what is its density in g/ml?

$$d = \frac{4.13 \text{ g}}{3.780 \text{ ml}} = 1.09 \text{ g/ml}$$

44. A sample of magnesium has a volume of 4.94 ml. If the sample weighs 8.596 g, what is its density?

$$d = \frac{8.596 \text{ g}}{4.94 \text{ ml}} = 1.74 \text{ g/ml}$$

45. A metal ball has a radius of 0.751 cm. If the ball weighs 15.897 g, what is the density of the ball? Based on the data in Table 1.5, what is the identity of the metal?

$$\text{volume} = \frac{4}{3} \pi r^3 = \frac{4}{3} \pi (0.751 \text{ cm})^3 = 1.774224 \text{ cm}^3$$

$$d = \frac{\text{mass}}{\text{volume}} = \frac{15.897 \text{ g}}{1.774224 \text{ ml}} = 8.96 \text{ g/ml}$$

46. An unknown solid compound has a mass of 54.84 g. When submerged in water in a graduated cylinder, the volume was displaced from 28.77 ml to 34.89 ml. What is the density of the sample?

$$\text{volume} = 34.89 \text{ ml} - 28.77 \text{ ml} = 6.12 \text{ ml}$$

$$d = \frac{\text{mass}}{\text{volume}} = \frac{54.84 \text{ g}}{6.12 \text{ ml}} = 8.96 \text{ g/ml}$$

47. An unknown solid compound has a mass of 13.2 g. When submerged in water in a graduated cylinder, the volume was displaced from 10.00 ml to 22.34 ml. What is the density of the sample?

$$\text{volume} = 22.34 \text{ ml} - 10.00 \text{ ml} = 12.34 \text{ ml}$$

$$d = \frac{\text{mass}}{\text{volume}} = \frac{13.2 \text{ g}}{12.34 \text{ ml}} = 1.07 \text{ g/ml}$$

48. An unknown solid compound has a mass of 7.82 g. If the sample displaces 3.11 ml of water in a graduated cylinder, what is the sample's mass?

$$d = \frac{\text{mass}}{\text{volume}} = \frac{7.82 \text{ g}}{3.11 \text{ ml}} = 2.51 \text{ g/ml}$$

49. An unknown sample was submerged in a quantity of water contained in a graduated cylinder. Upon submersion, the water level rose from an initial volume of 12.50 ml to a final volume of 17.37 ml. If the sample's mass was measured to be 22.3 g, what is its density?

$$\text{volume} = 17.37 \text{ ml} - 12.50 \text{ ml} = 4.87 \text{ ml}$$

$$d = \frac{\text{mass}}{\text{volume}} = \frac{22.3 \text{ g}}{4.87 \text{ ml}} = 4.58 \text{ g/ml}$$

50. An unknown sample was submerged in a quantity of water contained in a graduated cylinder. Upon submersion, the water level rose from an initial volume of 14.30 ml to a final volume of 17.57 ml. If the sample's mass was measured to be 12.50 g, what is its density?

$$\text{volume} = 17.57 \text{ ml} - 14.30 \text{ ml} = 3.27 \text{ ml}$$

$$d = \frac{\text{mass}}{\text{volume}} = \frac{12.50 \text{ g}}{3.27 \text{ ml}} = 3.82 \text{ g/ml}$$

51. An unknown sample was submerged in a quantity of water contained in a graduated cylinder. Upon submersion, the water level rose from an initial volume of 42.71 ml to a final volume of 44.49 ml. If the sample's mass was measured to be 20.114 g, what is its density?

$$\text{volume} = 44.49 \text{ ml} - 42.71 \text{ ml} = 1.78 \text{ ml}$$

$$d = \frac{\text{mass}}{\text{volume}} = \frac{20.114 \text{ g}}{1.78 \text{ ml}} = 11.3 \text{ g/ml}$$

52. An unknown metal sample was weighed and found to have a mass of 22.587 g. The sample was then placed in a graduated cylinder containing water with a volume of 18.91 ml. Upon submersion of the sample, the water level rose to 21.43 ml. Based on this, calculate the density of the sample and use Table 1.5 to identify the metal.

$$\text{volume} = 21.43 \text{ ml} - 18.91 \text{ ml} = 2.52 \text{ ml}$$

$$d = \frac{\text{mass}}{\text{volume}} = \frac{22.587 \text{ g}}{2.52 \text{ ml}} = 8.96 \text{ g/ml}$$

53. An unknown sample was weighed and found to have a mass of 74.76 g. The sample was then placed in a graduated cylinder containing water with a volume of 39.66 ml. Upon submersion of the sample, the water level rose to 46.78 ml. Based on this, calculate the density of the sample and use Table 1.5 to identify the metal.

$$\text{volume} = 46.78 \text{ ml} - 39.66 \text{ ml} = 7.12 \text{ ml}$$

$$d = \frac{\text{mass}}{\text{volume}} = \frac{74.76 \text{ g}}{7.12 \text{ ml}} = 10.5 \text{ g/ml}$$

54. An unknown sample was weighed and found to have a mass of 3.402 g. The sample was then placed in a graduated cylinder containing water with a volume of 32.10 ml. Upon submersion of the sample, the water level rose to 33.36 ml. Based on this, calculate the density of the sample and use Table 1.5 to identify the metal.

$$\text{volume} = 33.36 \text{ ml} - 32.10 \text{ ml} = 1.26 \text{ ml}$$

$$d = \frac{\text{mass}}{\text{volume}} = \frac{3.402 \text{ g}}{1.26 \text{ ml}} = 2.70 \text{ g/ml}$$

55. Convert the following temperatures to the Kelvin Scale:

a. 0°F

$$K = \frac{(0^\circ\text{F} - 32)}{1.8} + 273.15 = 255 \text{ K}$$

b. 0°C

$$K = 0^\circ\text{C} + 273 = 273 \text{ K}$$

c. 45.0°C

$$K = 45.0^\circ\text{C} + 273.15 = 318.2 \text{ K}$$

d. 212°F

$$K = \frac{(212^\circ\text{F} - 32)}{1.8} + 273.15 = 373 \text{ K}$$

e. 250°C

$$K = 250^\circ\text{C} + 273.15 = 523 \text{ K}$$

56. Convert the following temperatures into the Celsius Scale:

a. 32°F

$$C = \frac{(32^{\circ}\text{F} - 32)}{1.8} = 0^{\circ}\text{C}$$

b. 500 K

$$C = 500\text{ K} - 273.15 = 227^{\circ}\text{C}$$

c. 250 K

$$C = 250\text{ K} - 273.15 = -23^{\circ}\text{C}$$

d. 120°F

$$C = \frac{(120^{\circ}\text{F} - 32)}{1.8} = 49^{\circ}\text{C}$$

e. 95°F

$$C = \frac{(95^{\circ}\text{F} - 32)}{1.8} = 35^{\circ}\text{C}$$

UNCERTAINTY IN MEASUREMENTS AND SIGNIFICANT FIGURES

57. Determine the number of significant figures in the following:

- 1.000 nm – 4 significant figures
- 100 nm – 1 significant figure
- 403100 L – 4 significant figures
- 91303 ml – 5 significant figures
- 9.1303 ml – 5 significant figures

58. Determine the number of significant figures in the following:

- 0.500 ml – 3 significant figures
- 9.1300 L – 5 significant figures
- 1001 balloons – Infinite significant figures – this is an exact number.
- 403°C – 3 significant figures
- 403.0°C – 4 significant figures
- 4.1×10^4 mm – 2 significant figures

59. Determine the number of significant figures in the following:

- 4.012×10^{-6} m – 4 significant figures
- 7.0123 m – 5 significant figures
- 0.0002341 L – 4 significant figures
- 0.004200 ml – 4 significant figures
- 100100 mi – 4 significant figures

60. Determine the number of significant figures in the following:

- a. 2.100 L – 4 significant figures
- b. 2.100 mL – 4 significant figures
- c. 2,100 L – 2 significant figures
- d. 2,100.00 L – 6 significant figures
- e. 0.0021000 mL – 5 significant figures

61. Which of the following are exact numbers?

- a. The ball was dropped 23.2 feet. – 3 significant figures
- b. There are 7 students in class. – Infinite significant figures – this is an exact number.
- c. The radius of a circle is the diameter divided by 2. – Infinite significant figures – this is an exact number.
- d. There are 12 inches in 1 foot. – Infinite significant figures - this is an exact number.
- e. The table is 12.5 feet long. – 3 significant figures

b., c., and d. are exact numbers.

62. Which of the following are exact numbers?

- a. During a trip an automobile travels at an average speed of 23 mph – 2 significant figures
- b. 12 = 1 dozen – Infinite significant figures – this is an exact number.
- c. The mass of a coin is 4.31 g. – 3 significant figures
- d. There are 7 pencils in my briefcase. – Infinite significant figures – this is an exact number.
- e. It is 32.25 km to the next town. – 4 significant figures

b., and d. are exact numbers.

63. Write 1,278,342 to 3 significant figures.

1,280,000

64. Write 0.087217005 to 4 significant figures.

0.08722

65. Write 2000 to 2 significant figures. (Hint: You may have to use scientific notation.)

2.0×10^3

66. Write each of the following to 4 significant figures:

- a. 1
1.000
- b. 10
10.00
- c. 123
123.0
- d. 1230001
 1.230×10^6

e. 2101.799

$2,102$

f. 0.0221945

0.02219

g. $2,222,999$

$2,223,000$

h. 7.901296430

7.901

67. Perform the following calculation to the correct number of significant figures:

$4.5 + 3.19 + 0.000321 =$

Since the last significant digit for 4.5 is in the tenths place, this will be the position of the last significant digit in the result: $7.690321 = \mathbf{7.7}$

68. Perform the following calculation to the correct number of significant figures:

$4.5 - 3.19 =$

Since the last significant digit for 4.5 is in the tenths place, this will be the position of the last significant digit in the result: $1.31 = \mathbf{1.3}$

69. Perform the following calculation to the correct number of significant figures:

$(3.98)(9.2134) =$

Since 3.98 has the fewest significant digits (3), the result will also have 3 significant digits: $36.66933 = \mathbf{36.7}$

70. Perform the following calculation to the correct number of significant figures:

$4.32 \div 67.009 = 0.0645$

71. Perform the following calculations to the correct number of significant figures:

a. $53.23 - 1.0 = 52.2$

b. $21.2241 + 7.23 + (4.321 \times 10^{-8}) = 28.45$

c. $1.93001 + 2.403 + 6.0000 = 10.333$

d. $77.88 + 88.1 - 10.0000 = 156.0$

72. Perform the following calculations to the correct number of significant figures:

a. $9.0000 + 10.0000 - 1.00 = 18.00$

b. $(2.0 \times 10^5) + 111 + 222 = 2.0 \times 10^5$

c. $23.321 + 1,000 - 10.25 = 1,000$

d. $32.78 - 16.11124 - 6.234 = 10.43$

73. Perform the following calculations to the correct number of significant figures:

- $5 \times 1000 = 5000$
- $5.32 \div 21.311 \times 120 = 30.$
- $66.21 \times 2.3 \times 9.5 = 1,400$
- $12345 \div 1 = 10,000$

74. Perform the following calculations to the correct number of significant figures:

- $(4.7 \times 10^4) \times 2.398 = 110,000$
- $8.129 \div 4.07 \times 6.231 = 12.4$
- $3.4037 \div (1.82 \times 10^{-3}) \div 5.001 = 374$
- $100.0 \div 2.10 \times 1,000,000 = 5 \times 10^7$

75. Explain the correct order of mathematical operations when carrying out calculations involving measured numbers.

Calculations should be carried out in the following order of mathematical operations:

- Parentheses** – all operations in parentheses should be carried out first and the resulting number of significant figures determined for the resulting values.
- Exponents** – all exponential notations should be executed.
- Multiplication/Division** – All multiplication and division should be carried out following any operations in parentheses or exponential terms.
- Addition/Subtraction**

At each step, the last significant figure should be determined in the resulting terms. This allows appropriate application of the rules regarding significant figures to be applied at each step of the process.

76. Perform the following calculations to the correct number of significant figures:

- $4.57 \times \frac{4.113}{(12.89 + 1.9975)} + 12.095 = 4.57 \times \frac{4.113}{14.8875} + 12.095 = 13.36$
- $(12.43 + 2.10001) + (3.776 - 1.2015) = 14.53001 + 2.5745 = 17.10$
- $6.109 \times \frac{(9.531 - 4.23)}{(894.2 - 892.109)} + 10.2387 = 6.109 \times \frac{5.301}{2.091} + 10.2387 = 26$
- $4.1 \div 1.064 \times (4.21 - 6.321) = -8.1$

77. Perform the following calculations to the correct number of significant figures:

- $7.019 + 42.1 \div 3.9000 = 17.8$
- $9.927 \times \frac{4.0000}{2.0} + 11.1 = 31$
- $1.1 \times 5.890 \div (10.1 + 9.013) = 0.34$
- $\frac{(7.01 - 2.5)}{(8.09991 \times 1.0)} \times (11.0021 + 4.1) = 8.4$

DIMENSIONAL ANALYSIS – CREATING AND USING CONVERSION FACTORS

78. If the density of a sample is 0.8901 g/ml, what is the mass of the sample if it displaces 4.12 ml of water in a graduated cylinder?

Since the sample displaces 4.12 ml of water, we know this is the volume of the sample. Therefore, we can use density as a conversion factor to determine its mass.

$$4.12 \text{ ml} \times \frac{0.8901 \text{ g}}{1 \text{ ml}} = 3.67 \text{ g}$$

79. The density of acetone (nail polish remover) is 0.7845 g/ml. What is the mass in kg of a sample with a volume of 2.73 L?

$$2.73 \text{ L} \times \frac{1000 \text{ ml}}{1 \text{ L}} \times \frac{0.7845 \text{ g}}{1 \text{ ml}} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 2.14 \text{ kg}$$

80. The density of isopropyl alcohol is 0.7860 g/ml. What is the mass of a sample (in grams) if its volume is 1.12 ml?

$$1.12 \text{ ml} \times \frac{0.7860 \text{ g}}{1 \text{ ml}} = 0.880 \text{ g}$$

81. The density of water is 1.00 g/ml. If a 3.0 L container is full of water, what is the mass of the water in the container?

$$3.0 \text{ L} \times \frac{1000 \text{ ml}}{1 \text{ L}} \times \frac{1.00 \text{ g}}{1 \text{ ml}} = 3.0 \times 10^3 \text{ g}$$

82. If a certain area is defined by a rectangle with a length of 7.31 miles and a width of 3.48 miles, what is this area in square meters?

$$(7.31 \text{ mi} \times 3.48 \text{ mi}) \times \left(\frac{1 \text{ km}}{0.62137 \text{ mi}} \right)^2 \times \left(\frac{1000 \text{ m}}{1 \text{ km}} \right)^2 = 6.59 \times 10^7 \text{ m}^2$$

83. If a backyard pool is 8.0 m long, 4.0 m wide, and has an average depth of 2.0 m (from the water level to the bottom), how many gallons of water are required to fill the pool? (Hint: 1 gal. = 3.785 L)

$$(8.0 \text{ m} \times 4.0 \text{ m} \times 2.0 \text{ m}) \times \left(\frac{10 \text{ dm}}{1 \text{ m}} \right)^3 \times \frac{1 \text{ L}}{1 \text{ dm}^3} \times \frac{1 \text{ gal}}{3.785 \text{ L}} = 17,000 \text{ gallons}$$

84. How many inches are in 1 Tm? (Hint: 2.54 cm = 1 in)

$$1 \text{ Tm} \times \frac{10^{12} \text{ m}}{1 \text{ Tm}} \times \frac{100 \text{ cm}}{1 \text{ m}} \times \frac{1 \text{ in.}}{2.54 \text{ cm}} = 3.94 \times 10^{13} \text{ in.}$$

85. How many cm are in 1 foot? (Hint: 2.54 cm = 1 in.)

$$1 \text{ ft.} \times \frac{12 \text{ in.}}{1 \text{ ft.}} \times \frac{2.54 \text{ cm}}{1 \text{ in.}} = 30.5 \text{ cm}$$

86. If a container weighs 111.34 g empty and is then filled with water, weighed again, and found to weigh 611.76 g when full, what volume can the container hold?

First you need to recall that the density of water is 1.00 g/ml. Then you must deduce the weight of the water alone. This weight is determined by calculating the difference in weight between the empty and full container.

$$(611.76 \text{ g} - 111.34 \text{ g}) \times \frac{1 \text{ ml}}{1.00 \text{ g}} = 500.42 \text{ ml}$$

This is an approximately ½ L-container

KEY TERMS

Absolute zero The temperature at which there is no thermal energy at all. As such, the point 0 Kelvin (0 K) is the lowest possible temperature reading on the Kelvin scale.

Celsius One of the three main temperature scales. In the Celsius scale, pure water freezes at 0°C and boils at 100°C. The Celsius scale is of practical convenience because its units and reference point are all based on the freezing and boiling points of pure water.

Chemistry The study of matter, its structure, its properties, and the processes it undergoes.

Conversion factor A ratio constructed from a mathematic equality which can be used to interconvert between different units of measurement.

Density The quantitative relation between the mass of a substance and its volume. It is a measure of how much matter is contained in a given unit of volume for a particular substance.

Derived units *Units* are quantities. As such, they can be multiplied and divided like any other algebraic quantity. The results of applying mathematical operations to *units*, is the formation of new units. These are sometimes referred to as *derived units*.

Dimensional analysis A method which relies on the construction and use of *conversion factors* to convert from one set of units to another in the expression of a given quantity.

Experiment A scientific procedure carried out under controlled conditions to test a theory, law, or hypothesis.

Fahrenheit One of the three main temperature scales. In the Fahrenheit scale, saturated salt water freezes at 0°F and pure water boils at 212°F.

Gram The base unit of the measurement for mass in the metric system.

Hypothesis A tentative or speculative explanation for observations. This becomes the basis for future experiment(s) and observation(s).

Imperial system The most common system of measurement in the United States. This system includes familiar units such as the pound (lb), the mile (mi), yards (yds), feet (ft), inches (in), quarts (qt), and gallons (gal).

International system (SI) The official system of measurement for most of the world. The SI system is based on the *metric system*.

Kelvin One of the three main temperature scales. The Kelvin scale is unique in that its zero point is the coldest possible temperature, *absolute zero*.

Liter A unit of volume in the metric system. The liter is defined as 1 cubic decimeter (dm^3).

Mass The measure of how much matter an object contains. More accurately, it is the quantitative measure of how much matter makes up a sample.

Matter (from the Latin word, *materia*, meaning material) is defined as anything that has mass and occupies space.

Meter The base unit in the metric and SI systems for length. 1 meter is equal to 3.28 feet.

Metric system A base-10 system of measurement. The metric system is the basis for the SI system and employs prefix multipliers to amplify or diminish base units of measurement by powers of 10.

Observation An observation may be *qualitative* and as simple as noting some phenomenon observed by the naked eye. It may also be *quantitative* in nature, requiring tools or instruments in order to be recorded and understood.

Prefix multipliers A prefix multiplier is applied to a unit and either multiplies or divides it by some power of 10. For example, 1 centimeter is 1/100 of a meter.

Scientific law A summary statement (or mathematical equation) which describes a set of observations and can be used to make predictions about the outcome of future events or experiments.

Scientific method The systematic acquisition of knowledge through observation and experiment.

Scientific notation A system in which numbers are expressed as products of a coefficient between 1 and 10 multiplied by powers of ten.

Significant figures Those digits in a measured or calculated number which are meaningful.

Temperature The measure of the average kinetic energy of the molecules or particles that make up a sample.

Theory A model which describes the underlying explanations of all observations. Theories are the height of scientific knowledge. They are models of how the world works, which are supported by large bodies of experimental data and can be used to predict entirely new observations across a wide range of phenomena.

Unit of measurement A generally accepted *quantity* which is used to accurately and reproducibly report experimental measurements.

Volume The measure of how much space a sample of matter occupies.