Chapter 2

Evidence Collection and Preservation

2. [Answers will vary.] An example of a chemical process is converting carbohydrates into ATP (usable energy) to “run” your body. An example of a physical process is when rain freezes and turns into snow/ice.

4. Examples of chemical properties include flammability, rusting, and explosiveness.

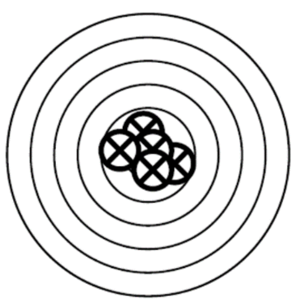
6. The unit of a measurement communicates critical information about the size of an object. For example, the length of a 1-m object is different than the length of a 1-km object.

8. 1 mL (milliliter) = 1 cc (cubic centimeter) = 1 cm^3 (centimeter cubed)

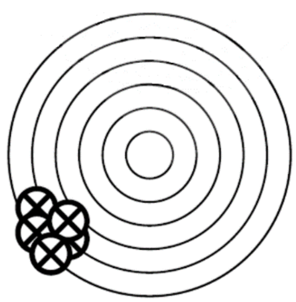
10. A conversion factor is used by dividing by the units you wish to cancel and multiplying by the units you want in the final answer. It is a mathematical method of using proportionalities to convert from one unit to another.

12. Whenever you make a measurement, you basically are sure of all digits except the last one, which can change based on observations between people. This is the inherent error in any measurement.

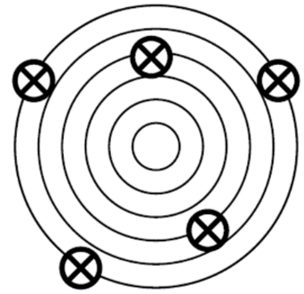
14.



Accurate and Precise



Precise but Not Accurate



Neither Accurate nor Precise

16. (a) Formation of clouds and rain is a physical change.
    (b) Freezing biological samples for storage is a physical change.
    (c) Baking bread dough is a chemical change.
    (d) Detonation of TNT is a chemical change.

18. (a) Refractive index is a physical property.
    (b) Boiling point is a physical property.
    (c) Explosiveness is a chemical property.
    (d) Inertness is a chemical property

20. (a) Weight is measured in pounds.
    (b) Weight measures gravity pulling on matter.
    (c) Mass is measured with a balance.
    (d) Mass is independent of gravity.

22. (a) mega-; M; 1,000,000 (c) milli-; m; 0.001
    (b) deci-; d; 0.1 (d) giga-; G; 1,000,000,000

24. (a) 0.01 = c (centi-)
    (b) 1,000,000 = M (mega-)
    (c) 0.000 001 = µ (micro-)
    (d) 1,000,000,000 = G (giga-)

26. (a) $4.43\times10^{6}\,\text{g}\left(\frac{1\,\text{Mg}}{10^{6}\ \text{g}}\right)=4.43\,\text{Mg}$

    (b) $7.22\,\text{m}\left(\frac{1\,\text{cm}}{10^{-2}\ \text{m}}\right)=7.22\times10^{2}\ \text{m}$

    (c) $1.20\times10^{-4}\,\text{s}\left(\frac{1\,\text{ms}}{10^{-3}\ \text{s}}\right)=1.20\times10^{-1}\ \text{ms}$

    (d) $0.214\,\text{g}\left(\frac{1\,\text{mg}}{10^{-3}\ \text{g}}\right)=2.14\times10^{2}\ \text{mg}$

28. (a) $18.1\,\text{ft.}\left(\frac{12\,\text{in.}}{1\ \text{ft.}}\right)\left(\frac{2.54\,\text{cm}}{1\ \text{in.}}\right)=552\,\text{cm}$

    (b) $328\,\text{cm}\left(\frac{1\text{in.}}{2.54\ \text{cm}}\right)\left(\frac{1\text{ft}}{12\ \text{in.}}\right)\left(\frac{1\,\text{yd}}{3\ \text{ft.}}\right)=3.59\,\text{yd.}$

    (c) $72.5\text{in.}\left(\frac{1\text{ft.}}{12\ \text{in.}}\right)\left(\frac{1\,\text{yd.}}{3\ \text{ft.}}\right)=2.01\,\text{yd.}$

    (d) $1.88\,\text{yd.}\left(\frac{3\text{ft.}}{1\ \text{yd.}}\right)\left(\frac{12\,\text{in.}}{1\ \text{ft.}}\right)\left(\frac{2.54\,\text{cm}}{1\ \text{in.}}\right)\left(\frac{10^{-2}\ \text{m}}{1\ \text{cm}}\right)=1.72\,\text{m}$

30. (a) $61\,\text{yd.}^2\left(\frac{3\,\text{ft.}}{1\,\text{yd.}}\right)^2\left(\frac{12\,\text{in.}}{1\,\text{ft.}}\right)^2\left(\frac{2.54\,\text{cm}}{1\,\text{in.}}\right)^2\left(\frac{10^{-2}\,\text{m}}{1\,\text{cm}}\right)^2 = 51\,\text{m}^2$

(b) $322\,\text{km}^2\left(\frac{10^3\,\text{m}}{1\,\text{km}}\right)^2\left(\frac{1\,\text{cm}}{10^{-2}\,\text{m}}\right)^2 = 3.22\times10^{12}\,\text{cm}^2$

(c) $8.0\,\text{m}^3\left(\frac{1\,\text{cm}}{10^{-2}\,\text{m}}\right)^3 = 8.0\times10^6\,\text{cm}^3$

(d) $14\,\text{in.}^3\left(\frac{2.54\,\text{cm}}{1\,\text{in.}}\right)^3\left(\frac{10^{-2}\,\text{m}}{1\,\text{cm}}\right)^3\left(\frac{1\,\text{mm}}{10^{-3}\,\text{m}}\right)^3 = 2.3\times10^5\,\text{mm}^3$

32. (a) $38\frac{\mu\text{L}}{\text{min}}\left(\frac{10^{-6}\,\text{L}}{1\,\mu\text{L}}\right)\left(\frac{1\,\text{mL}}{10^{-3}\,\text{L}}\right)\left(\frac{60\,\text{min}}{1\,\text{hr}}\right) = 2.3\frac{\text{mL}}{\text{hr}}$

(b) $46\frac{\text{gal}}{\text{day}}\left(\frac{3.79\,\text{L}}{1\,\text{gal}}\right)\left(\frac{1\,\text{day}}{24\,\text{hr}}\right)\left(\frac{1\,\text{hr}}{60\,\text{min}}\right)\left(\frac{1\,\text{min}}{60\,\text{s}}\right) = 2.0\times10^{-3}\frac{\text{L}}{\text{s}}$

(c) $324\frac{\text{ft.}}{\text{s}}\left(\frac{12\,\text{in.}}{1\,\text{ft.}}\right)\left(\frac{2.54\,\text{cm}}{1\,\text{in.}}\right)\left(\frac{10^{-2}\,\text{m}}{1\,\text{cm}}\right)\left(\frac{1\,\text{km}}{10^3\,\text{m}}\right)\left(\frac{60\,\text{s}}{1\,\text{min}}\right)\left(\frac{60\,\text{min}}{1\,\text{hr}}\right) = 356\frac{\text{km}}{\text{hr}}$

(d) $79\frac{\text{mg}}{\text{mL}}\left(\frac{10^{-3}\,\text{g}}{1\,\text{mg}}\right)\left(\frac{1\,\text{kg}}{10^3\,\text{g}}\right)\left(\frac{1\,\text{mL}}{10^{-3}\,\text{L}}\right) = 7.9\times10^{-2}\frac{\text{kg}}{\text{L}}$

34. (a) 3
(b) 3
(c) 3
(d) 3

36. (a) $125 = 1.25 \times 10^2$
(b) $0.00032 = 3.2 \times 10^{-4}$
(c) $51 = 5.1 \times 10^1$
(d) $0.00223 = 2.23 \times 10^{-3}$

38. (a) 84.5°C
(b) 58.0°C
(c) 69.0°C
(d) 92.0°C

40. (a) 2.50×10^3
(b) 0.0310
(c) 289
(d) 4.40×10^5

42. (a) $51.220 = 5.12 \times 10^1$ with 3 significant figures
(b) $4{,}655.82 = 4.656 \times 10^3$ with 4 significant figures
(c) $77.56 = 7.76 \times 10^1$ with 3 significant figures
(d) $0.00157 = 2 \times 10^{-3}$ with 1 significant figure

46. (a) $0.003757 = 3.76 \times 10^{-3}$ with 3 significant figures
(b) $85{,}817 = 8.58 \times 10^{4}$ with 3 significant figures
(c) $1{,}267{,}300 = 1.267 \times 10^{6}$ with 4 significant figures
(d) $0.2281 = 2.3 \times 10^{-1}$ with 2 significant figures

48. (a) $45.5 + 0.0023 + 17 = 62.5023 \approx 63$
(b) $34.4 - 7.92 - 0.0731 = 26.4069 \approx 26.4$
(c) $56 - 17.98 + 0.02 = 38.04 \approx 38$
(d) $1.45 + 101 - 12.02 = 90.43 \approx 9.0 \times 10^{1}$

50. (a) $642 \div 32.90 \div 100.0 = 0.1951367781 \approx 0.195$
(b) $47 \times 23.3 \times 10.1 = 11{,}000 = 11{,}060.51 = 1.106051 \times 10^{4} \approx 1.1 \times 10^{4}$
(c) $82.901 \div 26.8 \times 3.33 = 10.30075858 \approx 10.3$
(d) $3967 \times 0.022 \div 9.09 = 9.60110011 \approx 9.6$

52. (a) $76.3 - 23.345 \div 16.0 = 76.3 - 1.4590625 \approx 76.3 - 1.46 = 74.84 \approx 74.8$
(b) $8.240 \times 37.2 - 119.00 = 306.528 - 119.00 \approx 307 - 119.00 = 188$
(c) $(1.003 \times 23.0) + 173.90 = 23.069 + 173.90 \approx 23.1 + 173.90 = 197.0$
(d) $56.2 \div 2.300 + 9 = 24.43478261 + 9 \approx 24.4 + 9 = 33.4 \approx 33$

54. Set (d) has good precision but poor accuracy. The numbers are grouped closely together but are all significantly different from the true value of the measurement.

56. (a) $D = \dfrac{12.82\,\text{g}}{8.571\,\text{cc}} = 1.496\ \text{g/cc} = 1.496\,\text{g/cm}^3$

(b) $D = \dfrac{2.34\,\text{g}}{1.54\,\text{mL}} = 1.52\ \text{g/mL} = 1.52\,\text{g/cm}^3$

(c) $D = \dfrac{9.23\,\text{g}}{4.23\,\text{cm}^3} = 2.18\,\text{g/cm}^3$

(d) $D = \dfrac{4.73\,\text{g}}{7.66\,\text{mL}} = 0.617\,\text{g/mL} = 0.617\,\text{g/cm}^3$

58. In all four cases, use the formula volume = mass ÷ density.

(a) $V = \dfrac{24.51\,\text{g}}{0.864\,\text{g/mL}} = 28.4\,\text{mL}$

(b) $V = \dfrac{16.6\,\text{g}}{2.77\,\text{g/cc}} = 5.99\,\text{cc}$

(c) $V = \dfrac{6.31\,\text{g}}{11.0\,\text{g/mL}} = 0.574\,\text{mL}$

(d) $V = \dfrac{5.300\,\text{g}}{8.76\,\text{g/cm}^3} = 0.605\,\text{cm}^3$

60. In all four cases, use the formula mass = density × volume.

(a) $m = \left(3.91 \frac{\text{g}}{\text{mL}}\right) \times (8.12\,\text{mL}) = 31.7\,\text{g}$

(b) $m = \left(0.791 \frac{\text{g}}{\text{mL}}\right) \times (14.3\,\text{mL}) = 11.3\,\text{g}$

(c) $m = \left(2.34 \frac{\text{g}}{\text{cc}}\right) \times (4.70\,\text{cc}) = 11.0\,\text{g}$

(d) $m = \left(7.44 \frac{\text{g}}{\text{cm}^3}\right) \times (25.0\,\text{cm}^3) = 186\,\text{g}$

62. Physical properties that are used to compare soils could be color, odor, hardness, and texture. If a soil sample from the suspect matches that from the crime scene, then water and mineral composition need to be determined and matched as well.

64. $$0.08 \frac{\text{g}}{\text{dL}} \left(\frac{1\ \text{mg}}{10^{-3}\ \text{g}}\right)\left(\frac{1\ \text{dL}}{10^{-1}\ \text{L}}\right)\left(\frac{10^{-3}\ \text{L}}{1\ \text{mL}}\right) = 0.8 \frac{\text{mg}}{\text{mL}}$$

$$0.08 \frac{\text{g}}{\text{dL}} \left(\frac{1\ \text{dL}}{10^{-1}\ \text{L}}\right) = 0.8 \frac{\text{g}}{\text{L}}$$

$$0.08 \frac{\text{g}}{\text{dL}} \left(\frac{1\ \text{mg}}{10^{-3}\ \text{g}}\right) = 80 \frac{\text{mg}}{\text{dL}}$$

66. If the legal BAC is 80 mg/dL (see solution for question 64), then it is possible to mistake a sober victim as legally drunk because of postmortem alcohol production.

68. If ΔV = 27.54 mL – 24.00 mL = 3.54 mL, and the mass of the glass is 7.89 g, then the density is equal to 7.89 g ÷ 3.54 mL = 2.23 g/mL. The glass that matches this density is borosilicate.

70. This is a chemical change because the gunpowder has been ignited and isn't the same solid; it's a heterogeneous mixture because the smoke clearly has different regions.

72. If a glass sample has a softening point in the range of 718°C to 723°C, the possible glass types are alkali borosilicate, alkali zinc borosilicate, and borosilicate. Once the density is determined to be 2.6 g/cm^3, the glass sample is positively identified as being alkali zinc borosilicate.

74. $$9.68\,\text{grams} \times \left(\frac{1\,\text{grain}}{0.0648\,\text{grams}}\right) = 149\,\text{grains}$$

If a .357 Magnum bullet could range from 125 grains to 180 grains, then the bullet recovered from the crime scene could possibly have been a Magnum bullet.

76. $$154\,\text{lb}\left(\frac{454\,\text{g}}{1\,\text{lb}}\right)\left(\frac{1\text{ kg}}{10^3\text{ g}}\right)=69.9\,\text{kg}$$

$$69.9\,\text{kg body mass}\left(\frac{192\,\text{mg caffeine}}{1\,\text{kg body mass}}\right)\left(\frac{10^{-3}\,\text{g}}{1\,\text{mg}}\right)=13.4\,\text{g caffeine}$$

$$69.9\,\text{kg body mass}\left(\frac{0.3\,\text{mg nicotine}}{1\,\text{kg body mass}}\right)\left(\frac{10^{-3}\,\text{g}}{1\,\text{mg}}\right)=0.0210\,\text{g nicotine}$$

78. At most, only half of the surface area of the human body is visible at any given time (it is impossible to see all of one person; either the front or the back is visible, for example). If the average surface area of a human is 1.8 m^2, then at most 0.9 m^2 would be visible from any given direction.

$$10\,\text{mi}^2\left(\frac{1\,\text{km}}{0.621\,\text{mi}}\right)^2\left(\frac{10^3\text{ m}}{1\text{ km}}\right)^2=2.6\times10^7\text{ m}^2\text{ area}$$

($0.9\text{ m}^2 \div 2.6 \times 10^7\text{ m}^2$) × 100% = 3.5×10^{-6}% of the 10-square-mile area

80. [Answers will vary.] Pollen analysis would likely not be helpful for this particular case as the pollen profiles of the various areas around the camp where the murder took place may not be significantly different or unique.

82. If the only evidence at the scene is a shard of glass, the investigator must be extremely careful in considering the possibilities. The shard of glass might come from a bottle or jar that is made in a particular location or manufacturing plant, so it might be possible to link the shard to a specific location. It might be possible that the suspect could collect a particular type of glass container and that the glass used has some sort of unique composition. The color, refractive index, thickness, and shape of the glass shard should be closely compared with reference samples to determine whether a link can be made.

84. $$\frac{41.2\,\text{ft.}}{0.546\,\text{s}}\left(\frac{1\,\text{mi}}{5280\text{ ft.}}\right)\left(\frac{60\,\text{s}}{1\text{ min}}\right)\left(\frac{60\,\text{min}}{1\text{ hr}}\right)=51.4\,\frac{\text{mi}}{\text{hr}}$$

Yes, the suspect was speeding on the surveillance camera tape.