CHAPTER 1

MATTER—ITS PROPERTIES AND MEASUREMENT

PRACTICE EXAMPLES

1A **(E)** Convert the Fahrenheit temperature to Celsius and compare.
$^\circ C = \left(^\circ F - 32^\circ F\right)\frac{5^\circ C}{9^\circ F} = \left(350\ ^\circ F - 32^\circ F\right)\frac{5^\circ C}{9^\circ F} = 177\ ^\circ C$.

1B **(E)** We convert the Fahrenheit temperature to Celsius. $^\circ C = \left(^\circ F - 32\ ^\circ F\right)\frac{5^\circ C}{9^\circ F} = \left(-15^\circ F - 32\ ^\circ F\right)\frac{5^\circ C}{9^\circ F} = -26\ ^\circ C$. The antifreeze only protects to $-22^\circ C$ and thus it will not offer protection to temperatures as low as $-15\ ^\circ F = -26.1\ ^\circ C$.

2A **(E)** The mass is the difference between the mass of the full and empty flask.

$$\text{density} = \frac{291.4\text{ g} - 108.6\text{ g}}{125\text{ mL}} = 1.46\text{ g/mL}$$

2B **(E)** First determine the volume required. V = (1.000 × 10^3 g) ÷ (8.96 g cm^{-3}) = 111.$\underline{6}$ cm^3.
Next determine the radius using the relationship between volume of a sphere and radius.

$$V = \frac{4}{3}\pi r^3 = 111.\underline{6}\text{ cm}^3 = \frac{4}{3}(3.1416)r^3 \qquad r = \sqrt[3]{\frac{111.6\times 3}{4(3.1416)}} = 2.987\text{ cm}$$

3A **(E)** The volume of the stone is the difference between the level in the graduated cylinder with the stone present and with it absent.

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{28.4\text{ g rock}}{44.1\text{ mL rock \&water} - 33.8\text{ mL water}} = 2.76\text{ g/mL} = 2.76\text{ g/cm}^3$$

3B **(E)** The water level will remain unchanged. The mass of the ice cube displaces the same mass of liquid water. A 10.0 g ice cube will displace 10.0 g of water. When the ice cube melts, it simply replaces the displaced water, leaving the liquid level unchanged.

4A **(E)** The mass of ethanol can be found using dimensional analysis.

$$\text{ethanol mass} = 25\text{ L gasohol}\times\frac{1000\text{ mL}}{1\text{ L}}\times\frac{0.71\text{ g gasohol}}{1\text{ mL gasohol}}\times\frac{10\text{ g ethanol}}{100\text{ g gasohol}}\times\frac{1\text{ kg ethanol}}{1000\text{ g ethanol}}$$
$$= 1.8\text{ kg ethanol}$$

4B **(E)** We use the mass percent to determine the mass of the 25.0 mL sample.

$$\text{rubbing alcohol mass} = 15.0\text{ g (2-propanol)}\times\frac{100.0\text{ g rubbing alcohol}}{70.0\text{ g (2-propanol)}} = 21.4\underline{3}\text{ g rubbing alcohol}$$

$$\text{rubbing alcohol density} = \frac{21.4\text{ g}}{25.0\text{ mL}} = 0.857\text{ g/mL}$$

5A **(M)** For this calculation, the value 0.000456 has the least precision (three significant figures), thus the final answer must also be quoted to three significant figures.

$$\frac{62.356}{0.000456 \times 6.422 \times 10^3} = 21.3$$

5B **(M)** For this calculation, the value 1.3×10^{-3} has the least precision (two significant figures), thus the final answer must also be quoted to two significant figures.

$$\frac{8.21 \times 10^4 \times 1.3 \times 10^{-3}}{0.00236 \times 4.071 \times 10^{-2}} = 1.1 \times 10^6$$

6A **(M)** The number in the calculation that has the least precision is 102.1 ($\pm$0.1), thus the final answer must be quoted to just one decimal place. $0.236 + 128.55 - 102.1 = 26.7$

6B **(M)** This is easier to visualize if the numbers are not in scientific notation.

$$\frac{\left(1.302 \times 10^3\right) + 952.7}{\left(1.57 \times 10^2\right) - 12.22} = \frac{1302 + 952.7}{157 - 12.22} = \frac{2255}{145} = 15.6$$

INTEGRATIVE EXAMPLE

A **(D)** *Stepwise Approach:* First, determine the density of the alloy by the oil displacement.
Mass of oil displaced = Mass of alloy in air – Mass of alloy in oil
= 211.5 g – 135.3 g = 76.2 g

V_{Oil} = m / D = 76.2 g / 0.926 g/mL = 82.3 mL = $V_{Mg\text{-}Al}$

$D_{Mg\text{-}Al}$ = 211.5 g / 82.3 mL = 2.57 g/cc
Now, since the density is a linear function of the composition,

$D_{Mg\text{-}Al}$ = mx + b, where x is the mass fraction of Mg, and b is the y-intercept.
Substituting 0 for x (no Al in the alloy), everything is Mg and the equation becomes:

1.74 = m · 0 + b. Therefore, b = 1.74

Assuming 1 for x (100% by weight Al):

2.70 = (m × 1) + 1.74, therefore, m = 0.96

Therefore, for an alloy:

2.57 = 0.96x + 1.74

x = 0.86 = mass % of Al

Mass % of Mg = 1 – 0.86 = 0.14, 14%

B **(M)** *Stepwise approach:*

Mass of seawater = D • V = 1.027 g/mL × 1500 mL = 1540.5 g

$$1540.5 \text{ g seawater} \times \frac{2.67 \text{ g NaCl}}{100 \text{ g seawater}} \times \frac{39.34 \text{ g Na}}{100 \text{ g NaCl}} = 16.18 \text{ g Na}$$

Then, convert mass of Na to atoms of Na

$$16.18 \text{ g Na} \times \frac{1 \text{ kg Na}}{1000 \text{ g Na}} \times \frac{1 \text{ Na atom}}{3.817\times10^{-26} \text{ kg Na}} = 4.239\times10^{23} \text{ Na atoms}$$

Conversion Pathway:

$$1540.5 \text{ g seawater} \times \frac{2.67 \text{ g NaCl}}{100 \text{ g seawater}} \times \frac{39.34 \text{ g Na}}{100 \text{ g NaCl}} \times \frac{1 \text{ kg Na}}{1000 \text{ g Na}} \times \frac{1 \text{ Na atom}}{3.8175\times10^{-26} \text{ kg Na}}$$

EXERCISES

The Scientific Method

1. **(E)** One theory is preferred over another if it can correctly predict a wider range of phenomena and if it has fewer assumptions.

2. **(E)** No. The greater the number of experiments that conform to the predictions of the law, the more confidence we have in the law. There is no point at which the law is ever verified with absolute certainty.

3. **(E)** For a given set of conditions, a cause, is expected to produce a certain result or effect. Although these cause-and-effect relationships may be difficult to unravel at times ("God is subtle"), they nevertheless do exist ("He is not malicious").

4. **(E)** As opposed to scientific laws, legislative laws are voted on by people and thus are subject to the whims and desires of the electorate. Legislative laws can be revoked by a grass roots majority, whereas scientific laws can only be modified if they do not account for experimental observations. As well, legislative laws are imposed on people, who are expected to modify their behaviors, whereas, scientific laws cannot be imposed on nature, nor will nature change to suit a particular scientific law that is proposed.

5. **(E)** The experiment should be carefully set up so as to create a controlled situation in which one can make careful observations after altering the experimental parameters, preferably one at a time. The results must be reproducible (to within experimental error) and, as more and more experiments are conducted, a pattern should begin to emerge, from which a comparison to the current theory can be made.

6. **(E)** For a theory to be considered as plausible, it must, first and foremost, agree with and/or predict the results from controlled experiments. It should also involve the fewest number of assumptions (i.e., follow Occam's Razor). The best theories predict new phenomena that are subsequently observed after the appropriate experiments have been performed.

Properties and Classification of Matter

7. **(E)** When an object displays a physical property it retains its basic chemical identity. By contrast, the display of a chemical property is accompanied by a change in composition.

(a) Physical: The iron nail is not changed in any significant way when it is attracted to a magnet. Its basic chemical identity is unchanged.

(b) Chemical: The paper is converted to ash, $CO_2(g)$, and $H_2O(g)$ along with the evolution of considerable energy.

(c) Chemical: The green patina is the result of the combination of water, oxygen, and carbon dioxide with the copper in the bronze to produce basic copper carbonate.

(d) Physical: Neither the block of wood nor the water has changed its identity.

8. **(E)** When an object displays a physical property it retains its basic chemical identity. By contrast, the display of a chemical property is accompanied by a change in composition.

(a) Chemical: The change in the color of the apple indicates that a new substance (oxidized apple) has formed by reaction with air.

(b) Physical: The marble slab is not changed into another substance by feeling it.

(c) Physical: The sapphire retains its identity as it displays its color.

(d) Chemical: After firing, the properties of the clay have changed from soft and pliable to rigid and brittle. New substances have formed. (Many of the changes involve driving off water and slightly melting the silicates that remain. These molten substances cool and harden when removed from the kiln.)

9. **(E)** **(a)** Homogeneous mixture: Air is a mixture of nitrogen, oxygen, argon, and traces of other gases. By "fresh," we mean no particles of smoke, pollen, etc., are present. Such species would produce a heterogeneous mixture.

(b) Heterogeneous mixture: A silver plated spoon has a surface coating of the element silver and an underlying baser metal (typically iron). This would make the coated spoon a heterogeneous mixture.

(c) Heterogeneous mixture: Garlic salt is simply garlic powder mixed with table salt. Pieces of garlic can be distinguished from those of salt by careful examination.

(d) Substance: Ice is simply solid water (assuming no air bubbles).

10. **(E)** **(a)** Heterogeneous mixture: We can clearly see air pockets within the solid matrix. On close examination, we can distinguish different kinds of solids by their colors.

(b) Homogeneous mixture: Modern inks are solutions of dyes in water. Older inks often were heterogeneous mixtures: suspensions of particles of carbon black (soot) in water.

(c) Substance: This is assuming that no gases or organic chemicals are dissolved in the water.

(d) Heterogeneous mixture: The pieces of orange pulp can be seen through a microscope. Most "cloudy" liquids are heterogeneous mixtures; the small particles impede the transmission of light.

11. **(E)** **(a)** If a magnet is drawn through the mixture, the iron filings will be attracted to the magnet and the wood will be left behind.

(b) When the glass-sucrose mixture is mixed with water, the sucrose will dissolve, whereas the glass will not. The water can then be boiled off to produce pure sucrose.

(c) Olive oil will float to the top of a container and can be separated from water, which is more dense. It would be best to use something with a narrow opening that has the ability to drain off the water layer at the bottom (i.e., buret).

(d) The gold flakes will settle to the bottom if the mixture is left undisturbed. The water then can be decanted (i.e., carefully poured off).

12. **(E)** **(a)** Physical: This is simply a mixture of sand and sugar (i.e., not chemically bonded).

(b) Chemical: Oxygen needs to be removed from the iron oxide.

(c) Physical: Seawater is a solution of various substances dissolved in water.

(d) Physical: The water-sand slurry is simply a heterogeneous mixture.

Exponential Arithmetic

13. **(E)** **(a)** $8950. = 8.950\times10^{3}$ (4 sig. fig.)

(b) $10,700. = 1.0700\times10^{4}$ (5 sig. fig.) **(c)** $0.0240 = 2.40\times10^{-2}$

(d) $0.0047 = 4.7\times10^{-3}$ **(e)** $938.3 = 9.383\times10^{2}$ **(f)** $275,482 = 2.75482\times10^{5}$

14. **(E)** **(a)** $3.21\times10^{-2} = 0.0321$ **(b)** $5.08\times10^{-4} = 0.000508$

(c) $121.9\times10^{-5} = 0.001219$ **(d)** $16.2\times10^{-2} = 0.162$

15. **(E)** **(a)** 34,000 centimeters / second $= 3.4\times10^{4}$ cm/s

(b) six thousand three hundred seventy eight kilometers = 6378 km $= 6.378\times10^{3}$ km

(c) (trillionth $= 1\times10^{-12}$) hence, 74×10^{-12} m or 7.4×10^{-11} m

(d) $$\frac{(2.2\times10^{3})+(4.7\times10^{2})}{5.8\times10^{-3}} = \frac{2.7\times10^{3}}{5.8\times10^{-3}} = 4.6\times10^{5}$$

16. **(E)** **(a)** 173 thousand trillion watts $= 173{,}000{,}000{,}000{,}000{,}000\ \text{W} = 1.73 \times 10^{17}\ \text{W}$

(b) one ten millionth of a meter = $1 \div 10{,}000{,}000\ \text{m} = 1 \times 10^{-7}\ \text{m}$

(c) (trillionth = 1×10^{-12}) hence, 142×10^{-12} m or 1.42×10^{-10} m

(d) $$\frac{(5.07 \times 10^{4}) \times \left(1.8 \times 10^{-3}\right)^{2}}{0.065 + \left(3.3 \times 10^{-2}\right)} = \frac{0.16}{0.098} = 1.6$$

Significant Figures

17. **(E)** **(a)** An exact number—500 sheets in a ream of paper.

(b) Pouring the milk into the bottle is a process that is subject to error; there can be slightly more or slightly less than one liter of milk in the bottle. This is a measured quantity.

(c) Measured quantity: The distance between any pair of planetary bodies can only be determined through certain astronomical measurements, which are subject to error.

(d) Measured quantity: the internuclear separation quoted for O_2 is an estimated value derived from experimental data, which contains some inherent error.

18. **(E)** **(a)** The number of pages in the text is determined by counting; the result is an exact number.

(b) An exact number. Although the number of days can vary from one month to another (say, from January to February), the month of January always has 31 days.

(c) Measured quantity: The area is determined by calculations based on measurements. These measurements are subject to error.

(d) Measured quantity: Average internuclear distance for adjacent atoms in a gold medal is an estimated value derived from X-ray diffraction data, which contain some inherent error.

19. **(E)** Each of the following is expressed to four significant figures.

(a) $3984.6 \approx 3985$ **(b)** $422.04 \approx 422.0$ **(c)** $186{,}000 = 1.860 \times 10^{5}$

(d) $33{,}900 \approx 3.390 \times 10^{4}$ **(e)** 6.321×10^{4} is correct **(f)** $5.0472 \times 10^{-4} \approx 5.047 \times 10^{-4}$

20. **(E)** **(a)** 450 has two or three significant figures; trailing zeros left of the decimal are indeterminate, if no decimal point is present.

(b) 98.6 has three significant figures; non-zero digits are significant.

(c) 0.0033 has two significant digits; leading zeros are not significant.

(d) 902.10 has five significant digits; trailing zeros to the right of the decimal point are significant, as are zeros flanked by non-zero digits.

(e) 0.02173 has four significant digits; leading zeros are not significant.

(f) 7000 can have anywhere from one to four significant figures; trailing zeros left of the decimal are indeterminate, if no decimal point is shown.

(g) 7.02 has three significant figures; zeros flanked by non-zero digits are significant.

(h) 67,000,000 can have anywhere from two to eight significant figures; there is no way to determine which, if any, of the zeros are significant, without the presence of a decimal point.

21. **(E)** **(a)** $0.406 \times 0.0023 = 9.3 \times 10^{-4}$ **(b)** $0.1357 \times 16.80 \times 0.096 = 2.2 \times 10^{-1}$

(c) $0.458 + 0.12 - 0.037 = 5.4 \times 10^{-1}$ **(d)** $32.18 + 0.055 - 1.652 = 3.058 \times 10^{1}$

22. **(M)** **(a)** $\dfrac{320 \times 24.9}{0.080} = \dfrac{3.2 \times 10^{2} \times 2.49 \times 10^{1}}{8.0 \times 10^{-2}} = 1.0 \times 10^{5}$

(b) $\dfrac{432.7 \times 6.5 \times 0.002300}{62 \times 0.103} = \dfrac{4.327 \times 10^{2} \times 6.5 \times 2.300 \times 10^{-3}}{6.2 \times 10^{1} \times 1.03 \times 10^{-1}} = 1.0$

(c) $\dfrac{32.44 + 4.9 - 0.304}{82.94} = \dfrac{3.244 \times 10^{1} + 4.9 - 3.04 \times 10^{-1}}{8.294 \times 10^{1}} = 4.47 \times 10^{-1}$

(d) $\dfrac{8.002 + 0.3040}{13.4 - 0.066 + 1.02} = \dfrac{8.002 + 3.040 \times 10^{-1}}{1.34 \times 10^{1} - 6.6 \times 10^{-2} + 1.02} = 5.79 \times 10^{-1}$

23. **(M)** **(a)** 2.44×10^{4} **(b)** 1.5×10^{3} **(c)** 40.0

(d) 2.131×10^{3} **(e)** 4.8×10^{-3}

24. **(M)** **(a)** 7.5×10^{1} **(b)** 6.3×10^{12} **(c)** 4.6×10^{3}

(d) 1.058×10^{-1} **(e)** 4.2×10^{-3} (quadratic equation solution)

25. **(M)** **(a)** The average speed is obtained by dividing the distance traveled (in miles) by the elapsed time (in hours). First, we need to obtain the elapsed time, in hours.

$$9\text{ days} \times \frac{24\text{ h}}{1\text{ d}} = 216.000\text{ h} \quad 3\text{ min} \times \frac{1\text{ h}}{60\text{ min}} = 0.050\text{ h} \quad 44\text{ s} \times \frac{1\text{ h}}{3600\text{ s}} = 0.012\text{ h}$$

$$\text{total time} = 216.000\text{ h} + 0.050\text{ h} + 0.012\text{ h} = 216.062\text{ h}$$

$$\text{average speed} = \frac{25{,}012\text{ mi}}{216.062\text{ h}} \times \frac{1.609344\text{ km}}{1\text{ mi}} = 186.30\text{ km/h}$$

(b) First compute the mass of fuel remaining

$$\text{mass} = 14 \text{ gal} \times \frac{4 \text{ qt}}{1 \text{ gal}} \times \frac{0.9464 \text{ L}}{1 \text{ qt}} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{0.70 \text{ g}}{1 \text{ mL}} \times \frac{1 \text{ lb}}{453.6 \text{ g}} = 82 \text{ lb}$$

Next determine the mass of fuel used, and then finally, the fuel consumption. Notice that the initial quantity of fuel is not known precisely, perhaps at best to the nearest 10 lb, certainly ("nearly 9000 lb") not to the nearest pound.

$$\text{mass of fuel used} = (9000 \text{ lb} - 82 \text{ lb}) \times \frac{0.4536 \text{ kg}}{1 \text{ lb}} \cong 4045 \text{ kg}$$

$$\text{fuel consumption} = \frac{25{,}012 \text{ mi}}{4045 \text{ kg}} \times \frac{1.609344 \text{ km}}{1 \text{ mi}} = 9.95 \text{ km/kg or} \sim 10 \text{ km/kg}$$

26. **(M)** If the proved reserve truly was an estimate, rather than an actual measurement, it would have been difficult to estimate it to the nearest trillion cubic feet. A statement such as 2,911,000 trillion cubic feet (or even $3 \times 10^{18} \text{ ft}^3$) would have more realistically reflected the precision with which the proved reserve was known.

Units of Measurement

27. **(E)** **(a)** $0.127 \text{ L} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 127 \text{ mL}$ **(b)** $15.8 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 0.0158 \text{ L}$

(c) $981 \text{ cm}^3 \times \frac{1 \text{ L}}{1000 \text{ cm}^3} = 0.981 \text{ L}$ **(d)** $2.65 \text{ m}^3 \times \left(\frac{100 \text{ cm}}{1 \text{ m}}\right)^3 = 2.65 \times 10^6 \text{ cm}^3$

28. **(E)** **(a)** $1.55 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} = 1.55 \times 10^3 \text{ g}$ **(b)** $642 \text{ g} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 0.642 \text{ kg}$

(c) $2896 \text{ mm} \times \frac{1 \text{ cm}}{10 \text{ mm}} = 289.6 \text{ cm}$ **(d)** $0.086 \text{ cm} \times \frac{10 \text{ mm}}{1 \text{ cm}} = 0.86 \text{ mm}$

29. **(E)** **(a)** $68.4 \text{ in.} \times \frac{2.54 \text{ cm}}{1 \text{ in.}} = 174 \text{ cm}$ **(b)** $94 \text{ ft} \times \frac{12 \text{ in.}}{1 \text{ ft}} \times \frac{2.54 \text{ cm}}{1 \text{ in.}} \times \frac{1 \text{ m}}{100 \text{ cm}} = 29 \text{ m}$

(c) $1.42 \text{ lb} \times \frac{453.6 \text{ g}}{1 \text{ lb}} = 644 \text{ g}$ **(d)** $248 \text{ lb} \times \frac{0.4536 \text{ kg}}{1 \text{ lb}} = 112 \text{ kg}$

(e) $1.85 \text{ gal} \times \frac{4 \text{ qt}}{1 \text{ gal}} \times \frac{0.9464 \text{ dm}^3}{1 \text{ qt}} = 7.00 \text{ dm}^3$ **(f)** $3.72 \text{ qt} \times \frac{0.9464 \text{ L}}{1 \text{ qt}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 3.52 \times 10^3 \text{ mL}$

30. **(M)** **(a)** $1.00\ \text{km}^2 \times \left(\dfrac{1000\ \text{m}}{1\ \text{km}}\right)^2 = 1.00\times10^6\ \text{m}^2$

(b) $1.00\ \text{m}^3 \times \left(\dfrac{100\ \text{cm}}{1\ \text{m}}\right)^3 = 1.00\times10^6\ \text{cm}^3$

(c) $1.00\ \text{mi}^2 \times \left(\dfrac{5280\ \text{ft}}{1\ \text{mi}}\times\dfrac{12\ \text{in.}}{1\ \text{ft}}\times\dfrac{2.54\ \text{cm}}{1\ \text{in.}}\times\dfrac{1\ \text{m}}{100\ \text{cm}}\right)^2 = 2.59\times10^6\ \text{m}^2$

<u>31</u>. **(E)** Express both masses in the same units for comparison.

$3245\mu\text{g}\times\left(\dfrac{1\text{g}}{10^6\ \mu\text{g}}\right)\times\left(\dfrac{10^3\ \text{mg}}{1\ \text{g}}\right) = 3.245\ \text{mg}$, which is larger than 0.00515 mg.

32. **(E)** Express both masses in the same units for comparison. $0.000475\ \text{kg}\times\dfrac{1000\ \text{g}}{1\ \text{kg}} = 0.475\ \text{g}$,

which is smaller than $3257\ \text{mg}\times\dfrac{1\ \text{g}}{10^3\ \text{mg}} = 3.257\ \text{g}$.

<u>33</u>. **(E)** *Conversion pathway approach:*

$\text{height} = 15\ \text{hands}\times\dfrac{4\ \text{in.}}{1\ \text{hand}}\times\dfrac{2.54\ \text{cm}}{1\ \text{in.}}\times\dfrac{1\ \text{m}}{100\ \text{cm}} = 1.5\ \text{m}$

Stepwise approach:

$15\ \text{hands}\ \times\dfrac{4\ \text{in.}}{1\ \text{hand}} =\ 60\ \text{in.}$

$60\ \text{in.}\ \times\dfrac{2.54\ \text{cm}}{1\ \text{in.}} =\ 152.4\ \text{cm}$

$152.4\ \text{cm}\ \times\dfrac{1\ \text{m}}{100\ \text{cm}} = 1.524\ \text{m} = 1.5\ \text{m}$

34. **(M)** A mile is defined as being 5280 ft in length. We must use this conversion factor to find the length of a link in inches.

$1.00\ \text{link}\times\dfrac{1\ \text{chain}}{100\ \text{links}}\times\dfrac{1\ \text{furlong}}{10\ \text{chains}}\times\dfrac{1\ \text{mile}}{8\ \text{furlongs}}\times\dfrac{5280\ \text{ft}}{1\ \text{mi}}\times\dfrac{12\ \text{in.}}{1\ \text{ft}}\times\dfrac{2.54\ \text{cm}}{1\ \text{in.}} = 20.1\ \text{cm}$

<u>35</u>. **(M)** **(a)** We use the speed as a conversion factor, but need to convert yards into meters.

$\text{time} = 100.0\ \text{m}\times\dfrac{9.3\ \text{s}}{100\ \text{yd}}\times\dfrac{1\ \text{yd}}{36\ \text{in.}}\times\dfrac{39.37\ \text{in.}}{1\ \text{m}} = 10.\ \text{s}$

The final answer can only be quoted to a maximum of two significant figures.

(b) We need to convert yards to meters.

$$\text{speed} = \frac{100\text{ yd}}{9.3\text{ s}} \times \frac{36\text{ in.}}{1\text{ yd}} \times \frac{2.54\text{ cm}}{1\text{ in.}} \times \frac{1\text{ m}}{100\text{ cm}} = 9.8\underline{3}\text{ m/s}$$

(c) The speed is used as a conversion factor.

$$\text{time} = 1.45\text{ km} \times \frac{1000\text{ m}}{1\text{ km}} \times \frac{1\text{ s}}{9.8\underline{3}\text{ m}} \times \frac{1\text{min}}{60\text{ s}} = 2.5\text{min}$$

36. **(M)** **(a)** $\text{mass}\left(\text{mg}\right) = 2\text{ tablets} \times \frac{5.0\text{ gr}}{1\text{ tablet}} \times \frac{1.0\text{ g}}{15\text{ gr}} \times \frac{1000\text{ mg}}{1\text{ g}} = 6.7 \times 10^2\text{ mg}$

(b) $\text{dosage rate} = \frac{6.7 \times 10^2\text{ mg}}{155\text{ lb}} \times \frac{1\text{ lb}}{453.6\text{ g}} \times \frac{1000\text{ g}}{1\text{ kg}} = 9.5\text{ mg aspirin/kg body weight}$

(c) $\text{time} = 1.0\text{ kg} \times \frac{1000\text{ g}}{1\text{ kg}} \times \frac{2\text{ tablets}}{0.67\text{ g}} \times \frac{1\text{ day}}{2\text{ tablets}} = 1.5 \times 10^3\text{ days}$

<u>37</u>. **(D)** $1\text{ hectare} = 1\text{ hm}^2 \times \left(\frac{100\text{ m}}{1\text{ hm}} \times \frac{100\text{ cm}}{1\text{ m}} \times \frac{1\text{ in.}}{2.54\text{ cm}} \times \frac{1\text{ ft}}{12\text{ in.}} \times \frac{1\text{ mi}}{5280\text{ ft}}\right)^2 \times \frac{640\text{ acres}}{1\text{ mi}^2}$

1 hectare = 2.47 acres

38. **(D)** Here we must convert pounds per cubic inch into grams per cubic centimeter:

$$\text{density for metallic iron} = \frac{0.284\text{ lb}}{1\text{ in.}^3} \times \frac{454\text{ g}}{1\text{ lb}} \times \frac{(1\text{ in.})^3}{(2.54\text{ cm})^3} = 7.87\ \frac{\text{g}}{\text{cm}^3}$$

<u>39</u>. **(D)** $\text{pressure} = \frac{32\text{ lb}}{1\text{ in.}^2} \times \frac{453.6\text{ g}}{1\text{ lb}} \times \left(\frac{1\text{ in.}}{2.54\text{ cm}}\right)^2 = 2.2 \times 10^3\text{ g/cm}^2$

$$\text{pressure} = \frac{2.2 \times 10^3\text{ g}}{1\text{ cm}^2} \times \frac{1\text{ kg}}{1000\text{ g}} \times \left(\frac{100\text{ cm}}{1\text{ m}}\right)^2 = 2.2 \times 10^4\text{ kg/m}^2$$

40. **(D)** First we will calculate the radius for a typical red blood cell using the equation for the volume of a sphere. $V = 4/3\pi r^3 = 90.0 \times 10^{-12}\text{ cm}^3$

$r^3 = 2.15 \times 10^{-11}\text{ cm}^3$ and $r = 2.78 \times 10^{-4}$ cm

Thus, the diameter is $2 \times r = 2 \times 2.78 \times 10^{-4}\text{ cm} \times \frac{10\text{ mm}}{1\text{ cm}} = 5.56 \times 10^{-3}\text{ mm}$

Temperature Scales

41. **(E)** low: $^\circ F = \frac{9^\circ F}{5^\circ C}(^\circ C) + 32\ ^\circ F = \frac{9^\circ F}{5^\circ C}\left(-10\ ^\circ C\right) + 32\ ^\circ F = 14\ ^\circ F$

high: $^\circ F = \frac{9^\circ F}{5^\circ C}(^\circ C) + 32\ ^\circ F = \frac{9^\circ F}{5^\circ C}\left(50\ ^\circ C\right) + 32\ ^\circ F = 122\ ^\circ F$

42. **(E)** high: $^\circ C = \left(^\circ F - 32\ ^\circ F\right)\frac{5^\circ C}{9^\circ F} = \left(118\ ^\circ F - 32\ ^\circ F\right)\frac{5^\circ C}{9^\circ F} = 47.8\ ^\circ C \approx 48\ ^\circ C$

low: $^\circ C = \left(^\circ F - 32\ ^\circ F\right)\frac{5^\circ C}{9^\circ F} = \left(17\ ^\circ F - 32\ ^\circ F\right)\frac{5^\circ C}{9^\circ F} = -8.3\ ^\circ C$

43. **(M)** Let us determine the Fahrenheit equivalent of absolute zero.

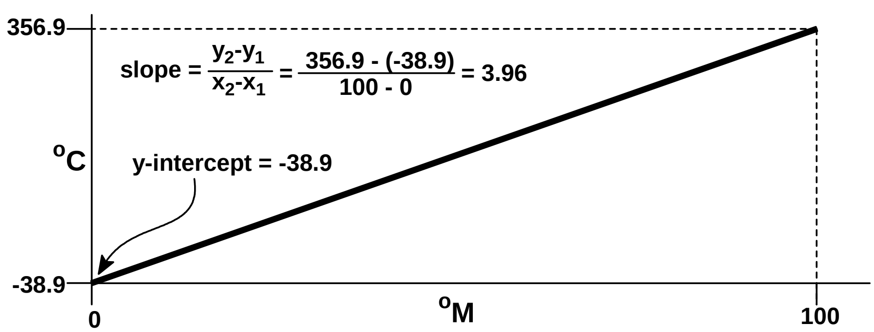
$$^\circ F = \frac{9^\circ F}{5^\circ C}(^\circ C) + 32\ ^\circ F = \frac{9^\circ F}{5^\circ C}\left(-273.15\ ^\circ C\right) + 32\ ^\circ F = -459.7\ ^\circ F$$

A temperature of $-465\ ^\circ F$ cannot be achieved because it is below absolute zero.

44. **(M)** Determine the Celsius temperature that corresponds to the highest Fahrenheit temperature, $240\ ^\circ F$. $^\circ C = \left(^\circ F - 32\ ^\circ F\right)\frac{5^\circ C}{9^\circ F} = \left(240\ ^\circ F - 32\ ^\circ F\right)\frac{5^\circ C}{9^\circ F} = 116\ ^\circ C$

Because $116\ ^\circ C$ is above the range of the thermometer, this thermometer cannot be used in this candy making assignment.

45. **(D)** **(a)** From the data provided we can write down the following relationship: -38.9 °C = 0 °M and 356.9 °C = 100 °M. To find the mathematical relationship between these two scales, we can treat each relationship as a point on a two-dimensional Cartesian graph:



Therefore, the equation for the line is y = 3.96*x* - 38.9 The algebraic relationship between the two temperature scales is

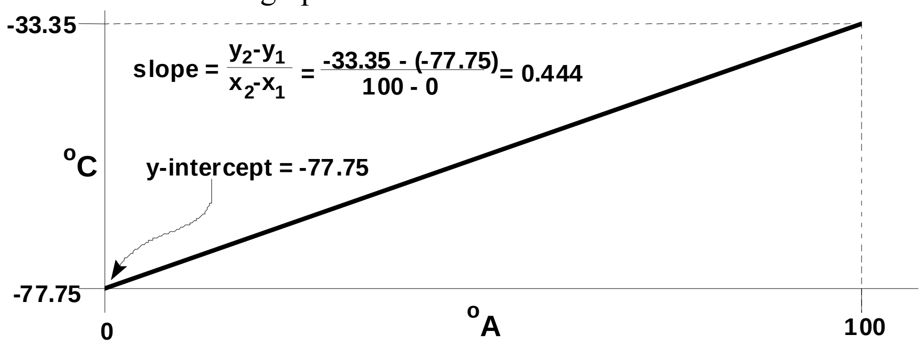
t(°C) = 3.96(°M) - 38.9 or rearranging, $t(°M) = \frac{t(^\circ C) + 38.9}{3.96}$

Alternatively, note that the change in temperature in °C corresponding to a change of 100 °M is [356.9 – (-38.9)] = 395.8 °C, hence, (100 °M/395.8 °C) = 1 °M/3.96 °C. This factor must be multiplied by the number of degrees Celsius above zero on the M scale. This number of degrees is t(°C) + 38.9, which leads to the general equation t(°M) = [t(°C) + 38.9]/3.96.

The boiling point of water is 100 °C, corresponding to $t(°M) = \dfrac{100 + 38.9}{3.96} = 35.1°M$

(b) $t(°M) = \dfrac{-273.15 + 38.9}{3.96} = -59.2\ °M$ would be the absolute zero on this scale.

46. **(D)** **(a)** From the data provided we can write down the following relationship: -77.75 = 0 °A and -33.35 °C = 100 °A. To find the mathematical relationship between these two scales, we can treat each relationship as a point on a two-dimensional Cartesian graph.



Therefore, the equation for the line is y = 0.444*x* - 77.75
The algebraic relationship between the two temperature scales is

$t(°C) = 0.444(°A) - 77.75$ or rearranging $t(°A) = \dfrac{t(°C) + 77.75}{0.444}$

The boiling point of water (100 °C) corresponds to $t(°A) = \dfrac{100 + 77.75}{0.444} = 400.\ °A$

(b) $t(°A) = \dfrac{-273.15 + 77.75}{0.444} = -440.\ °A$

Density

<u>47</u>. **(E)** $\text{butyric acid density} = \dfrac{\text{mass}}{\text{volume}} = \dfrac{2088\text{ g}}{2.18\text{ L}} \times \dfrac{1\text{ L}}{1000\text{ mL}} = 0.958\text{ g/mL}$

48. **(E)** $\text{chloroform density} = \dfrac{\text{mass}}{\text{volume}} = \dfrac{22.54\text{ kg}}{15.2\text{ L}} \times \dfrac{1\text{ L}}{1000\text{ mL}} \times \dfrac{1000\text{ g}}{1\text{ kg}} = 1.48\text{ g/mL}$

<u>49</u>. **(M)** The mass of acetone is the difference in masses between empty and filled masses.

Conversion pathway approach:

$$\text{density} = \frac{437.5\text{ lb} - 75.0\text{ lb}}{55.0\text{ gal}} \times \frac{453.6\text{ g}}{1\text{ lb}} \times \frac{1\text{ gal}}{3.785\text{ L}} \times \frac{1\text{ L}}{1000\text{ mL}} = 0.790\text{ g/mL}$$

Stepwise approach:

$$437.5\text{ lb} - 75.0\text{ lb} = 362.5\text{ lb}$$

$$362.5\text{ lb}\times\frac{453.6\text{ g}}{1\text{ lb}} = 1.644\times10^5\text{g}$$

$$55.0\text{ gal}\times\frac{3.785\text{ L}}{1\text{ gal}} = 208\text{ L}$$

$$208\text{ L}\times\frac{1000\text{ mL}}{1\text{ L}} = 2.08\times10^5\text{mL}$$

$$\frac{1.644\times10^5\text{g}}{2.08\times10^5\text{mL}} = 0.790\text{ g/mL}$$

50. **(M)** Density is a conversion factor.

$$\text{volume} = (283.2\text{ g filled} - 121.3\text{ g empty})\times\frac{1\text{ mL}}{1.59\text{ g}} = 102\text{ mL}$$

<u>51</u>. **(M)** $\text{acetone mass} = 7.50\text{ L antifreeze}\times\frac{1000\text{ mL}}{1\text{ L}}\times\frac{0.9867\text{ g antifreeze}}{1\text{ mL antifreeze}}\times\frac{8.50\text{ g acetone}}{100.0\text{ g antifreeze}}$

$$\times\frac{1\text{ kg}}{1000\text{ g}} = 0.629\text{ kg acetone}$$

52. **(M)**

$$\text{solution mass} = 1.00\text{ kg sucrose}\times\frac{1000\text{ g sucrose}}{1\text{ kg sucrose}}\times\frac{100.00\text{ g solution}}{10.05\text{ g sucrose}} = 9.95\times10^3\text{ g solution}$$

<u>53</u>. **(M)** $\text{fertilizer mass} = 225\text{ g nitrogen}\times\frac{1\text{ kg N}}{1000\text{ g N}}\times\frac{100\text{ kg fertilizer}}{21\text{ kg N}} = 1.0\underline{7}\text{ kg fertilizer}$

54. **(M)**

$$m_{\text{acetic acid}} = 1.00\text{ L vinegar}\times\frac{1000\text{ mL vinegar}}{1\text{ L}}\times\frac{1.006\text{ g vinegar}}{1\text{ mL vinegar}}\times\frac{5.4\text{ g acetic acid}}{100\text{ g vinegar}}$$

$$m_{\text{acetic acid}} = 54.\underline{3}\text{ g acetic acid}$$

<u>55</u>. **(M)** The calculated volume of the iron block is converted to its mass by using the provided density.

$$\text{mass} = 52.8\text{ cm}\times6.74\text{ cm}\times3.73\text{ cm}\times7.86\frac{\text{g}}{\text{cm}^3} = 1.04\times10^4\text{ g iron}$$

56. **(D)** The calculated volume of the steel cylinder is converted to its mass by using the provided density.

$$\text{mass} = \text{V(density)} = \pi r^2 h(d) = 3.14159(1.88\text{ cm})^2\,18.35\text{ cm}\times7.75\frac{\text{g}}{\text{cm}^3} = 1.58\times10^3\text{ g steel}$$

57. **(M)** We start by determining the mass of each item.

(1) $\text{mass of iron bar} = (81.5\text{ cm}\times 2.1\text{ cm}\times 1.6\text{ cm})\times 7.86\text{ g/cm}^3 = 2.2\times 10^3\text{ g iron}$

(2) $\text{mass of Al foil} = (12.12\text{ m}\times 3.62\text{ m}\times 0.003\text{ cm})\times\left(\dfrac{100\text{ cm}}{1\text{ m}}\right)^2\times 2.70\text{ g Al/cm}^3 = 4\times 10^3\text{ g Al}$

(3) $\text{mass of water} = 4.051\text{ L}\times\dfrac{1000\text{ cm}^3}{1\text{ L}}\times 0.998\text{ g/cm}^3 = 4.04\times 10^3\text{ g water}$

In order of increasing mass, the items are: iron bar $<$ aluminum foil $<$ water. Please bear in mind, however, that, strictly speaking, the rules for significant figures do not allow us to distinguish between the masses of aluminum and water.

58. **(M)** Total volume of 125 pieces of shot

$V = 8.9\text{ mL} - 8.4\text{ mL} = 0.5\text{ mL};\qquad \dfrac{\text{mass}}{\text{shot}} = \dfrac{0.5\text{ mL}}{125\text{ shot}}\times\dfrac{1\text{ cm}^3}{1\text{ mL}}\times\dfrac{8.92\text{ g}}{1\text{ cm}^3} = 0.04\text{ g/shot}$

59. **(D)** First determine the volume of the aluminum foil, then its area, and finally its thickness.

$\text{volume} = 2.568\text{ g}\times\dfrac{1\text{ cm}^3}{2.70\text{ g}} = 0.951\text{ cm}^3;\qquad \text{area} = (22.86\text{ cm})^2 = 522.6\text{ cm}^2$

$\text{thickness} = \dfrac{\text{volume}}{\text{area}} = \dfrac{0.951\text{ cm}^3}{522.6\text{ cm}^2}\times\dfrac{10\text{ mm}}{1\text{ cm}} = 1.82\times 10^{-2}\text{ mm}$

60. **(D)** The vertical piece of steel has a $\text{volume} = 12.78\text{ cm}\times 1.35\text{ cm}\times 2.75\text{ cm} = 47.4\text{ cm}^3$
The horizontal piece of steel has a $\text{volume} = 10.26\text{ cm}\times 1.35\text{ cm}\times 2.75\text{ cm} = 38.1\text{ cm}^3$
$V_{\text{total}} = 47.4\text{ cm}^3 + 38.1\text{ cm}^3 = 85.5\text{ cm}^3$. $\text{mass} = 85.5\text{ cm}^3\times 7.78\text{ g/cm}^3 = 665\text{ g of steel}$

61. **(D)** Here we are asked to calculate the number of liters of whole blood that must be collected in order to end up with 0.5 kg of red blood cells. Each red blood cell has a mass of $90.0\times 10^{-12}\text{ cm}^3\times 1.096\text{ g cm}^{-3} = 9.864\times 10^{-11}\text{ g}$

$\text{red blood cells (mass per mL)} = \dfrac{9.864\times 10^{-11}\text{ g}}{1\text{ cell}}\times\dfrac{5.4\times 10^9\text{ cells}}{1\text{ mL}} = \dfrac{0.533\text{ g red blood cells}}{1\text{ mL of blood}}$

For 0.5 kg or 5×10^2 g of red blood cells, we require

$= 5\times 10^2\text{ g red blood cells}\times\dfrac{1\text{ mL of blood}}{0.533\text{ g red blood cells}} = 9\times 10^2\text{ mL of blood or 0.9 L blood}$

62. **(D)** The mass of the liquid mixture can be found by subtracting the mass of the full bottle from the mass of the empty bottle = 15.4448 g − 12.4631 g = 2.9817 g liquid. Similarly, the total mass of the water that can be accommodated in the bottle is 13.5441 g − 12.4631 g = 1.0810 g H_2O. The volume of the water and hence the internal volume for the bottle is equal to

$$1.0810 \text{ g } H_2O \times \frac{1 \text{ mL } H_2O}{0.9970 \text{ g } H_2O} = 1.084 \text{ mL } H_2O \ \ (25\ °C)$$

Thus, the density of the liquid mixture = $\frac{2.9817 \text{ g liquid}}{1.084 \text{ mL}} = 2.751 \text{ g mL}^{-1}$

Since the calcite just floats in this mixture of liquids, it must have the same density as the mixture. Consequently, the solid calcite sample must have a density of 2.751 g mL^{-1} as well.

Percent Composition

<u>63</u>. **(E)** The percent of students with each grade is obtained by dividing the number of students with that grade by the total number of students. $\%A = \frac{7 \text{ A's}}{76 \text{ students}} \times 100\% = 9.2\% \text{ A}$

$$\%B = \frac{22 \text{ B's}}{76 \text{ students}} \times 100\% = 28.9\% \text{ B} \qquad \%C = \frac{37 \text{ C's}}{76 \text{ students}} \times 100\% = 48.7\% \text{ C}$$

$$\%D = \frac{8 \text{ D's}}{76 \text{ students}} \times 100\% = 11\% \text{ D} \qquad \%F = \frac{2 \text{ F's}}{76 \text{ students}} \times 100\% = 3\% \text{ F}$$

Note that the percentages add to 101% due to rounding effects.

64. **(E)** The number of students with a certain grade is determined by multiplying the total number of students by the fraction of students who earned that grade.

$$\text{no. of A's} = 84 \text{ students} \times \frac{18 \text{ A's}}{100 \text{ students}} = 15 \text{ A's}$$

$$\text{no. of B's} = 84 \text{ students} \times \frac{25 \text{ B's}}{100 \text{ students}} = 21 \text{ B's} \qquad \text{no. of C's} = 84 \text{ students} \times \frac{32 \text{ C's}}{100 \text{ students}} = 27 \text{ C's}$$

$$\text{no. of D's} = 84 \text{ students} \times \frac{13 \text{ D's}}{100 \text{ students}} = 11 \text{ D's} \qquad \text{no. of F's} = 84 \text{ students} \times \frac{12 \text{ F's}}{100 \text{ students}} = 10 \text{ F's}$$

<u>65</u>. **(M)** Use the percent composition as a conversion factor.

Conversion pathway approach:

$$\text{mass of sucrose} = 3.50 \text{ L} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{1.118 \text{ g soln}}{1 \text{ mL}} \times \frac{28.0 \text{ g sucrose}}{100 \text{ g soln}} = 1.10 \times 10^3 \text{ g sucrose}$$

Stepwise approach:

$$3.50\text{ L}\times\frac{1000\text{ mL}}{1\text{ L}} = 3.50\times10^{3}\text{mL}$$

$$3.50\times10^{3}\text{mL}\times\frac{1.118\text{ g soln}}{1\text{ mL}} = 3.91\times10^{3}\text{ g soln}$$

$$3.91\times10^{3}\text{ g soln}\times\frac{28.0\text{ g sucrose}}{100\text{ g soln}} = 1.10\times10^{3}\text{ g sucrose}$$

66. **(D)** Again, percent composition is used as a conversion factor. We are careful to label both the numerator and denominator for each factor.

$$V_{\text{solution}} = 2.25\text{ kg sodium hydroxide}\times\frac{1000\text{ g}}{1\text{ kg}}\times\frac{100.0\text{ g soln}}{12.0\text{ g sodium hydroxide}}\times\frac{1\text{ mL}}{1.131\text{ g soln}}$$

$$V_{\text{solution}} = 1.66\times10^{4}\text{ mL soln}\times\frac{1\text{ L}}{1000\text{ mL}} = 16.6\text{ L soln}$$

INTEGRATIVE AND ADVANCED EXERCISES

67. **(M)** 99.9 is known to 0.1 part in 99.9, or 0.1%. 1.008 is known to 0.001 part in 1.008, or 0.1%. The product 100.7 also is known to 0.1 part in 100.7, or 0.1%, which is the same precision as the two factors. On the other hand, the three-significant-figure product, 101, is known to 1 part in 101 or 1%, which is ten times less precise than either of the two factors. Thus, the result is properly expressed to four significant figures.

68. **(M)**

$1.543 = 1.5794 - 1.836\times10^{-3}(t\text{-}15)$ $1.543 - 1.5794 = -1.836\times10^{-3}(t\text{-}15) = 0.036\underline{4}$

$(t\text{-}15) = \dfrac{-0.036\underline{4}}{-1.836\times10^{-3}} = 19.\underline{8}\ °C$ $t = 19.\underline{8} + 15 = 34.\underline{8}\ °C$

69. **(D)** $\text{volume needed} = 18{,}000\text{ gal}\times\frac{4\text{ qt}}{1\text{ gal}}\times\frac{0.9464\text{ L}}{1\text{ qt}}\times\frac{1000\text{ mL}}{1\text{ L}}\times\frac{1.00\text{ g}}{1\text{ mL}}\times\frac{1\text{ g Cl}}{10^{6}\text{ g water}}$

$$\times\frac{100\text{ g soln}}{7\text{ g Cl}}\times\frac{1\text{ mL soln}}{1.10\text{ g soln}}\times\frac{1\text{ L soln}}{1000\text{ mL soln}} = 0.9\text{ L soln}$$

70. **(D)** We first determine the volume of steel needed. This volume, divided by the cross-sectional area of the bar of steel, gives the length of the steel bar needed.

$$V = 1.000 \text{ kg steel} \times \frac{1000 \text{ g steel}}{1 \text{ kg steel}} \times \frac{1 \text{ cm}^3 \text{ steel}}{7.70 \text{ g steel}} = 129.\underline{87} \text{ cm}^3 \text{ of steel}$$

For an equilateral triangle of length s, area $= \dfrac{s^2\sqrt{3}}{4} = \dfrac{(2.50 \text{ in.})^2\sqrt{3}}{4} = 2.70\underline{6} \text{ in.}^2$

$$\text{length} = \frac{\text{volume}}{\text{area}} = \frac{129.\underline{87} \text{ cm}^3}{2.70\underline{6} \text{ in.}^2} \times \left(\frac{1 \text{ in.}}{2.54 \text{ cm}}\right)^2 \times \frac{1 \text{ in.}}{2.54 \text{ cm}} = 2.93 \text{ in.}$$

71. **(D)** *Conversion pathway approach:*

$$\text{NaCl mass} = 330{,}000{,}000 \text{ mi}^3 \times \left(\frac{5280 \text{ ft}}{1 \text{ mi}} \times \frac{12 \text{ in.}}{1 \text{ ft}} \times \frac{2.54 \text{ cm}}{1 \text{ in.}}\right)^3 \times \frac{1 \text{ mL}}{1 \text{ cm}^3} \times \frac{1.03 \text{ g}}{1 \text{ mL}}$$
$$\times \frac{3.5 \text{ g sodium chloride}}{100.0 \text{ g sea water}} \times \frac{1 \text{ lb}}{453.6 \text{ g}} \times \frac{1 \text{ ton}}{2000 \text{ lb}} = 5.5 \times 10^{16} \text{ tons}$$

Stepwise approach:

$$330{,}000{,}000 \text{ mi}^3 \times \left(\frac{5280 \text{ ft}}{1 \text{ mi}}\right)^3 = 4.9 \times 10^{19} \text{ ft}^3$$

$$4.9 \times 10^{19} \text{ ft}^3 \times \left(\frac{12 \text{ in.}}{1 \text{ ft}}\right)^3 = 8.4 \times 10^{22} \text{ in.}^3$$

$$8.4 \times 10^{22} \text{ in.}^3 \times \left(\frac{2.54 \text{ cm}}{1 \text{ in.}}\right)^3 = 1.4 \times 10^{24} \text{ cm}^3$$

$$1.4 \times 10^{24} \text{ cm}^3 \times \frac{1 \text{ mL}}{1 \text{ cm}^3} \times \frac{1.03 \text{ g}}{1 \text{ mL}} = 1.4 \times 10^{24} \text{ g}$$

$$1.4 \times 10^{24} \text{ g} \times \frac{3.5 \text{ g sodium chloride}}{100.0 \text{ g sea water}} = 4.9 \times 10^{22} \text{ g NaCl}$$

$$4.9 \times 10^{22} \text{ g NaCl} \times \frac{1 \text{ lb}}{453.6 \text{ g}} = 1.1 \times 10^{20} \text{ lb}$$

$$1.1 \times 10^{20} \text{ lb} \times \frac{1 \text{ ton}}{2000 \text{ lb}} = 5.4 \times 10^{16} \text{ tons}$$

The answers for the stepwise and conversion pathway approaches differ slightly due to a cumulative rounding error that is present in the stepwise approach.

72. **(D)** First, we find the volume of the wire, then its cross-sectional area, and finally its length. We carry an additional significant figure through the early stages of the calculation to help avoid rounding errors.

$$V = 1\text{ lb} \times \frac{453.6\text{ g}}{1\text{ lb}} \times \frac{1\text{ cm}^3}{8.92\text{ g}} = 50.8\underline{5}\text{ cm}^3 \qquad \text{Note: area} = \pi r^2$$

$$\text{area} = 3.1416 \times \left(\frac{0.05082\text{ in.}}{2} \times \frac{2.54\text{ cm}}{1\text{ in.}}\right)^2 = 0.01309\text{ cm}^2$$

$$\text{length} = \frac{\text{volume}}{\text{area}} = \frac{50.8\underline{5}\text{ cm}^3}{0.01309\text{ cm}^2} \times \frac{1\text{ m}}{100\text{ cm}} = 38.8\text{ m}$$

73. **(M)**

$$V_{\text{seawater}} = 1.00\times10^5\text{ ton Mg} \times \frac{2000\text{ lb Mg}}{1\text{ ton Mg}} \times \frac{453.6\text{ g Mg}}{1\text{ lb Mg}} \times \frac{1000\text{ g seawater}}{1.4\text{ g Mg}} \times \frac{0.001\text{ L}}{1.025\text{ g seawater}} \times \frac{1\text{ m}^3}{1000\text{ L}} = 6\times10^7\text{ m}^3\text{ seawater}$$

74. **(D) (a)**

$$\text{dustfall} = \frac{10\text{ ton}}{1\text{ mi}^2 \bullet 1\text{ mo}} \times \left(\frac{1\text{ mi}}{5280\text{ ft}} \times \frac{1\text{ ft}}{12\text{ in.}} \times \frac{39.37\text{ in.}}{1\text{ m}}\right)^2 \times \frac{2000\text{ lb}}{1\text{ ton}} \times \frac{454\text{ g}}{1\text{ lb}} \times \frac{1000\text{ mg}}{1\text{ g}}$$

$$= \frac{3.5\times10^3\text{ mg}}{1\text{m}^2 \bullet 1\text{mo}} \times \frac{1\text{ month}}{30\text{ d}} \times \frac{1\text{ d}}{24\text{ h}} = \frac{5\text{ mg}}{1\text{m}^2 \bullet 1\text{h}}$$

(b) This problem is solved by the conversion factor method, starting with the volume that deposits on each square meter, 1 mm deep.

$$\frac{(1.0\text{ mm}\times 1\text{ m}^2)}{1\text{ m}^2} \times \frac{1\text{ cm}}{10\text{ mm}} \times \left(\frac{100\text{ cm}}{1\text{ m}}\right)^2 \times \frac{2\text{ g}}{1\text{ cm}^3} \times \frac{1000\text{ mg}}{1\text{ g}} \times \frac{1\text{ m}^2 \bullet \text{h}}{4.9\text{ mg}}$$

$= 4.1\times10^5\text{ h} = 5\times10^1\text{ y}$ It would take about half a century to accumulate a depth of 1 mm.

75. **(D) (a)** $\text{volume} = 3.54\times10^6\text{ acre-feet} \times \dfrac{1\text{ mi}^2}{640\text{ acre}} \times \left(\dfrac{5280\text{ ft}}{1\text{ mi}}\right)^2 = 1.54\times10^{11}\text{ ft}^3$

(b) $\text{volume} = 1.54\times10^{11}\text{ ft}^3 \times \left(\dfrac{12\text{ in.}}{1\text{ ft}} \times \dfrac{2.54\text{ cm}}{1\text{ in.}} \times \dfrac{1\text{ m}}{100\text{ cm}}\right)^3 = 4.36\times10^9\text{ m}^3$

(c) $\text{volume} = 4.36\times10^9\text{ m}^3 \times \dfrac{1000\text{ L}}{1\text{ m}^3} \times \dfrac{1\text{ gal}}{3.785\text{ L}} = 1.15\times10^{12}\text{ gal}$

76. **(M)** Let F be the Fahrenheit temperature and C be the Celsius temperature. $C = (F - 32)\frac{5}{9}$

(a)

$F = C - 49$ $\quad C = (C - 49 - 32)\frac{5}{9} = \frac{5}{9}(C - 81)$ $\quad C = \frac{5}{9}C - \frac{5}{9}(81)$ $\quad C = \frac{5}{9}C - 45$

$\frac{4}{9}C = -45$ $\quad$ Hence: $C = -101.\underline{25}$

When it is ~ -101 °C, the temperature in Fahrenheit is -150. °F (49 ° lower).

(b) $F = 2\,C$ $\quad C = (2C - 32)\frac{5}{9} = \frac{10}{9}C - 17.8$ $\quad 17.8 = \frac{10}{9}C - C = \frac{1}{9}C$

$C = 9 \times 17.8 = 160.\ °C$ $\quad F = \frac{9}{5}C + 32 = \frac{9}{5}(160.) + 32 = 320.\ °F$

(c) $F = \frac{1}{8}C$ $\quad C = (\frac{1}{8}C - 32)\frac{5}{9} = \frac{5}{72}C - 17.8$ $\quad 17.8 = \frac{5}{72}C - C = -\frac{67}{72}C$

$C = -\dfrac{72 \times 17.8}{67} = -19.1\ °C$ $\quad F = \frac{9}{5}C + 32 = \frac{9}{5}(-19.1) + 32 = -2.4\ °F$

(d) $F = C + 300$ $\quad C = (C + 300 - 32)\frac{5}{9} = \frac{5}{9}C + 148.9$ $\quad 148.9 = \frac{4}{9}C$

$C = \dfrac{9 \times 148.9}{4} = 335\ °C$ $\quad F = \frac{9}{5}C + 32 = \frac{9}{5}(335) + 32 = 635\ °F$

77. **(M)** We will use the density of diatomaceous earth, and its mass in the cylinder, to find the volume occupied by the diatomaceous earth.

$$\text{diatomaceous earth volume} = 8.0\text{ g} \times \frac{1\text{ cm}^3}{2.2\text{ g}} = 3.6\text{ cm}^3$$

The added water volume will occupy the remaining volume in the graduated cylinder.

$$\text{water volume} = 100.0\text{ mL} - 3.6\text{ mL} = 96.4\text{ mL}$$

78. **(M)** We will use the density of water, and its mass in the pycnometer, to find the volume of liquid held by the pycnometer.

$$\text{pycnometer volume} = (35.552\text{ g} - 25.601\text{ g}) \times \frac{1\text{ mL}}{0.99821\text{ g}} = 9.969\text{ mL}$$

The mass of the methanol and the pyncnometer's volume determine liquid density.

$$\text{density of methanol} = \frac{33.490\text{ g} - 25.601\text{ g}}{9.969\text{ mL}} = 0.7914\text{ g/mL}$$

79. **(D)** We use the density of water, and its mass in the pycnometer, to find the volume of liquid held by the pycnometer.

$$\text{pycnometer volume} = (35.552\text{ g} - 25.601\text{ g}) \times \frac{1\text{ mL}}{0.99821\text{ g}} = 9.969\text{ mL}$$

The mass of the ethanol and the pyncnometer's volume determine liquid density.

$$\text{density of ethanol} = \frac{33.470\text{ g} - 25.601\text{ g}}{9.969\text{ mL}} = 0.7893\text{ g/mL}$$

The difference in the density of pure methanol and pure ethanol is 0.0020 g/mL. If the density of the solution is a linear function of the volume-percent composition, we would see that the maximum change in density (0.0020 g/mL) corresponds to a change of 100% in the volume percent. This means that the absolute best accuracy that one can obtain is a differentiation of 0.0001 g/mL between the two solutions. This represents a change in the volume % of ~ 5%. Given this apparatus, if the volume percent does not change by at least 5%, we would not be able to differentiate based on density (probably more like a 10 % difference would be required, given that our error when measuring two solutions is more likely $\pm$ 0.0002 g/mL).

80. **(D)** We first determine the pycnometer's volume.

$$\text{pycnometer volume} = (35.55\text{ g} - 25.60\text{ g}) \times \frac{1\text{ mL}}{0.9982\text{ g}} = 9.97\text{ mL}$$

Then we determine the volume of water present with the lead.

$$\text{volume of water} = (44.83\text{ g} - 10.20\text{ g} - 25.60\text{ g}) \times \frac{1\text{ mL}}{0.9982\text{ g}} = 9.05\text{ mL}$$

Difference between the two volumes is the volume of lead, which leads to the density of lead.

$$\text{density} = \frac{10.20\text{ g}}{(9.97\text{ mL - b}9.05\text{ mL})} = 11\text{ g/mL}$$

Note that the difference in the denominator has just two significant digits.

81. **(M)**

$$\text{Water used (in kg/week)} = 1.8\times10^{6}\text{people} \times \left(\frac{750\text{ L}}{1\text{ day}}\right) \times \left(\frac{7\text{ day}}{1\text{ week}}\right) \times \frac{1\text{ kg}}{1\text{ L}} = 9.45\times10^{9}\text{ kg water/week}$$

Given: Sodium hypochlorite is NaClO

$$\text{mass of NaClO} = 9.45\times10^{9}\text{ kg water}\left(\frac{1\text{ kg chlorine}}{1\times10^{6}\text{ kg water}}\right) \times \left(\frac{100\text{ kg NaClO}}{47.62\text{ kg chlorine}}\right)$$

$$= 1.98\times10^{4}\text{ kg sodium hypochlorite}$$

82. **(M)** $\frac{1.77\text{ lb}}{1\text{ L}} \times \frac{1\text{ kg}}{2.2046\text{ lb}} = 0.803\text{ kg L}^{-1}$

22,300 kg of fuel are required, hence:

$$22{,}300\text{ kg fuel} \times \frac{1\text{ L}}{0.803\text{ kg}} = 2.78 \times 10^{4}\text{ L of fuel}$$

(Note, the plane had 7682 L of fuel left in the tank.)
Hence, the volume of fuel that should have been added = 2.78×10^{4} L – 0.7682 L = 2.01×10^{4} L

83. **(D)** **(a)** Density of water at 10. °C:

$$\text{density} = \frac{0.99984 + (1.6945\times10^{-2}(10.) - (7.987\times10^{-6}(10.)^2)}{1+(1.6880\times10^{-2}(10.))} = 0.9997\ \text{g cm}^{-3}\ \text{(4 sig fig)}$$

(b) Set a = 0.99984, b = 1.6945 × 10^2, c = 7.987 × 10^{-6}, d = 1.6880 × 10^{-2} (for simplicity)

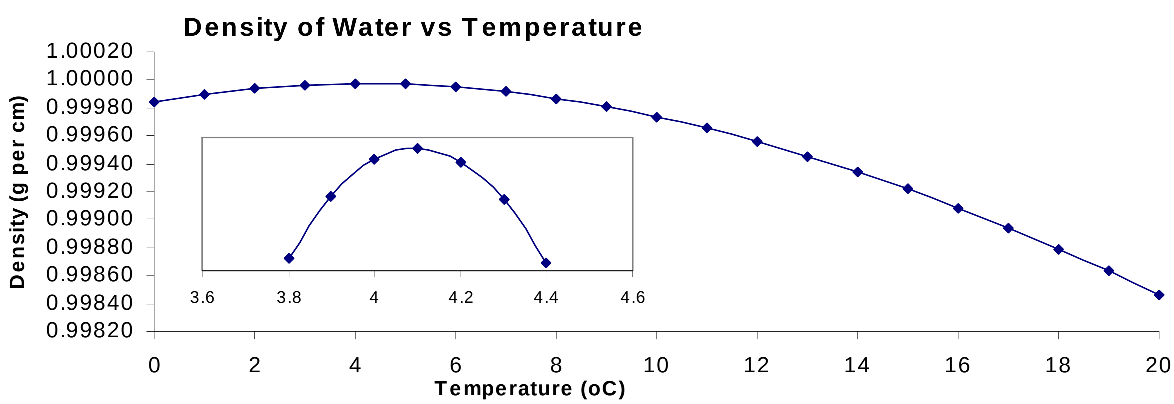
$$0.99860 = \frac{0.99984 + (1.6945\times10^{-2}(t) - (7.987\times10^{-6}(t)^2)}{1+(1.6880\times10^{-2}t)} = \frac{a+bt-ct^2}{1+dt}$$

Multiply both sides by (1 + dt): 0.99860(1 + dt) = 0.99860 + 0.99860dt = a + bt – ct^2
Bring all terms to the left hand side: 0 = a + bt – ct^2 – 0.99860 – 0.99860dt
Collect terms 0 = a – 0.99860 + bt – 0.99860dt – ct^2
Substitute in for a, b, c and d:
0 = 0.99984 – 0.99860 + 1.6945 × 10^{-2}t – 0.99860(1.6880 × 10^{-2})t – 7.987 × $10^{-6}t^2$
Simplify: 0 = 0.00124 + 0.000088623t – 7.987 × $10^{-6}t^2$
Solve the quadratic equation: t = 19.188 °C

(c) **i)** Maximum density by estimation:
Determine density every 5 °C then narrow down the range to the degree.
First set of data suggests ~5 °C, the second set of data suggests ~4 °C and the final set of data suggests about 4.1 °C (+/-0.1 °C)

1st data set		2nd data set		3rd data set	
0 °C	0.999840	3 °C	0.999965	3.6 °C	0.999972
5 °C	0.999968	4 °C	0.999974	3.8 °C	0.999973
10 °C	0.999736	5 °C	0.999968	4.0 °C	0.999974
15 °C	0.999216	6 °C	0.999948	4.2 °C	0.999974
20 °C	0.998464	7 °C	0.999914	4.4 °C	0.999973

ii) Graphical method shown below:



iii) Method based on differential calculus: set the first derivative equal to zero

Set a = 0.99984, b = 1.6945×10^{2}, c = 7.987×10^{-6}, d = 1.6880×10^{-2} (simplicity)

$f(t) = \dfrac{a + bt - ct^2}{1 + dt}$ $\quad f'(t) = \dfrac{(b - 2ct)(1 + dt) - (a + bt - ct^2)d}{(1+dt)^2}$ (quotient rule)

$f'(t) = \dfrac{b + bdt - 2ct - 2cdt^2 - ad - bdt + cdt^2}{(1+dt)^2} = \dfrac{b - 2ct - cdt^2 - ad}{(1+dt)^2} = 0$ (max)

We need to set the first derivative = 0, hence consider the numerator = 0

Basically we need to solve a quadratic: $0 = -cdt^2 - 2ct + b - ad$

$t = \dfrac{2c \pm \sqrt{(2c)2 - 4(-cd)(b - ad)}}{-2cd}$ only the positive solution is acceptable.

Plug in a = 0.99984, b = 1.6945×10^{2}, c = 7.987×10^{-6}, d = 1.6880×10^{-2}

By solving the quadratic equation, one finds that a temperature of 4.09655 °C has the highest density (0.999974 g cm^{-3}). Hence, ~ 4.1 °C is the temperature where water has its maximum density.

84. **(D)** First, calculate the volume of the piece of Styrofoam:

V = 36.0 cm × 24.0 cm × 5.0 cm = 4.32×10^{3} cm^3

Calculate the volume of water displaced (using dimensions in the figure):

V = 36.0 cm × 24.0 cm × 3.0 cm = 2.592×10^{3} cm^3

The mass of displaced water is given as: m = D×V = 1.00 g/cm^3 × 2.592×10^{3} cm^3
= 2.592×10^{3} g

Since the object floats, it means that the water is exerting a force equivalent to the mass of Styrofoam/book times the acceleration due to gravity (g). We can factor out g, and are left with masses of Styrofoam and water:

mass of book + mass of Styrofoam = mass of water

1.5×10^{3} g + D × 4.32×10^{3} cm^3 = 2.592×10^{3} g

Solving for D, we obtain:

D = 0.25 g/cm^3

85. **(M)** (a) When the mixture is pure benzene, %N = 0, d = 1/1.153 = 0.867 g/cm^3
(b) When mixture is pure naphthalene, %N = 100, d = 1.02 g/cm^3
(c) %N = 1.15, d = 0.869 g/cm^3
(d) Using d = 0.952 g/cm^3 and the quadratic formula to solve for %N. %N = 58.4

86. **(M)** First, calculate the total mass of ice in the Antarctic, which yields the total mass of water which is obtained if all the ice melts:

$$3.01\times10^7\ \text{km}^3\ \text{ice} \times \frac{(1\times10^5\ \text{cm})^3}{1\ \text{km}^3} \times \frac{0.92\ \text{g ice}}{1\ \text{cm}^3\ \text{ice}} = 2.769\times10^{22}\ \text{g ice}$$

all of which converts to water. The volume of this extra water is then calculated.

$$2.769\times10^{22}\ \text{g H}_2\text{O} \times \frac{1\ \text{cm}^3\ \text{H}_2\text{O}}{1\ \text{g H}_2\text{O}} \times \frac{1\ \text{km}^3\ \text{H}_2\text{O}}{(1\times10^5\ \text{cm})^3\ \text{H}_2\text{O}} = 2.769\times10^7\ \text{km}^3\ \text{H}_2\text{O}$$

Assuming that Vol (H_2O on Earth) = A × h = 3.62×10^8 km^2, the total increase in the height of sea levels with the addition of the melted continental ice will be:

h = 2.769×10^7 km^3 / 3.62×10^8 km^2 = 0.0765 km = 76.4 m.

87. **(M)** First, calculate the mass of wine: 4.72 kg – 1.70 kg = 3.02 kg
Then, calculate the mass of ethanol in the bottle:

$$3.02\ \text{kg wine} \times \frac{1000\ \text{g wine}}{1\ \text{kg wine}} \times \frac{11.5\ \text{g ethanol}}{100\ \text{g wine}} = 347.3\ \text{g ethanol}$$

Then, use the above amount to determine how much ethanol is in 250 mL of wine:

$$250.0\ \text{mL ethanol} \times \frac{1\ \text{L ethanol}}{1000\ \text{mL ethanol}} \times \frac{347.3\ \text{g ethanol}}{3.00\ \text{L bottle}} = 28.9\ \text{g ethanol}$$

88. **(M)**_First, determine the total volume of tungsten:

$$\text{vol W} = \text{m/D} = \frac{0.0429\ \text{g W}}{19.3\ \text{g/cm}^3} \times \frac{(10\ \text{mm})^3}{1\ \text{cm}^3} = 2.22\ \text{mm}^3\ \text{W}$$

The wire can be viewed as a cylinder. Therefore:
vol cylinder = A×h = $\pi(D/2)^2$ × h = $\pi(D/2)^2$ × (0.200 m × 1000 mm/1 m) = 2.22 mm^3
Solving for D, we obtain: D = 0.119 mm

89. **(M)** First, determine the amount of alcohol that will cause a BAC of 0.10%:

$$\text{mass of ethanol} = \frac{0.100\ \text{g ethanol}}{100\ \text{mL of blood}} \times 5400\ \text{mL blood} = 5.4\ \text{g ethanol}$$

This person's body metabolizes alcohol at a rate of 10.0 g/h. Therefore, in 3 hours, this person metabolizes 30.0 g of alcohol. For this individual to have a BAC of 0.10% after 3 hours, he must consume 30.0 + 5.4 = 35.4 g of ethanol.

Now, calculate how many glasses of wine are needed for a total intake of 35.4 g of ethanol:

$$35.4 \text{ g ethanol} \times \frac{100 \text{ g wine}}{11.5 \text{ g eth.}} \times \frac{1 \text{ mL wine}}{1.01 \text{ g wine}} \times \frac{1 \text{ glass wine}}{145 \text{ mL wine}} = 2.1 \text{ glasses of wine}$$

FEATURE PROBLEMS

90. **(M)** All of the pennies minted before 1982 weigh more than 3.00 g, while all of those minted after 1982 weigh less than 2.60 g. It would not be unreasonable to infer that the composition of a penny changed in 1982. In fact, pennies minted prior to 1982 are composed of almost pure copper (about 96% pure). Those minted after 1982 are composed of zinc with a thin copper cladding. Both types of pennies were minted in 1982.

91. **(E)** After sitting in a bathtub that was nearly full and observing the water splashing over the side, Archimedes realized that the crown—when submerged in water—would displace a volume of water equal to its volume. Once Archimedes determined the volume in this way and determined the mass of the crown with a balance, he was able to calculate the crown's density. Since the gold-silver alloy has a different density (it is lower) than pure gold, Archimedes could tell that the crown was not pure gold.

92. **(M)** Notice that the liquid does not fill each of the floating glass balls. The quantity of liquid in each glass ball is sufficient to give each ball a slightly different density. Note that the density of the glass ball is determined by the density of the liquid, the density of the glass (greater than the liquid's density), and the density of the air. Since the density of the liquid in the cylinder varies slightly with temperature—the liquid's volume increases as temperature goes up, but its mass does not change, ergo, different balls will be buoyant at different temperatures.

93. **(M)** The density of the canoe is determined by the density of the concrete and the density of the hollow space inside the canoe, where the passengers sit. It is the hollow space, (filled with air), that makes the density of the canoe less than that of water (1.0 g/cm^3). If the concrete canoe fills with water, it will sink to the bottom, unlike a wooden canoe.

<u>94.</u> **(D)** In sketch (a), the mass of the plastic block appears to be 50.0 g.
In sketch (b), the plastic block is clearly visible on the bottom of a beaker filled with ethanol, showing that it is both insoluble in and more dense than ethanol (i.e., > 0.789 g/cm^3).
In sketch (c), because the plastic block floats on bromoform, the density of the plastic must be less than that for bromoform (i.e., < 2.890 g/cm^3). Moreover, because the block is ~ 40% submerged, the volume of bromoform having the same 50.0 g mass as the block is only about 40% of the volume of the block. Thus, using the expression V = m/d, we can write

volume of displaced bromoform ~ $0.40 \times V_{block}$

$$\frac{\text{mass of bromoform}}{\text{density of bromoform}} = \frac{0.40\times\text{mass of block}}{\text{density of plastic}} = \frac{50.0\text{ g of bromoform}}{2.890\ \frac{\text{g bromoform}}{\text{cm}^3}} = 0.40\times\frac{50.0\text{ g of plastic}}{\text{density of plastic}}$$

$$\text{density of plastic} \approx \frac{2.890\ \frac{\text{g bromoform}}{\text{cm}^3}}{50.0\text{ g of bromoform}} \times 0.40 \times 50.0\text{ g of plastic} \approx 1.1\underline{6}\ \frac{\text{g}}{\text{cm}^3}$$

The information provided in sketch (d) provides us with an alternative method for estimating the density of the plastic (use the fact that the density of water is 0.99821 g/cm^3 at 20 °C).
mass of water displaced = 50.0 g – 5.6 g = 44.4 g

$$\text{volume of water displaced} = 44.4\text{ g} \times \frac{1\text{ cm}^3}{0.99821\text{ g}} = 44.5\text{ cm}^3$$

$$\text{Therefore the density of the plastic} = \frac{mass}{volume} = \frac{50.0\text{ g}}{44.5\text{ cm}^3} = 1.12\ \frac{\text{g}}{\text{cm}^3}$$

This is reasonably close to the estimate based on the information in sketch (c).

95. **(M)** One needs to convert (lb of force) into (Newtons) 1 lb of force = 1 slug × 1 ft s^{-2}

(1 slug = 14.59 kg). Therefore, 1 lb of force = $\frac{14.59\text{ kg} \bullet 1\text{ ft}}{1\text{ s}^2}$

$$= \left(\frac{14.59\text{ kg} \times 1\text{ ft}}{1\text{ s}^2}\right)\left(\frac{12\text{ in.}}{1\text{ ft}}\right)\left(\frac{2.54\text{ cm}}{1\text{ in.}}\right)\left(\frac{1\text{ m}}{100\text{ cm}}\right) = \frac{4.45\text{ kg} \bullet \text{m}}{1\text{ s}^2} = 4.45\text{ Newtons}$$

From this result it is clear that 1 lb of force = 4.45 Newtons.

SELF-ASSESSMENT EXERCISES

96. **(E)** (a) mL: milliliters, is 1/1000 of a liter or the volume of 1 g of H_2O at 25 °C. (b) % by mass: number of grams of a substance in 100 g of a mixture or compound. (c) °C: degrees Celsius, 1/100 of the temperature difference between the freezing and boiling points of water at sea level. (d) density: an intrinsic property of matter expressed as the ratio between a mass of a substance and the volume it occupies. (e) element: matter composed of a single type of atom.

97. **(E)** (a) SI (*le **S**ystème **i**nternational d'unités)* base units are seven decimal based measurement systems used to quantify length, mass, time, electric current, temperature, luminous intensity and amount of a substance. (b) Significant figures are an indication of the capability of the measuring device and how precise can the measurement can possibly be. (c) Natural law is the reduction of observed data into a simple mathematical or verbal expression. (d) Exponential notation is a method of expressing numbers as multiples of powers of 10.

98. **(E)** (a) Mass is an intrinsic property of matter, and is determined by the total number of atoms making up the substance. Weight is the acceleration due to gravity imparted on the material, and can change depending on the gravitational field exerted on the material.
(b) An intensive property does not depend on the amount of material present (such as density), while an extensive property depends on the amount of material present (such as volume of the sample). (c) substance in simple terms is any matter with a definite chemical composition, whereas a mixture contains more than one substance. (d) Systematic error is a consistent error inherent to the measurement (such as the scale with an offset), whereas random errors are not consistent and are most likely the result of the observer making mistakes during measurement. (e) A hypothesis is a tentative explanation of a natural law. A theory is a hypothesis that has been supported by experimentation and data.

99. **(E)** The answer is (e), a natural law.

100. **(E)** The answer is (a), because the gas is fully dissolved in the liquid and remains there until the cap is removed. (b) and (c) are pure substances and therefore not mixtures, and material in a kitchen blender is heterogeneous in appearance.

101. **(E)** The answer is (c), the same. Mass is an intrinsic property of matter, and does not change with varying gravitational fields. Weight, which is acceleration due to gravity, does change.

102. **(E)** (d) and (f).

103. **(E)** The answer is (d). To compare, all values are converted to Kelvins.
Converting (c) 217 °F to K: T (K) = ((217-32) × 5/9) + 273 = 376 K.
Converting (d) 105 °C to K: 105 + 273 = 378 K.

104. **(M)** The answer is (b). The results are listed as follows: (a) 752 mL H_2O × 1 g/mL = 752 g.
(b) 1050 mL ethanol × 0.789 g/mL = 828 g. (c) 750 g as stated.
(d) (19.20 cm × 19.20 cm × 19.20 cm) balsa wood × 0.11 g/mL = 779 g.

105. **(E)** The problem can be solved using dimensional analysis:

(a) g/L: $0.9982\ \frac{\text{g}}{\text{cm}^3} \times \frac{1000\ \text{cm}^3}{1\ \text{L}} = 998.2\ \frac{\text{g}}{\text{L}}$

(b) kg/m^3: $0.9982\ \frac{\text{g}}{\text{cm}^3} \times \frac{1\ \text{kg}}{1000\ \text{g}} \times \frac{(100\ \text{cm})^3}{1\ \text{m}^3} = 998.2\ \frac{\text{kg}}{\text{m}^3}$

(c) kg/m^3: $0.9982\ \frac{\text{g}}{\text{cm}^3} \times \frac{1\ \text{kg}}{1000\ \text{g}} \times \frac{(100\ \text{cm})^3}{1\ \text{m}^3} \times \frac{(1000\ \text{m})^3}{1\ \text{km}^3} = 9.982\times10^{11}\ \frac{\text{kg}}{\text{km}^3}$

106. **(E)** Student A is more accurate, Student B more precise.

107. **(E)** The answer is (b). Simply determining the volume from the dimensions (36 cm × 20.2 cm × 0.9 cm, noting that 9 mm = 0.9 cm) gives a volume of 654.48 cm^3. Since one of the dimensions only has one significant figure, the volume is 7×10^2 cm^3.

108. **(E)** (e), (a), (c), (b), (d), listed in order of increasing significant figures, which indicates an increasing precision in the measurement

109. **(E)** The answer is (d). A 10.0 L solution with a density of 1.295 g/mL has a mass of 12,950 g, 30 mass% of which is an iron compound. Since the iron compound is 34.4% by mass iron, the total Fe content is 12950×0.300×0.344 = Having an iron content of 34.4 % Fe means that the mass is 1336 g or ~1340 g.

110. **(M)** First, you must determine the volume of copper. To do this, the mass of water displaced by the copper is determined, and the density used to calculate the volume of copper as shown below:

$\Delta m = 25.305 - 22.486 = 2.819$ g, mass of displaced water
Vol. of displaced H_2O = m/D = 2.819 g / 0.9982 $g \cdot mL^{-1}$ = 2.824 mL or cm^3 = Vol. of Cu

Vol of Cu = 2.824 cm^3 = surf. Area × thickness = 248 cm^2 × x
Solving for x, the value of thickness is therefore 0.0114 cm or 0.114 mm.

111. **(E)** In short, no, because a pure substance by definition is homogeneous. However, if there are other phases of the same pure substance present (such as pure ice in pure water), we have a heterogeneous mixture from a physical standpoint.

112. **(M)** To construct a concept map, one must first start with the most general concepts. These concepts are defined by or in terms of other more specific concepts discussed in those sections. In this chapter, these concepts are very well categorized by the sections. Looking at sections 1-1 through 1-4, the following general concepts are being discussed: The Scientific Method (1-1), Properties of Matter (1-2) and Measurement of Matter (1-4). The next stage is to consider more specific concepts that derive from the general ones. Classification of Matter (1-3) is a subset of Properties of Matter, because properties are needed to classify matter. Density and Percent Composition (1-5) and Uncertainties in Scientific Measurements (1-6) are both subsets of Measurement of Matter. The subject of Buoyancy would be a subset of (1-5). Significant Figures (1-7) would be a subset of (1-6). Afterwards, link the general and more specific concepts with one or two simple words. Take a look at the subsection headings and problems for more refining of the general and specific concepts.