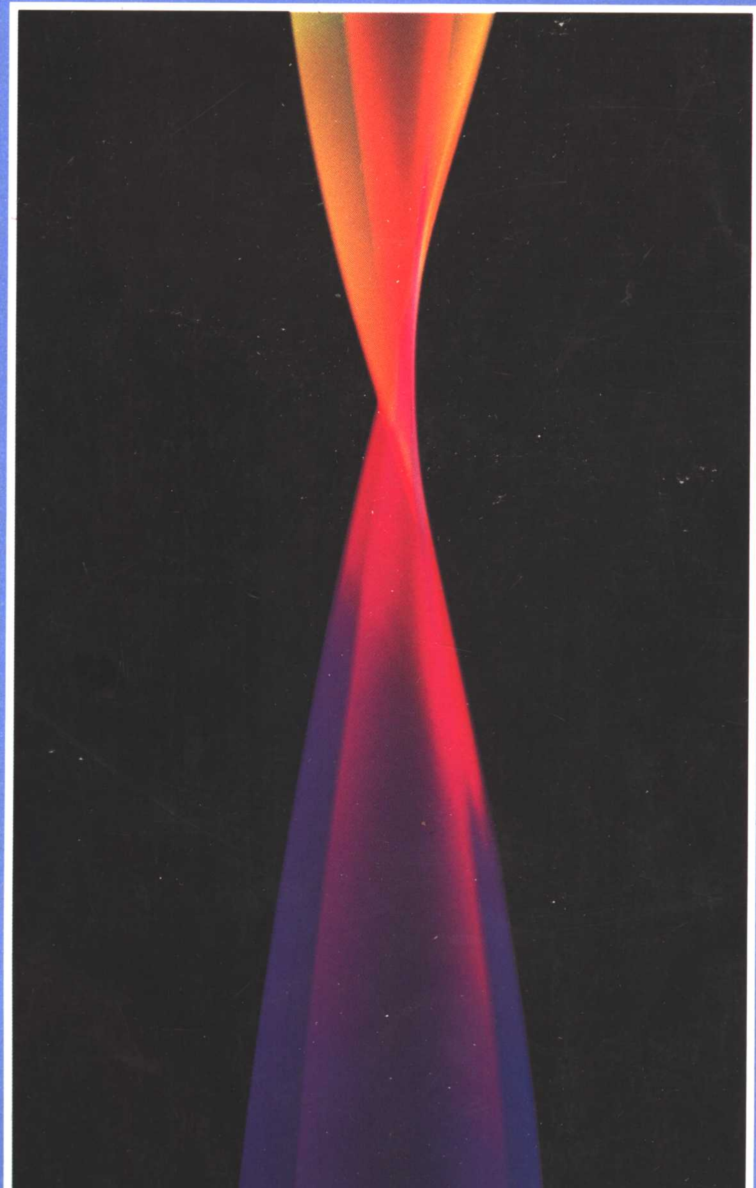
Solutions Guide for CHEMISTRY

SECOND EDITION

Steven S. Zumdahl



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by

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D. C. Heath and Company
Lexington, Massachusetts Toronto

Cover photo: Ted Hansen/Slide Graphics of New England.

Published simultaneously in Canada.

Printed in the United States of America.

International Standard Book Number: 0-669-16714-2

10 9 8 7

TO THE STUDENT: HOW TO USE THIS GUIDE

Chemistry is an applied science. Chemistry is valuable because a collection of facts about chemical behavior can be dealt with in a systematic manner and applied to solving the new problems that chemists encounter daily. In your study of chemistry you should give a priority to solving problems over other activities.

Solutions to about 2/3 of the end of chapter exercises are in this manual. This "Solutions Guide" can be very valuable if you use it properly. The way NOT to use it is to look at an exercise in the book and then check the solution, often saying to yourself, "That's easy, I can do it." Chemistry is easy once you get the hang of it, but it takes work. Don't look up a solution to a problem until you have tried to work it on your own. If you are completely stuck, see if you can find a similar problem in the Sample Exercises in the chapter. Then look up the solution. After you do this, look for a similar problem in the end of chapter exercises and try working it. The more problems you do, the easier chemistry becomes. It is also in your self interest to try to work as many problems as possible. Most exams that you will take in chemistry will involve a lot of problem solving. If you have worked several problems similar to the ones on an exam you will do much better than if the exam is the first time you try to solve a particular type problem. No matter how much you read and study the text, or how well you think you understand the material, you don't really understand it until you have taken the information in the text and used it to solve a problem.

We are grateful to Tom Hummel, Barbara Whitmarsh, Delores Wyatt, Claire Szoke, Eunice Zumdahl, and Judy and Martin Ashley for their help in preparing and checking this manual.

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CHAPTER ONE: CHEMICAL FOUNDATIONS

Scientific Method

1. a. law: A law is a concise statement or equation that summarizes a great variety of observations.

   theory: A theory is an hypothesis that has been tested over a length of time.

   A law is less likely to be challenged or modified than a theory.

   b. theory versus experiment: A theory is our explanation of why things behave the way they do, while experiment is the process of observing that behavior. Theories attempt to explain the results of experiments and are, in turn, tested by further experiments.

   c. qualitative: quantitative: A qualitative measurement only measures a quality while a quantitative measurement attaches a number to the observations. Examples:

   qualitative observations: The water was hot to the touch. Mercury was found in the drinking water. quantitative observations: The temperature of the water was 62°C. The concentration of mercury in the drinking water was 1.5 ppm.

   d. hypothesis: theory: Both are explanations of experimental observation. A theory is an hypothesis that has been tested over time and found to still be valid, with, perhaps, some modifications.

2. No, it is useful whenever a systematic approach of observation and hypothesis testing can be used.

4. a. No   b. Yes   c. Yes

6. a. inexact

   c. exact,

   $$\frac{36\ \text{in}}{\text{yd}} \times \frac{2.54\ \text{cm}}{\text{m}} \times \frac{1\ \text{m}}{100\ \text{cm}} = \frac{0.9144\ \text{yd}}{\text{m}}$$ (All conversion factors used are exact.)

   e. exact   f. inexact

7. Accuracy is a measure of how close a measurement is to the true value, while precision is a measure of the scatter in a series of identical measurements.

10. a. $0.00\underline{12}$; 2 S.F.   b. $\underline{437},000$; 3 S.F.   c. $\underline{900.0}$; 4 S.F.

    d. $\underline{106}$; 3 S.F.   e. $\underline{125,904},000$; 6 S.F.   f. $\underline{1.0012}$; 5 S.F.

11. a. 1.2×10^{-3} b. 4.37×10^{5} c. 9.000×10^{2}

    d. 1.06×10^{2} e. 1.25904×10^{8} f. 1.0012×10^{0}

12. a. 6×10^8 b. 5.8×10^8 c. 5.82×10^8

13. a. 8.41 (2.16 has only three significant figures)

c. 52.5 e. 0.009

14. a. 467; (25.27 − 24.16 = 1.11, only 3 significant figures)

b. 0.24; (8.925 − 8.904 = 0.021, 2 significant figures)

c. (9.04 − 8.23 + 21.954 + 81.0) ÷ 3.1416 = 103.8 ÷ 3.1416 = 33.02

d. $\frac{9.2 \times 100.65}{8.321 + 4.026} = \frac{9.2 \times 100.65}{12.347} = 7.5 \times 10^1$

15. a. $6.022 \times 10^{23} \times 1.05 \times 10^2 = 6.32 \times 10^{25}$

b. $\frac{6.6262 \times 10^{-34} \times 2.998 \times 10^8}{2.54 \times 10^{-9}} = 7.82 \times 10^{-17}$

c. $1.285 \times 10^{-2} + 1.24 \times 10^{-3} + 1.879 \times 10^{-1}$

$= 0.1285 \times 10^{-1} + 0.0124 \times 10^{-1} + 1.879 \times 10^{-1} = 2.020 \times 10^{-1}$

d. $1.285 \times 10^{-2} - 1.24 \times 10^{-3} = 1.285 \times 10^{-2} - 0.124 \times 10^{-2}$

$= 1.161 \times 10^{-2}$

16. a. For $\frac{103 \pm 1}{101 \pm 1}$: Maximum $= \frac{104}{100} = 1.04$; Minimum $= \frac{102}{102} = 1.00$

So $\frac{103 \pm 1}{101 \pm 1} = 1.02 \pm 0.02$

b. For $\frac{101 \pm 1}{99 \pm 1}$: Maximum $= \frac{102}{98} = 1.04$; Minimum $= \frac{100}{100} = 1.00$

So $\frac{101 \pm 1}{99 \pm 1} = 1.02 \pm 0.02$

c. For $\frac{99 \pm 1}{101 \pm 1}$: Maximum $= \frac{100}{100} = 1.00$; Minimum $= \frac{98}{102} = 0.96$

So $\frac{99 \pm 1}{101 \pm 1} = 0.98 \pm 0.02$

Considering the error limits, (a) and (b) should be expressed to three significant figures and (c) to two significant figures. The division rule differs in (b). The rule says (b) should be expressed to two significant figures. If we do this for (b) we imply that the answer is 1.0 or between 0.995 and 1.05. The actual range is less than this, so we should use the more precise way of expressing uncertainty. The significant figure rules only give us guidelines for estimating uncertainty. When we have a better handle on the uncertainty we should use it in precedence of the significant figure guidelines.

17. a. $\frac{2.70 - 2.64}{2.70} \times 100 = 2\%$ b. $\frac{16.48 - 16.12}{16.12} \times 100 = 2.2\%$

18. In a subtraction, the result gets smaller, but the uncertainties add. If the two numbers are very close together, the uncertainty may be larger than the result. For example, let us assume we want to take the difference of the following two measured quantities.

$$999{,}999 \pm 2 \text{ and } 999{,}996 \pm 2$$

The difference is 3 ± 4.

Units and Unit Conversions

19. a. $1\text{ km} = 10^3\text{ m} = 10^6\text{ mm} = 10^{15}\text{ pm}$

b. $1\text{ g} = 10^{-3}\text{ kg} = 10^3\text{ mg} = 10^9\text{ ng}$

c. $1\text{ mL} = 10^{-3}\text{ L} = 10^{-3}\text{ dm}^3 = 1\text{ cm}^3$

d. $1\text{ mg} = 10^{-6}\text{ kg} = 10^{-3}\text{ g} = 10^3\ \mu\text{g} = 10^6\text{ ng} = 10^9\text{ pg} = 10^{12}\text{ fg}$

e. $1\text{ s} = 10^3\text{ ms} = 10^9\text{ ns}$

21. $1\text{ Å} \times \frac{10^{-8}\text{ cm}}{\text{Å}} \times \frac{1\text{ m}}{100\text{ cm}} \times \frac{10^9\text{ nm}}{\text{m}} = 1 \times 10^{-1}\text{ nm}$

$1 \times 10^{-1}\text{ nm} \times \frac{10^{-9}\text{ m}}{\text{nm}} \times \frac{1\text{ pm}}{10^{-12}\text{ m}} = 1 \times 10^2\text{ pm}$

22. a. Since 1 in = 2.54 cm, then an uncertainty of $\pm \frac{1}{2}$ in is going to be about $\pm$ 1 cm after we convert from in to cm. Thus, we should express the heights to the nearest centimeter.

7'6" = 7(12) + 6 in = 90 in

$90\text{ in} \times \frac{2.54\text{ cm}}{\text{in}} = 229\text{ cm} = 229 \times 10^{-2}\text{ m} = 2.29\text{ m}$

5'2" = 5(12) + 2 in = 62 in

$62\text{ in} \times \frac{2.54\text{ cm}}{\text{in}} = 157\text{ cm} = 157 \times 10^{-2}\text{ m} = 1.57\text{ m}$

b. $25{,}000\text{ mi} \times \frac{1.61\text{ km}}{\text{mi}} = 4.0 \times 10^4\text{ km}$

We can derive this conversion factor from information in the chapter.

$1\text{ mi} \times \frac{5280\text{ ft}}{\text{mi}} \times \frac{1\text{ yd}}{3\text{ ft}} = 1760\text{ yd}$

and

$$1760 \text{ yd} \times \frac{1 \text{ m}}{1.094 \text{ yd}} \times \frac{1 \text{ km}}{1000 \text{ m}} = 1.61 \text{ km}$$

or $1 \text{ mi} = 5280 \text{ ft} = 1760 \text{ yd} = 1.61 \text{ km}$

$$4.0 \times 10^4 \text{ km} \times \frac{1000 \text{ m}}{\text{km}} = 4.0 \times 10^7 \text{ m}$$

23. a. $\frac{100.8 \text{ mi}}{\text{hr}} \times \frac{1760 \text{ yd}}{\text{mi}} \times \frac{1 \text{ m}}{1.094 \text{ yd}} \times \frac{\text{hr}}{60 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ s}} = \frac{45.05 \text{ m}}{\text{s}}$

b. $60 \text{ ft } 6 \text{ in} = 60(12) + 6 \text{ in} = 726 \text{ in}$

$$726 \text{ in} \times \frac{2.54 \text{ cm}}{\text{in}} \times \frac{1 \text{ m}}{100 \text{ cm}} \times \frac{1 \text{ s}}{45.05 \text{ m}} = 0.409 \text{ s}$$

24. $126 \text{ gal} \times \frac{4 \text{ qt}}{\text{gal}} \times \frac{1 \text{ L}}{1.06 \text{ qt}} = 475 \text{ L}$

25. $$5 \text{ warp factor} \times \frac{\frac{3.00 \times 10^8 \text{ m}}{\text{s}}}{\text{warp factor}} \times \frac{1.094 \text{ yd}}{\text{m}} \times \frac{60 \text{ s}}{\text{min}} \times \frac{60 \text{ min}}{\text{hr}}$$

$$\times \frac{1 \text{ knot}}{\frac{2000 \text{ yds}}{\text{hr}}} = 3 \times 10^9 \text{ knots}$$

26. a. $18 \text{ gal} \times \frac{4 \text{ qt}}{\text{gal}} \times 0.946 \frac{\text{L}}{\text{qt}} = 68 \text{ L} = 68 \text{ dm}^3$

b. $4.00 \times 10^2 \text{ in}^3 \times \left(\frac{2.54 \text{ cm}}{\text{in}}\right)^3 = 6.55 \times 10^3 \text{ cm}^3 = 6.55 \text{ L}$

c. $0.25 \text{ in} \times \frac{2.54 \text{ cm}}{\text{in}} = 0.64 \text{ cm}$

d. $14{,}110 \text{ ft} \times \frac{1 \text{ yd}}{3 \text{ ft}} \times \frac{1 \text{ m}}{1.0936 \text{ yd}} = 4301 \text{ m}$

27. a. $\frac{0.30 \text{ g}}{\text{mL}} \times \frac{1000 \text{ mg}}{\text{mL}} = \frac{3.0 \times 10^2 \text{ mg}}{\text{mL}}$

b. $\frac{0.30 \text{ g}}{\text{mL}} \times \frac{1 \text{ kg}}{10^3 \text{ g}} \times \frac{1 \text{ ml}}{\text{cm}^3} \times \left(\frac{100 \text{ cm}}{\text{m}}\right)^3 = \frac{3.0 \times 10^2 \text{ kg}}{\text{m}^3}$

c. $\frac{0.30 \text{ g}}{\text{mL}} \times \frac{10^6 \ \mu\text{g}}{\text{g}} = \frac{3.0 \times 10^5 \ \mu\text{g}}{\text{mL}}$

d. $\frac{0.30 \text{ g}}{\text{mL}} \times \frac{10^9 \text{ ng}}{\text{g}} = \frac{3.0 \times 10^8 \text{ ng}}{\text{mL}}$

e. $\frac{0.30 \text{ g}}{\text{mL}} \times \frac{10^6 \ \mu\text{g}}{\text{g}} \times \frac{1000 \text{ mL}}{\text{L}} \times \frac{1 \text{ L}}{10^6 \ \mu\text{L}} = \frac{3.0 \times 10^2 \ \mu\text{g}}{\mu\text{L}}$

28. a. $928\ mi \times \frac{5280\ ft}{mi} \times \frac{1\ fathom}{6\ ft} \times \frac{1\ cable\ length}{100\ fathoms} \times \frac{1\ nautical\ mi}{10\ cable\ lengths}$

$\times \frac{1\ league}{3\ nautical\ miles} = 272\ leagues$

$928\ mi \times \frac{5280\ ft}{mi} \times \frac{1\ yd}{3\ ft} \times \frac{1\ m}{1.094\ yd} \times \frac{1\ km}{1000\ m} = 1.49 \times 10^3\ km$

b. $1.0\ cable\ length \times \frac{100\ fathom}{cable\ length} \times \frac{6\ ft}{fathom} \times \frac{1\ yd}{3\ ft} \times \frac{1\ m}{1.094\ yd} \times \frac{1\ km}{1000\ m}$

$= 0.18\ km$

$1.0\ cable\ length = 0.18\ km \times \frac{1000\ m}{km} \times \frac{100\ cm}{m} = 1.8 \times 10^4\ cm$

c. $315\ ft \times \frac{12\ in}{ft} \times \frac{2.54\ cm}{in} \times \frac{1\ m}{100\ cm} = 96.0\ m$

$37\ ft \times \frac{12\ in}{ft} \times \frac{2.54\ cm}{in} \times \frac{1\ m}{100\ cm} = 11\ m$

$315\ ft \times \frac{1\ fathom}{6\ ft} \times \frac{1\ cable\ length}{100\ fathoms} = 5.25 \times 10^{-1}\ cable\ length$

$37\ ft \times \frac{1\ fathom}{6\ ft} = 6.2\ fathoms$

31. a. $1\ lb\ troy \times \frac{12\ oz\ tr}{1\ lb\ troy} \times \frac{20\ pw}{1\ troy\ oz} \times \frac{24\ gr}{pw} \times \frac{0.0648\ g}{gr} \times \frac{1\ kg}{1000\ g}$

$= 0.373\ kg$

$1\ troy\ lb = 0.373\ kg \times \frac{2.205\ lb}{kg} = 0.822\ lb$

b. $1\ oz\ tr \times \frac{20\ pw}{oz\ tr} \times \frac{24\ gr}{pw} \times \frac{0.0648\ g}{gr} = 31.1\ g$

$1\ oz\ tr = 31.1\ g \times \frac{1\ carat}{0.200\ g} = 156\ carats$

c. $1\ lb\ tr = 0.373\ kg$

$0.373\ kg \times \frac{1000\ g}{kg} \times \frac{1\ cm^3}{19.3\ g} = 19.3\ cm^3$

32. a. $1\ gr\ ap \times \frac{1\ scruple}{20\ gr\ ap} \times \frac{1\ dram\ ap}{3\ scruple} \times \frac{3.888\ g}{dram\ ap} = 0.06480\ g$

From the previous question we are given that 1 gr tr = 0.0648 g. So the two are the same.

1 gr ap = 1 gr tr

b. $1 \text{ oz ap} \times \frac{8 \text{ dram ap}}{\text{oz ap}} \times \frac{3.888 \text{ g}}{\text{dram ap}} \times \frac{1 \text{ oz tr}^*}{31.1 \text{ g}} = 1.00 \text{ oz tr}$ *from 31b

c. $5.00 \times 10^2 \text{ mg} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ dram}}{3.888 \text{ g}} \times \frac{3 \text{ scruple}}{\text{dram}} = 0.386 \text{ scruple}$

$0.386 \text{ scruple} \times \frac{20 \text{ gr}}{\text{scruple}} = 7.72 \text{ gr}$

d. $1 \text{ scruple} \times \frac{1 \text{ dram}}{3 \text{ scruple}} \times \frac{3.888 \text{ g}}{\text{dram}} = 1.296 \text{ g}$

34. $1.00 \text{ ns} \times \frac{1 \text{ s}}{10^9 \text{ ns}} \times \frac{3.00 \times 10^8 \text{ m}}{\text{s}} = 0.300 \text{ m}$

35. a. $85.0 \text{ crowns} \times \frac{1 \text{ royal}}{20 \text{ crowns}} = 4.25 \text{ royals}$

$85.0 \text{ crowns} \times \frac{100 \text{ weights}}{\text{crown}} = 8.50 \times 10^3 \text{ weights}$

$50 \text{ royals} \times \frac{1 \text{ horse}}{4.25 \text{ royals}} = 11.8 \text{ horses}$

So, 11 horses can be bought.

$11 \text{ horses} \times \frac{4.25 \text{ royals}}{\text{horse}} = 46.75 \text{ royals}$

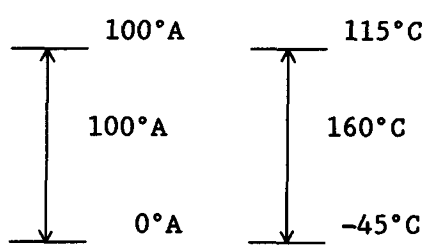
$50 - 46.75 = 3.25$ royals will be left

b. $\frac{13 \text{ crowns}}{\text{bundle}} \times \frac{100 \text{ weights}}{\text{crown}} \times \frac{1 \text{ bundle}}{25 \text{ haigus hides}} = \frac{52 \text{ weights}}{\text{haigus hide}}$

$288 \text{ bundles} \times \frac{13 \text{ crowns}}{\text{bundle}} \times \frac{1 \text{ royal}}{20 \text{ crowns}} = 187 \text{ royals}$

Temperature

36. a.



A change in temperature of 160°C equals a change in temperature of 100°A.

So, $\frac{160°\text{C}}{100°\text{A}}$ is our conversion for a change in temperature.

$0°\text{A} = -45°\text{C}$ or $°\text{C} = °\text{A} - 45$ At the freezing point

Combining the two pieces of information

$°\text{C} = \frac{160°\text{C}}{100°\text{A}} °\text{A} - 45; \quad °\text{C} = \frac{8}{5} °\text{A} - 45$

b. $°F = \frac{9}{5}\,°C + 32;\quad °C = \frac{5}{9}\,(°F - 32)$ (Assume 32 is exact.)

$\frac{5}{9}\,(°F - 32) = \frac{8}{5}\,°A - 45$

$°F - 32 = \frac{72}{25}\,°A - 81;\quad °F = \frac{72}{25}\,°A - 49$

c. $°C = \frac{8}{5}\,°A - 45$ and $°C = °A$

So $°C = \frac{8}{5}\,°C - 45;\quad \frac{3}{5}\,°C = 45;\quad °C = 75 = °A$

d. $°C = \frac{8}{5}\,°A - 45;\quad °C = \frac{8}{5}\,(86) - 45 = 93\ °C$

$°F = \frac{72}{25}\,°A - 49;\quad °F = \frac{72}{25}\,(86) - 49 = 199\ °F$

e. $°C = \frac{8}{5}\,°A - 45;\quad \frac{8}{5}\,°A = °C + 45$

$°A = \frac{5}{8}\,(°C + 45);\quad °A = \frac{5}{8}\,(45 + 45) = 56\ °A$

37. $°C = \frac{5}{9}\,(°F - 32) = \frac{5}{9}\,(102.5 - 32) = 39.2°C,\ K = °C + 273.2 = 312.4\ K$

38. $°F = \frac{9}{5}\,°C + 32 = \frac{9}{5}\,(25) + 32 = 77°F$

40. We can do this two ways.

First, we calculate the high and low temperature and get the uncertainty from the range.

20.6 °C ± 0.1 °C means the temperature can range from 20.5 °C to 20.7 °C.

$T_F = \frac{9}{5}\,T_c + 32$ (32 is exact)

$T_F(\text{min}) = \frac{9}{5}\,(20.5) + 32 = 68.9\ °F$

$T_F(\text{max}) = \frac{9}{5}\,(20.7) + 32 = 69.3\ °F$

So, the temperature ranges from 68.9 °F to 69.3 °F which we can express as 69.1 °F ± 0.2 °F.

An alternative way is to treat the uncertainty and the temperature in °C separately.

$$T_F = \frac{9}{5} T_c = 32 + \frac{9}{5}(20.6) + 32 = 69.1\ °F$$

and $\pm 0.1\ °C \times \frac{9\ °F}{5\ °C} = \pm 0.18\ °F \approx \pm 0.2\ °F$

Combining the two calculations

$T_F = 69.1\ °F \pm 0.2\ °F$

Density

42. $\frac{2.70\ g}{cm^3} \times \frac{1\ kg}{1000\ g} \times \left(\frac{100\ cm}{m}\right)^3 = \frac{2.70 \times 10^3\ kg}{m^3}$

$$\frac{2.70\ g}{cm^3} \times \frac{1\ lb}{454\ g} \times \left(\frac{2.54\ cm}{in}\right)^3 \times \left(\frac{12\ in}{ft}\right)^3 = \frac{168\ lb}{ft^3}$$

43. $D = \frac{mass}{volume}$

mass $= 1.67 \times 10^{-24}$ g; $r = d/2 = 5.0 \times 10^{-4}$ pm

$$V = \frac{4}{3}\pi r^3 = \frac{4}{3}(3.14) \times \left(5.0 \times 10^{-4}\ pm \times \frac{10^{-12}\ m}{pm} \times \frac{100\ cm}{m}\right)^3$$

$V = 5.24 \times 10^{-40}\ cm^3$

$$D = \frac{1.67 \times 10^{-24}\ g}{5.24 \times 10^{-39}\ cm^3} = \frac{3.2 \times 10^{15}\ g}{cm^3}$$

45. Heavy pennies (old): mean mass $= 3.08 \pm 0.05$ g

Light pennies (new): mean mass $= \frac{(2.467 + 2.545 + 2.518)}{3}$

$= 2.51 \pm 0.04$ g

Average Density of old pennies:

$$D_{old} = \frac{\frac{95 \times 8.96\ g}{cm^3} + \frac{5 \times 7.14\ g}{cm^3}}{100} = \frac{8.87\ g}{cm^3}$$

Average Density of new pennies:

$$D_{new} = \frac{\frac{2.4 \times 8.96\ g}{cm^3} + \frac{97.6 \times 7.14\ g}{cm^3}}{100} = \frac{7.18\ g}{cm^3}$$

Since $D = \frac{mass}{volume}$ and the volume of old and new pennies are the same, then $\frac{D_{new}}{D_{old}} = \frac{Mass_{new}}{Mass_{old}}$; $\frac{D_{new}}{D_{old}} = \frac{7.18}{8.87} = 0.809 = 0.81$

$$\frac{Mass_{new}}{Mass_{old}} = \frac{2.51}{3.08} = 0.815 = 0.81$$

To two decimal places the ratios are the same. We can reasonably conclude that yes, the difference in mass is accounted for by the difference in the alloy used.

47. a. both are the same mass

b. 1.0 mL of mercury. Mercury has a greater density than water.

Mass of mercury $= 1.0\text{ mL} \times \frac{13.6\text{ g}}{\text{mL}} = 13.6$ g of mercury

mass of water $= 1.0\text{ mL} \times \frac{1.0\text{ g}}{\text{mL}} = 1.0$ g of water

48. a. 1.0 kg feathers, feathers are less dense than lead

b. 100 g water

49. We will calculate the largest and smallest values that the density can be.

Since, $D = \frac{\text{Mass}}{\text{Volume}}$

$$D_{max} = \frac{M_{max}}{V_{min}} = \frac{16.52\text{ g}}{15.3\text{ cm}^3} = \frac{1.08\text{ g}}{\text{cm}^3}$$

$$D_{min} = \frac{M_{min}}{V_{max}} = \frac{16.48\text{ g}}{15.7\text{ cm}^3} = \frac{1.05\text{ g}}{\text{cm}^3}$$

$$D = \frac{M}{V} = \frac{16.50\text{ g}}{15.5\text{ cm}^3} = \frac{1.06\text{ g}}{\text{cm}^3}$$

Combing these results, we can express the density as

$$\frac{1.06\text{ g}}{\text{cm}^3} \pm \frac{0.02\text{ g}}{\text{cm}^3}$$

50. $D_{max} = \frac{M_{max}}{V_{min}}$

V = V(final) - V(initial)

We get V_{min} from $9.7\text{ cm}^3 - 6.5\text{ cm}^3 = 3.2\text{ cm}^3$

$$D_{max} = \frac{28.93\text{ g}}{3.2\text{ cm}^3} = \frac{9.0\text{ g}}{\text{cm}^3}$$

$$D_{min} = \frac{M_{min}}{V_{max}} = \frac{28.87\ g}{9.9\ cm^3 - 6.3\ cm^3} = \frac{8.0\ g}{cm^3}$$

or, the density is $\frac{8.5\ g}{cm^3} \pm \frac{0.5\ g}{cm^3}$

Classification and Separation of Matter

52. Solid: own volume, own shape, does not flow

    Liquid: own volume, takes shape of container, flows

    Gas: takes volume and shape of container, flows

53. homogeneous: only one phase present

    heterogeneous: more than one phase present

    a. heterogeneous

    b. heterogeneous: There is usually a fair amount of particulate matter present in the atmosphere (dirt) in addition to condensed water (rain, clouds).

    c. heterogeneous

    d. homogeneous

    e. homogeneous

    f. homogeneous

54. a. pure b. mixture c. mixture d. pure e. mixture

55. Iron and uranium are elements. Water and table salt are compounds.

56. Chemical changes involve the making and breaking of chemical forces (bonds). Physical changes do not. The identity of a substance changes after a chemical change, but not after a physical change.

Additional Exercises

58. a. $\text{Density} = \frac{\text{mass}}{\text{volume}}$

    $\text{Volume of a sphere} = \frac{4}{3}\pi r^3$

$$D = \frac{2 \times 10^{36}\ kg}{\frac{4}{3} \times 3.14 \times (6.96 \times 10^5\ km)^3} = \frac{2 \times 10^{36}\ kg}{1.41 \times 10^{18}\ km^3}$$

$$= \frac{1.4 \times 10^{18}\ kg}{km^3} \approx \frac{1 \times 10^{18}\ kg}{km^3}$$

b. $\frac{1 \times 10^{18}\ kg}{km^3} \times \left(\frac{1\ km}{1000\ m}\right)^3 = \frac{1 \times 10^9\ kg}{m^3}$

59. a. No, because if the volumes were the same the gold idol would have a much greater mass.

b. $$\text{Mass} = 1.0\ \text{L} \times \frac{1000\ \text{cm}^3}{\text{L}} \times \frac{19.32\ \text{g}}{\text{cm}^3} \times \frac{1\ \text{kg}}{1000\ \text{g}} = 19.32\ \text{kg}$$

It wouldn't be easy to play catch with the idol.

61. Circumference = $2\pi r$

$$V = \frac{4\pi r^3}{3} = \frac{4\pi}{3}\left(\frac{c}{2\pi}\right)^3 = \frac{c^3}{6\pi^2}$$

$$\text{Largest density} = \frac{5.25\ \text{oz}}{\frac{(9.00\ \text{in})^3}{6\pi^2}} = \frac{5.25\ \text{oz}}{12.3\ \text{in}^3} = \frac{0.426\ \text{oz}}{\text{in}^3}$$

$$\text{Smallest density} = \frac{5.00\ \text{oz}}{\frac{(9.25\ \text{in})^3}{6\pi^2}} = \frac{5.00\ \text{oz}}{13.4\ \text{in}^3} = \frac{0.374\ \text{oz}}{\text{in}^3}$$

Maximum range is $\frac{(0.37 - 0.43)\ \text{oz}}{\text{in}^3}$

or $\frac{0.40 \pm 0.03\ \text{oz}}{\text{in}^3}$

62. Experimental results are the facts that we deal with. Theories are our attempts to rationalize those facts. If the experiment is done properly and the theory can't account for the facts, then the theory is wrong.

63. $$\frac{\$1.09}{\text{gal}} \times \frac{1\ \text{gal}}{4\ \text{qt}} \times \frac{1.06\ \text{qt}}{\text{L}} = \frac{\$0.289}{\text{L}} \text{ or } \frac{28.9\ ¢}{\text{L}}$$

64. If the measurement is not precise, then it may be close to a particular "true" value only by chance. The next measurement may be way off or even the next several may be far from the true value.

65. $$\frac{100\ \text{yard}}{9.1\ \text{s}} \times \frac{3\ \text{ft}}{\text{yard}} = \frac{33\ \text{ft}}{\text{s}}$$

$$\frac{100\ \text{yard}}{9.1\ \text{sec}} \times \frac{1\ \text{mi}}{1760\ \text{yd}} \times \frac{60\ \text{s}}{\text{min}} \times \frac{60\ \text{min}}{\text{hr}} = \frac{22\ \text{mi}}{\text{hr}}$$

$$\frac{100\ \text{yard}}{9.1\ \text{s}} \times \frac{0.9144\ \text{m}}{\text{yd}} = \frac{1.0 \times 10^1\ \text{m}}{\text{s}}$$

$$\frac{1.0 \times 10^1\ \text{m}}{\text{s}} \times \frac{1\ \text{km}}{1000\ \text{m}} \times \frac{60\ \text{s}}{\text{min}} \times \frac{60\ \text{min}}{\text{hr}} = \frac{36\ \text{km}}{\text{hr}}$$

$$1.00 \times 10^2\ \text{m} \times \frac{1\ \text{s}}{1.0 \times 10^1\ \text{m}} = 1.0 \times 10^1\ \text{s}$$

CHAPTER TWO: ATOMS, MOLECULES, AND IONS

1. $\frac{1.188}{1.188} = 1.00$

$\frac{2.375}{1.188} = 2.00$ The masses of fluorine are in simple ratios of whole numbers to each other.

$\frac{3.563}{1.188} = 3.00$

2. $Cl_2 + 3\ F_2 \rightarrow 2\ X$

Two molecules of X contain 6 atoms of F and two atoms of Cl. Therefore, the formula of X is ClF_3.

3. a. The composition of a substance depends on the numbers of atoms of each element making up the compound (i.e. the formula of the compound) and not on the composition of the mixture from which it was formed.

b. $H_2 + Cl_2 \rightarrow 2\ HCl$ The volume of HCl produced is twice the volume of H_2 (or Cl_2) used.

4. To get the atomic mass of H to be 1.00, we divide the mass that reacts with 1.0 g of oxygen by 0.1260. $\frac{0.1260}{0.1260} = 1.00$

To get Na and Mg on the same scale, we do the same division.

$$Na: \frac{2.8750}{0.1260} = 22.8$$

$$Mg: \frac{1.5000}{0.1260} = 11.9$$

	Scale	Accepted value
H	1.00	1.00
Na	22.8	23.0
Mg	11.9	24.3

The atomic mass of Mg is incorrect. The atomic masses of H and Na are close. Something must be wrong about the assumed formulas of the compounds. It turns out the correct formulas are H_2O, Na_2O, and MgO.

5. There should be no difference. It does not matter how a substance is produced, it is still that substance.

6. a. Atoms have mass and are neither destroyed nor created by chemical reactions. Therefore, mass is neither created nor destroyed by chemical reactions. Mass is conserved.

b. The composition of a substance depends on the number and kinds of atoms that form it.