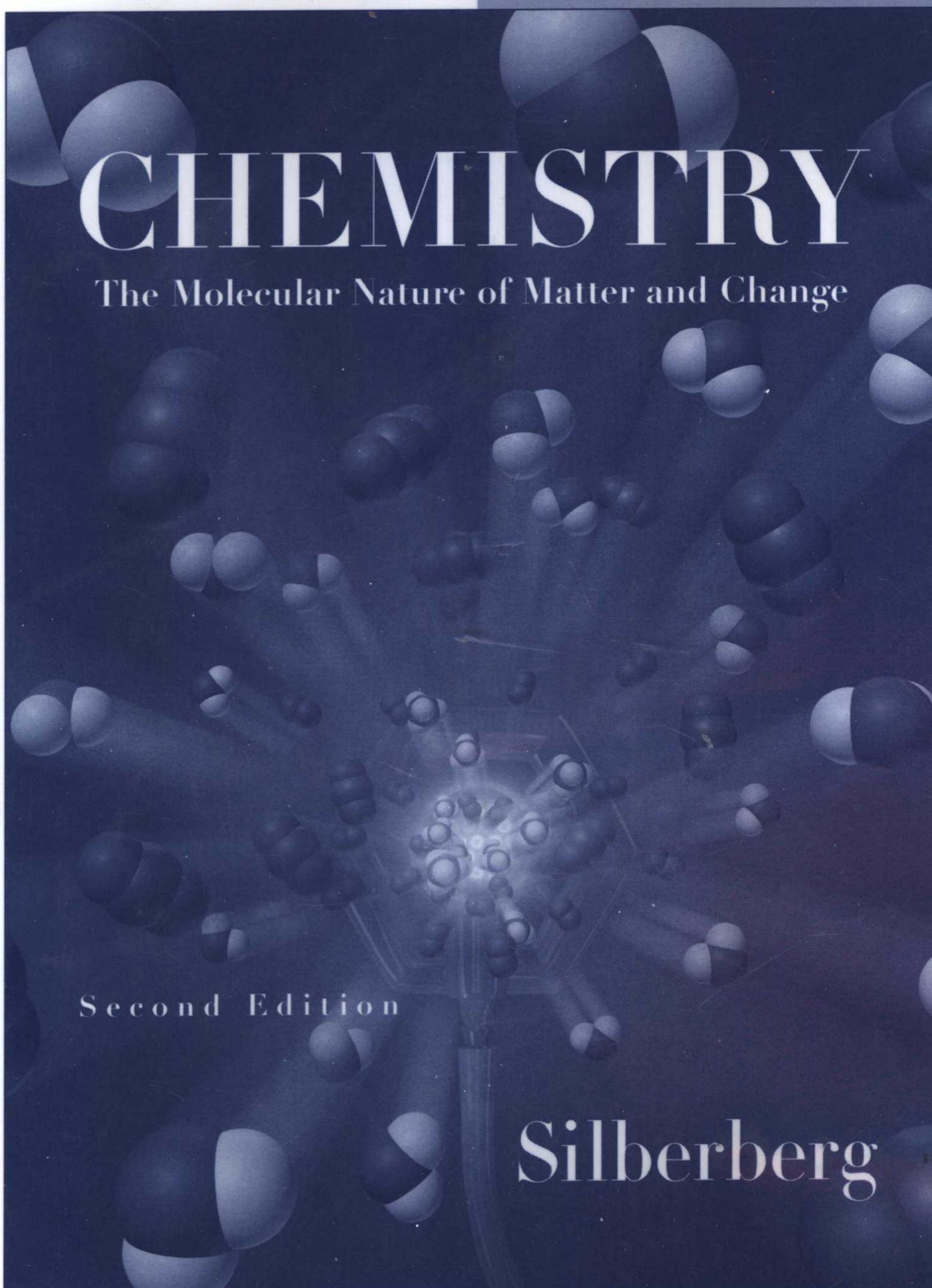
Student Solutions Manual

to accompany



Prepared by
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Student Solutions Manual

to accompany

Chemistry:

The Molecular Nature of Matter and Change

Second Edition

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PREFACE

WELCOME TO YOUR STUDENT SOLUTIONS MANUAL

Your Student Solutions Manual (SSM) includes detailed solutions for the Follow-up Problems and for the highlighted End-of-Chapter Problems in the second edition of Martin Silberberg's *Chemistry: The Molecular Nature of Matter and Change*.

You should use the Student Solutions Manual in your study of chemistry as a study tool to

- *better understand the reasoning behind problem solutions.* The plan-solution-check format illustrates the problem-solving thought process for all Follow-up Problems and for selected End-of-Chapter Problems.
- *better understand the concepts through their application in problems.* Explanations and hints for problems are in response to questions from students in general chemistry courses.
- *check your problem solutions.* Solutions provide comments on the solution process as well as the answer. In addition, alternate solutions are given for a few problems.

To succeed in general chemistry you must develop skill in problem-solving. Not only does this mean being able to follow a solution path and reproduce it on your own, but also to analyze problems you have never seen before and develop a solution strategy. Chemistry problems are story problems that bring together chemistry concepts and mathematical reasoning. In our years of teaching general chemistry we have found that the analysis of new problems is the most difficult step in problem-solving for students. You may face this in the initial few chapters or not until later in the year when the material is less familiar. When you find that you are having difficulty starting problems, don't be discouraged. This is an opportunity to learn new skills that will benefit you in future courses and your future career. The following two strategies, tested and found successful by our students, may help you develop the skills you need.

The first strategy is designed to make you more aware of your thought process as you solve problems. Draw a line down the right margin of your paper. As you solve a problem write in the margin your thought process - why you are doing each step and any questions that you ask during the solution. After completing the problem go back and make an outline of the process you used in the solution while reviewing the reasoning behind the solution. It may be useful to write a paragraph describing the solution process you used.

The second strategy helps you develop the ability to transfer a solution process to a new problem. After solving a problem, rewrite the problem to ask a different question. One way to rewrite the question is to ask the question backwards - find what has been given in the problem from the answer to the problem. Another approach is to change the conditions - for instance, ask yourself what if the temperature is higher or there is twice as much carbon dioxide present? A third method is to change the reaction or process taking place - what if the substance is melting instead of boiling.

At times you may find slight differences between your answer and the one in the Student Solutions Manual. Two reasons may account for the differences. First, SSM calculations do not round answers until the final step so this may impact the exact numerical answer. Note that in preliminary calculation steps one or two extra significant figures are retained and are shown as subscripts in the answer. The second reason for discrepancies may be that your solution route was different than the one given in the SSM. Valid alternate solution paths exist for many problems, but space allows only a few alternate solutions to be included. So trust your solution as long as the discrepancy with the SSM answer is small and use the different calculation route to better understand the concepts used in the problem.

You may also find slight differences between the answer in the textbook appendix and the one in the Student Solutions Manual. One case where this occurs is when the rounding mentioned above leads to differences in the final answer. The SSM answers were calculated retaining extra significant figures and the appendix answers generally were not. Another difference occurs when questions are open-ended, such as, "Give an example of an acid." The example given in the SSM may differ from the one in the appendix, but both answers are correct.

Symbols may differ between textbook and SSM. Occasionally the same font used in the textbook is not available for the SSM. One example is the script M that is used in the textbook for molar mass. The SSM instead uses a bold M. The SSM highlights these differences when they first appear in the SSM.

In the Student Solutions Manual names and formulae of compounds are used interchangeably to help familiarize you with the nomenclature of chemistry. Use this to review your ability to name compounds.

We thank Margaret Horn, our editor at McGraw-Hill, for her assistance, particularly her timely response to our questions. We thank both of our families for their support, particularly Michael Hablewitz for his technical expertise.

Tristine Samberg and Deborah Wiegand
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CONTENTS

CHAPTER 1

KEYS TO THE STUDY OF CHEMISTRY

FOLLOW-UP PROBLEMS

1.1 a) Changing iodine solid to iodine vapor is a physical change since the composition of the iodine does not change.

b) Combustion of gasoline fumes is a chemical change since the gasoline is converted into other substances.

c) A scab forms as the result of a chemical change since the composition of the wound changes.

1.2 Plan: We know the area of each bolt and the area of fabric needed for each chair. Converting the area in ft^2 to m^2 using conversion factor: $1 m^2 = (3.281 \text{ ft})^2 = 10.76 \text{ ft}^2$

Solution:

$$3\,bolts\left(\frac{200.\,m^2}{bolt}\right)\left(\frac{10.76\,ft^2}{1\,m^2}\right)\left(\frac{1\,chair}{31.5\,ft^2}\right) = \mathbf{205\ chairs}$$

Check: 205 chairs would require 205 x 31.5 ft^2 = 6460 ft^2 of fabric. Three bolts contain 3 x 200. = 600. m^2 of fabric that converts to 6460 ft^2 of fabric.

1.3 Plan: The volume of the cylinder contents equals the volume of the water (31.8 mL) plus the volume of the cube. The volume of a cube equals (length of side)^3. The length of the side of the cube is in mm, so first we will convert this to cm, then find volume in units of cm^3. Using the conversion factor 1 cm^3 = 1mL, we convert the cube volume to mL and add it to the water volume also in mL. Then convert the mL to L: 1000m L = 1L.

Solution: Note that additional significant figures are retained in the calculation until the final step. The addition step limits the digits beyond the decimal point to one.

$$\left[15.0\,mm\left(\frac{1\,cm}{10\,mm}\right)\right]^3\left(\frac{1\,mL}{1\,cm^3}\right) = 3.375\,mL$$

$$(3.375\,mL + 31.8\,mL)\left(\frac{1\,L}{1000\,mL}\right) = \mathbf{0.0352\ L}$$

Check: Since the length of a side of the cube is greater than 1 cm its volume should be greater than 1 cm^3 or 1 mL. 3.375 mL is greater, so this result agrees with our expectations. Units of L are correct.

1.4 Plan: From the total time (1.5 h) and the number of raindrops per minute we can use the conversion factor 60 min = 1 h to determine the total number of raindrops. Multiplying the total number of raindrops times the mass of one raindrop gives the mass of the rain that falls in 1.5 h. Use conversion factors 1 g = 1000mg and 1 kg = 1000g to convert mg raindrops to kg raindrops.

Solution:

$$1.5\,h\left(\frac{60\text{ min}}{1\,h}\right)\left(\frac{5.1\,x\,10^5\,raindrops}{\text{min}}\right)\left(\frac{65\,mg}{raindrop}\right)\left(\frac{1\,g}{1000\,mg}\right)\left(\frac{1\,kg}{1000\,g}\right) = \mathbf{3.0 x 10^3\ kg}$$

Check: The magnitude of the answer can be estimated: ~100min x 500000 raindrops/min x 0.0001kg/raindrop = 5000. The answer of 3000 kg is within this order of magnitude. Units are correct as kg of raindrops.

1.5 Plan: Mass can be calculated by multiplying the density by the volume. Then convert the mass in grams to kg using conversion factor 1000g = 1 kg.

Solution: $4.6\ cm^3\left(\frac{7.5\ g}{cm^3}\right)\left(\frac{1\ kg}{1000\ g}\right) = \mathbf{0.034\ kg}$

Check: The units are correct and the estimated answer is 5 x 7 = 35 g or 0.035 kg.

1.6 Plan: First convert the temperature in K to °C using formula T (in °C)= -273.15 + T (in K). Then convert the temperature in °C to °F using the formula T(in °F) = 9/5 T(in °C) +32.

Solution: T (in °C)= -273.15 + 234K = **-39 °C**

T(in °F) = 9/5(-39.15 °C) +32 = **-38 °F**

Check: The Celsius temperature is below zero as expected from a Kelvin temperature below 273. The temperature at which the Celsius and Fahrenheit scales have the same value is –40 degrees. Thus, with a Celsius temperature of –39 we'd expect the Fahrenheit temperature to be close, and it is.

1.7 Zeros between significant digits are significant. Zeros that end a number and lie either before or after the decimal point are significant.

a) 31.<u>0</u>7<u>0</u> mg; five significant figures
b) 0.06<u>0</u>6<u>0</u> g; four significant figures
c) 85<u>0</u>. °C; three significant figures – note terminal decimal point that makes zero significant.
d) 2.<u>000</u> x 10^2 mL; 4 significant figures
e) 3.9 x 10^{-6} m; 2 significant figures
f) 4.<u>0</u>1 x 10^{-4} L; 3 significant figures

1.8 Adding 25.65 and 37.4 will give an answer significant to the tenths digit. Dividing this answer with 3 significant figures by 73.55 with 4 significant figures and an exact number will give an answer with 3 significant figures.

$$\frac{25.65\,mL + 37.4\,mL}{73.55\,s\left(\frac{1\,min}{60\,s}\right)} = \mathbf{51.4\ mL/min}$$

END-OF-CHAPTER PROBLEMS

1.2 Gas molecules are distributed throughout the entire volume of a container while liquids and solids have a definite volume, so if the volume of the container is more than the volume of the liquid or solid the molecules will only fill part of the volume of the container.

a) Helium is a <u>gas</u> that expands to fill the entire volume of the balloon. The size of the balloon is determined by the balance of pressure exerted by the He gas atoms on the inner walls of the balloon and the pressure exerted by air molecules on the outside of the balloon.

b) Mercury forms a column of liquid inside the thin tube of the thermometer. The top of the mercury column has a surface. Mercury gas exists in the space between the liquid surface and sealed top of the thermometer.

c) Soup is a liquid that is contained by the sides of the soup bowl and forms a surface.

1.4 Physical property: characteristic of a substance that does not involve the production of another substance.

Chemical property: characteristic of a substance that results in the formation of another substance.

a) chemical property: the interaction between chlorine gas and sodium metal to produce another substance.

b) physical property: no new substance produced since iron remains iron after interaction with magnet.

1.6 a) physical change – boiled canned soup can be cooled to obtain the original soup.

b) chemical change – a toasted slice of bread has changed in its composition such that it cannot change back into an untoasted slice of bread

c) physical change – although the log is in smaller pieces, the small pieces have the same chemical composition as the log.

d) chemical change – the wood is converted into other substances, such as ashes, soot and carbon dioxide gas.

1.8 a) Fuel has higher energy because energy is released from fuel to run car.

b) Wood has higher energy because heat energy is released as wood burns.

1.12 This observation contradicted the claim that combustion always resulted in the loss of phlogiston and established that a change in mass during a chemical reaction was an important factor in monitoring chemical changes. The only way a metal could gain weight during combustion, thereby losing phlogiston, was if phlogiston had negative mass.

1.16 A well-designed experiment

1) involves at least two variables that are believed to be related.
2) can be controlled so that only one variable is changed at a time.
3) is easily reproducible by other experimenters.
4) is able to connect what is changing to the cause of the change.

1.19 a) To convert from in^2 to cm^2, use $(2.54\ cm/1\ in)^2$ or $(6.45\ cm^2/1\ in^2)$.

b) To convert from km^2 to m^2, use $(1000\ m/1\ km)^2$ or $(1 \times 10^6\ m^2/1\ km^2)$

c) This problem requires two conversion factors: one for distance and one for time. To convert distance, mi to cm, use:

$(1.609\ km/1\ mi)x(1000\ m/1\ km)x(100\ cm/1\ m) = 1.609 \times 10^5\ cm/mi$.

To convert time, h to s, use:

(1 hr/60 min)(1 min/60 s) = 1 hr/3600 s.

Therefore, the complete conversion factor is $(1.609 \times 10^5\ cm/mi)(1\ hr/3600\ s) = 5.792 \times 10^8 \frac{cm \cdot hr}{mi \cdot s}$. Do the units cancel when you start with a measurement of mi/hr?

1.21 The value of an extensive property depends on the amount of the substance, while the value of an intensive property does not depend on the amount of the substance. Density (b) and melting point (d) are intensive properties.

1.26 Use conversion factors: 1 m = 1 x 10^{12} pm; 1 m = 1 x 10^9 nm

$$radius = (128\ pm)\left(\frac{1\,m}{1x10^{12}\ pm}\right)\left(\frac{1x10^{9}\,nm}{1\,m}\right) = \mathbf{0.128\ nm}$$

1.28 Use conversion factors: 1 m = 100 cm; 1 inch = 2.54 cm; 12 inches = 1 ft

$$length = 100\ m\left(\frac{100\,cm}{1\,m}\right)\left(\frac{1\ inch}{2.54\,cm}\right)\left(\frac{1\,ft}{12\ inches}\right) = \mathbf{328\ ft}$$

1.30 a) Use conversion factors: $(1\ m)^2 = (100\ cm)^2$; $(1\ km)^2 = (1000\ m)^2$
$(32.7\ cm^2)(1\ m^2/1 \times 10^4\ cm^2)(1\ km^2/1 \times 10^6\ m^2) =$ **3.27×10^{-9} km^2.**
b) Use conversion factor: $(1\ inch)^2 = (2.54\ cm)^2$
$(32.7\ cm^2)(1\ in^2/6.45\ cm^2)(\$2.75/\ in^2) =$ **\$13.9.**

1.32 Use conversion factor: 1 kg = 2.205 lb. Assuming a body weight of 155 lbs,

$$155\,lb\left(\frac{1\,kg}{2.205\,lb}\right) = \mathbf{70.3\ kg}$$

1.34 a) $$\left(\frac{5.52\,g}{cm^3}\right)\left(\frac{100\,cm}{m}\right)^3\left(\frac{kg}{1000\,g}\right) = \mathbf{5.52x10^3\ kg/m^3}$$

b) $$\left(\frac{5.52\,g}{cm^3}\right)\left(\frac{2.54\,cm}{in}\right)^3\left(\frac{12\,in}{ft}\right)^3\left(\frac{kg}{1000\,g}\right)\left(\frac{2.205\,lb}{kg}\right) = \mathbf{345\ lb/ft^3}$$

1.36 a) $$volume = \left(\frac{1.35\,\mu m^3}{cell}\right)\left(\frac{1\,mm^3}{1x10^9\,\mu m^3}\right) = \mathbf{1.35x10^{-9}\ mm^3/cell}$$

b) $$volume = (1\,x\,10^5\,cells)\left(\frac{1.35\,\mu m^3}{cell}\right)\left(\frac{1\,cm^3}{(1x10^4\,\mu m)^3}\right)\left(\frac{1\,mL}{1\,cm^3}\right)\left(\frac{1\,L}{1000\,mL}\right) = \mathbf{1x10^{-10}\ L}$$

1.38 a) mass of mercury = 185.56 g – 42.45 g = 143.11 g
volume of mercury = volume of vial = 143.11 g/(13.53 g/cm^3) = **10.58 cm^3.**
b) mass of water = 10.57 cm^3 x 0.997 g/cm^3 = 10.5 g
mass of vial filled with water = 42.45 g + 10.5 g = **53.0 g**

1.40 Volume of a cube = (length of side)^3
Use conversion factor: 1 cm = 10 mm

$$15.6\,mm\left(\frac{1\,cm}{10\,mm}\right) = 1.56\,cm;\ Al\ cube\ volume = (1.56\,cm)^3 = 3.79_{64}\ cm^3$$

Note: Keep extra significant figures until the end of problem, so use 3.79_{64} cm^3 as the cube volume with the subscripted 64 as the additional significant figures.

Density = mass/volume = 10.25 g/3.79_{64} cm^3 = **2.70 g/cm^3**

1.42 Equations 1.2 – 1.5 on pp. 31-32 show the conversions between the three temperature scales.

a) T (in °C) = [T(in °F) –32] $5/9$ = (72-32) $5/9$ = **22 °C**

T (in K) = T(in °C) + 273.15 = 22 + 273.15 = **295 K**

b) T (in K) = -164 + 273.15 = **109 K**

T (in °F) = $9/5$ T (in °C) + 32 = $9/5$ (-164) + 32 = **-263 °F**

c) T(in °C) = T(in K) – 273.15 = 0 – 273.15 = **-273 °C**

T (in °F) = $9/5$ T (in °C) + 32 = $9/5$ (-273) + 32 = **-459 °F**

1.44 $length = 0.025\ inch\left(\frac{2.54\ cm}{1\ inch}\right)\left(\frac{1\ m}{100\ cm}\right)$ = **6.4x10^{-4} m**

1.46 If we convert the mass of gold into its equivalent volume, we can determine the sheet thickness because the other two dimensions of volume (length x width = 40.0 ft^2) are given.

Volume of gold = mass ÷ density = 1.10 g/(19.32 g/cm^3) = 0.0569 cm^3

Volume = length x width x depth (or thickness), so 0.0569 cm^3 = 40.0 ft^2 x (depth)

$$0.0569\ cm^3 = 40.0\,ft^2\left(\frac{12\,in}{ft}\right)^2\left(\frac{2.54\,cm}{in}\right)^2(depth)$$

0.0569 cm^3 = (3.72 x 10^4 cm^2)(depth)

depth or thickness = **1.53 x 10^{-6} cm**

1.50 Rule: Zeros between significant digits are significant. Zeros that end a number and lie either before or after the decimal point are significant.

1.52 a) no significant zeros; b) no significant zeros; c) $0.039\underline{0}$; d) $3.\underline{0}9\underline{00}$ x 10^4.

1.54 a) 0.00036; b) 35.83; c) 22.5

1.56 $\left(\frac{10\times 160\times 8}{2\times 3\times 4}\right) = 500$ (vs. 520 with original number of significant digits)

1.58 a) 1.34 m; b) 1.52x10^3 cm^3; c) 4.43x10^2 cm

1.60 a) 1.310000 x 10^5 (Note that all zeros are significant)

b) 4.7×10^{-4} (No zeros are significant)
c) 2.10006×10^{5}
d) 2.1605×10^{3}

1.62 a) 5550 Do not use terminal decimal point since zero is not significant.
b) 10070. Use terminal decimal point since final zero is significant.
c) 0.000000885
d) 0.003004

1.64 a) 8.025×10^{4} Add exponents when multiplying powers of ten: $8.02 \times 10^{2} \times 10^{2}$
b) 1.0098×10^{-3} $1.0098 \times 10^{3} \times 10^{-6}$
c) 7.7×10^{-11} $7.7 \times 10^{-2} \times 10^{-9}$

1.66 a) 3.45×10^{-19} J (576×10^{-9} m limits the answer to 3 significant figures)
b) 9.20×10^{24} molecules (7.04×10^{2} g limits answer to 3 significant figures)
c) 1.82×10^{5} J/mol (2.18×10^{-18} J/atom limits answer to 3 significant figures)

1.68 Exact numbers are those which have no uncertainty. Unit definitions and number counts of items in a group are examples of exact numbers.
a) A person's height is a measured quantity. This is not an exact number.
b) The number of planets in the solar system is a number count. This is an exact number.
c) The number of grams in a pound is not a unit definition. This is not an exact number.
d) The number of millimeters in a meter is a definition of the prefix "milli-". This is an exact number.

1.70 Scale markings are 0.2 cm apart. The end of the metal strip falls between the mark for 7.4 cm and 7.6 cm. It is assumed that one can divide the space between markings into fourths. Thus, since the end of the metal strip falls between 7.45 and 7.55 we can report its length as 7.50 ± 0.05 cm. (Note: If the assumption is that one can divide the space between markings into halves only then the result is 7.5 ± 0.1 cm.)

1.72 The numbers 300, 3, 2, and 4 are exact numbers because they are number counts of items in a group. The number 18 is not exact because it is a measured quantity. You can imagine that the mass of garbage could be determined to the nearest mg, and this would still be inexact because the measurement is limited by the precision of the balance.

1.74 a) $I_{avg} = \dfrac{8.72\,g + 8.74\,g + 8.70\,g}{3} = 8.72\,g$

$$II_{avg} = \frac{8.56\,g + 8.77\,g + 8.83\,g}{3} = 8.72\,g$$

$$III_{avg} = \frac{8.50\,g + 8.48\,g + 8.51\,g}{3} = 8.50\,g$$

$$IV_{avg} = \frac{8.41\,g + 8.72\,g + 8.55\,g}{3} = 8.56\,g$$

Sets **I and II** are most accurate since their average value, 8.72 g, is closest to true value, 8.72 g.

b) Deviations are calculated as $|\text{measured value} - \text{average value}|$. Average deviation is the average of the deviations. To distinguish between the deviations an additional significant figure is retained.

$$I_{avgdev} = \frac{|8.72-8.72|+|8.74-8.72|+|8.70-8.72|}{3} = 0.013\,g$$

$$II_{avgdev} = \frac{|8.56-8.72|+|8.77-8.72|+|8.83-8.72|}{3} = 0.11\,g$$

$$III_{avgdev} = \frac{|8.50-8.50|+|8.48-8.50|+|8.51-8.50|}{3} = 0.010\,g$$

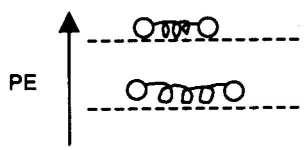
$$IV_{avgdev} = \frac{|8.41-8.56|+|8.72-8.56|+|8.55-8.56|}{3} = 0.11\,g$$

Set **III** is the most precise, but is the least accurate.

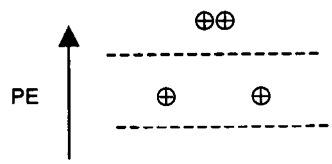
c) Set **I** has the best combination of high accuracy and high precision.

d) Set **IV** has both low accuracy and low precision.

1.76 a)



b)



a) The balls on the relaxed spring have a lower potential energy and are more stable. The balls on the compressed spring have a higher potential energy, because the balls will move once the spring is released. This configuration is less stable.

b) The two ⊕ charges apart from each other have a lower potential energy and are more stable. The two ⊕ charges near each other have a higher potential energy, because they repel one another. This arrangement is less stable.

1.79 What is the volume of the room and thus the volume of air in the room, assuming there is nothing else in the room to take up space?

$V_{air} = V_{room} = 11\,ft \times 12\,ft \times 8.5\,ft = 1.1_{22} \times 10^3\,ft^3$

Conversion from ft^3 to L: $(1\text{ ft})^3 = (12\text{ inches})^3$; $(1\text{ inch})^3 = (2.54\text{ cm})^3$; $1\text{cm}^3 = 1\text{ mL}$; 1000 mL = 1 L

$$volume = 1.1_{22} \times 10^3\,ft^3 \left(\frac{1728\,in^3}{1\,ft^3}\right)\left(\frac{16.39\,cm^3}{1\,in^3}\right)\left(\frac{1\,mL}{1\,cm^3}\right)\left(\frac{1\,L}{1000\,mL}\right) = 3.1_{78} \times 10^4\,L$$

At a rate of 1200L/min, how many minutes will it take to replace all the air in the room?

$3.1_{78} \times 10^4$ L ÷ 1200 L/min = **26 minutes**

Note: 2 additional significant figures (subscripted numbers) were kept in the calculation until the final step.

1.80 The volume of the flask is guaranteed to contain 100.0 ± 0.1 mL, so the volume is known to four significant figures.

1.82 When multiplying numbers together, we use the *convention* of reporting the result to the number of significant figures of the least significant number. Conventions are good generalizations, but are not foolproof. The researcher reports the result to three significant figures, because she knows the area of the rectangular piece is <u>not</u> 1.0 cm^2, because that would require the polymer to have the dimensions of 1.0 cm by 1.0 cm.

If we calculate the highest possible answer (0.99 x 1.07 = 1.0593) and the lowest possible answer (0.97 x 1.05 = 1.0185) the range of answers fall within 0.04 units which supports reporting the answer to the hundredths place giving three significant figures in the answer.

1.88 a) T(in °C) = T(in K) – 273.15 = 77.36 – 273.15 = **-195.79 °C**

b) T (in °F) = $\frac{9}{5}$ T (in °C) + 32 = $\frac{9}{5}$ (-195.79) + 32 = **-320.42 °F**

c) The mass of nitrogen is conserved, meaning that the mass of the nitrogen gas equals the mass of the liquid nitrogen. We first find the mass of liquid nitrogen and then convert that quantity to volume using the density of the <u>liquid</u>.

Mass of liquid nitrogen = mass of gaseous nitrogen = 500.0 L * (4.566 g/L) = 2283 g liquid N_2

Volume of liquid N_2 = 2283 g liquid N_2 ÷ (809 g liquid N_2/L of liquid N_2) = **2.82 L**

1.89 To calculate speed of sound in rubber, use the conversion factor 100 cm = 1 m:

$$\left(\frac{5.4 \times 10^3\ cm}{s}\right)\left(\frac{1\ m}{100\ cm}\right) = \mathbf{54\ m/s}$$

To calculate the speed of sound in granite, use the conversion factors 1 ft = 12 in; 1 in = 2.54 cm; 100 cm = 1 m:

$$\left(\frac{1.97 \times 10^4\ ft}{s}\right)\left(\frac{12\ in}{1\ ft}\right)\left(\frac{2.54\ cm}{1\ in}\right)\left(\frac{1\ m}{100\ cm}\right) = \mathbf{6.00 \times 10^3\ m/s}$$

1.93 a) In this example, the volume of the brass cylinder will equal the volume of the water displaced. The brass cylinder displaces 75.14 – 66.21 g = 8.93 g of water

Volume of water = vol of brass cylinder = 8.93 g of water ÷ (0.998 g water/mL water) = 8.95 mL

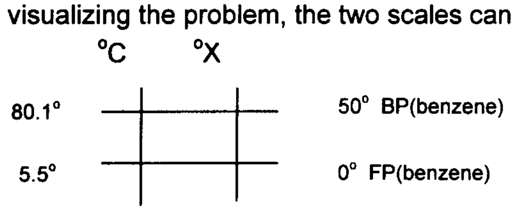
Density of brass cylinder = mass/volume = 75.14 g/8.95 mL = 8.40 g/mL or **8.40 g/cm^3** (volumes in mL refer to liquids; since we know brass is a solid, it is more accurate to report density in g/cm^3)

b) The sample of galena displaces 24.61 – 18.83 g = 5.78 g of mineral oil

Volume of mineral oil = vol of galena = 5.78 g of mineral oil ÷ 1.75 g oil/cm^3 = 3.30$_{28}$ cm^3

Density of galena = mass/volume = 24.61g/3.30$_{28}$ cm^3 = **7.45 g/cm^3**

1.97 In visualizing the problem, the two scales can be set next to each other:



There are 50 divisions between the freezing point and boiling point of benzene on the °X scale and 74.6 divisions on the °C scale. So $^\circ X = \left(\frac{50\ ^\circ X}{74.6\ ^\circ C}\right)^\circ C$

This does not account for the offset of 5.5 divisions in the °C scale from the zero point on the °X scale.

So $^\circ X = \left(\dfrac{50\,^\circ X}{74.6\,^\circ C}\right)\left(^\circ C - 5.5^\circ C\right)$

<u>Check</u>: Plug in 80.1 °C and see if result agrees with expected value of 50 °X.

$$^\circ X = \left(\frac{50\,^\circ X}{74.6\,^\circ C}\right)\left(80.1^\circ C - 5.5^\circ C\right) = 50^\circ X$$

Use this formula to find the freezing and boiling points of water on the °X scale.

$$FP_{H_2O}\ in\ ^\circ X = \left(\frac{50\,^\circ X}{74.6\,^\circ C}\right)\left(0.00^\circ C - 5.5^\circ C\right) = -3.7^\circ X$$

$$BP_{H_2O}\ in\ ^\circ X = \left(\frac{50\,^\circ X}{74.6\,^\circ C}\right)\left(100.0^\circ C - 5.5^\circ C\right) = 63.3^\circ X$$

CHAPTER 2

THE COMPONENTS OF MATTER

FOLLOW-UP PROBLEMS

2.1 Plan: Because oxygen is the only other element present in pitchblende, the mass fraction of oxygen is (1.000 – 0.848) = 0.152. However, the problem specifies a mass of uranium, not mass of pitchblende. First, determine how much pitchblende is present. Then determine the mass of oxygen using the oxygen mass fraction.

Solution:

$$mass\ pitchblende = 2.3\,t\ uranium \times \frac{1.00\,t\ pitchblende}{0.848\,t\ uranium} = \mathbf{2.7\ t\ pitchblende}$$

$$mass\ oxygen = 2.7\,t\ pitchblende \times \frac{0.152\,t\ oxygen}{1.00\,t\ pitchblende} = \mathbf{0.41\ t\ oxygen}$$

Check: Because the majority of pitchblende is composed of uranium, it makes sense that oxygen has a smaller mass than uranium.

2.2 Plan: The superscript represents the *mass* number, N, (protons + neutrons) and subscript represents the *atomic* number, Z, (protons). Obtain the number of neutrons by calculating N – Z , recognize that the number of electrons = Z for an element, and identify element by comparing the Z value to the periodic table.

Solution:

a) N = 11 and Z = 5; therefore this element contains 5 p^+, 6 n^o, and 5 e^-. Q = Boron or **B**.
b) N = 41 and Z = 20; this element contains 20 p^+, 21 n^o, and 20 e^-. X = Calcium or **Ca**.
c) N = 131 and Z = 53; this element contains 53 p^+, 78 n^o, and 53 e^-. Y = Iodine or **I**.

2.3 Plan: Write an equation that expresses the atomic mass of boron as the sum of the two weighted isotopic abundances, and then substitute the known values.

Solution:

Atomic mass of B = (isotopic mass ^{10}B)(abundance) + (isotopic mass ^{11}B)(abundance)

$10.81 = 10.0129x + (11.0093)(1-x)$

$10.81 = 11.0093 - 0.9964x$

$-0.20 = -0.9964x$ (10.81 dictates that S.F.'s are restricted to the hundredths place)

$x = 0.20;\ 1 - x = 0.80$

% abundance of ^{10}B = 20.%; % abundance of ^{11}B = **80.%**

Check: Boron-11 should have the larger % abundance because the average atomic mass (10.81 amu) is closer to the atomic mass of ^{11}B than the atomic mass of ^{10}B.

2.4 a) $\mathbf{S^{2-}}$. Sulfur is a nonmetal that gains 2 electrons to have the same number of electrons as $_{18}$Ar.
b) $\mathbf{Rb^{+}}$. Rubidium is an alkali metal that loses 1 electron to have the same number of electrons as $_{36}$Kr.
c) $\mathbf{Ba^{2+}}$. Barium is an alkaline earth metal that loses 2 electrons to have the same number of electrons as $_{54}$Xe.

2.5 a) Zinc [Group 2B(12)] and oxygen [Group 6A(16)]
b) Silver [Group 1B(11)] and bromine [Group 7A(17)]
c) Lithium [Group 1A(1)] and chlorine [Group 7A(17)]
d) Aluminum [Group 3A(13)] and sulfur [Group 6A(16)]

2.6 a) Zn^{2+} and O^{2-} combine to form **ZnO**. The charge on one zinc ion, +2, is balanced by the charge on one oxide ion, -2, to give a compound with no net charge, ZnO.
b) Ag^+ and Br^- combine to form **AgBr**. The charge on one silver ion, +1, is balanced by the charge on one bromide ion, -1, to give a compound with no net charge, AgBr.
c) Li^+ and Cl^- combine to form **LiCl**. The charge on one lithium ion, +1, is balanced by the charge on one chloride ion, -1, to give a compound with no net charge, LiCl.
d) Al^{3+} and S^{2-} combine to form **Al_2S_3**. The charge on two aluminum ions, 2(+3) = +6, is balanced by the charge on three sulfide ions, 3(-2) = -6, to give a compound with no net charge, Al_2S_3.

2.7 a) Lead(IV) is Pb^{4+} and oxide is O^{2-}, so their combination yields **PbO_2**.
b) Sulfide has a –2 charge, so the copper has a +1 charge. Because copper can form more than one cation, the name needs to specifically identify the compound. The systematic name is **copper(I) sulfide** (common name = cuprous sulfide).
c) Bromide has a –1 charge, so the iron has a +2 charge. Iron can also form more than one cation, so its systematic name is **iron(II) bromide** (or ferrous bromide).
d) The mercuric ion is Hg^{2+}, so the correct formula is **$HgCl_2$**.

2.8 a) The cupric ion is Cu^{2+} and the sulfate ion is SO_4^{2-}; **$CuSO_4 \cdot 5H_2O$**.
b) The zinc ion is Zn^{2+} and the hydroxide ion is OH^-; **$Zn(OH)_2$**.
c) Lithium forms only one cation, so no numerals or suffixes are necessary; **lithium cyanide**.

2.9 a) The ammonium ion is NH_4^+ and the phosphate ion is PO_4^{3-}. Three ammonium ions combine with one phosphate ion to form **$(NH_4)_3PO_4$**.
b) Parenthesis are needed to around the polyatomic anion, OH^-; **$Al(OH)_3$**. The formula as written describes a compound with one Al atom, one oxygen atom, and three hydrogen atoms whereas the revised formula correctly reflects one Al ion combined with three hydroxide ions.
c) Mg is magnesium and can only have a +2 charge, therefore roman numerals are not needed. HCO_3^- is the hydrogen carbonate (or bicarbonate) ion. The correct name is **magnesium hydrogen carbonate**.
d) The suffix '-ic' is not used in combination with Roman numerals. NO_3^- is the nitr*ate* ion, not the nitr*ide* ion. The correct name is **chromium(III) nitrate**.
e) Ca is the symbol for calcium, not cadmium. NO_2^- is the nitr*ite* ion, not nitr*ate*. The correct name is **calcium nitrite**.

2.10 a) Chloric acid is an oxoacid. "Chloric" corresponds to the chlorate ion (ClO_3^-) so the corresponding acid is **$HClO_3$**.
b) HF is a binary acid, **hydrofluoric acid**.
c) Acetic acid is an oxoacid and corresponds to the acetate ion, CH_3COO^-. The acid formula is **CH_3COOH** (also written as $HC_2H_3O_2$).
d) Sulfurous acid is an oxoacid and is derived from the sulfite ion, SO_3^{2-}. The acid formula is **H_2SO_3**.