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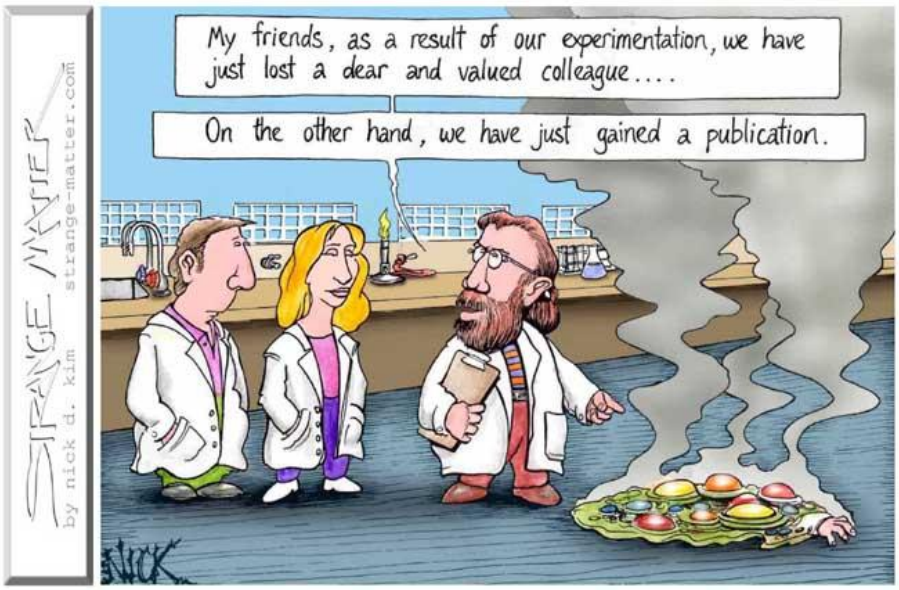
Chapter 4:
Problem Solving

Main Idea Summary:

- Problem solving is a skill learned through practice. The more you practice, the more proficient you become.
- Problem solving involves developing a plan, and mapping out a pathway through a problem before solving.
- Any two measurements that are equal to one another but expressed in different units can be written as a ratio.
- A ratio of equivalent measurements is called a conversion factor and is equal to unity.
- Conversion factors are used in the problem solving technique of dimensional analysis.
- A ratio of equivalent measurements has two forms. The correct conversion factor for solving a particular problem will have the known unit in the denominator and the unknown unit in the numerator.
- Conversion problems in which you are asked to express a measurement in some other unit are easily solved using dimensional analysis.
- In dimensional analysis, units are used to help write the solution to a problem.
- Many complex problems, whether they be in chemistry or in daily life, can be successfully solved by breaking the solution down into steps.
- More than one conversion factor may be required in some more complex conversion problems.
- The given measurement in a rate problem has a ratio of units. Rate problems may be solved by converting the unit in the numerator followed by converting the unit in the denominator.



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Chapter 4 – Problem Solving

Vocabulary

Conversion factor:
(examples of conversion factors):
Dimensional anaylsis:
unit
density
Boling point
temperature
Celsius
volume
mass
known
unknown

Encounter
techniques
situations
proficient
developing
destination
conveniently
approach
strategy
evaluate
modifications
express (express a measurement)

TEXT REVIEW 4.1 What do I do now?

1. Write a word problem so someone would be forced to calculate the distance from school to your home._____
_____
_____
_____
_____
_____

2. Now show the solution to that word problem (just make up numbers, they don't have to be correct).

3. Summarize the three step method to solving a problem.

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TEXT REVIEW section 4.2- Simple Conversion Problems.

1. Write a list of conversion factors for the weekly salary of a person who works 40 hours at $8.75 per hour. In all American coins and bills.

2. What is the term which means " a ratio of equivalent measures" _____.

3. Explain why in figure 4.4 the 100 is really large, and so is the m, but the 1 and the cm are small.

4. What are "units"?

5. Circle the "units" listed below:

a) 3.0 m	b) purple	c) 9 cm^3	d) ½ cup	e) run	f) 10^8 nm	g) 0.5 L	f) flying
g) ½ serving	h) 43°C	i) 99 K	j) pretty	k) 3 tsp	l) $1.00	m) 33 GB	n) volume

6. Use dimensional analysis to calculate how old your teacher is in seconds. I was born in 1964.
Start by subtracting the year. Assume that the month, day and time of day are irrelevant.

7. Calculate how many seconds old you are.

5280 feet = 1 mile	16 oz = 1 pounds	12 inches = 1 foot
1 pint = 473 milliliters	1 ton = 2000 pounds	5 carats = 1 kilograms

Perform the following conversions. Show all work. Write clearly.

8. 32 miles = ? feet

9. 45 oz = ? pounds

10. 3.4 pints = ? milliliters

11. 5.6 pounds = ? tons

12. 56 inches = ? feet

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TEXT REVIEW 4.2

5280 feet = 1 mile	16 oz = 1 pounds	12 inches = 1 foot
1 pint = 473 milliliters	1 ton = 2000 pounds	5 carats = 1 kilograms

1. 0 .6 carats = ? kilograms

2. 65 pounds = ? oz

3. 500 milliliters = ? pints

4. 4.5 pounds = ? tons

5. 1.56 tons = ? pounds

Multi-step problems (section 4.3)

6. 8500 oz = ? tons (hint: *convert from oz to pounds to tons.*)

7. 0.075 tons = ? oz

8. 6302 inches = ? miles

9. 67 miles = ? inches

10. 0.015 tons = ? oz

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One of the first math-related skills that you must master in your study of chemistry is the ability to convert units. However, it is not enough to understand how to set up unit conversion problems. You must also be able to input the numbers into your calculator to get the correct answer.

If you were to go through the unit conversion process for converting 2 hours into seconds, you would get the following result, by canceling units with standard conversion factors.

$$\frac{2\ \cancel{hours}}{1} \times \frac{60\ \cancel{minutes}}{1\ \cancel{hour}} \times \frac{60\ seconds}{1\ \cancel{minute}} = ???$$

What you have done is create an arrangement of fractions that need to be combined together. Do this by multiplying each of the numerators together, and dividing each of the denominators. It's just that simple. You don't have to combine them into one big fraction. You don't have to use the parenthesis function on your calculator to keep the numerator and denominator separate. This is unnecessary, and will only result in mistakes. **Multiply the numbers on top. Divide the numbers on the bottom.**

$$\frac{2}{1} \times \frac{60}{1} \times \frac{60}{1} = 2 \div 1 \times 60 \div 1 \times 60 \div 1 = 7200\ seconds.$$

If you remember to multiply the numbers on top, and divide each of the numbers on the bottom, you will never get any of these calculations wrong. (Of course, you don't have to bother multiplying and dividing by one.) Here is the calculation of how many miles are in 6 inches, requiring the division function.

$$\frac{6\ \cancel{inches}}{1} \times \frac{1\ \cancel{foot}}{12\ \cancel{inches}} \times \frac{1\ mile}{5280\ \cancel{feet}} = 6 \div 12 \div 5280 = 0.0000946\ miles$$

Of course, the numerical answer should be a very small number. There shouldn't be many miles in 6 inches. Think about your answers as you calculate them, and double check them by making sure that the answer makes sense.

Dimensional analysis requires no knowledge, just practice.

8 schaten = 50 leitung	1 euch = 10 gesetz	1 doodlemunch = 2 luften
1 pupli = 6 tanzen	11 euch = 1 gelassen	1 gesetz = 10 kubel
3 schaten = 91 dirigent	3 freude = 21 machen	100 luften = 7 tanzen
1200 gelassen = 1 klavier	1 durchen = 4 gelassen	1 durchen = 1000 kubel

Perform the following conversions. Show all work. Write clearly.

1. 8 schaten = ? leitung

2. 84 tanzen = ? pupli

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TEXT REVIEW 4.2 & 4.3 practice with silly units.

8 schaten = 50 leitung	1 euch = 10 gesetz	1 doodlemunch = 2 luften
1 pupli = 6 tanzen	11 euch = 1 gelassen	1 gesetz = 10 kubel
3 schaten = 91 dirigent	3 freude = 21 machen	100 luften = 7 tanzen
1200 gelassen = 1 klavier	1 durchen = 4 gelassen	1 durchen = 1000 kubel

1. 12 kubel = ? gelassen

2. 50 luften = ? tanzen

3. 32 schaten = ? leitung

4. 32 leitung = ? dirigent

5. 65.4 gelassen = ? gesetz

6. 604 doodlemunch = ? luften

7. 80 tanzen = ? doodlemunch

8. 43 machen = ? freude

9. 740 dirigent = ? schaten

10. 84 klavier = ? gelassen

11. 54 dirigent = ? leitung

12. 45 kubel = ? euch

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Practice with Metric Units

0.001 kg = 1 g = 10 dg = 100 cg = 1000 mg
0.001 kL = 1 L = 10 dL = 100 cL = 1000 mL
0.001 km = 1 m = 10 dm = 100 cm = 1000 mm

STUDENTS: Please memorize the conversions on the left. They are vital to your success in this unit.

Perform the following conversions. Show all work. Write clearly.

1. 67 dg = ? cg

2. 56 mL = ? dL

3. 0.012 kL = ? dL

4. 954 mg = ? dg

5. 0.054 g = ? mg

6. 50 cm = ? dm

7. 0.0014 km = ? cm

8. 700 cL = ? dL

9. 750000 cL = ? kL

10. 200 m = ? dm

11. 860 mm = ? dm

12. 600 cg = ? mg

13. 13 kg = ? mg

It is a fact that one liter is equal to 1 cubic decimeter. That is, one liter of liquid will fit into a cube that is one decimeter in length, width, and height.

Mathematically speaking:

$$1\ L = 1\ dm^3$$

Suppose we don't want to know how much liquid we have in cubic decimeters. Suppose we know that we want to measure liquid in a cubic unit of length, like cubic millimeters. One liter is equal to one cubic decimeter, but how many cubic millimeters is it?

$$1\ L = ?\ mm^3$$

We can begin with our standard technique for solving unit conversion problems. First, write what is given over the number one:

$$\frac{1\ L}{1}$$

We cannot convert from liters to cubic millimeters. The only conversion that we know of is from liters to cubic decimeters. Let's go ahead and do that, and see where it gets us:

$$\frac{1\ \cancel{L}}{1} \times \frac{1\ dm^3}{1\ \cancel{L}} = 1\ dm^3$$

We're on the right track. We now have units of cubic length, but not cubic millimeters, as we desire. We need to convert cubic decimeters to cubic milliliters. Since one cubic decimeter, dm^3 is the same as 1 dm × dm × dm, and one cubic milliliter, mm^3, is the same as 1 mm × mm × mm, we will have to convert these cubic units three times. **If a unit is raised to a power, it must be canceled multiple times.** Thus, the answer to the problem above can be found in the following way:

$$\frac{1\ \cancel{L}}{1} \times \frac{1\ \cancel{dm}^3}{1\ \cancel{L}} \times \frac{1000\ mm}{10\ \cancel{dm}} \times \frac{1000\ mm}{10\ \cancel{dm}} \times \frac{1000\ mm}{10\ \cancel{dm}} = 1000000\ mm^3$$

Use this method to cancel any units that are raised to a power. Remember:

<u>Squared units must be canceled twice. Cubic units must be canceled three times.</u>

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Metric Practice with Volume Units.

0.001 kg = 1 g = 10 dg = 100 cg = 1000 mg
0.001 kL = 1 L = 10 dL = 100 cL = 1000 mL
0.001 km = 1 m = 10 dm = 100 cm = 1000 mm

STUDENTS: Please memorize the conversions on the left. They are vital to your success in this unit.

1 mL = 1 cm^3
1 L = 1 dm^3

NOTE: There are two new conversions for units of volume

Perform the following conversions. Show all work. Write clearly.

4.2 dm = ? m

14 mg = ? dg

0.056 g = ? cg

56 L = ? dm^3

64.67 dm^3 = ? cL

1.23 mL = ? cm^3

634 dm^3 = ? mL

1.03 L = ? mm^3

130 dg = ? mg

1.025 mm^3 = ? dL

302.7 m^3 = ? L

556 mg = ? dg

6 dm^3 = ? L

78 L = ? cm^3

6.037 kg = ? mg

16 dL = ? dm^3

0.042 kL = ? m^3

854 cL = ? mm^3

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MORE PRACTICE WITH LOTS OF UNITS

0.001 kg = 1 g = 10 dg = 100 cg = 1000 mg
0.001 kL = 1 L = 10 dL = 100 cL = 1000 mL
0.001 km = 1 m = 10 dm = 100 cm = 1000 mm
1 mL = 1 cm^3
1 L = 1 dm^3
1 mile = 5280 feet = 1609 m
1 inch = 2.54 cm

Perform the following conversions. Show all work. Write clearly.

15 miles = ? m

1 hour = ? seconds

15 miles per hour = ? meters per second

55 miles per hour = ? meters per minute

68 km per hour = ? meters per second

506 mL = ? dL

102 feet per second = ? inches per hour

50.03 dL = ? cm^3

60 kg/hr = ? mg/sec

105 mg/sec = ? dg/year

60 kg = ? mg

1 hr = ? sec

16 years = ? sec

2 m = ? cm

0.125 m/yr = ? cm/sec

126 mL = ? dm^3

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Density of Pennies Lab

US Pennies have been composed of copper and zinc since 1959, but the ratio of copper to zinc has changed over the years due to the increases in the price of copper. Copper and zinc are both metallic elements and they share many physical properties, but they have different densities. Pure copper has a density of 9.0 g/mL, while pure zinc has a density of 7.1 g/mL. By measuring the density of pennies from different years, it's possible to track changes in the composition of the penny.

Materials: Pennies of varying mint dates, Balance, Graduated cylinder, Water, Paper towel

Procedure:

1. Wear goggles
2. Procure ten to twenty pennies, in 3 sets: BEFORE 1982, 1982, AFTER 1982. The bigger the sample size the better your data (and the higher your grade). Record the range of mint dates.
3. Weigh all of the pennies on the balance. Record the mass.
4. Fill a graduated cylinder about halfway full of water. Record the initial volume.
5. **Gently** place the pennies in the water. Record the final volume of the water.
6. Calculate the amount of water displaced by the pennies. This is equal to the volume of the pennies.
7. Divide the mass of the pennies from Step 3 by the volume of the pennies from Step 6 to get the density of the pennies. Record the density of the pennies.
8. Dry the pennies used in this trial. Procure a new set of pennies, and repeat the experiment as many times in the time allotted. Record all data in a chart of your own design.

Questions:

1. Classify the pennies in your data table as "mostly zinc" or "mostly copper."
2. Look at the data from your class. Did the composition change before 1982, or during 1982?
3. What factors do you think might lead to error in your density measurements? Which of these factors could not be corrected by improved technique?
4. Explain how you might determine the identity of an irregularly shaped solid that is soluble in water.
5. In 1943, all pennies issued by the US mint were struck from zinc-plated steel. Why? (Internet research should be used to find the answer to this question.)
6. Why would the increase in the price of copper cause the mint to change the composition of pennies?

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More Practice with multi-step problems

0.001 kg = 1 g = 10 dg = 100 cg = 1000 mg
0.001 kL = 1 L = 10 dL = 100 cL = 1000 mL
0.001 km = 1 m = 10 dm = 100 cm = 1000 mm
1 mL = 1 cm^3
1 L = 1 dm^3
1 mile = 5280 feet = 1609 m
1 inch = 2.54 cm

Perform the following conversions. Show all work. Write clearly.

15 miles/sec = ? m/hour

1 mile·hour = ? feet·second

15 kg·miles/hour = ? cg·meters/second

55 mile·cg/hour = ? meter·dg/min

68 km·mL/hour·dollars = ? meter·cL/sec·quarters

506 mL/feet = ? dL/mile

102 $feet^2$/second·mg = ? $inch^2$/hour·dg

50.03 miles·hour/dm^3 = ? feet·min/cm^3

60 kg/hr·L = ? mg/sec·mm^3

105 kg·$mile^2$/sec·mm^3 = ? dg·$inch^2$/year·dm^3

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Challenging Problems

0.001 kg = 1 g = 10 dg = 100 cg = 1000 mg
0.001 kL = 1 L = 10 dL = 100 cL = 1000 mL
0.001 km = 1 m = 10 dm = 100 cm = 1000 mm
1 mL = 1 cm^3
1 L = 1 dm^3
1 mile = 5280 feet = 1609 m
1 inch = 2.54 cm

Perform the following conversions. Show all work. Write clearly.

7.3 miles = ? mm

12.02 hours = ? centuries

44.09 kg·feet = ? cg·meters

5.02 $mile^2 \cdot cg/hour^3$ = ? $meter^2 \cdot dg/min^3$

60.02 $km^4 \cdot mL/years$ = ? $meter^4 \cdot cL/min$

0.004306 cL/feet·cg = ? $mm^3/mile \cdot kg$

51.005 $feet^2$ = ? $inch^2$

450.03 miles·dm^3 = ? inch·km^3

40.60 kg = ? mg

1000.54 mm^3 = ? kL

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TEST REVIEW p1

Convert the following items into millimeters. Show work at right.

1. 100 m
2. 40.5 dm
3. 3023 cm
4. 56 km
5. 42.87 m

II. Convert the following into liters. Show work at right.

1. 43 dL
2. 156 mL
3. 64.3 cL
4. 356 cubic centimeters
5. 1 mole of a gas at STP (Huh?! What is STP?!)

III. You won't see the unit "kL" appear in this or any chemistry textbook. Why do you think that is?

Note to students:

If something looks strange and new, like II, #5, do NOT just ignore it and have faith that I will explain it tomorrow. Don't be lazy. Look it up. Flip ahead a few chapters if you have to. It won't take that much time – just a few minutes. In the long run, this new information will pay off by preparing you for future chemistry problem challenges – the earlier you learn it, the earlier you master it. In the short run, you'll get full credit (and your classmates and I will be impressed by your initiative and knowledge). Trust me on this one.

–The Management

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MORE TEST REVIEW

Useful information:

1 m = 1000 mm = 10 dm = 100 cm
1 g = 1000 mg = 10 dg = 100 cg
1000 m = 1 km
1 L = 1 dm^3
1 mL = 1 cm^3
2.54 cm = 1 in
5280 ft = 1 mi
12 in = 1 ft

I. Convert the following complex units:

1. 72 mm^3 into m^3
2. 68 mm^3 into km^3
3. 450 L into dm^3
4. 450 L into m^3
5. 873 g/cm^3 into kg/m^3
6. 55 miles/hour into m/s
7. 55 miles/hour into cm/s
8. 642 cg into kg
9. 1 m^3 into mm^3
10. 75% correct on a 620 question exam