Additional Problems

1. Convert each of the following quantities to the required unit.

a. 12.75 Mm to kilometers

b. 277 cm to meters

c. 30 560 m^2 to hectares (1 ha = 10 000 m^2)

d. 81.9 cm^2 to square meters

e. 300 000 km to megameters

2. Convert each of the following quantities to the required unit.

a. 0.62 km to meters

b. 3857 g to milligrams

c. 0.0036 mL to microliters

d. 0.342 metric tons to kilograms (1 metric ton = 1000 kg)

e. 68.71 kL to liters

3. Convert each of the following quantities to the required unit:

a. 856 mg to kilograms

b. 1 210 000 µg to kilograms

c. 6598 µL to cubic centimeters (1 mL = 1 cm^3)

d. 80 600 nm to millimeters

e. 10.74 cm^3 to liters

4. Convert each of the following quantities to the required unit:

a. 7.93 L to cubic centimeters

b. 0.0059 km to centimeters

c. 4.19 L to cubic decimeters

d. 7.48 m^2 to square centimeters

e. 0.197 m^3 to liters

5. An automobile uses 0.05 mL of oil for each kilometer it is driven. How much oil in liters is consumed if the automobile is driven 20 000 km?

6. How many microliters are there in a volume of 370 mm^3 of cobra venom?

7. A baker uses 1.5 tsp of vanilla extract in each cake. How much vanilla extract in liters should the baker order to make 800 cakes? (1 tsp = 5 mL)

8. A person drinks eight glasses of water each day, and each glass contains 300 mL. How many liters of water will that person consume in a year? What is the mass of this volume of water in kilograms? (Assume one year has 365 days and the density of water is 1.00 kg/L.)

9. At the equator Earth rotates with a velocity of about 465 m/s.

a. What is this velocity in kilometers per hour?

b. What is this velocity in kilometers per day?

10. A chemistry teacher needs to determine what quantity of sodium hydroxide to order. If each student will use 130 g and there are 60 students, how many kilograms of sodium hydroxide should the teacher order?

11. The teacher in item 10 also needs to order plastic tubing. If each of the 60 students needs 750 mm of tubing, what length of tubing in meters should the teacher order?

12. Convert the following to the required units.

a. 550 μL/h to milliliters per day

b. 9.00 metric tons/h to kilograms per minute

c. 3.72 L/h to cubic centimeters per minute

d. 6.12 km/h to meters per second

13. Express the following in the units indicated.

a. 2.97 kg/L as grams per cubic centimeter

b. 4128 g/dm^2 as kilograms per square centimeter

c. 5.27 g/cm^3 as kilograms per cubic decimeter

d. 6.91 kg/m^3 as milligrams per cubic millimeter

14. A gas has a density of 5.56 g/L.

a. What volume in milliliters would 4.17 g of this gas occupy?

b. What would be the mass in kilograms of 1 m^3 of this gas?

15. The average density of living matter on Earth's land areas is 0.10 g/cm^2. What mass of living matter in kilograms would occupy an area of 0.125 ha?

16. A textbook measures 250. mm long, 224 mm wide, and 50.0 mm thick. It has a mass of 2.94 kg.

a. What is the volume of the book in cubic meters?

b. What is the density of the book in grams per cubic centimeter?

c. What is the area of one cover in square meters?

17. A glass dropper delivers liquid so that 25 drops equal 1.00 mL.

a. What is the volume of one drop in milliliters?

b. How many milliliters are in 37 drops?

c. How many drops would be required to get 0.68 L?

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Skills Worksheet

Problem Solving

Significant Figures

A lever balance used to weigh a truckload of stone may be accurate to the nearest 100 kg, giving a reading of 15 200 kg, for instance. The measurement should be written in such a way that a person looking at it will understand that it represents the mass of the truck to the nearest 100 kg, that is, that the mass is somewhere between 15 100 kg and 15 300 kg.

Some laboratory balances are sensitive to differences of 0.001 g. Suppose you use such a balance to weigh 0.206 g of aluminum foil. A person looking at your data table should be able to see that the measurement was made on a balance that measures mass to the nearest 0.001 g. You should not state the measurement from the laboratory balance as 0.2060 g instead of 0.206 g because the balance was not sensitive enough to measure 0.0001 g.

To convey the accuracy of measurements, all people working in science use significant figures. *A significant figure is a digit that represents an actual measurement.* The mass of the truck was stated as 15 200 kg. The 1, 5, and 2 are significant figures because the balance was able to measure ten-thousands, thousands, and hundreds of kilograms. The truck balance was not sensitive enough to measure tens of kilograms or single kilograms. Therefore, the two zeros are not significant and the measurement has three significant figures. The mass of the foil was correctly stated as 0.206 g. There are three decimal places in this measurement that are known with some certainty. Therefore, this measurement has three significant figures. Had the mass been stated as 0.2060 g, a fourth significant figure would have been incorrectly implied.

Rules for Determining Significant Figures

A. All digits that are not zeros are significant.

All are nonzero digits.	All are nonzero digits.
↓ ↓ ↓	↓ ↓ ↓ ↓
3 2 5 mL of ethanol	1.3 2 5 g of zinc
The measurement has three significant figures.	**The measurement has four significant figures.**

B. Zeros may or may not be significant. To determine whether a zero is significant, use the following rules:

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Problem Solving *continued*

1. Zeros appearing between nonzero digits are significant.

Nonzero digits
↓ ↓
4 0. 7 L of ammonia
↑
Zero between nonzero digits

The measurement has three significant figures.

Nonzero digits
↓ ↓ ↓
3 2 0 0 6 m of wire
↑ ↑
Zero between nonzero digits

The measurement has five significant figures.

2. Zeros appearing in front of nonzero digits are not significant.

Nonzero digits
↓ ↓ ↓
0.0 5 7 2 m^2 of foil

The measurement has three significant figures.

Nonzero digits
↓
0.000 2 g of RNA

The measurement has one significant figure.

3. Zeros at the end of a number and to the right of a decimal are significant figures. Zeros between nonzero digits and significant zeros are also significant. This is a restatement of Rule 1.

Nonzero digits
↓ ↓
9 7. 0 0 kg of tungsten
↑ ↑
Zeros to the right of a number and after a decimal point

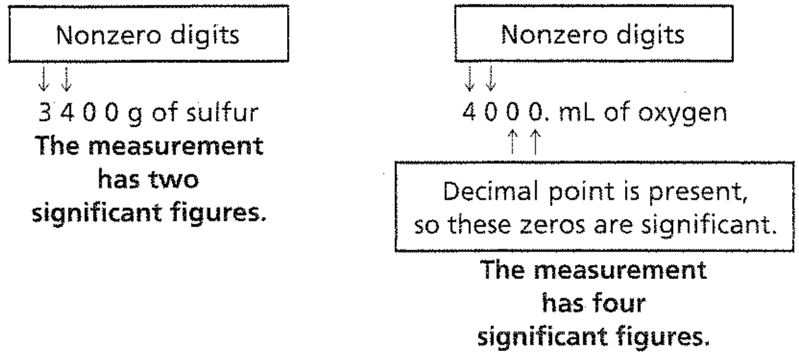
The measurement has four significant figures.

Nonzero digits
↓ ↓
1 2 0 0.0 0 cm^3 of lead
↑ ↑ ↑ ↑
Zeros to the right of a number and after a decimal point

The measurement has six significant figures.

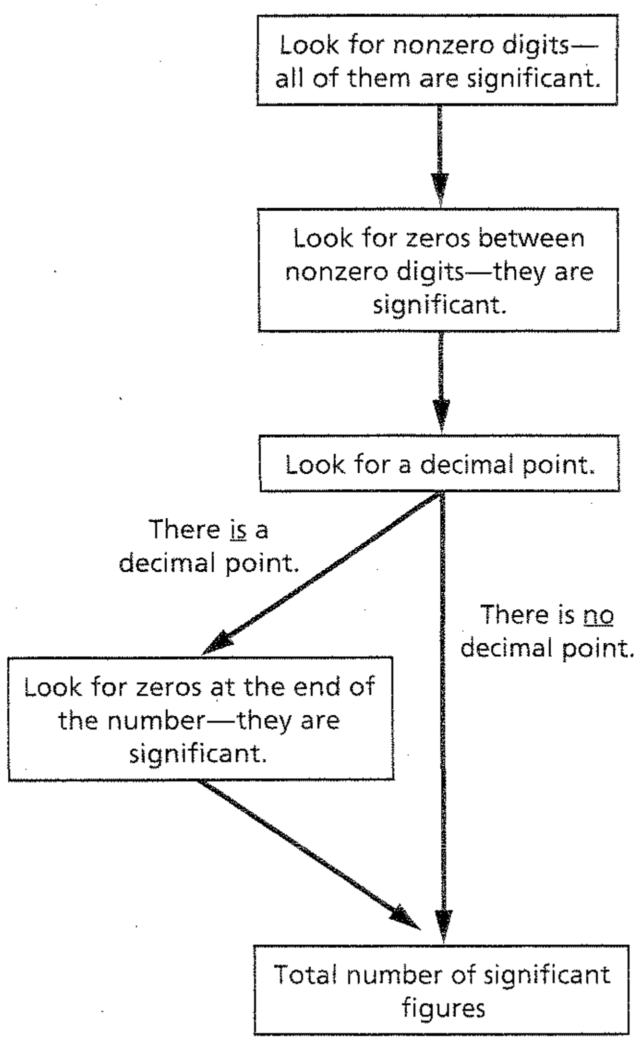
4. Zeros at the end of a number but to the left of a decimal may or may not be significant. If such a zero has been measured or is the first estimated digit, it is significant. On the other hand, if the zero has not been measured or estimated but is just a place holder, it is not significant. A decimal placed after the zeros indicates that they are significant.

Problem Solving *continued*



The rules are summarized in the following flowchart:

General Plan for Determining Significant Figures



You can determine density on your calculator and get the following result:

$$D = \frac{m}{V} = \frac{11.079\ \text{g}}{12.7\ \text{mL}} = 0.872\ 362\ 204\ \text{g/mL}$$

Although the numbers divide out to give the result shown, it is not correct to say that this quantity is the density of the solution. Remember that you are dealing with measurements, not just numbers. Consider the fact that you measured the mass of the solution with a balance that gave a reading with five significant figures: 11.079 g. In addition, you measured the volume of the solution with a graduated cylinder that was readable only to three significant figures: 12.7 mL. It seems odd to claim that you now know the density with an accuracy of nine significant figures.

You can calculate the density—or any measurement—*only as accurately as the least accurate measurement* that was used in the calculation. In this case the least accurate measurement was the volume because the measuring device you used was capable of giving you a measurement with only three significant figures. Therefore, you can state the density to only three significant figures.

Rules for Calculating with Measured Quantities

Operation	**Rule**
Multiplication and division	• Round off the calculated result to the same number of significant figures as the measurement having the fewest significant figures.
Addition and subtraction	• Round off the calculated result to the same number of decimal places as the measurement with the fewest decimal places. If there is no decimal point, round the result back to the digit that is in the same position as the leftmost uncertain digit in the quantities being added or subtracted.

In the example given above, you must round off your calculator reading to a value that contains three significant figures. In this case, you would say:

$$D = \frac{m}{V} = \frac{11.079\ \text{g}}{12.7\ \text{mL}} = 0.872\ \cancel{362\ 204}\ \text{g/mL} = 0.872\ \text{g/mL}$$

Additional Problems

1. Determine the number of significant figures in the following measurements:
   a. 0.0120 m
   b. 100.5 mL
   c. 101 g
   d. 350 cm^2
   e. 0.97 km
   f. 1000 kg
   g. 180. mm
   h. 0.4936 L
   i. 0.020 700 s
2. Round the following quantities to the specified number of significant figures:
   a. 5 487 129 m to three significant figures
   b. 0.013 479 265 mL to six significant figures
   c. 31 947.972 cm^2 to four significant figures
   d. 192.6739 m^2 to five significant figures
   e. 786.9164 cm to two significant figures
   f. 389 277 600 J to six significant figures
   g. 225 834.762 cm^3 to seven significant figures
3. Perform the following calculations, and express the answer in the correct units and number of significant figures.
   a. 651 cm × 75 cm
   b. 7.835 kg ÷ 2.5 L
   c. 14.75 L ÷ 1.20 s
   d. 360 cm × 51 cm × 9.07 cm
   e. 5.18 m × 0.77 m × 10.22 m
   f. 34.95 g ÷ 11.169 cm^3
4. Perform the following calculations, and express the answer in the correct units and number of significant figures.
   a. 7.945 J + 82.3 J − 0.02 J
   b. 0.0012 m − 0.000 45 m − 0.000 11 m
   c. 500 g + 432 g + 2 g
   d. 31.2 kPa + 0.0035 kPa − 0.147 kPa
   e. 312 dL − 31.2 dL − 3.12 dL
   f. 1701 kg + 50 kg + 43 kg
5. A rectangle measures 87.59 cm by 35.1 mm. Express its area with the proper number of significant figures in the specified unit:
   a. in cm^2
   b. in mm^2
   c. in m^2

6. A box measures 900. mm by 31.5 mm by 6.3 cm. State its volume with the proper number of significant figures in the specified unit:

a. in cm^3

b. in m^3

c. in mm^3

7. A 125 mL sample of liquid has a mass of 0.16 kg. What is the density of the liquid in the following measurements?

a. kg/m^3

b. g/mL

c. kg/dm^3

8. Perform the following calculations, and express the results in the correct units and with the proper number of significant figures.

a. $13.75\ mm \times 10.1\ mm \times 0.91\ mm$

b. $89.4\ cm^2 \times 4.8\ cm$

c. $14.9\ m^3 \div 3.0\ m^2$

d. $6.975\ m \times 30\ m \times 21.5\ m$

9. What is the volume of a region of space that measures 752 m × 319 m × 110 m? Give your answer in the correct unit and with the proper number of significant figures.

10. Perform the following calculations, and express the results in the correct units and with the proper number of significant figures.

a. $7.382\ g + 1.21\ g + 4.7923\ g$

b. $51.3\ mg + 83\ mg - 34.2\ mg$

c. $0.007\ L - 0.0037\ L + 0.012\ L$

d. $253.05\ cm^2 + 33.9\ cm^2 + 28\ cm^2$

e. $14.77\ kg + 0.086\ kg - 0.391\ kg$

f. $319\ mL + 13.75\ mL + 20.\ mL$

11. A container measures 30.5 mm × 202 mm × 153 mm. When it is full of a liquid, it has a mass of 1.33 kg. When it is empty, it has a mass of 0.30 kg. What is the density of the liquid in kilograms per liter?

12. If 7.76 km of wire has a mass of 3.3 kg, what is the mass of the wire in g/m? What length in meters would have a mass of 1.0 g?

13. A container of plant food recommends an application rate of 52 kg/ha. If the container holds 10 kg of plant food, how many square meters will it cover ($1\ ha = 10\ 000\ m^2$)?

14. A chemical process produces 974 550 kJ of energy as heat in 37.0 min. What is the rate in kilojoules per minute? What is the rate in kilojoules per second?

Name ____________________ Class ____________ Date ____________

Skills Worksheet

Problem Solving

Scientific Notation

People who work in scientific fields often have to use very large and very small numbers. Look at some examples in the following table:

Measurement	Value
Density of air at 27°C and 1 atm pressure	0.001 61 g/cm^3
Radius of a calcium atom	0.000 000 000 197 m
One light-year	9 460 000 000 000 km
The mass of a neutron	0.000 000 000 000 000 000 000 001 675 g

You can see that measurements such as these would be awkward to write out repeatedly. Also, calculating with very long numbers is likely to lead to errors because it's so easy to miscount zeros and decimal places. To make these numbers easier to handle, scientists express them in a form known as *scientific notation*, which uses powers of 10 to reduce the number of zeros to a minimum.

Look at a simple example of the way that scientific notation works. Following are some powers of 10 and their decimal equivalents.

$$10^{-2} = 0.01$$
$$10^{-1} = 0.1$$
$$10^{0} = 1$$
$$10^{1} = 10$$
$$10^{2} = 100$$

Suppose we rewrite the values in the table using scientific notation. The numbers become much less cumbersome.

Measurement	Value
Density of air at 27°C and 1 atm pressure	1.61×10^{-3} g/cm^3
Radius of a calcium atom	1.97×10^{-10} m
One light-year	9.46×10^{12} km
Mass of a neutron	1.675×10^{-24} g

Additional Problems

1. Express the following quantities in scientific notation:
   - a. 158 000 km
   - b. 0.000 009 782 L
   - c. 837 100 000 cm^3
   - d. 6 500 000 000 mm^2
   - e. 0.005 93 g
   - f. 0.000 000 006 13 m
   - g. 12 552 000 J
   - h. 0.000 008 004 g/L
   - i. 0.010 995 kg
   - j. 1 050 000 000 Hz
2. Perform the following calculations, and express the result in scientific notation with the correct number of significant figures:
   - a. 2.48×10^2 kg + 9.17×10^3 kg + 7.2×10^1 kg
   - b. 4.07×10^{-5} mg + 3.966×10^{-4} mg + 7.1×10^{-2} mg
   - c. 1.39×10^4 m^3 + 6.52×10^2 m^3 − 4.8×10^3 m^3
   - d. 7.70×10^{-9} m − 3.95×10^{-8} m + 1.88×10^{-7} m
   - e. 1.111×10^5 J + 5.82×10^4 J + 3.01×10^6 J
   - f. 9.81×10^{27} molecules + 3.18×10^{25} molecules − 2.09×10^{26} molecules
   - g. 1.36×10^7 cm + 3.456×10^6 cm − 1.01×10^7 cm + 5.122×10^5 cm
3. Perform the following computations, and express the result in scientific notation with the correct number of significant figures:
   - a. 1.54×10^{-1} L ÷ 2.36×10^{-4} s
   - b. 3.890×10^4 mm × 4.71×10^2 mm^2
   - c. 9.571×10^3 kg ÷ 3.82×10^{-1} m^2
   - d. 8.33×10^3 km ÷ 1.97×10^2 s
   - e. 9.36×10^2 m × 3.82×10^3 m × 9.01×10^{-1} m
   - f. 6.377×10^4 J ÷ 7.35×10^{-3} s
4. Your electric company charges you for the electric energy you use, measured in kilowatt-hours (kWh). One kWh is equivalent to 3 600 000 J. Express this quantity in scientific notation.
5. The pressure in the deepest part of the ocean is 11 200 000 Pa. Express this pressure in scientific notation.
6. Convert 1.5 km to millimeters, and express the result in scientific notation.
7. Light travels at a speed of about 300 000 km/s.
   - a. Express this value in scientific notation.
   - b. Convert this value to meters per hour.
   - c. What distance in centimeters does light travel in 1 μs?