Name ______________________ Date __________ Class __________

SKILLS DEVELOPMENT

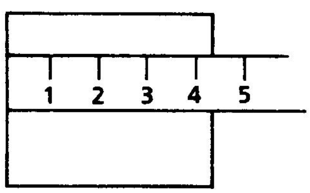
Text Reference: Section 2-13

Significant Figures

Making measurements in science most often involves using instruments. In the chemistry lab, for example, you will use rulers to measure length, graduated cylinders to measure liquid volume, and balances to measure mass. Making a measurement usually involves a certain process and the use of an instrument.

Making Measurements

The process of measurement can be illustrated by measuring the length of a wooden block, as shown in the drawing. According to the ruler, the length of the block lies somewhere between 4 and 5 cm. The exact measurement might be 4.3 or 4.4 cm. The second figure is estimated, or doubtful.



Significant Figures

All measurements are doubtful to some extent. To indicate the degree of certainty in a measurement or a number derived from measurements, scientists use significant figures. The significant figures in a quantity are those digits that are known accurately plus one doubtful digit. The block measurement contained one certain digit and one estimated, or uncertain, digit. Thus it consisted of two significant figures.

The number of significant figures appropriate for a given measurement depends on the limitations of the measuring instrument. For example, a ruler with a mark for every millimeter could be read to a greater number of significant figures than the one used to measure the block. The estimated digit would be in hundredths, rather than tenths, of a centimeter.

Derived Quantities

Suppose the volume of a block was calculated using measurements of its length, width, and height. The exactness of the calculated volume would depend on the exactness of the measurements of length, width, and height. The number of significant digits in the derived quantity—that is, the volume—should indicate its degree of exactness. By the use of some simple rules concerning the use of significant figures, the exactness of derived quantities can be indicated.

In addition and subtraction, the result must be only as exact as the least exact measurement. For example, if a ruler measures only to the nearest 0.1 cm, then the sum of measurements made with that ruler can be exact only to the nearest 0.1 cm.

Example 1
The length of an object is the sum of three measurements, each made with a different measuring device. The measurements are 27.15 cm, 5.6 cm, and 8.725 cm. What is the sum, expressed in the appropriate number of significant figures?

Solution
The answer is 41.5 cm. Because the least accurate measurement is doubtful in the tenths place, the sum is also doubtful in the tenths place.

In multiplication and division, the result should have no more significant figures than are present in the least exact quantity used to obtain the result.

Example 2
A piece of lead has a mass of 404.2 g and a volume of 51.6 cm^3. Its density equals 404.2 g divided by 51.6 cm^3. What is the density, expressed to the appropriate number of significant figures?

Solution
The answer is 7.83 g/cm^3. The appropriate number of significant figures is that of the less accurate of the two measurements—that is, 51.6 cm^3.

When you obtain a result—with the use of a hand calculator, for example—that includes more than the appropriate number of significant figures, you must round it off. For example, if a hand calculator gave the density as 7.833333 g/cm^3, you would round off to 7.83 g/cm^3 because the digit following the 3 is less than five. If the result had been 7.836333 g/cm^3, then you would have rounded off to 7.84 g/cm^3 because the digit following the 3 is greater than five. If the digit following the 3 had been five, (that is, 7.835333), then the rule is to round up to 7.84.

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Significant Figures (continued)

Zeros in Significant Figures

Zeros are not significant figures when they only serve to mark the decimal place. For example, the zeros in 0.0054 are not significant. The number could be written in exponential notation as 5.4×10^{-3}, which clearly shows that it contains only two significant figures. In the number 705 000, the last three zeros are probably not significant, but the first one is. In exponential notation the number might be written as 7.05×10^{5}. If the last three zeros *were* significant, the exponential form of the number would be written 7.05000×10^{5}.

Exercises

Indicate the number of significant figures.

1. 453.4 m — 1. ______
2. 0.0356 g — 2. ______
3. 11.0 cL — 3. ______
4. 1.75×10^{1} s — 4. ______
5. 0.0010 GL — 5. ______

Express the results of the following calculations to the correct number of significant figures.

6. 25.56 cm + 5.755 cm + 9.5 cm — 6. ______
7. 706 × 23 — 7. ______
8. 0.0012 ÷ 5.0 — 8. ______

Round off the following number to the indicated number of significant figures: 5.404 57

9. Four significant figures. — 9. ______
10. Five significant figures. — 10. ______

Significant Digits

All digits occupying places for which actual measurement was made are significant digits. The last digit in such a value is uncertain or estimated. The exactness of the measurement is indicated by the number of significant digits in the measurement.

Review the rules in your text for determining the number of significant digits in a measurement and then answer the questions that follow.

5. Yolanda found that each of 2 pine boards had a mass of 3000 grams and measured 4.15 cm by 8.90 cm by 175 cm. Determine the number of significant digits in each of these numbers.

   ____

6. A rectangular building block that measures 2.00 cm on each of two sides and 10.00 cm on the third side has a mass of 120.0 grams. How many significant digits are in each of these values?

   ____

7. The length of a long wall is measured in three segments of 4.2 meters, 6.17 meters, and 14.15 meters. How many significant digits are in each of these measurements?

   ____

8. How many significant digits are in each of the following values obtained in laboratory measurements of masses?

   a. 0.0013 g ______________

   b. 70.020 g ______________

   c. 100 000 mg ______________

   d. 200 000.0 mg ______________

   e. 1.000 300 g ______________

   f. 1 000 300 mg ______________

Significant Digits I

Name:
Date: Period:

Perform the following operations and round your answer to the correct place value.

1) 126 L + 13.9 L =

2) 0.0024 mL + 1.45 mL =

3) 14.2 m + 4.33 m =

4) 102 mm - 54.2 mm =

5) 69.9 Kg + 72.3 Kg + 0.45 kg =

6) 72.65 cm - 21.0 cm =

Indicate the number of significant digits in the following measurements.

7) 410 L

8) 100001 mm

9) 5236.001 Kg

10) 234 m

11) 30000 m

12) 490000.001 cm

13) 0.0030 mL

14) 0.008 g

15) 98.11 cm^3

16) .00200 L

17) 4.000 Kg

18) 46 000 000 000 Km

Round the following measurements so that it contains 3 significant digits

19) 456432 Kg

20) 1000.0001 L

21) 0.0234478 Km

22) 345.67 m

23) 2452.456 cm^2

24) 3454686.0347 mm

Perform the following operations and round your answer to the correct number of significant digits.

25) 65.04 cm x 34.2 cm =

26) 65.040 L x 34.200 L =

27) 65.040 cm x 34 cm =

28) 64.3 Km / 32.07 Km =

29) 0.0042 mm x 4800 mm =

30) 5.6 Km / 56.0 Km =

31) 0.00040 cm x .434 cm =

32) 1.03 L x 210 L =

33) 4.0 km / 2.00 km =

34) 410 m / 205.3 m =

35) 2.0 m x 123.456 m =

36) 100.0 cm x (3.0 x 10^3) cm =

37) 1.0 m x 34.5 m =

38) 1.000 mL x 7453.45 mL =

Significant Digits II

Name:

Date: Period:

Perform the following operations and round your answer to the correct place value.

1) 12.3 m + 1.22 m =

2) 89 L + 12.6 L =

3) 0.0053 mL + 0.74 mL =

4) 83.78 cm - 21.5 cm =

5) 909 mm - 41.6 mm =

6) 78.2 kg + 21.852 kg + 14.6 kg =

Indicate the number of significant digits in the following measurements.

7) 12 100 cm

8) 93.00 m

9) 5 003 kg

10) 160 mg

11) 700.000 m

12) 499.002 00 mm

13) 600.700 mL

14) 98.000 0 cm^3

15) 0.00023 L

16) 0.030 0 mm

17) 23 000.000 kg

18) 0.007 8

Round the following measurements so that it contains 3 significant digits.

19) 608 626 kg

20) 5 821 cm

21) 0.003 632 km

22) 829.3 m

23) 99.000 00 L

24) 2 431 634.72 mL

Perform the following operations and round your answer to the correct number of significant digits.

25) 12.3 cm x 3.00 cm =

20) 12.30 m x 3.000 m =

21) 12.30 km x 3.0 km =

22) 68.4 mm x 12 mm =

23) 44.321 nm x 0.0632 nm =

24) 12.000 m x 11.000 m =

25) 0.030 cm x 0.40 cm =

26) 891 mm x 71 mm =

27) 9.00 km ÷ 3.0 km =

28) 123 cm ÷ 16 cm =

29) 19.00 m ÷ 8.00 m =

30) 1.00 mm ÷ 3.00 mm =

31) 1.0 mm ÷ 3.0 mm =

32) 1.000 000 nm ÷ 3.000 nm =

Practice Problems

Write your answers on a separate sheet of paper. Show all work.

1. An object is 12 m long, 0.65 m wide, and 1.3 m high. Calculate the quantity *length* × *width* × *height* for this object, making sure that your answer is in the appropriate SI derived units. What is the name of the quantity you have calculated?

2. An object is 6.8 m long, 125 cm wide, and 0.90 m high. Calculate the quantity *length* × *width* × *height* for this object, making sure that your answer is in the appropriate SI derived units.

3. Calculate the volume of a liquid that fills a rectangular container that is 365 cm long, 455 cm wide, and 1012 cm high. Make sure that your answer is in the appropriate SI derived units.

4. An object moves 328.4 m in 8.24 s. Calculate the quantity $\frac{distance}{time}$ for this situation, making sure that your answer is in the appropriate SI derived units. What is the name of the quantity you have calculated?

5. An object has a mass of 600 g, and is 3.1 cm long, 2.5 cm wide, and 21 cm high. Calculate the ratio of its mass to its volume, making sure that your answer is in the appropriate SI derived units. What is the name of the quantity you have calculated?

6. An object whose mass is 2.0 kg is pushed through a distance of 8.0 m in 4.0 s. Calculate the quantity $\frac{distance \times mass}{time \times time}$ for this situation, making sure that your answer is in the appropriate SI derived units. What is the name of the quantity you have calculated, and what is the name and symbol of its unit?

7. An object pushes down on another object with a force of 496 N. This force is exerted over a rectangular area that is 6.25 m long and 1.56 m wide. Calculate the ratio of force to area for this situation, making sure that your answer is in the appropriate SI derived units. What is the name of the quantity you have calculated, and what is the name and symbol of its unit? (Hint: Begin by converting newtons, N, to SI derived units. Compare the units in your answer to those in Figure 2-9 in your textbook.)

8. An object that has a mass of 7.96 kg is moved through a distance of 16.0 m in 2.99 s. Calculate the quantity $\frac{distance \times distance \times mass}{time \times time}$ for this situation, making sure that your answer is in the appropriate SI derived units. What is the name of the quantity you have calculated, and what is the name and symbol of its unit?

9. Calculate the total length of three pieces of wood whose individual lengths are 15.0 cm, 11.05 cm, and 4.9 cm. (Make sure that your answer contains the proper number of significant figures.)

10. The mass of a beaker is found to be 60.2 g. The mass of the beaker plus a substance placed into it is 63.16 g. Calculate the mass of the substance.

11. A desk top is found to be 1.26 m long and 0.55 m wide. Calculate its area.

12. A car travels 70.5 km in 0.85 h. Calculate its average speed.

13. The surface area of a table top is 1.08 m^2, and its length is 0.84 m. Calculate its width.

14. A metal safe is 0.45 m long, 0.832 m wide, and 0.6413 m high. Calculate its volume.

15. The volume of a large desk drawer is 0.31 m^3. How high is the drawer if it is 0.94 m long and 0.879 m wide?

16. How much time does it take a train whose average velocity is 80.6 km/h to travel 327 km?

17. Two samples of the same liquid are mixed together. If the total volume is 95.3 cm^3, and the volume of one of the liquids alone was 13.624 cm^3, what was the volume of the other liquid?

18. A runner actually covers a certain distance in 45.4 s. Your measurement of the time involved is 44.8 s. Calculate the percent error of your measurement.

19. A metal rod is actually 34.336 m long. You measure the length as 34.337 m. Calculate the percent error of your measurement.