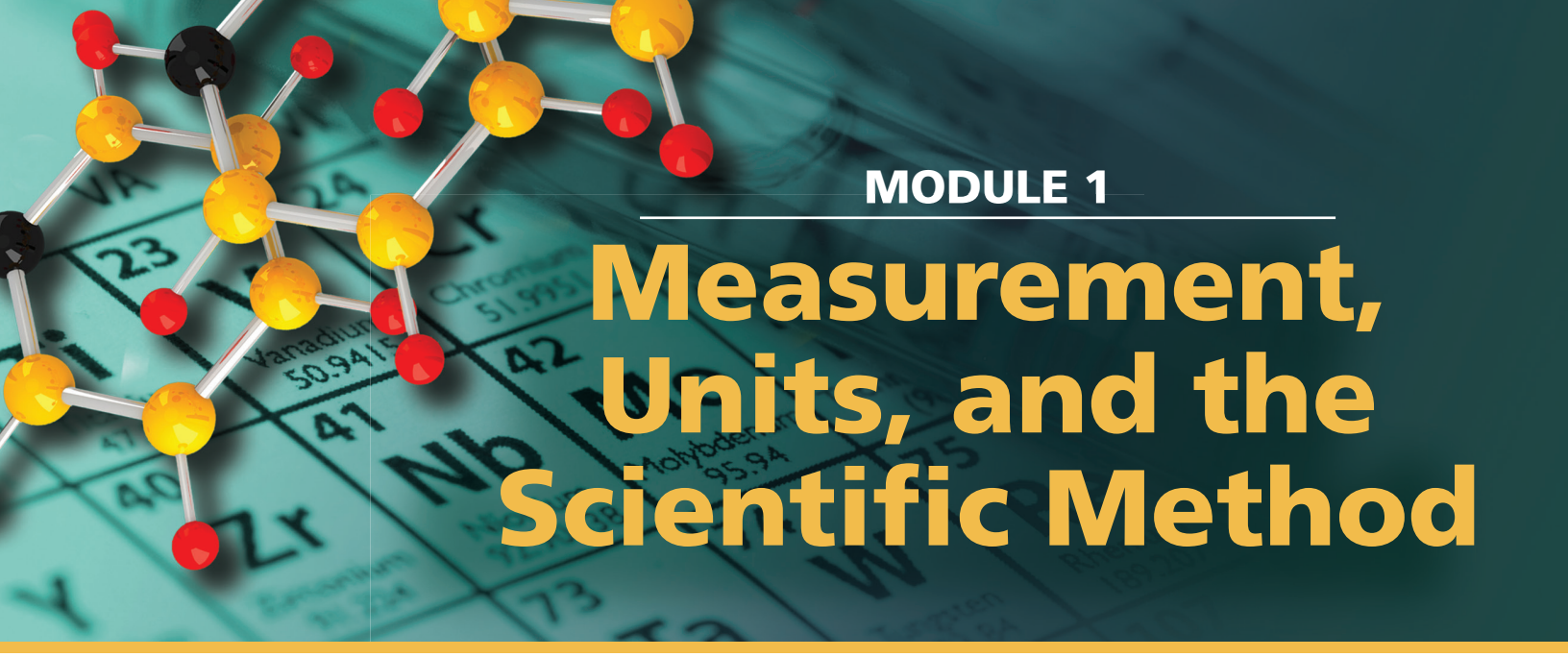


MODULE 1

Measurement, Units, and the Scientific Method

ON YOUR OWN QUESTIONS

1.1 A student measures the mass of a bag of sand to be 9,321 g. What is the bag's mass in kg?

1.2 If a glass contains 0.465 L of water, what is the volume of water in mL?

1.3 On a professional basketball court, the distance from the 3-point line to the basket is 724.0 cm. What is this distance in meters?

1.4 How many kilograms are in 8.465 slugs?

1.5 If an object occupies a volume of 6.1236 liters, how many gallons does it occupy?

1.6 A balloon is blown up so that its volume is 1,500 mL. What is its volume in kL?

1.7 If the length of a race car track is 2.0 km, what is it in cm?

1.8 How many mg are in 0.01 Mg?

1.9 Should you be impressed if someone says she can hold her breath for 0.00555 hours? You must first convert this to seconds to answer. (HINT: 1 hour = 60 minutes and 1 minute = 60 seconds.)

1.10 How many cm^3 are in 0.0091 kL?

1.11 The area of a room is 32 m^2. What is the area of the room in mm^2?

1.12 How many significant figures are in the following measurements?

Measurement	Significant Figures
a. 3.0220 cm	
b. 0.0060 m	
c. 1.00450 L	

Measurement	Significant Figures
d. 61.054 kg	
e. 300,000 mm	

1.13 Convert the following numbers from decimal to scientific notation.

Decimal Numbers	Scientific Notation
a. 26,089,000	
b. 12,000,000,003	
c. 0.00009870	
d. 0.980	

1.14 Convert the following numbers from scientific notation to decimal form.

Scientific Notation	Decimal Notation
a. 3.456×10^{14}	
b. 1.2341×10^{3}	

Scientific Notation	Decimal Notation
c. 3.45×10^{-5}	
d. 3.10×10^{-1}	

1.15 Normal body temperature is 98.6 °F. What is this temperature in Celsius?

1.16 Rubbing alcohol boils at 180.5 °C. What is the boiling temperature of rubbing alcohol in Fahrenheit?

1.17 What is the Fahrenheit equivalent of 0.00 Kelvin? (Use 3 significant figures for this measurement.

STUDY GUIDE QUESTIONS

1 Which of the following contains no matter? _____

a. A baseball

b. A balloon full of air

c. Heat

d. A light ray

2 List the base metric units used to measure length, mass, time, and volume.

3 In the metric system, what does the prefix milli- mean?

4 All conversion factors, when in the form of a fraction, must equal _____.

5 Which has more liquid: a glass holding 0.05 kL or a glass holding 12,000 mL?

6 How long is the bar in the picture below?

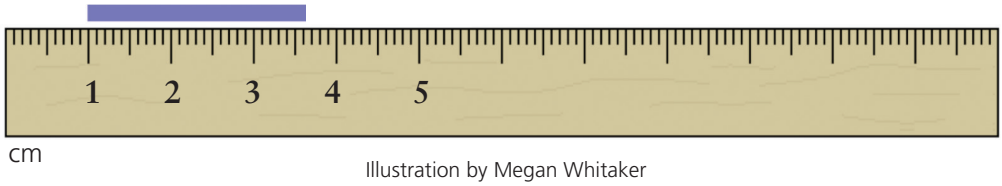


Illustration by Megan Whitaker

7 Two students measure the mass of an object that is known to be 50.0 grams. The first student measures the mass to be 49.8123 grams. The second measures the mass to be 50.1 grams. Which student was more precise? Which student was more accurate?

8 Explain what a significant figure is.

9 How many significant figures are in the following numbers?

Number	Significant Figures
a. 120350	
b. 10.020	
c. 0.000000012	
d. 7.20×10^2	

10 A student measures the mass of object A to be 50.3 grams and measures the mass of object B to be 200.24 grams. She then reports the combined mass to be 251 grams. Is this student correct? Why or why not?

11 What would be the units on the following calculations? You do not have to do the math since this question only wants to know the units.

a. 8 cm + 2 cm =

b. 4 g ÷ 2 mL =

12 Which answer for question 11 will be a derived unit?

13 What are the two basic rules for using scientific notation?

14 Which is colder: 50.0 grams of water at 0.00 °C or 50.0 g of water at 32.00 °F?

PRACTICE PROBLEMS

Be sure to use the proper number of significant figures in all of your answers!

1 Convert 2.4 mL into L.

2 Convert 69.00 km into m.

3 Convert 0.091 kg into cg.

4 If an object has a volume of 69.2 mL, how many kL of space does it occupy?

5 A box is measured to be 23 cm by 45 cm by 38 cm. What is its volume in cubic meters?

6 A nurse injects 71.0 cc of medicine into a patient. How many liters is that?

7 Convert the following decimal numbers into scientific notation:

Decimal Numbers	Scientific Notation
a. 12.45000	
b. 3,040,000	
c. 6,100.500	
d. 0.001234	

8 Convert the following numbers back into decimal:

Scientific Notation	Decimal Notation
a. 6×10^{9}	
b. 3.0450×10^{-3}	
c. 1.56×10^{21}	
d. 4.50000×10^{-7}	

9 Convert 85.6 °C into Fahrenheit.

10 The temperature of the moon during its day is 396 K. What is that in Celsius? In Fahrenheit?

11 The average low temperature of International Falls, MN, in January is –7.0 °F. What is that in °C?

EXTRA PRACTICE PROBLEMS

1 Two students measure the mass of a kilogram standard known to be exactly 1.000000 kg. The first student uses one scale and reports a mass of 1,002.0 g. The second student uses a different scale and reports a mass of 1,000 g. Which student is more precise? Which is more accurate?

2 How many cg are in 403.1 g?

3 If an object has a volume of 1,355.1 mL, what is its volume in liters?

4 How many inches is 26.2 miles? (1 foot = 12 inches; 1 mile = 5.280×10^3 feet)

5 How many kilometers are equal to 5,000,700 mm?

6 The volume of a box is given by the equation:

V = length x width x height

If a box measures 0.12 m by 0.34 m by 0.050 m, what is its volume in liters?

7 A string measures 32.0 inches. How many centimeters is the string?

8 How many hours are in 4,200 seconds?

9 Convert these numbers into scientific notation:

Decimal Notation	Scientific Notation
a. 70,800	
b. 0.007840	

10 Convert these numbers into decimal notation:

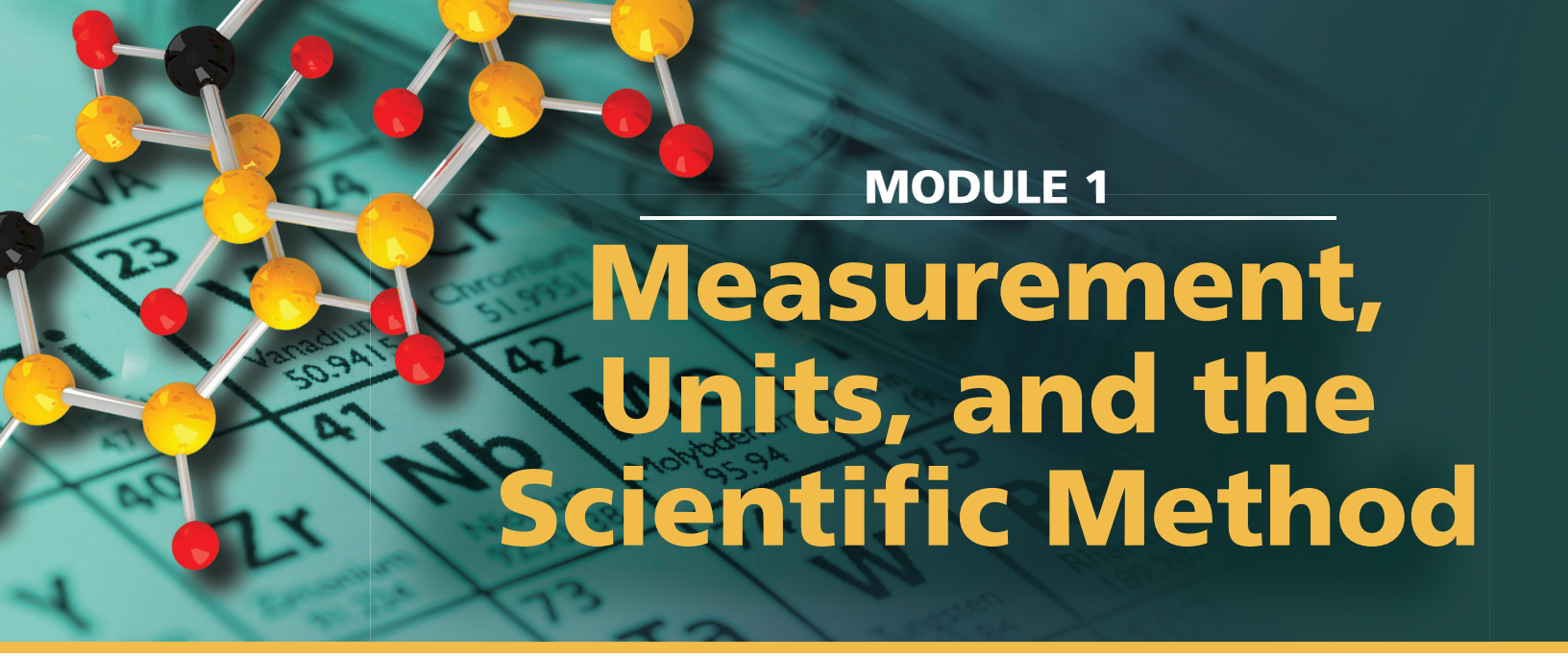
Scientific Notation	Decimal Notation
a. 9.510×10^{-14}	
b. 9.0050×10^{6}	

11 How many significant figures are in these numbers?

Number	Significant Figures
a. 0.007350	
b. 7350	
c. 7.005×10^4	

12 Convert 34.5 °C into °F.

13 Convert 350.0 °F into K.



MODULE 1

Measurement, Units, and the Scientific Method

EXPERIMENT 1.1

DATE

Purpose:
To determine if air has mass.

Materials:
- Meterstick (A yardstick will work as well, but a 12-inch ruler is not long enough.)
- Two 8-inch or larger balloons
- 2 pieces of string long enough to tie the balloons to the meterstick
- Tape
- Safety goggles

Question:
Does air have mass?

Procedure:
1. Without blowing them up, tie the balloons to the strings. Be sure to make the knots loose so that you can untie one of the balloons later in the experiment.

2. Tie the other end of each string to an end of the meterstick. Try to attach the strings as close to the ends of the meterstick as possible.

3. Once the strings have been tied to the meterstick, tape them down so that they cannot move.

4. Go into your bathroom and pull back the shower curtain so that a large portion of the curtain rod is bare. Balance the meterstick (with the balloons attached) on the bare part of the shower curtain rod. You should be able to balance it very well. If you don't have a shower curtain rod or you are having trouble using yours, you can use any surface that is adequate for delicate balancing like the upper part of a chair.

5. Once you have the meterstick balanced, stand back and look at it. **Record your observations in the data table.** The meterstick balances now because the total mass on one side equals the total mass on the other side. To knock it off balance, you would need to move the meterstick or add more mass to one side. You will do the latter.

6. Have someone else hold the meterstick so that it does not move. For this experiment to work properly, the meterstick must stay stationary.

7. While the meterstick is held stationary, remove one of the balloons from its string (do not untie the string from the meterstick), and blow up the balloon.

8. Tie the balloon closed so that the air does not escape, then reattach it to its string.

9. Have the person holding the meterstick let go. **Record your observations in the data table.** If the meterstick was not moved while you were blowing up the balloon, it will tilt toward the side with the inflated balloon as soon as the person lets it go. This is because you added air to the balloon. Since air has mass, it knocks the meterstick off balance. So, air does have mass!

10. Clean up and return everything to the proper place.

Hypothesis: Pick one: Either air has mass or air does not have mass.

DATA and OBSERVATIONS:

TABLE	
	Qualitative observations
Step 5	
Step 9	

Conclusions: What did you think? Write something about what you observed related to the fact that air has mass and takes up space in the space below.

EXPERIMENT 1.2

DATE

Purpose:
To determine if air takes up space.

Materials:
- Tall glass
- Paper towel
- Sink full of water
- Safety goggles

Question:
Does air take up space?

Pick one: Either air takes up space or air does not take up space. **Record your choice in the hypothesis section.**

Procedure:
1. Fill the sink with water until the water level is high enough to submerge the entire glass.

2. Make sure the inside of the glass is dry.

3. Wad up the paper towel and shove it down into the bottom of the glass.

4. Turn the glass upside down and be sure that the paper towel does not fall out of the glass.

5. Submerge the glass upside down in the water, being careful not to tip the glass at any time.

6. Wait a few seconds and remove the glass, still being careful not to tip the glass at any time.

7. Pull the paper towel out of the glass. **Record your observations in the data table.** You will find that the paper towel is completely dry. Even though the glass was submerged in water, the paper towel never got wet. Why? When you tipped the glass upside down, there was air inside the glass. When you submerged it in the water, the air could not escape the glass, so the glass was still full of air. Since air takes up space, there was no room for water to enter the glass, so the paper towel stayed dry.

8. Repeat the experiment, but this time be sure to tip the glass while it is underwater. **Record your observations.** You will see large bubbles rise to the surface of the water. When you pull the glass out, you will find that it has water in it and that the paper towel is wet. This is because tilting the glass allowed the air trapped inside it to escape. Once the air escaped, there was room for the water to come into the glass.

9. Clean up and return everything to the proper place.
(do not untie the string from the meterstick), and blow up the balloon.

Hypothesis:

DATA and OBSERVATIONS:

TABLE	
Steps	**Observations**
7	
8	

Conclusions: What did you think? Write something about what you observed related to the fact that air takes up space in the space below.

EXPERIMENT 1.3

DATE

Purpose:
To compare conversions to measurements.

Materials:
- Book (not oversized)
- Metric and English rulers
- Safety goggles

Question:
How do measurements compare to conversions?

Procedure:
1. Lay the book on a table and measure its length in inches. Read the ruler as shown in the measurement section above, estimating any answer that falls between the markings on the scale. Next, convert the fraction to a decimal (as we did in the measurement section above) and round it to the hundredths place because that's the precision of an English ruler. **Record the decimal measurement in the data table.**

2. Measure the width of the book in the same way. **Record.**

3. Now that you have the length and width measured, multiply them together to get the sur face area of the book. **Record.** Since you are multiplying inches by inches, your area unit should be in^2. Remember to count the significant figures in each of the measurements and round your final answer so that it has the same number of significant figures as the measurement with the least number of significant figures.

4. Use the relationship given in table 1.3 to convert the length measurement into cm. Do the same thing to the width measurement, making sure to keep the proper number of significant figures. **Record.** Note that the relationship between inches and centimeters is exact. The 2.54 cm should not be taken into account when considering the significant figures because 1 inch is exactly 2.54 cm.

5. Use the metric ruler to measure the length and width of the book in centimeters. **Record.** Once again, do it as shown in the measurements section in the text. If the scale of the ruler is marked off in 0.1 cm, then your length and width measurements should be written to the hundredths of a centimeter. Compare these answers to the length and width you calculated by converting from inches. They should be nearly the same. If they are different by only a small percentage, there is no problem. However, if they differ by more than a small percentage, recheck your measurements and your conversions.

6. Multiply the length and width measurements you took with the metric ruler to calculate the surface area of the book in cm^2. **Record.** Use the relationship between inches and centimeters to convert your answer into in^2. **Record.** Remember, since you are using a derived unit, the conversion is more complicated. You might want to review example 1.4.

7. Now compare the converted value for the surface area to the one you calculated in step 3 using your English measurements. Once again, they should be equal or close to equal. If not, you have either measured wrongly or made a mistake in your conversion.

8. Clean up and return everything to the proper place.

Hypothesis: Write a hypothesis about how close you expect your conversions to be to the measurements.

DATA and OBSERVATIONS:

TABLE						
	Length in inches	Width in inches	Area (in^2) L x W	Length in cm	Width in cm	Area (cm^2) L x W
Measure						
Convert	Length in cm	Width in cm	Area (cm^2) L x W	Length in inches	Width in inches	Area (in^2) L x W

Conclusions: Write something about how well you made your measurements.