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- » **Crunching numbers in scientific and exponential notation**
- » **Telling the difference between accuracy and precision**
- » **Doing math with significant figures**

# Chapter **1**

# Noting Numbers Scientifically

**L**ike any other kind of scientist, a chemist tests hypotheses by doing experiments. Better tests require more reliable measurements, and better measurements are those that have more accuracy and precision. This explains why chemists get so giggly and twitchy about high-tech instruments: Those instruments take better measurements!

How do chemists report their precious measurements? What's the difference between accuracy and precision? And how do chemists do math with measurements? These questions may not keep you awake at night, but knowing the answers to them will keep you from making rookie mistakes in chemistry.

## Using Exponential and Scientific Notation to Report Measurements

Because chemistry concerns itself with ridiculously tiny things like atoms and molecules, chemists often find themselves dealing with extraordinarily small or extraordinarily large numbers. Numbers describing the distance between two atoms joined by a bond, for example, run in the ten-billionths of a meter. Numbers describing how many water molecules populate a drop of water run into the trillions of trillions.

To make working with such extreme numbers easier, chemists turn to scientific notation, which is a special kind of exponential notation. *Exponential notation* simply means writing a number in a way that includes exponents. In scientific notation, every number is written as the product of two numbers, a coefficient and a power of 10. In plain old exponential notation, a coefficient can be any value of a number multiplied by a power with a base of 10 (such as  $10^4$ ). But scientists have rules for coefficients in scientific notation. In *scientific notation*, the coefficient is always at least 1 and always less than 10. For example, the coefficient could be 7, 3.48, or 6.0001.



TIP

To convert a very large or very small number to scientific notation, move the decimal point so it falls between the first and second digits. Count how many places you moved the decimal point to the right or left, and that's the power of 10. If you moved the decimal point to the left, the exponent on the 10 is positive; to the right, it's negative. (Here's another easy way to remember the sign on the exponent: If the initial number value is greater than 1, the exponent will be positive; if the initial number value is between 0 and 1, the exponent will be negative.)

To convert a number written in scientific notation back into decimal form, just multiply the coefficient by the accompanying power of 10.



EXAMPLE

**Q.** Convert 47,000 to scientific notation.

**A.**  $47,000 = 4.7 \times 10^4$ . First, imagine the number as a decimal:

47,000.

Next, move the decimal point so it comes between the first two digits:

4.7000

Then count how many places to the left you moved the decimal (four, in this case) and write that as a power of 10:  $4.7 \times 10^4$ .

**Q.** Convert 0.007345 to scientific notation.

**A.**  $0.007345 = 7.345 \times 10^{-3}$ . First, put the decimal point between the first two nonzero digits:

7.345

Then count how many places to the right you moved the decimal (three, in this case) and write that as a power of 10:  $0.007345 = 7.345 \times 10^{-3}$ .

1 Convert 200,000 into scientific notation.

2 Convert 80,736 into scientific notation.

3 Convert 0.00002 into scientific notation.

4 Convert  $6.903 \times 10^2$  from scientific notation into decimal form.

# Multiplying and Dividing in Scientific Notation

A major benefit of presenting numbers in scientific notation is that it simplifies common arithmetic operations. The simplifying abilities of scientific notation are most evident in multiplication and division. (As we note in the next section, addition and subtraction benefit from exponential notation but not necessarily from strict scientific notation.)



REMEMBER

To multiply two numbers written in scientific notation, multiply the coefficients and then add the exponents. To divide two numbers, simply divide the coefficients and then subtract the exponent of the *denominator* (the bottom number) from the exponent of the *numerator* (the top number).



EXAMPLE

**Q.** Multiply using the shortcuts of scientific notation:  $(1.4 \times 10^2) \times (2.0 \times 10^{-5})$ .

**A.**  $2.8 \times 10^{-3}$ . First, multiply the coefficients:

$$1.4 \times 2.0 = 2.8$$

Next, add the exponents of the powers of 10:

$$10^2 \times 10^{-5} = 10^{2+(-5)} = 10^{-3}$$

Finally, join your new coefficient to your new power of 10:

$$2.8 \times 10^{-3}$$

**Q.** Divide using the shortcuts of scientific notation:  $\frac{3.6 \times 10^{-3}}{1.8 \times 10^4}$ .

**A.**  $2.0 \times 10^{-7}$ . First, divide the coefficients:

$$\frac{3.6}{1.8} = 2.0$$

Next, subtract the exponent in the denominator from the exponent in the numerator:

$$\frac{10^{-3}}{10^4} = 10^{-3-4} = 10^{-7}$$

Then join your new coefficient to your new power of 10:

$$2.0 \times 10^{-7}$$

5 Multiply  $(2.2 \times 10^9) \times (5.0 \times 10^{-4})$ .

6 Divide  $\frac{9.3 \times 10^{-5}}{3.1 \times 10^2}$ .

7 Using scientific notation, multiply  $52 \times 0.035$ .

8 Using scientific notation, divide  $\frac{0.00809}{20.3}$ .

## Using Exponential Notation to Add and Subtract

Addition or subtraction gets easier when you express your numbers as coefficients of identical powers of 10. To wrestle your numbers into this form, you may need to use coefficients less than 1 or greater than 10. So scientific notation is a bit too strict for addition and subtraction, but exponential notation still serves you well.



REMEMBER

To add two numbers easily by using exponential notation, first express each number as a coefficient and a power of 10, making sure that 10 is raised to the same exponent in each number. Then add the coefficients. To subtract numbers in exponential notation, follow the same steps but subtract the coefficients.



EXAMPLE

**Q.** Use exponential notation to add these numbers:  $3,710 + (2.4 \times 10^2)$ .

**A.**  $39.5 \times 10^2$ . First, convert both numbers to the same power of 10:

$$37.1 \times 10^2 \text{ and } 2.4 \times 10^2$$

Next, add the coefficients:

$$37.1 + 2.4 = 39.5$$

Finally, join your new coefficient to the shared power of 10:

$$39.5 \times 10^2$$

**Q.** Use exponential notation to subtract:  $0.0743 - 0.0022$ .

**A.**  $7.21 \times 10^{-2}$ . First, convert both numbers to the same power of 10:

$$7.43 \times 10^{-2} \text{ and } 0.22 \times 10^{-2}$$

Next, subtract the coefficients:

$$7.43 - 0.22 = 7.21$$

Then join your new coefficient to the shared power of 10:

$$7.21 \times 10^{-2}$$

9 Add  $(398 \times 10^{-6}) + (147 \times 10^{-6})$ .

10 Subtract  $(7.685 \times 10^5) - (1.283 \times 10^5)$ .

11 Use exponential notation to add  $0.00206 + 0.0381$ .

12 Use exponential notation to subtract  $9,352 - 431$ .

# Distinguishing between Accuracy and Precision



REMEMBER

Accuracy and precision, precision and accuracy . . . same thing, right? Chemists everywhere gasp in horror, reflexively clutching their pocket protectors — accuracy and precision are different!

- » **Accuracy:** Accuracy describes how closely a measurement approaches an actual, true value.
- » **Precision:** Precision, which we discuss more in the next section, describes how close repeated measurements are to one another, regardless of how close those measurements are to the actual value. The bigger the difference between the largest and smallest values of a repeated measurement, the less precision you have.

The two most common measurements related to accuracy are *error* and *percent error*:

- » **Error:** Error measures accuracy, the difference between a measured value and the actual value:

$$\text{Actual value} - \text{Measured value} = \text{Error}$$

- » **Percent error:** Percent error compares error to the size of the thing being measured:

$$\frac{|\text{Error}|}{\text{Actual value}} = \text{Fraction error}$$

$$\text{Fraction error} \times 100 = \text{Percent error}$$

Being off by 1 meter isn't such a big deal when measuring the altitude of a mountain, but it's a shameful amount of error when measuring the height of an individual mountain climber.



EXAMPLE

- Q.** A police officer uses a radar gun to clock a passing Ferrari at 131 miles per hour (mph). The Ferrari was really speeding at 127 mph. Calculate the error in the officer's measurement.

- A.** **−4 mph.** First, determine which value is the actual value and which is the measured value:

- Actual value = 127 mph
- Measured value = 131 mph

Then calculate the error by subtracting the measured value from the actual value:

$$\text{Error} = 127 \text{ mph} - 131 \text{ mph} = -4 \text{ mph}$$

- Q.** Calculate the percent error in the officer's measurement of the Ferrari's speed.

- A.** **3.15%.** First, divide the error's absolute value (the size, as a positive number) by the actual value:

$$\frac{|-4 \text{ mph}|}{127 \text{ mph}} = \frac{4 \text{ mph}}{127 \text{ mph}} = 0.0315$$

Next, multiply the result by 100 to obtain the percent error:

$$\text{Percent error} = 0.0315 \times 100 = 3.15\%$$

13 Two people, Reginald and Dagmar, measure their weight in the morning by using typical bathroom scales, instruments that are famously unreliable. The scale reports that Reginald weighs 237 pounds, though he actually weighs 256 pounds. Dagmar's scale reports her weight as 117 pounds, though she really weighs 129 pounds. Whose measurement incurred the greater error? Who incurred a greater percent error?

14 Two jewelers were asked to measure the mass of a gold nugget. The true mass of the nugget is 0.856 grams (g). Each jeweler took three measurements. The average of the three measurements was reported as the "official" measurement with the following results:

- **Jeweler A:** 0.863 g, 0.869 g, 0.859 g
- **Jeweler B:** 0.875 g, 0.834 g, 0.858 g

Which jeweler's official measurement was more accurate? Which jeweler's measurements were more precise? In each case, what was the error and percent error in the official measurement?

## Expressing Precision with Significant Figures

When you know how to express your numbers in scientific notation and how to distinguish between precision and accuracy (we cover both topics earlier in this chapter), you can bask in the glory of a new skill: using scientific notation to express precision. The beauty of this system is that simply by looking at a measurement, you know just how precise that measurement is.



REMEMBER

When you report a measurement, you should include digits only if you're really confident about their values. Including a lot of digits in a measurement means something — it means that you really know what you're talking about — so we call the included digits *significant figures*. The more significant figures (sig figs) in a measurement, the more accurate that measurement must be. The last significant figure in a measurement is the only figure that includes any uncertainty, because it's an estimate. Here are the rules for deciding what is and what isn't a significant figure:

- » **Any nonzero digit is significant.** So 6.42 contains three significant figures.
- » **Zeros sandwiched between nonzero digits are significant.** So 3.07 contains three significant figures.

» **Zeros on the left side of the first nonzero digit are not significant.** So 0.0642 and 0.00307 each contain three significant figures.

» **One or more final zeros (zeros that end the measurement) used after the decimal point are significant.** So 1.760 has four significant figures, and 1.7600 has five significant figures. The number 0.0001200 has only four significant figures because the first zeros are not final.

» **When a number has no decimal point, any zeros after the last nonzero digit may or may not be significant.** So in a measurement reported as 1,370, you can't be certain whether the 0 is a certain value or is merely a placeholder.

Be a good chemist. Report your measurements in scientific notation to avoid such annoying ambiguities. (See the earlier section "Using Exponential and Scientific Notation to Report Measurements" for details on scientific notation.)

» **If a number is already written in scientific notation, then all the digits in the coefficient are significant.** So the number  $3.5200 \times 10^{-6}$  has five significant figures due to the five digits in the coefficient.

» **Numbers from counting (for example, 1 kangaroo, 2 kangaroos, 3 kangaroos) or from defined quantities (say, 60 seconds per 1 minute) are understood to have an unlimited number of significant figures.** In other words, these values are completely certain.



REMEMBER

The number of significant figures you use in a reported measurement should be consistent with your certainty about that measurement. If you know your speedometer is routinely off by 5 miles per hour, then you have no business protesting to a policeman that you were going only 63.2 mph in a 60 mph zone.



EXAMPLE

**Q.** How many significant figures are in the following three measurements?

- 20,175 yards
- 1.75 yards
- 1.750 yards

**A.** **a) Five, b) three, and c) four significant figures.** In the first measurement, all digits are nonzero, except for a 0 that's sandwiched between nonzero digits, which counts as

significant. The coefficient in the second measurement contains only nonzero digits, so all three digits are significant. The coefficient in the third measurement contains a 0, but that 0 is the final digit and to the right of the decimal point, so it's significant.

15 Identify the number of significant figures in each measurement:

- a.  $76.093 \times 10^{-2}$  meters
- b. 0.000769 meters
- c. 769.3 meters

16 In chemistry, the potential error associated with a measurement is often reported alongside the measurement, as in  $793.4 \pm 0.2$  grams. This report indicates that all digits are certain except the last, which may be off by as much as 0.2 grams in either direction. What, then, is wrong with the following reported measurements?

- a.  $893.7 \pm 1$  gram
- b.  $342 \pm 0.01$  gram

## Doing Arithmetic with Significant Figures

Doing chemistry means making a lot of measurements. The point of spending a pile of money on cutting-edge instruments is to make really good, really precise measurements. After you've got yourself some measurements, you roll up your sleeves, hike up your pants, and do some math.



REMEMBER

When doing math in chemistry, you need to follow some rules to make sure that your sums, differences, products, and quotients honestly reflect the amount of precision present in the original measurements. You can be honest (and avoid the skeptical jeers of surly chemists) by taking things one calculation at a time, following a few simple rules. One rule applies to addition and subtraction, and another rule applies to multiplication and division.

» **Adding or subtracting:** Round the sum or difference to the same number of decimal places as the measurement with the fewest decimal places. Rounding like this is honest, because you're acknowledging that your answer can't be any more precise than the least-precise measurement that went into it.

» **Multiplying or dividing:** Round the product or quotient so that it has the same number of significant figures as the least-precise measurement — the measurement with the fewest significant figures.

Notice the difference between the two rules. When you add or subtract, you assign significant figures in the answer based on the number of decimal places in each original measurement. When you multiply or divide, you assign significant figures in the answer based on the smallest number of significant figures from your original set of measurements.



TIP

Caught up in the breathless drama of arithmetic, you may sometimes perform multi-step calculations that include addition, subtraction, multiplication, and division, all in one go. No problem. Follow the normal order of operations, doing multiplication and division first, followed by addition and subtraction. At each step, follow the simple significant-figure rules, and then move on to the next step.



EXAMPLE

**Q.** Express the following sum with the proper number of significant figures:

$$35.7 \text{ miles} + 634.38 \text{ miles} + 0.97 \text{ miles} = ?$$

**A.** **671.1 miles.** Adding the three values yields a raw sum of 671.05 miles. However, the 35.7 miles measurement extends only to the tenths place. Therefore, you round the answer to the tenths place, from 671.05 to 671.1 miles.

**Q.** Express the following product with the proper number of significant figures:

$$27 \text{ feet} \times 13.45 \text{ feet} = ?$$

**A.**  **$3.6 \times 10^2 \text{ feet}^2$ .** Of the two measurements, one has two significant figures (27 feet) and the other has four significant figures (13.45 feet). The answer is therefore limited to two significant figures. You need to round the raw product, 363.15  $\text{feet}^2$ . You could write 360  $\text{feet}^2$ , but doing so may imply that the final 0 is significant and not just a placeholder. For clarity, express the product in scientific notation, as  $3.6 \times 10^2 \text{ feet}^2$ .

17 Express this difference using the appropriate number of significant figures:

$$127.379 \text{ seconds} - 13.14 \text{ seconds} \\ + (1.2 \times 10^{-1} \text{ seconds}) = ?$$

18 Express the answer to this calculation using the appropriate number of significant figures:

$$345.6 \text{ feet} \times \left( \frac{12 \text{ inches}}{1 \text{ foot}} \right) = ?$$

19 Report the difference using the appropriate number of significant figures:

$$(3.7 \times 10^{-4} \text{ minutes}) - 0.009 \text{ minutes} = ?$$

20 Express the answer to this multi-step calculation using the appropriate number of significant figures:

$$\frac{87.95 \text{ feet} \times 0.277 \text{ feet} + 5.02 \text{ feet} - 1.348 \text{ feet}}{10.0 \text{ feet}} = ?$$

# Answers to Questions on Noting Numbers Scientifically

The following are the answers to the practice problems in this chapter.

- 1  $2 \times 10^5$ . Move the decimal point immediately after the 2 to create a coefficient between 1 and 10. Because you're moving the decimal point five places to the left, multiply the coefficient, 2, by the power  $10^5$ .
- 2  $8.0736 \times 10^4$ . Move the decimal point immediately after the 8 to create a coefficient between 1 and 10. You're moving the decimal point four places to the left, so multiply the coefficient, 8.0736, by the power  $10^4$ .
- 3  $2 \times 10^{-5}$ . Move the decimal point immediately after the 2 to create a coefficient between 1 and 10. You're moving the decimal point five spaces to the right, so multiply the coefficient, 2, by the power  $10^{-5}$ .
- 4 **690.3**. You need to understand scientific notation to change the number back to regular decimal form. Because  $10^2$  equals 100, multiply the coefficient, 6.903, by 100. This moves the decimal point two spaces to the right.
- 5  $1.1 \times 10^6$ . First, multiply the coefficients:  $2.2 \times 5.0 = 11$ . Then multiply the powers of 10 by adding the exponents:  $10^9 \times 10^{-4} = 10^{9+(-4)} = 10^5$ . The raw calculation yields  $11 \times 10^5$ , which converts to the given answer when you express it in scientific notation.
- 6  $3.0 \times 10^{-7}$ . The ease of math with scientific notation shines through in this problem. Dividing the coefficients yields a coefficient quotient of  $9.3/3.1 = 3.0$ , and dividing the powers of 10 (by subtracting their exponents) yields a quotient of  $10^{-5} / 10^2 = 10^{-5-2} = 10^{-7}$ . Marrying the two quotients produces the given answer, already in scientific notation.
- 7 **1.8**. First, convert each number to scientific notation:  $5.2 \times 10^1$  and  $3.5 \times 10^{-2}$ . Next, multiply the coefficients:  $5.2 \times 3.5 = 18.2$ . Then add the exponents on the powers of 10:  $10^{1+(-2)} = 10^{-1}$ . Finally, join the new coefficient with the new power:  $18.2 \times 10^{-1}$ . Expressed in scientific notation, this answer is  $1.82 \times 10^0 = 1.82$ . Looking back at the original numbers, you see that both factors have only two significant figures; therefore, you have to round your answer to match that number of sig figs, making it 1.8.
- 8  $3.99 \times 10^{-4}$ . First, convert each number to scientific notation:  $8.09 \times 10^{-3}$  and  $2.03 \times 10^1$ . Then divide the coefficients:  $8.09/2.03 = 3.99$ . Next, subtract the exponent on the denominator from the exponent of the numerator to get the new power of 10:  $10^{-3-1} = 10^{-4}$ . Join the new coefficient with the new power:  $3.99 \times 10^{-4}$ . Finally, express gratitude that the answer is already conveniently expressed in scientific notation.
- 9  $545 \times 10^{-6}$ . Because the numbers are each already expressed with identical powers of 10, you can simply add the coefficients:  $398 + 147 = 545$ . Then join the new coefficient with the original power of 10.
- 10  $6.402 \times 10^5$ . Because the numbers are each expressed with the same power of 10, you can simply subtract the coefficients:  $7.685 - 1.283 = 6.402$ . Then join the new coefficient with the original power of 10.

- 11  **$40.16 \times 10^{-3}$  (or an equivalent expression).** First, convert the numbers so they each use the same power of 10:  $2.06 \times 10^{-3}$  and  $38.1 \times 10^{-3}$ . Here, we use  $10^{-3}$ , but you can use a different power as long as the power is the same for each number. Next, add the coefficients:  $2.06 + 38.1 = 40.16$ . Finally, join the new coefficient with the shared power of 10.
- 12  **$89.21 \times 10^2$  (or an equivalent expression).** First, convert the numbers so each uses the same power of 10:  $93.52 \times 10^2$  and  $4.31 \times 10^2$ . Here, we've picked  $10^2$ , but any power is fine as long as the two numbers have the same power. Then subtract the coefficients:  $93.52 - 4.31 = 89.21$ . Finally, join the new coefficient with the shared power of 10.
- 13 **Reginald's measurement incurred the greater magnitude of error, and Dagmar's measurement incurred the greater percent error.** Reginald's scale reported with an error of 256 pounds  $-$  237 pounds = 19 pounds, and Dagmar's scale reported with an error of 129 pounds  $-$  117 pounds = 12 pounds. Comparing the *magnitudes* of error, you see that 19 pounds is greater than 12 pounds. However, Reginald's measurement had a percent error of  $(19 \text{ pounds} / 256 \text{ pounds}) \times 100 = 7.4\%$ , while Dagmar's measurement had a percent error of  $(12 \text{ pounds} / 129 \text{ pounds}) \times 100 = 9.3\%$ .
- 14 Jeweler A's official average measurement was 0.864 grams, and Jeweler B's official measurement was 0.856 grams. You determine these averages by adding up each jeweler's measurements and then dividing by the total number of measurements, in this case 3. Based on these averages, **Jeweler B's official measurement is more accurate** because it's closer to the actual value of 0.856 grams.

However, **Jeweler A's measurements were more precise** because the differences between A's measurements were much smaller than the differences between B's measurements. Despite the fact that Jeweler B's average measurement was closer to the actual value, the *range* of his measurements (that is, the difference between the largest and the smallest measurements) was 0.041 grams ( $0.875 \text{ g} - 0.834 \text{ g} = 0.041 \text{ g}$ ). The range of Jeweler A's measurements was 0.010 grams ( $0.869 \text{ g} - 0.859 \text{ g} = 0.010 \text{ g}$ ).

This example shows how low-precision measurements can yield highly accurate results through averaging of repeated measurements. In the case of Jeweler A, the error in the official measurement was  $0.864 \text{ g} - 0.856 \text{ g} = 0.008 \text{ g}$ . The corresponding percent error was  $(0.008 \text{ g} / 0.856 \text{ g}) \times 100 = 0.9\%$ . In the case of Jeweler B, the error in the official measurement was  $0.856 \text{ g} - 0.856 \text{ g} = 0.000 \text{ g}$ . Accordingly, the percent error was 0%.

- 15 The correct number of significant figures is as follows for each measurement: **a) 5, b) 3, and c) 4.**
- 16 **a) " $893.7 \pm 1 \text{ gram}$ " is an improperly reported measurement because the reported value, 893.7, suggests that the measurement is certain to within a few tenths of a gram.** The reported error is known to be greater, at  $\pm 1$  gram. The measurement should be reported as " $894 \pm 1 \text{ gram}$ ."
- b) " $342 \pm 0.01 \text{ gram}$ " is improperly reported because the reported value, 342, gives the impression that the measurement becomes uncertain at the level of grams.** The reported error makes clear that uncertainty creeps into the measurement only at the level of hundredths of a gram. The measurement should be reported as " $342.00 \pm 0.01 \text{ gram}$ ."
- 17 **114.36 seconds.** The trick here is remembering to convert all measurements to the same power of 10 before comparing decimal places for significant figures. Doing so reveals that  $1.2 \times 10^{-1}$  seconds goes to the hundredths of a second, despite the fact that the measurement contains only two significant figures. The raw calculation yields 114.359 seconds, which rounds properly to the hundredths place (taking significant figures into account) as 114.36 seconds, or  $1.1436 \times 10^2$  seconds in scientific notation.

- 18  **$4.147 \times 10^3$  inches.** Here, you have to recall that defined quantities (1 foot is defined as 12 inches) have unlimited significant figures. So your calculation is limited only by the number of significant figures in the measurement 345.6 feet. When you multiply 345.6 feet by 12 inches per foot, the feet cancel, leaving units of inches:

$$(345.6 \text{ ft}) \times \left( \frac{12 \text{ in.}}{1 \text{ ft}} \right) = 4,147.2 \text{ in.}$$

The raw calculation yields 4,147.2 inches, which rounds properly to four significant figures as 4,147 inches, or  $4.147 \times 10^3$  inches in scientific notation.

- 19 **-0.009 minutes.** Here, it helps here to convert all measurements to the same power of 10 so you can more easily compare decimal places in order to assign the proper number of significant figures. Doing so reveals that  $3.7 \times 10^{-4}$  minutes goes to the hundred-thousandths of a minute, and 0.009 minutes goes to the thousandths of a minute. The raw calculation yields -0.00863 minutes, which rounds properly to the thousandths place (taking significant figures into account) as -0.009 minutes, or  $-9 \times 10^{-3}$  minutes in scientific notation.

- 20 **2.81 feet.** Following standard order of operations, you can do this problem in two main steps, first performing multiplication and division and then performing addition and subtraction.

Following the rules of significant-figure math, the first step yields 24.4 feet + 5.02 feet - 1.348 feet. Each product or quotient contains the same number of significant figures as the number in the calculation with the fewest number of significant figures.

After completing the first step, divide by 10.0 feet to finish the problem:

$$\frac{28.07 \text{ ft}}{10.0 \text{ ft}} = 2.807 \text{ ft} = 2.81 \text{ ft}$$

You write the answer with three sig figs because the measurement 10.0 feet contains three sig figs, which is the smallest available between the two numbers.

