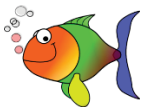
Significant Figures ChemGIL



Key Skill: Identifying the significant figures in a measurement.

Information: All measurement equipment has limits on how accurately the measurement can be recorded. We have seen that the number of digits that the measurement can have is dependent on the number of lines marked on the side of the glassware or other device. A really precise piece of glassware can produce lots of digits (which we will call significant figures from now on.)

One piece of metal is weighed on two different balances. Here are the results:

Balance A: 2.3 g — This is a cheap (inexpensive) and low precision balance that produces 2 digits.

Balance B: 2.38 g — This is a better (and more expensive) balance that produces 3 digits.

Some digits in a measurement, however, have are never important (or significant) because they are simply place holders. In the measurement **0**.37 g, the bolded zero was not really measured, it simply emphasized the location of the decimal. Here are 3 important rules for determining if a digit is significant or not:

1. Zeros at the beginning of a number are **never** *significant* (important).
2. Zeros at the end of a number are not significant **unless**… (you'll find out later)
3. Zeros that are between two nonzero numbers are always significant.

Therefore, the number 47,200 has *three* **significant figures**: only three of the digits are important—the four, the seven, and the two. The number 16,150 has four significant figures because the zero at the end is not considered significant. All of the digits in the number 20,007 are significant because the zeros are in between two nonzero numbers (Rule #3).

Critical Thinking Questions

1. Verify that each of the following numbers contains <u>four</u> significant figures. Circle the digits that are significant.

   a) 0.00004182 b) 494,100,000 c) 32,010,000,000 d) 0.00003002

2. How many significant figures are in each of the following numbers?

   _____ a) 0.000015045 _____ b) 4,600,000 _____ c) 2406

   _____ d) 0.000005 _____ e) 0.0300001 _____ f) 12,000

Information: The Exception to Rule #2

There is one exception to the second rule. Consider the following measured values.

It is **1200 miles** from my town to Atlanta.

It is **1200.0 miles** from my town to Atlanta.

The quantity "1200.0 miles" is more precise than "1200 miles". The decimal point in the quantity "1200.0 miles" means that it was measured very precisely—right down to a tenth of a mile.

Therefore, the complete version of Rule #2 is as follows:

Rule #2: Zero's at the end of a number are not significant **unless there is a decimal point in the number.** A decimal point ***anywhere*** in the number makes zeros <u>at the end</u> of a number significant.

Not significant because these are at the beginning .

This zero is significant because it is at the end of the number and <u>there is a decimal</u>

$$\overbrace{0.000000}7290$$

Critical Thinking Questions

3. Verify that each of the following numbers contains <u>five</u> significant figures. Circle the digits that are significant.

a) 0.00030200 b) 200.00 c) 2300.0 d) 0.000032000

4. How many significant figures are there in each of the following numbers?

_____ a) 0.000201000 _____ b) 23,001,000 _____ c) 0.0300

_____ d) 24,000,410 _____ e) 2400.100 _____ f) 0.000021

STOP

_____ Check with Instructor

Information: Rounding Numbers

In numerical problems, it is often necessary to round numbers to the appropriate number of significant figures. Consider the following examples in which each number is rounded so that each of them contains 4 significant figures. Study each example and make sure you understand why they were rounded as they were:

42,008,000 → 42,010,000

12,562,425,217 → 12,560,000,000

0.00017837901 → 0.0001784

120 → 120.0

Critical Thinking Questions

5. Round the following numbers so that they contain 3 significant figures.

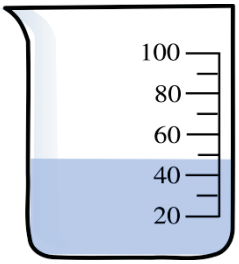
a) 173,792	b) 0.0025021	c) 0.0003192	d) 30
_____	_____	_____	_____

6. Round the following numbers so that they contain 4 significant figures.

a) 249,441	b) 0.00250122	c) 12,049,002	d) 0.00200210
_____	_____	_____	_____

Key Skill: Reporting the answer of a calculation to the correct number of significant figures. Case #1: Multiplying and Dividing

When measuring the density of a substance, a student records the mass to be 38.41 g from the balance, and they recorded the volume to be 48 mL from your beaker. Which of these two values is a better measurement? Explain:



When you calculate the density by dividing 38.40 by 48 you get 0.800208333333 g/mL.... How many of those digits should we write down? *A good rule of thumb is that the final answer can't have more significant figures than the measurement with the least amount of accuracy*. Think of it this way: If person is playing a guitar and singing, and they are an amazing guitarist, but sing horribly out of tune, the song will end up sounding horrible anyway. This is the same idea with measurements. Here's how to do the math:

1) Count the number of significant figures in each number that you are using in the calculation.
2) Round your answer so that it has the same number of significant figures as the number with the least number of sig figs.

Here's an example:

3 significant figures

$$\frac{4560}{14} = 325.714285714 = 330$$

2 significant figures

Final rounded answer should have only 2 significant figures since 2 is the least number of

Here's another example:

$$13.1 \times 1.2039 = 15.77109 = 15.8$$

3 significant figures

5 significant figures

Final rounded answer should have 3 significant figures since 3 is the least number of significant figures in this problem.

Critical Thinking Questions

7. Solve the following problems. Make sure your answers are in the correct number of significant figures.

a) (12.470)(270) = _____ b) 36,000/1245 = _____

c) (310.0)(12) = _____ d) 129.6/3 = _____

e) (125)(1.4452) = _____ f) 6000/2.53 = _____

STOP

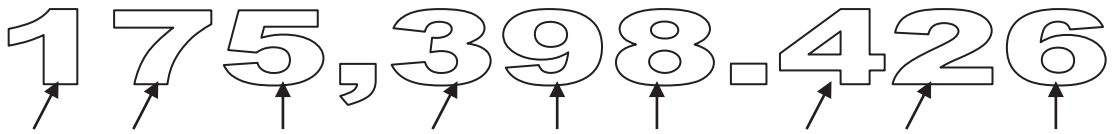
_____ Check with Instructor

Key Skill: Reporting the answer of a calculation to the correct number of significant figures. Case #2: Adding and Subtracting

Not all of the math that we do will involve multiplying and dividing (as was the case for density). The rules for adding and subtracting are different and we will do them as a class in just a minute. While you are waiting, review the rules for rounding because we will need them to understand adding and subtracting with sig figs.

Information: Rounding to a desired decimal place

As you will soon discover, sometimes it is necessary to round to a decimal place. Recall the names of the decimal places:



The hundred thousands place	The ten thousands place	The thousands place	The hundreds place	The tens place	The ones place	The tenths place	The hundredths place	The thousandths place

If we rounded the above number to the hundreds place, that means that there can be no significant figures to the right of the hundreds place. Thus, "175,400" is the above number rounded to the hundreds place. If we rounded to the tenths place we would get 175,398.4. If we rounded to the thousands place we would get 175,000.

Critical Thinking Questions

8. Round the following numbers to the tens place.

a) 134,123,018 = _____ b) 23,190.109 = _____

c) 439.1931 = _____ d) 2948.2 = _____

STOP

_____ Check with Instructor

Adding and Subtracting with Significant Figures Examples. (We will do these together as a class.)

Critical Thinking Questions

9. a) 24.28 + 12.5 = _____ b) 120,000 + 420 = _____

   c) 140,100 – 1422 = _____ d) 2.24 – 0.4101 = _____

   e) 12,470 + 2200.44 = _____ f) 450 – 12.8 = _____

10. The following are problems involving multiplication, dividing, adding, and subtracting. Be careful of the different rules you need to follow!

    a) 245.4/120 = _____ b) 12,310 + 23.5 = _____

    c) (31,900)(4) = _____ d) (320.0)(145,712) = _____

    e) 1420 – 34 = _____ f) 4129 + 200 = _____