ChemQuest 2

Significant Figures

Name: _____

Date: _____

Hour: _____

Information: Significant Figures

We saw in the last ChemQuest that scientific notation can be a very nice way of getting rid of unnecessary zeros in a number. For example, consider how convenient it is to write the following numbers:

$$32{,}450{,}000{,}000{,}000{,}000{,}000{,}000{,}000{,}000{,}000{,}000 = 3.245 \times 10^{34}$$
$$0.000000000000000127 = 1.27 \times 10^{-16}$$

There are a whole lot of zeros in the above numbers that are not really needed. As another example, consider the affect of changing units:

$$21{,}500 \text{ meters} = 21.5 \text{ kilometers}$$
$$0.00582 \text{ meters} = 5.82 \text{ millimeters}$$

Notice that the zeros in "21,500 meters" and in "0.00582 meters" are not really needed when the units change. Taking these examples into account, we can introduce three general rules:

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 21,500 has *three* **significant figures**: only three of the digits are important—the two, the one, and the five. The number 10,210 has four significant figures because only the zero at the end is considered not significant. All of the digits in the number 10,005 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: Zeros 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 of the number!

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

$$0.0000007290$$

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

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:

$$42,008,000 \rightarrow 42,010,000$$
$$12,562,425,217 \rightarrow 12,560,000,000$$
$$0.00017837901 \rightarrow 0.0001784$$
$$120 \rightarrow 120.0$$

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

_____   _____   _____   _____

Information: Multiplying and Dividing

When you divide 456 by 13 you get 35.0769230769... How should we round such a number? The concept of significant figures has the answer. When multiplying and dividing numbers, you need to round your answers to the correct number of significant figures. To round correctly, follow these simple steps:

1) Count the number of significant figures in each number.
2) Round your answer to the least number of significant figures.

Here's an example:

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

3 significant figures

2 significant figures

Final rounded answer should have only 2 significant figures since 2 is the least number of significant figures in this problem.

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.

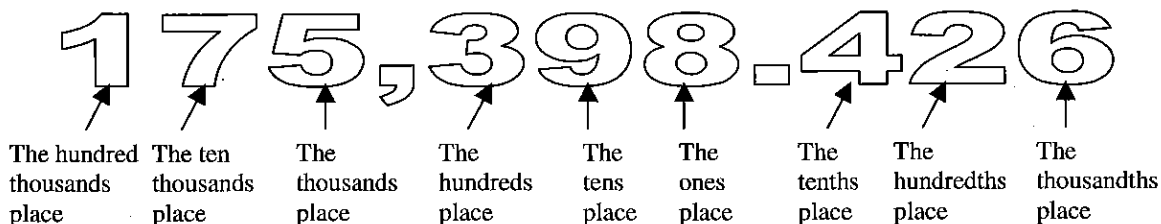a) (12.470)(270) = _____   b) 36,000/1245 = _____

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

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

Information: Rounding to a Decimal Place

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

$$175,398.426$$

| 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 = _____

Information: Adding and Subtracting

Did you know that 30,000 plus 1 does not always equal 30,001? In fact, usually 30,000 + 1 = 30,000! I know you are finding this hard to believe, but let me explain...

Recall that zeros in a number are not always important, or *significant*. Knowing this makes a big difference in how we add and subtract. For example, consider a swimming pool that can hold 30,000 gallons of water. If I fill the pool to the maximum fill line and then go and fill an empty one gallon milk jug with water and add it to the pool, do I then have exactly 30,001 gallons of water in the pool? Of course not. I had approximately 30,000 gallons before and after I added the additional gallon because "30,000 gallons" is not a very precise measurement. So we see that sometimes 30,000 + 1 = 30,000!

Rounding numbers when adding and subtracting is different from multiplying and dividing. In adding and subtracting you round to the least specific decimal place of any number in the problem.

Example #1: Adding

$$350.04$$
$$+720$$

The hundredths place contains a significant figure.

The tens place contains a significant figure.

$$1070.04$$

$$\downarrow$$

$$1070$$

The answer gets rounded to the *least* specific place that has a significant figure. In this case, the tens place is less specific than the hundredths place, so the answer is rounded to the tens place.

Example #2: Subtracting

$$7000$$
$$-1770$$

The tens place contains a significant figure.

The thousands place contains a significant figure.

$$5230$$

$$\downarrow$$

$$5000$$

The answer gets rounded to the *least* specific place that has a significant figure. In this case, the thousands place is less specific than the tens place, so the answer gets rounded to the thousands place.

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) $4129 + 200 =$ _____