ChemQuest 4

Numbers in Chemistry

Name: ______________________________

Date: _______________

Information: Qualitative vs. Quantitative

The following observations are qualitative.

The building is really tall.
It takes a long time for me to ride my bike to the store.
I live really far away.

The following observations are quantitative.

The river is 31.5 m deep.
The cheese costs $4.25 per pound.
It is 75^{o} F outside today.

Critical Thinking Questions

1. What is the difference between qualitative and quantitative observations? (Your answers should reveal an understanding of the definitions for qualitative and quantitative.)
   Qualitative refers to the general quality of a characteristic (tall, short, long, wide, etc.) whereas quantitative includes the quantity of the characteristic (how tall, how short, how long, how wide, etc.). Therefore, quantitative observations will always contain a number to specify more precisely than qualitative.
2. Write an example of a quantitative observation that you may make at home or at school.
   Any of the following are examples: I like to eat 2 bowls of cereal each day. My shoes are size 10.

3. Why are instruments such as rulers, scales (balances), thermometers, etc. necessary?
   Instruments help us to communicate with each other effectively. Without instruments, we could only speak in generalities. They also make it possible to know exact quantities.

Information: Units

Measurements are frequently needed in life as well as in science. Sizes of clothes, distances walked, and speeds driven are all measurements. A measurement is useless without a unit attached to it. For example if someone said that she ran 25, it wouldn't make sense. We need to know if she ran 25 yards or 25 miles—that makes a big difference. In science we will almost always stick with the metric system (centimeters and liters) instead of the English system (inches and gallons). The following tables contain common metric (SI) units and their prefixes.

Table 1: metric base units

Quantity	Unit	Unit Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Temperature	Kelvin	K
Volume	Liter	L
Amount of substance	mole	mol

Table 2: prefixes for metric base units.

Prefix	Symbol	Meaning
Mega	M	million
Kilo	k	thousand
Deci	d	tenth
Centi	c	hundredth
Milli	m	thousandth
Micro	μ	millionth
Nano	n	billionth
Pico	p	trillionth

Note the following examples:

- "milli" means thousandth so a milliliter (symbol: mL) is one thousandth of a Liter and it takes one thousand mL to make one L.
- "Mega" means million so "Megagram" (Mg) means one million grams NOT one millionth of a gram. One millionth of a gram would be represented by the microgram (μg). It takes one million micrograms to equal one gram and it takes one million grams to equal one Megagram.
- One cm is equal to 0.01 m because one cm is "one hundredth of a meter" and 0.01 m is the expression for "one hundredth of a meter"

Critical Thinking Questions

4. How many milligrams are there in one kilogram? 1,000,000 mg

5. 21.5 km is how many meters? 21,500 m

6. Is it possible to answer this question: How many mg are in one km? Explain.
   No, because milli<u>grams</u> and kilo<u>meters</u> are different units of measure.

7. What is the difference between a Mm and a mm? Which is larger one Mm or one mm?
   A Mm is a megameter (1,000,000 meters) and a mm is a millimeter (1/1000 of a meter).

Information: Scientific Notation

"**Scientific notation**" is used to make very large or very small numbers easier to handle. For example the number 45,000,000,000,000,000 can be written as "4.5×10^{16}". The "16" tells you that there are sixteen decimal places between the right side of the four and the end of the number.

> Another example: 2.641×10^{12} = 2,641,000,000,000 → the "12" tells you that there are 12 decimal places between the right side of the 2 and the end of the number.

Very small numbers are written with negative exponents. For example, 0.00000000000000378 can be written as 3.78×10^{-15}. The "-15" tells you that there are 15 decimal places between the right side of the 3 and the end of the number.

Another example: $7.45 \times 10^{-8} = 0.0000000745$ → the "-8" tells you that there are 8 decimal places between the right side of the 7 and the end of the number.

In both very large and very small numbers, the exponent tells you how many decimal points are between the right side of the first digit and the end of the number. If the exponent is positive, the decimal places are to the right of the number. If the exponent is negative, the decimal places are to the left of the number.

Critical Thinking Questions

8. Two of the following six numbers are written incorrectly. Circle the two that are incorrect.

a) 3.57×10^{-8} b) 4.23×10^{-2} c) 75.3×10^{2} d) 2.92×10^{9} e) 0.000354×10^{14} f) 9.1×10^{4}

What do you think is wrong about the two numbers you circled?
C should be written $7.53x10^{3}$ and E should be written $3.54x10^{10}$. The correct format for writing numbers in scientific notation is with only one digit to the left of the decimal place. Also, the number should not begin with zeros.

9. Write the following numbers in scientific notation:

25,310,000,000,000,000 = __$2.531x10^{16}$_____ 0.000000003018 = ___$3.018x10^{-9}$____

10. Write the following scientific numbers in regular notation:

8.41×10^{-7} = __0.000000841___ 3.215×10^{8} = ____321,500,000_____

Information: Multiplying and Dividing Using Scientific Notation

When you multiply two numbers in scientific notation, you must add their exponents. Here are two examples. Make sure you understand each step:

$(4.5x10^{12}) \times (3.2x10^{36}) = (4.5)(3.2) \times 10^{12+36} = 14.4x10^{44} \rightarrow 1.44x10^{45}$

$(5.9x10^{9}) \times (6.3x10^{-5}) = (5.9)(6.3) \times 10^{9+(-5)} = 37.17x10^{4} \rightarrow 3.717x10^{5}$

When you divide two numbers, you must subtract denominator's exponent from the numerator's exponent. Here are two examples. Make sure you understand each step:

$$\frac{2.8x10^{14}}{3.2x10^{7}} = \frac{2.8}{3.2}x10^{14-7} = 0.875x10^{7} = 8.75x10^{6}$$

$$\frac{5.7x10^{19}}{3.1x10^{-9}} = \frac{5.7}{3.1}x10^{19-(-9)} = 1.84x10^{19+9} = 1.84x10^{28}$$

Critical Thinking Questions

11. Solve the following problems.

a) $(4.6x10^{34})(7.9x10^{-21})$ = $(4.6)(7.9)$ x $10^{34+(-21)}$ = 36.34 x10^{13} → $3.634x10^{14}$

b) $(1.24x10^{12})(3.31x10^{20})$ = $(1.24)(3.31)x10^{12+20}$ = $4.1x10^{32}$

12. Solve the following problems.

a) $\frac{8.4x10^{-5}}{4.1x10^{17}} = \frac{8.4}{4.1} x10^{-5-17} = 2.05x10^{-22}$

b) $\frac{5.4x10^{32}}{7.3x10^{14}} = \frac{5.4}{7.3} x10^{32-14} = .74x10^{18} = 7.4x10^{17}$

Information: Adding and Subtracting Using Scientific Notation

Whenever you add or subtract two numbers in scientific notation, you must make sure that they have the same exponents. Your answer will them have the same exponent as the numbers you add or subtract. Here are some examples. Make sure you understand each step:

$4.2x10^6 + 3.1x10^5$ → make exponents the same, either a 5 or 6 → $42x10^5 + 3.1x10^5 = 45.1x10^5 = 4.51x10^6$

$7.3x10^{-7} - 2.0x10^{-8}$ → make exponents the same, either -7 or -8 → $73x10^{-8} – 2.0x10^{-8} = 71x10^{-8} = 7.1x10^{-7}$

Critical Thinking Questions

13. Solve the following problems.

a) $4.25x10^{13} + 2.10x10^{14}$ = first, change exponents so both are either 13 or 14
$4.25x10^{13} + 21.0x10^{13} = 25.25x10^{13}$ → 2.525 x 10^{14}

b) $6.4x10^{-18} – 3x10^{-19}$ = first, change exponents so both are either -18 or -19
$6.4x10^{-18} – 0.3x10^{-18}$ = 6.1 x 10^{-18}

c) $3.1x10^{-34} + 2.2x10^{-33}$ = first, change exponents so both are either -34 or -33
$3.1x10^{-34} + 22x10^{-34} = 25.1x10^{-34}$ → $2.51x10^{-33}$