Name ________________________ HONORS CHEM ____/____/____

Scientific Notation, Density, Percent Error & Metric Conversions

Scientific Notation

In chemistry, we often use numbers that are either very large (1 mole = 602 200 000 000 000 000 000 000 atoms) or very small (the mass of an electron = 0.000 000 000 000 000 000 000 000 000 000 910 939 kg). Writing numbers with so many digits would be tedious and difficult. To make writing very large and small numbers easier, scientists use an abbreviation method known as scientific notation. In scientific notation the numbers mentioned above would be written as 6.022×10^{23} and 9.10939×10^{-31}.

Converting a number to or from scientific notation

- If you move the decimal place to the left, the power of 10 value increases.
- If you move the decimal place to the right, the power of 10 value decreases.

To remember this, think**: Left (sounds like lift) something Up and Right (sounds like write) something Down**

Example: Let's look at the first number from above: 602 200 000 000 000 000 000 000
To put this number in scientific notation you would move your decimal place until there is one number to the left of the decimal. To do this, we must move our decimal 23 places to the left. When you move the decimal to the left, the power of 10 value increases. It increases from 0 to 23. Thus, the answer is **6.022×10^{23}**
Let's look at the second number from above: 0.000 000 000 000 000 000 000 000 000 000 910 939
To put this number in scientific notation we must move our decimal 31 places to the right. **REMEMBER: You must always have one digit to the left of the decimal when writing numbers in scientific notation.** Since we are moving our decimal to the right, we must decrease our power of 10 value. It decreases from 0 to –31. Our answer is **9.10939×10^{-31}**

Rules for multiplying & dividing using scientific notation:

- **When multiplying two numbers in scientific notation, ADD their power of 10 values**.

For example: $(3.45 \times 10^{6})(4.3 \times 10^{5}) = 14.835 \times 10^{11}$. But, we must also remember to express our answer in significant figures. Thus, the final answer is **1.5×10^{12}**

- **When dividing numbers in scientific notation, SUBTRACT the denominator's power of 10 value from the numerator's power of 10 value**.

For example: $(2.898 \times 10^{12}) \div (3.45 \times 10^{15}) = 0.840 \times 10^{-3}$ (I had to add the zero at the end to get the three significant figures needed.) I got 10^{-3} because 12 – 15 = –3. Make sure your answer is in proper scientific notation (one number to the left of the decimal). In this problem we have to move the decimal one place to the right. When we move our decimal to the right, we decrease our power of 10. –3 decreases by 1 to –4. Our final answer is: **8.40×10^{-4}**

Density

Density (d) is the ratio of the mass (m) of a substance to the volume (v) occupied by the substance. Pure water is used as the standard in measuring density. **The density of pure water is 1.0 g/mL**. If a substance has a density less than water, it will float; if a substance has a density greater than water, it will sink.

$$d=\frac{m}{v}$$

Mass is expressed in grams (g). Volume is expressed in either milliliters (mL) or cubic centimeters (cc or cm^3). Thus, density can be expressed as g/mL or g/cm^3.

Example: A piece of wood has a volume of 3350 cm^3. If the density of the wood is 0.512 g/mL, what is its mass?

Steps 1 & 2	**Step 3**	**Step 4**	**Step 5**	**Steps 6 & 7**
d = 0.512 g/mL v = 3350 cm^3 m = x	$\frac{d}{1}=\frac{m}{v}$	$\frac{0.512}{1} = \frac{X}{3350}$	X = 1715.2	**1.72×10^{3} grams**

Percent Error

The accuracy of your measurements can be checked by calculating the percent error. In a percent error calculation you will compare your experimental value to the accepted scientific value (referred to as the theoretical value). Since you are taking the absolute value of the subtraction**, your percent error will always be a positive number**. Remember to use significant figures in all % error calculations. In most quantitative lab experiments you will be expected to calculate your % error.

$$\textbf{\%Error} = \frac{|\text{ theoretical yield } - \text{ experimental yield }|}{\text{theoretical yield}} \times 100$$

Metric Conversions

All measurements in chemistry are made using the metric system. In using the metric system you must be able to convert between one value and another. YOU MUST MEMORIZE THE FOLLOWING PREFIXES AND FACTORS: (giga, mega, kilo, hector, deca, base unit, deci, centi, milli, micro, nano)

Factor	Prefix	Symbol
1×10^{12}	tera-	T
1×10^{9}	giga-	G
1×10^{6}	mega-	M
1×10^{3}	kilo-	k
1×10^{2}	hecto-	h
1×10^{1}	deca-	D
1×10^{0}	base unit	---
1×10^{-1}	deci-	d
1×10^{-2}	centi-	c
1×10^{-3}	milli-	m
1×10^{-6}	micro-	µ
1×10^{-9}	nano-	n
1×10^{-10}	angstrom	Å
1×10^{-12}	pico-	p

Example: Convert 18.3×10^{-1} kilograms to centigrams.

Step 1. Subtract the power of ten value you are solving for from the power of ten value you are given.
In this problem you are given 18.3 kilograms and you are converting to centigrams. Kilograms have a power of ten value of 3; centigrams have a power of ten value of -2. 3-(-2) = 5

Step 2. Write your result as the power of ten value of your answer.
In this problem our answer is 18.3×10^{-1} $\mathbf{\times 10^{5}}$.

Step 3. Put your answer in proper scientific notation.
$18.3 \times 10^{-1} \times 10^{5}$ is converted to $\mathbf{18.3 \times 10^{4}}$. Remember that when multiplying using powers of ten you add. Proper scientific notation has one number before the decimal. Your answer would be converted to $\mathbf{1.83 \times 10^{5}}$.

Homework: Solve each of the following problems on a separate sheet of paper.

1. Perform the following mathematical operations, and express the result to the correct number of significant figures.
   a. $(6.022 \times 10^{23}) \times (2.33 \times 10^{3})$
   b. 1.00876 + 0.87206 – 0.0996
   c. (7.915 – 7.908) ÷ 7.915 x 100.
   d. $(3.000 \times 10^{5}) \div (4.00 \times 10^{-6})$
   e. $2.38 \div 55.8 \times (6.022 \times 10^{23})$

2. Convert each of the following.
   a. 8.57 micrograms to centigrams
   b. 2.11×10^{-4} dekaliters to milliliters
   c. 1.95×10^{11} nanometers to meters
   d. 2.27 kilograms to decigrams
   e. 6.19×10^{-8} megagrams to micrograms

3. The density of pure platinum is 21.45 g/mL at 20°C. If 5.50 grams of pure platinum is added to 14.45 mL of water, to what volume will the level in the cylinder rise?

4. A 20.00 gram sample of a solid is placed in a graduated cylinder and then filled to the 50.00 mL mark with benzene. The mass of the benzene and the solid together is 58.80 g. Assuming that the solid is insoluble in benzene and the density of benzene is 0.880 grams/cm^3, calculate the density of the solid.