Scientific Notation[3]

There are many very large and very small numbers in scientific studies. How would you like have to calculate with:

1 Dalton = 0.000,000,000,000,000,000,000,00165 g

or

1 mol = 602,200,000,000,000,000,000,000 atoms

You can streamline large or small numbers with scientific notation. The standard is that you move the decimal point to the left or right until you get a number greater than 1 but less than 10. Adjust the exponent of ten (10^x) to reflect the number of times the decimal place was moved. The only question you might have trouble with is WHICH WAY to move the decimal. The easy way to remember that is: numbers that are less than one have negative exponent numbers in the scientific notation form, and numbers that are larger than one have positive exponent numbers.

Think of the change as creating a new number with two parts, a digit part and an exponent part, from the old number.

To change 0.000,000,000,000,000,000,000,00165 into scientific notation, move the decimal to the right 24 times so it is between the 1 and 6 (1.65 is greater than 1 but less than 10). Since the number began as a value less than 1 (a decimal), the decimal was moved to the right and the sign of the exponent is negative.

0.000,000,000,000,000,000,000,00165 = 1.65×10^{-24}

602,200,000,000,000,000,000,000 = 6.022×10^{23}

Here are some examples of scientific notation:

$10000 = 1 \times 10^4$	$24327 = 2.4327 \times 10^4$
$1000 = 1 \times 10^3$	$7354 = 7.354 \times 10^3$
$100 = 1 \times 10^2$	$482 = 4.82 \times 10^2$
$10 = 1 \times 10^1$	$89 = 8.9 \times 10^1$ (not usually done)
$1 = 10^0$	
$1/10 = 0.1 = 1 \times 10^{-1}$	$0.32 = 3.2 \times 10^{-1}$ (not usually done)
$1/100 = 0.01 = 1 \times 10^{-2}$	$0.053 = 5.3 \times 10^{-2}$
$1/1000 = 0.001 = 1 \times 10^{-3}$	$0.0078 = 7.8 \times 10^{-3}$
$1/10000 = 0.0001 = 1 \times 10^{-4}$	$0.00044 = 4.4 \times 10^{-4}$

Scientific notation can also be written in another form. Using the values from above:

0.000,000,000,000,000,000,000,00165 = 1.65×10^{-24} or **1.65 E-24**

602,200,000,000,000,000,000,000 = 6.022×10^{23} or **6.022 E23**

The "E" in the number stands for exponent. Your scientific calculator will use the numbers in the shortened form, usually best represented by the "E" form.

Scientific Notation on Your Calculator[4]

When you are using your calculator, typing "something times ten to the something" over and over again gets to be a pain. Most calculators have an "EE" button, to help you out. (Note that when you type the EE key, most calculators simply display "E"! Do not be alarmed by this. This is not the E that means error.)

Be careful! It's easy to make the following common mistake: Remember that EE -- times ten to the -- is not the same as ^ -- "to the"!

Make sure that the number in scientific notation is put into your calculator correctly. **Read** the directions for your particular calculator. For inexpensive scientific calculators:

1. Punch the number (the digit number) into your calculator.
2. Push the EE or EXP button. Do **NOT** use the x (times) button!!
3. Enter the exponent number. Use the +/- button to change its sign.
4. Voila! Treat this number normally in all subsequent calculations.

To check yourself, multiply 6.0×10^5 times 4.0×10^3 on your calculator. Your answer should be 2.4×10^9.

If you don't have a scientific calculator: You will need to be familiar with exponents since your calculator cannot take care of them for you.

Addition and Subtraction:

- All numbers are converted to the same power of 10, and the digit terms are added or subtracted.
- Example: $(4.215 \times 10^{-2}) + (3.2 \times 10^{-4}) = (4.215 \times 10^{-2}) + (0.032 \times 10^{-2}) = 4.247 \times 10^{-2}$
- Example: $(8.97 \times 10^4) - (2.62 \times 10^3) = (8.97 \times 10^4) - (0.262 \times 10^4) = 8.71 \times 10^4$

Multiplication:

- The digit terms are multiplied in the normal way and the exponents are added. The end result is changed so that there is only one nonzero digit to the left of the decimal.
- Example: $(3.4 \times 10^6)(4.2 \times 10^3) = (3.4)(4.2) \times 10^{(6+3)} = 14.28 \times 10^9 = 1.428 \times 10^{10}$
- Example: $(6.73 \times 10^{-5})(2.91 \times 10^2) = (6.73)(2.91) \times 10^{(-5+2)} = 19.58 \times 10^{-3} = 1.958 \times 10^{-2}$

Division:

- The digit terms are divided in the normal way and the exponents are subtracted. The quotient is changed (if necessary) so that there is only one nonzero digit to the left of the decimal.
- Example: $(6.4 \times 10^6)/(8.9 \times 10^2) = (6.4)/(8.9) \times 10^{(6-2)} = 0.719 \times 10^4 = 7.2 \times 10^3$ (to 2 significant figures)
- Example: $(3.2 \times 10^3)/(5.7 \times 10^{-2}) = (3.2)/(5.7) \times 10^{3-(-2)} = 0.561 \times 10^5 = 5.6 \times 10^4$ (to 2 significant figures)

Scientific Notation Practice Problems[5]:

Write the following numbers in *scientific notation*

1. 1001

2. 53

3. 6,926,300,000

4. -392

5. 0.00361

6. 0.13592

7. -0.0038

8. 0.00000013

9. -0.567

Take the numbers out of *scientific notation*

1. 1.92×10^3

2. 3.051×10^1

3. -4.29×10^2

4. 6.251×10^9

5. 8.317×10^6

6. 1.03×10^{-2}

7. 8.862×10^{-1}

8. 9.512×10^{-8}

9. -6.5×10^{-3}

10. 3.159×10^2

Use Scientific Notation (and only the scientific notation!) to find the answer to the following problems:

1. $4.1357 \times 10^{-15} * 5.4 \times 10^2 = ?$

2. $1.695 \times 10^4 \div 1.395 \times 10^{15} = ?$

3. $4.367 \times 10^5 * 1.96 \times 10^{11} = ?$

4. $6.97 \times 10^3 * 2.34 \times 10^{-6} + 3.2 \times 10^{-2} = ?$

5. $5.16 \times 10^{-4} \div 8.65 \times 10^{-8} + 9.68 \times 10^4 = ?$

Answers to Scientific Notation Problems[5]:

Write the following numbers in *scientific notation*.

1. 1001 = 1.001×10^{3}
2. 53 = 5.3×10^{1}
3. 6,926,300,000 = 6.9263×10^{9}
4. -392 = -3.92×10^{2}
5. 0.00361 = 3.61×10^{-3}
6. 0.13592 = 1.3592×10^{-1}
7. -0.0038 = -3.8×10^{-3}
8. 0.00000013 = 1.3×10^{-7}
9. -0.567 = -5.67×10^{-1}

Take the numbers out of *scientific notation*

1. 1.92×10^{3} = 1,920
2. 3.051×10^{1} = 30.51
3. -4.29×10^{2} = -429
4. 6.251×10^{9} = 6,251,000,000
5. 8.317×10^{6} = 8,317,000
6. 1.03×10^{-2} = 0.0103
7. 8.862×10^{-1} = 0.8862
8. 9.512×10^{-8} = 0.00000009512
9. -6.5×10^{-3} = -0.0065
10. 3.159×10^{2} = 315.9

Use Scientific Notation (and only the scientific notation!) to find the answer to the following problems:

1. $4.1357 \times 10^{-15} * 5.4 \times 10^{2} = 2.2 \times 10^{-12}$
2. $1.695 \times 10^{4} \div 1.395 \times 10^{15} = 1.215 \times 10^{-11}$
3. $4.367 \times 10^{5} * 1.96 \times 10^{11} = 8.56 \times 10^{16}$
4. $6.97 \times 10^{3} * 2.34 \times 10^{-6} + 3.2 \times 10^{-2} = 4.83 \times 10^{-2}$
5. $5.16 \times 10^{-4} \div 8.65 \times 10^{-8} + 9.68 \times 10^{4} = 1.03 \times 10^{5}$

Units of Measure[5]

In science, when quantities are measured or calculated, they must be given proper units. A measurement without a unit specification really does not make much sense. Imagine if someone told you that Mt. Everest is 10^4 tall. Without a unit specification this number should mean nothing to you.

There is a set of fundamental physical quantities - some of which you might already have some experience with - which form a sort of "building block" for measurements and calculation. The THREE fundamental or standard "building blocks" that are needed are: Length, Mass, and Time.

You are probably familiar with the fundamental units of length, mass and time in the American system: the yard, the pound, and the second. The other common units of the American system are often strange multiples of these fundamental units such as the ton (2000 lbs.), the mile (1760 yds.), the inch (1/36 yd.) and the ounce (1/16 lb.). Most of these units arose from accidental conventions, and so have few logical relationships.

Most of the world uses a much more rational system known as the **metric system** (the SI, *Systeme International d'Unites*, internationally agreed upon system of units) with the following fundamental units:

- The **meter** for length. Abbreviated "m".
- The **kilogram** for mass. Abbreviated "kg". (Note: kilogram, not gram, is the standard.)
- The **second** for time. Abbreviated "s".

Base 10 System of Units

All of the unit relationships in the metric system are based on multiples of 10, so it is very easy to multiply and divide. The SI system uses prefixes to make multiples of the units. All of the prefixes represent powers of 10. The table below gives prefixes used in the metric system, along with their abbreviations and values.

Metric Prefixes

Prefix	**Abbreviation**	**Value**		**Prefix**	**Abbreviation**	**Value**
deci	d	10^{-1}		deca	da	10^{1}
centi	c	10^{-2}		hecto	h	10^{2}
milli	m	10^{-3}		kilo	k	10^{3}
micro	m	10^{-6}		mega	M	10^{6}
nano	n	10^{-9}		giga	G	10^{9}
pico	p	10^{-12}		tera	T	10^{12}