

28.1 Scientific Notation

A number like 43,200,000,000,000,000 (43 quintillion, 200 quadrillion) can take a long time to write, and an even longer time to read. Because scientists frequently encounter very large numbers like this one (and also very small numbers, such as 0.000000012, or twelve trillionths), they developed a shorthand method for writing these types of numbers. This method is called scientific notation. A number is written in scientific notation when it is written as the product of two factors, where the first factor is a number that is greater than or equal to 1, but less than 10, and the second factor is an integer power of 10. Some examples of numbers written in scientific notation are given in the table below:

Scientific Notation	Standard Form
4.32×10^{19}	43,200,000,000,000,000,000
1.2×10^{-8}	0.000000012
5.2777×10^7	52,777,000
6.99×10^{-5}	0.0000699

EXAMPLES

Rewrite numbers given in scientific notation in standard form.

- Express 4.25×10^6 in standard form: $4.25 \times 10^6 = 4,250,000$
Move the decimal point (in 4.25) six places to the right. The exponent of the “10” is 6, giving us the number of places to move the decimal. We know to move it to the right since the exponent is a positive number.

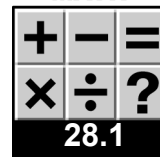
$$4.25 \times 10^6 = \underset{\substack{\text{move decimal six} \\ \text{places to the right}}}{4.2,5,0,0,0,0} = 4,250,000$$

- Express 4.033×10^{-3} in standard form: $4.033 \times 10^{-3} = 0.004033$
Move the decimal point (in 4.033) three places to the left. The exponent of the “10” is negative 3, giving the number of places to move the decimal. We know to move it to the left since the exponent is negative.

$$4.033 \times 10^{-3} = \underset{\substack{\text{move decimal three} \\ \text{places to the left}}}{0,0,4.033} = 0.004033$$

Rewrite numbers given in standard form in scientific notation.

- Express 26,040,000,000 in scientific notation: $26,040,000,000 = 2.604 \times 10^{10}$
Place the decimal point in 2 6 0 4 so that the number is greater than or equal to one (but less than ten). This gives the first factor (2.604). To get from 2.604 to 26,040,000,000 the decimal point has to move 10 places to the right, so the power of ten is positive 10.
- Express 0.0001009 in scientific notation: $0.0001009 = 1.009 \times 10^{-4}$
Place the decimal point in 1 0 0 9 so that the number is greater than or equal to one (but less than ten). This gives the first factor (1.009). To get from 1.009 to 0.0001009 the decimal point has to move four places to the left, so the power of ten is negative 4.


PRACTICE 

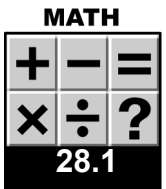
1. Fill in the missing numbers. Some will require converting scientific notation to standard form, while others will require converting standard form to scientific notation.

	Scientific Notation	Standard Form
a.	6.03×10^{-2}	
b.	9.11×10^5	
c.	5.570×10^{-7}	
d.		999.0
e.		264,000
f.		761,000,000
g.	7.13×10^7	
h.		0.00320
i.		0.000040
j.	1.2×10^{-12}	
k.		42,000,000,000,000
l.		12,004,000,000
m.	9.906×10^{-2}	

2. Explain why the numbers below are not written in scientific notation, then give the correct way to write the number in scientific notation.

Example: 0.06×10^5 is not written in scientific notation because the first factor (0.06) is not greater than or equal to 1. The correct way to write this number in scientific notation is 6.0×10^3 .

- 2.004×1^{11}
- 56×10^{-4}
- 2×100^2
- 10×10^{-6}



3. Write the numbers in the following statements in scientific notation:
- a. The national debt in 2005 was about \$7,935,000,000,000.
 - b. In 2005, the U.S. population was about 297,000,000
 - c. Earth's crust contains approximately 120 trillion (120,000,000,000,000) metric tons of gold.
 - d. The mass of an electron is 0.000 000 000 000 000 000 000 000 000 91 kilograms.
 - e. The usual growth of hair is 0.00033 meters per day.
 - f. The population of Iraq in 2005 was approximately 26,000,000.
 - g. The population of California in 2005 was approximately 33,900,000.
 - h. The approximate area of California is 164,000 square miles.
 - i. The approximate area of Iraq in 2005 was 169,000 square miles.
 - j. In 2005, one right-fielder made a salary of \$12,500,000 playing professional baseball.