Exponential Numbers (Scientific Notation)

Scientists often find it necessary to work with very large and very small numbers. To simplify the handling of these numbers, it is common to convert them into a simpler form called the **exponential** form.

In the exponential form, the exponent represents the number of places the decimal point has been moved.

For example, 50,000,000 can be written

$$5 \times 10^7$$

where the "7" in 10^7 tells us that the decimal point has been moved "7" places.

50,000,000

One of the most important numbers in chemistry is Avogadro's number.

602,300,000,000,000,000,000,000

Write Avogadro's number in the exponential form with one significant digit to the left of the decimal point. That's 6023 and 20 zeros.

$$6.023 \times 10^{23}$$

What must we do if the number has a value less than one?

If the numeric value of a number is less than one, the exponent is given a negative sign. For example, 0.003 would be written

$$3 \times 10^{-3}$$

Summary of the Rules to Follow When Writing Numbers in the Exponential Form

The exponent represents the number of places the decimal has been moved.

If the number has a numeric value greater than one, it must have a *positive* exponent.

If the number has a numeric value less than one, it must have a *negative* exponent.

In this class, always shift the decimal point in a manner that gives one significant digit to the left of the decimal point.

Always show all significant digits.

Write the following numbers in the exponential form, with *one significant digit to the left of the decimal point,* and with all its significant digits.

â 0.000341 _____

ã 240,000 _____

ä 0.60 _____

å 4.0 _____

æ 820,000,000,000 _____

ç 0.0000582 _____

Converting from the Exponential form to the Decimal Form

To convert a number from the exponential form into the decimal form, reverse the process performed when writing the exponential number. That is, move the decimal place left or right the number of places represented by the exponent. It may be necessary to add "zeros" until the proper number of places has been counted.

For example, write the number 3×10^4 in decimal form.

Starting at the "3" move the decimal point four places to the right by adding four zeros.

$$3 + 0000 = 30000$$

What if the number has a negative exponent?

For example, write the number 2.1×10^{-3} in decimal form.

Starting with the 2, move the decimal point three places to the left. Since the number has a negative exponent, it is necessary to add only two zeros.

$$.00 + 21 = 0.0021$$

What would the number 8.2×10^{-5} look like in decimal form?

$$0.000082$$

Convert each of the following numbers from the exponential form to the decimal form. Be certain to include all significant digits in your answer.

â 3.5×10^{4} _____

ã 1.33×10^{-2} _____

ä 2.00×10^{1} _____

å 1.010×10^{-5} _____

æ 3.44×10^{9} _____

Shifting the Decimal Point

One important skill in science is to be able to shift the decimal point in exponential numbers.

When shifting the decimal point, observe the following rules:

The numeric value of the number can not change.

Both the number and the exponent must change by the same number but in the opposite direction. That is, if the number increases by two decimal places, the exponent must decrease by two decimal places.

For example, how would you change a number from

$$20 \times 10^3 \quad \text{to} \quad ? \times 10^2 \quad ?$$

Since the exponent has decreased by one place, the number must increase by one decimal place.

That is, the exponent has *decreased* from 3 to 2 so that the number must *increase* from 20 to 200.

$$20 \times 10^3 \quad \text{to} \quad 200 \times 10^2$$

Convert 3400×10^7 to $3.4 \times 10^?$

$$3400 \times 10^7 \text{ to } 3.4 \times 10^{10}$$

Since the number has *decreased* by three places, the exponent must *increase* by three places.

Shift the decimal point in each of the following exponential number and give the missing value. Show all significant digits.

â $8.2 \times 10^{6} = ? \times 10^{4}$ _____

ã $5.6 \times 10^{-4} = ? \times 10^{-3}$ _____

ä $9.0 \times 10^{8} = 0.090 \times 10^{?}$ _____

å $64 \times 10^{-5} = 64000 \times 10^{?}$ _____

æ $0.00015 \times 10^{8} = 150 \times 10^{?}$ _____

ç $720 \times 10^{-2} = ? \times 10^{-4}$ _____

è $0.0092 \times 10^{-11} = ? \times 10^{-7}$ _____

Arithmetic Operations

When multiplying with exponential numbers without a calculator, first multiply the number portion, then add the exponents.

$(6.0 \times 10^{4})(8 \times 10^{7}) =$ _____

$(2.4 \times 10^{-11})(3.00 \times 10^{22}) =$ _____

When dividing with exponential numbers without a calculator, first divide the number portion, then subtract the exponents.

$$\frac{2.7 \times 10^{10}}{3.0 \times 10^{4}} = \underline{\qquad\qquad}$$

$$\frac{3.6 \times 10^{-40}}{1.2 \times 10^{-18}} = \underline{\qquad\qquad}$$

When raising exponential numbers to a power without a calculator, first raise the number portion to the power, then multiply the exponents.

$(3.0 \times 10^{3})^{2} =$ _____

$(4.0 \times 10^{-5})^{3} =$ _____

When finding the root of an exponential number without a calculator, first find the root the number portion, and then divide the exponent by the root. Be certain that the exponent is an even multiple of the root.

$\sqrt{8.1 \times 10^{21}} =$ _____

$\sqrt[4]{8.1 \times 10^{13}} =$ _____

Calculate each of the following problems. Express your answer in the exponential form, with one significant digit to the left of the decimal point, and with the correct number of significant digits.

$$\frac{4.800 \times 10^{34}}{1.6 \times 10^{20}} = \_\_\_\_\_$$

$$(8.2 \times 10^{-3})(3 \times 10^{9}) = \_\_\_\_\_$$

$$\sqrt[3]{1.25 \times 10^{14}} = \_\_\_\_\_$$

$$(2.0 \times 10^{-5})^{5} = \_\_\_\_\_$$

$$\frac{(1.6 \times 10^{6})(2.5 \times 10^{-3})}{(5 \times 10^{-7})} = \_\_\_\_\_$$

Addition and Subtraction with Exponents

To add or subtract exponential numbers without a calculator, the numbers must have the same exponent. Calculate

$(2.0 \times 10^3) + (3 \times 10^2) =$ _____

$$\begin{array}{r} 2.0 \times 10^3 \\ +\ 0.3 \times 10^3 \\ \hline 2.3 \times 10^3 \end{array}$$

$(6.5 \times 10^6) - (2.6 \times 10^4) =$ _____

$$\begin{array}{r} 6.5 \times 10^6 \\ -\ 0.026 \times 10^6 \\ \hline 6.474 \times 10^6 \end{array}$$

Calculate each of the following problems. Express your answer in the exponential form, with one significant digit to the left of the decimal point, and with the correct number of significant digits.

$(6.1 \times 10^{-3}) + (5.4 \times 10^{-2}) =$ _____

$(7.5 \times 10^{29}) - (2.1 \times 10^{28}) =$ _____

$$\frac{(3.4 \times 10^{7}) + (2.5 \times 10^{8})}{(2.0 \times 10^{-3})} =$$ _____

Calculate each of the following problems. Express your answer in the exponential form, with one significant digit to the left of the decimal point, and with the correct number of significant digits.

$(5.10 \times 10^{-21})(3.0 \times 10^{-9)} =$ _____

$$\frac{6.4 \times 10^{-3}}{1.6 \times 10^{-25}} =$$ _____

$(3.4 \times 10^{7}) + (2.1 \times 10^{6)} =$ _____

$\sqrt[3]{2.7 \times 10^{-20}} =$ _____

$$\frac{(1.20 \times 10^{5})(4.0 \times 10^{4})}{(2.400 \times 10^{-3})} =$$ _____

Calculate each of the following problems. Express your answer in the *exponential form,* with one significant digit to the *to the left of the decimal point,* and with the *correct* number of significant digits.

$(3.2 \times 10^{11})(3 \times 10^{6}) =$ _____

$(6 \times 10^{-8})^{2} =$ _____

$(4.9 \times 10^{-9})^{½} =$ _____

$$\frac{3.2 \times 10^{-8}}{5 \times 10^{-13}} =$$ _____

$(8.3 \times 10^{11}) + (6.1 \times 10^{9}) =$ _____