Appendix A

Scientific Notation and Powers of Ten Calculations

A.1 Scientific Notation

Often the quantities used in chemistry problems will be very large or very small numbers. It is much more convenient to express such quantities in **scientific notation** rather than in decimal form. A quantity written in scientific notation is expressed as a number between 1 and 10 multiplied by the appropriate power of ten (10 raised to some exponent).

It is a relatively simple matter to convert between a decimal form and scientific notation. This procedure is illustrated in Examples A.1 and A.2.

Example A.1 Problem Express 235 in proper scientific notation. Solution First express the original quantity as a number between 1 and 10. 235 → 2.35 Then multiply by the appropriate power of ten. This is determined by noting how many places, and in which direction, the decimal point was moved in the first step. Notice that we moved the decimal point 2 places to the left. In doing so, the original quantity has been reduced by 2 powers of ten (235 → 2.35). In order to restore the quantity to its original value you must multiply by 2 powers of ten; that is, 10².

235 \rightarrow 2.35 x 10²

Example A.2

Problem

Express 0.006994 in proper scientific notation.

Solution

First express the original quantity as a number between 1 and 10.

0.006994 → 6.994

Then multiply by the appropriate power of ten. This is determined by noting how many places, and in which direction, the decimal point was moved in the first step. Notice that we moved the decimal point 3 places to the right. This means that the power of ten to use is 3. However, since the decimal point was moved to the right, thereby making the number larger, the power of ten must be negative so that you are multiplying by a value smaller than 1; that is, 10^{-3} .

 $0.006994 \rightarrow 6.994 \times 10^{-3}$

In summary, for a starting quantity greater than one, move the decimal point to the left until you form a number between 1 and 10 and multiply by 10 raised to the number of places the decimal point was moved. For a starting quantity less than one, move the decimal point to the right until you form a number between 1 and 10 and multiply by 10 raised to the negative of the number of places the decimal point was moved. Examples A.3 and A.4 illustrate how to convert between scientific notation and decimal notation.

Example A.3

Problem

Express 5.1 x 10^{-5} in decimal notation.

Solution

Since the power of ten is a negative value, the number is less than one. Move the decimal point 5 places to the left using zeros to fill in four of the needed places.

 $5.1 \ge 10^{-5} \rightarrow 0.000051$

Example A.4

Problem

Express 6.49 x 10^2 in decimal notation.

Solution

Since the power of ten is a positive value, the number is greater than one. Move the decimal point 2 places to the right.

 $6.49 \ge 10^2 \rightarrow 649.$

A.2 Calculations Involving Powers of Ten

When multiplying powers of ten, the exponent for the product is the sum of the exponents in all of the factors. In general, $(A \times 10^x) \cdot (B \times 10^y) = A \cdot B \times 10^{x+y}$. This is illustrated in Example A.5.

Example A.5	
Problem	
Calculate $(3.0 \times 10^4) \times (2.5 \times 10^{-2})$.	
Solution	
$(3.0 \times 10^4) \times (2.5 \times 10^{-2}) = (3.0 \times 2.5) \times 10^{4+(-2)} = 7.5 \times 10^2$	

When dividing powers of ten, the exponent of the quotient is the difference between the exponent in the numerator and the exponent in the denominator.

In general, $\frac{A \times 10^{x}}{B \times 10^{y}} = \frac{A}{B} \times 10^{x-y}$. This is illustrated in Example A.6.

Example A.6

Problem

Calculate
$$\frac{9.6 \times 10^3}{2.0 \times 10^4}$$
.

Solution

 $\frac{9.6 \, x \, 10^3}{2.0 \, x \, 10^4} = \frac{9.6}{2.0} \, x \, 10^{3 - 4} = 4.8 \, x \, 10^{-1}$

When adding or subtracting numbers with a power of ten, the powers of ten exponents must be the same. The largest exponent is usually the most convenient one to duplicate. This process is illustrated in Example A.7.

Example A.7

Problem

Calculate $(4.19 \times 10^2) + (2.3 \times 10^1)$.

Solution

First covert 2.3 x 10^1 into a number having a power of ten exponent equal to 2. This requires increasing the exponent by one unit (making a tenfold increase in the power of ten) so the decimal number must be decreased tenfold.

 $2.3 \ge 10^1 \rightarrow 0.23 \ge 10^2$

Then add the decimal numbers and use the common power of ten.

 $+ \begin{array}{c} 4.19 \ x \ 10^2 \\ + \ 0.23 \ x \ 10^2 \\ \hline 4.42 \ x \ 10^2 \end{array}$



Answers to Check for Understanding A.1 Problems