Appendix B
Scientific Notation

Numbers expressed in scientific notation have the following form:

Exponent, a positive or negative integer

$$a \times 10^{b}$$

Coefficient,
a number with 1 nonzero digit
to the left of the decimal point

Exponential term

For example, there are about 5.5×10^{21} carbon atoms in a 0.55 carat diamond. In the number 5.5×10^{21}, 5.5 is the coefficient, 10^{21} is the exponential term, and 21 is the exponent. The coefficient, which should have just one nonzero digit to the left of the decimal point, reflects the number's uncertainty. It is common to assume that numbers are plus or minus one in the last position reported unless otherwise stated. Using this guideline, 5.5×10^{21} carbon atoms in a 0.55 carat diamond suggests that there are from 5.4×10^{21} to 5.6×10^{21} carbon atoms in the stone.

The exponential term shows the size of the number. Positive exponents are used for large numbers, and negative exponents are used for small numbers. For example, the moon orbits the sun at 2.2×10^4 or 22,000 mi/hr.

$$2.2 \times 10^4 = 2.2 \times 10 \times 10 \times 10 \times 10 = 22{,}000$$

A red blood cell has a diameter of about 5.6×10^{-4} or 0.00056 inches.

$$5.6 \times 10^{-4} = 5.6 \times \frac{1}{10^4} = \frac{5.6}{10 \times 10 \times 10 \times 10} = 0.00056$$

Use the following steps to convert from a decimal number to scientific notation.

- Shift the decimal point until there is one nonzero number to the left of the decimal point, counting the number of positions the decimal point moves.
- Write the resulting coefficient times an exponential term in which the exponent is positive if the decimal point was moved to the left and negative if the decimal position was moved to the right. The number in the exponent is equal to the number of positions the decimal point was shifted.

For example, when 22,000 is converted to scientific notation, the decimal point is shifted four positions to the left so the exponential term has an exponent of 4.

$$22{,}000 = 2.2 \times 10^4$$

When 0.00056 is converted to scientific notation, the decimal point is shifted four positions to the right so the exponential term has an exponent of −4.

$$5.6 \times 10^{-4} = 0.00056$$

To convert from scientific notation to a decimal number, shift the decimal point in the coefficient to the right if the exponent is positive and to the left if it is negative. The number in the exponent tells you the number of positions to shift the decimal point. For example, when 2.2×10^4 is converted to a decimal number, the decimal point is shifted four positions to the right because the exponent is 4.

2.2×10^4 goes to 22,000

When 5.6×10^{-4} is converted to a decimal number, the decimal point is shifted four positions to the left because the exponent is −4.

$$5.6 \times 10^{-4} \text{ goes to } 0.00056$$

There are two reasons for using scientific notation. The first is for convenience. It takes a lot less time and space to report the mass of an electron as 9.1096×10^{-28}, rather than 0.00000000000000000000000000091096 g. The second reason is to more clearly report the uncertainty of a value. For example, a typical peanut butter sandwich provides our bodies about 1.4×10^3 kJ of energy. Because of the variation in the type and amount of peanut butter added to the sandwich, there's some variation in the energy provided. The value 1.4×10^3 kJ suggests that the energy from a typical peanut butter sandwich could range from 1.3×10^3 kJ to 1.5×10^3 kJ. If the value is reported as 1400 kJ, its uncertainty would not be so clear. It could be 1400 ± 1, 1400 ± 10, or 1400 ± 100.

When multiplying exponential terms, add exponents.

$$10^3 \cdot 10^6 = 10^{3+6} = 10^9$$

$$10^3 \cdot 10^{-6} = 10^{3+(-6)} = 10^{-3}$$

$$3.2 \times 10^{-4} \cdot 1.5 \times 10^9 = 3.2 \cdot 1.5 \times 10^{-4+9} = 4.8 \times 10^5$$

When dividing exponential terms, subtract exponents.

$$\frac{10^{12}}{10^3} = 10^{12-3} = 10^9$$

$$\frac{10^6}{10^{-3}} = 10^{6-(-3)} = 10^9$$

$$\frac{9.0 \times 10^{11}}{1.5 \times 10^{-6}} = \frac{9.0}{1.5} \times 10^{11-(-6)} = 6.0 \times 10^{17}$$

$$\frac{10^2 \cdot 10^{-3}}{10^6} = 10^{2+(-3)-6} = 10^{-7}$$

$$\frac{1.5 \times 10^4 \cdot 4.0 \times 10^5}{2.0 \times 10^{12} \cdot 10^3} = \frac{1.5 \cdot 4.0}{2.0} \times 10^{4+5-12-3} = 3.0 \times 10^{-6}$$

When raising exponential terms to a power, multiply exponents.

$$(10^4)^3 = 10^{4 \cdot 3} = 10^{12}$$

$$(3 \times 10^5)^2 = (3)^2 \times (10^5)^2 = 9 \times 10^{10}$$