Chapter 5 Measurements and Calculations

5.1 Scientific Notation and Units

Key Terms

measurement	scientific notation	units
English system	metric system	International System (SI)
volume	liter	milliliter
mass	gram	

Summary

Scientific notation is a method for making very large or very small numbers more compact and easier to write. It expresses a number as a product of a number between 1 and 10 and the appropriate power of 10. A power of 10 is 10 multiplied by itself. Powers of 10 are indicated by exponents, which are small numbers above and to the right of the number 10. To express a large number in scientific notation, we count the number of places the decimal point must be moved to get a number between 1 and 10. For numbers smaller than 10, the decimal point is moved to the right, and the power of 10 is written with a negative exponent. Thus 0.00093 would be written 9.3×10^{-4}.

To have meaning, a *measurement* must contain not only numbers but also words (*units*) that tell in which scale or standard the measurement is being expressed. Feet, meters, and inches are called units of measurements. Units of the *metric system* have long been preferred for most scientific work. The units used for scientific work are called SI units. The fundamental, or basic, SI units are the meter, kilogram, second, and Kelvin. The *International System (SI)* uses prefixes to indicate changes in the size of the units.

The fundamental SI unit of length is the meter, which is equal to about 39 inches, or 3 feet, 3 inches. The fundamental SI unit of volume is the cubic meter. *Volume* is the amount of three-dimensional space a substance takes up. A cubic meter is based on the volume of a cube that measures 1 meter on all sides. The fundamental SI unit of mass is the kilogram. *Mass* describes the amount of matter contained in an object.

5.2 Uncertainty in Measurement and Significant Figures

Key Terms

significant figures	rounding off

Summary

All measurements have some degree of uncertainty. Often objects or samples being measured do not correspond exactly to the graduations (lines of measurement) provided on a measuring device. For example, we might use a ruler with 1-mm graduations to measure the length of a pin. If the end of the pin appears to reach halfway between 2.8 and 2.9 cm, we might estimate that the pin is 2.85 cm long. However, another person might make an estimate of 2.86 cm. In this case, the first two digits (numbers) in each measurement are the same. These digits are called the certain numbers of the measurement. The third digit, which varies depending on who made the measurement, is called the uncertain number. When making measurements, scientists usually use all the certain numbers plus the first uncertain number.

In a measurement, all the certain numbers together with the first uncertain number are called *significant figures.* In doing calculations, it is important to know how much uncertainty is present in the measurements being used. Scientists have established rules for counting significant figures. If the result of a calculation has too many significant figures, we reduce it to fewer digits by a process known as *rounding off.*.

5.3 Problem Solving and Unit Conversions

Key Terms

conversion factor	equivalence statement	dimensional analysis
Fahrenheit scale	Celsius scale	Kelvin (absolute) scale
density	specific gravity	

Summary

To change a measurement from one unit to another, we use a *conversion factor,* which is a number that shows the relationship between two different units of measurement. Table 5.7 shows some conversion factors between English units and metric units. To convert a measure from one unit to another, we generally multiply or divide the known unit by the correct conversion factor.

The three temperature scales are the *Fahrenheit, Celsius,* and *Kelvin (absolute)* scales. On the Fahrenheit scale, water boils at 212°F and freezes at 32°F. On the Celsius scale, water boils at 100°C and freezes at 0°C. On the Kelvin scale, water boils at 373 K and freezes at 273 K. The size of the degrees is the same in the Kelvin and Celsius scales. The Fahrenheit degree is smaller than the Celsius and Kelvin unit, and the zero points are different on all three scales.

To convert a Celsius temperature to a Kelvin temperature, add 273 to the Celsius temperature. To convert a Kelvin temperature to a Celsius temperature, subtract 273 from the Kelvin temperature. To convert Celsius to Fahrenheit, multiply the Celsius temperature by 1.80 and add 32. To convert Fahrenheit to Celsius, subtract 32 from the Fahrenheit temperature and then divide the result by 1.80.

Density is the amount of matter present in a given volume of a substance. Another way to express density is mass per unit volume. To calculate density, divide mass by volume. The common unit of density is grams per cubic centimeter (g/cm^3). The density of a liquid is sometimes described as *specific gravity,* the ratio of the density of a given liquid to the density of water at 4°C.

Additional Active Reading Questions

1. What is scientific notation?

2. Express the following numbers in scientific notation: 150, 0.000263, 129,000,000.

3. Name the four fundamental SI units.

4. What is the fundamental SI unit of volume?

5. Which numbers in the following pair are certain numbers? Which are uncertain numbers? 578.43, 578.42

6. Which digits in a number are always counted as significant figures?

7. Round off the following numbers to two digits: 1.657, 75.1, 0.352

8. What is a conversion factor?

9. How do you convert a Kelvin temperature to Celsius? Fahrenheit temperature to Celsius?

10. What is the density of an object with a mass of 30 g and a volume of 6 cm^3?