Chapter 2
Standards for Measurement
Advanced Chemistry

2.1 Scientific Notation

Learning Objective	
Write decimal numbers in scientific notation.	The sign on the exponent indicates the direction the decimal was moved. • Moved right → negative exponent 0.000124 → decimal moves 4 places to right → 1.23×10^{-4} • Moved left → positive exponent 2468 → decimal moves 3 places to left → 2.468×10^{3}
Key Terms	
Measurement	A quantitative observation that requires both a number and a unit.
Scientific notation	A convenient way of expressing large and small numbers using powers of 10. To write a number as a power of 10 move the decimal point in the original number so that it is located after the first nonzero digit, and follow the new number by a multiplication sign and 10 with an exponent (called its power) that is the number of places the decimal point was moved. Example: $2468 = 2.468 \times 10^{3}$.

2.2 Measurement and Uncertainty

Learning Objective	
Explain the significance of uncertainty in measurement in chemistry and how significant figures are used to indicate a measurement's certainty.	• All measurements reflect some amount of uncertainty, which is indicated by the number of significant figures in the measurement. • The significant figures include all those known with certainty plus one estimated digit.
Key Term	
Significant figures	The number of digits that are known plus one estimated digits are considered significant in a measured quantity; also called significant digits.

2.3 Significant Figures

Learning Objective	

Determine the number of significant figures in a given measurement and round measurements to a specific number of significant figures.	• Rules exist for counting significant figures in a measurement:
	  o Nonzero numbers are always significant.
	  o Exact number have an indefinite number of significant figures.
	  o The significance of a zero in a measurement is determined by its position within the number.
	• Rules exist for rounding off the result of a calculation to the correct number of significant figures.
	  o If the first number after the one you want to retain is 4 or less, that digit and all those after it are dropped.
	  o If the first number after the one you want to retain is 5 or greater, that digit and all those after it are dropped and the last digit retained is increased by one.

Key Term	
Rounding off numbers	The process by which the value of the last digit retained is determined after dropping non-significant digits.

2.4 Significant Figures in Calculations

Learning Objective	
Apply the rules for significant figures, in calculations involving addition, subtraction, multiplication, and division.	• Addition or Subtraction: The answer contains the same number of signification figures as the least precise measurement. 158.7 - 12.0 146.7 should be reported as 1470 or 1.47×10^3 • Multiplication or Division: The answer contains the same number of significant figures as the measurement with the least number of significant figures.

2.5 The Metric System

Learning Objective	
Name the units for mass, length, and volume in the metric system and convert from one unit to another.	• The standard unit for mass in the metric system is the kilogram. In chemistry, we often use the gram instead, as we tend to work in smaller quantities. • Length in the metric system is measured by the standard unit of meter. • Volume is the amount of space occupied by matter. The standard unit for volume is the cubic meter. In chemistry, we usually use the volume unit of the liter or the milliliter.
Key Terms	
Metric system or International System (SI)	The metric system is a decimal system of measurements. SI (Systeme International, or International System) is an agreed-upon standard system of measurements used by scientists around the world.
Meter (m)	The standard unit of length in the SI and metric systems; 1 meter equals 39.37 inches.
Conversion factor	A ratio of equivalent quantities.
Solution map	An outline for the path of a unit conversion.
Mass	The quantity or amount of matter that an object possesses.
Weight	A measure of Earth's gravitational attraction for a body (object).
Kilogram (kg)	The standard unit of mass in the metric system; 1 kilogram equals 2.205 pounds.
Volume	The amount of space occupied by matter; measured in SI units by cubic meters (m^3) but also commonly in liters and milliliters.
Liter (L)	A unit of volume commonly used in chemistry; 1 L = 1000 mL; the volume of a kilogram of water at 4°C.

2.6 Dimensional Analysis: A Problem-Solving Method

Learning Objective	
Use dimensional analysis to solve problems involving unit conversions.	$unit_1$ x conversion factor = $unit_2$ Example: How many milliliters are contained in 3.5 liters? Solution Map: L → mL $(3.5\cancel{L}) \times \left(\frac{1000mL}{1\cancel{L}}\right) = 3500mL$

2.7 Measurement of Temperature

Learning Objective	
Convert measurements among the Fahrenheit, Celsius, and Kelvin temperature scales.	• $K = ℃ + 273.15$ • $°F = (1.8 \times ℃) + 32$ • $℃ = \frac{°F - 32}{1.8}$
Key Terms	
Thermal energy	A form of energy associated with the motion of small particles.
Temperature	A measure of the intensity of heat, or of how hot or cold a system is; the SI unit is the kelvin (K).
Heat	Flow of energy due to a temperature difference.

2.8 Density

Learning Objective	
Solve problems involving density.	$D = \frac{m}{V}$
Key Terms	
Density	The mass of an object divided by its volume.
Specific gravity	The ratio of the density of one substance to the density of another substance taken as a standard. Water is usually the standard for liquids and solids; air, for gases.