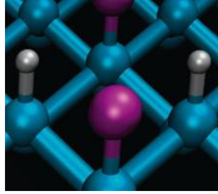
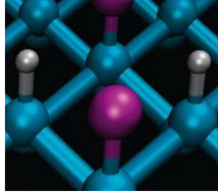


Chapter 1

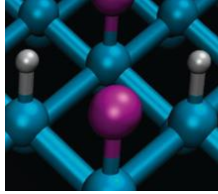
Introduction to Chemistry

The Science of Chemistry: Observations, Models, and Systems



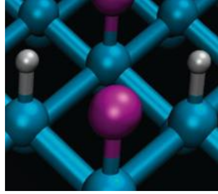
- Chemistry is an empirical science and is studied by:
  - Measuring physical properties and observing chemical reactions
  - Creating models to explain observations and organizing collected data

Observations in Science



- Observations are recorded via measurements
  - Accuracy: How close the observed value is to the “true” value
  - Precision: The spread in values obtained from measurements

Observations in Science



- Measurements can have poor precision and poor accuracy
  - Darts are widely scattered and far away from the target

Observations in Science

- Measurements can have good precision and poor accuracy
  - Darts are clustered together but are clustered far from the bull's-eye

Observations in Science)

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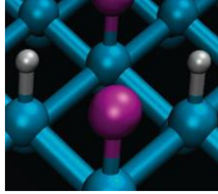
- Measurements can have good precision and good accuracy
  - Darts are clustered together and close to the target



Numbers and Measurements in Chemistry

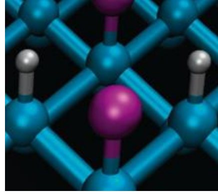
- Chemists quantify data, expressing collected data with units and significant figures
  - Units: Designate the type of quantity measured
  - Prefixes: Provide scale to a base unit
  - Significant Figures: Indicate the amount of information that is reliable when discussing a measurement

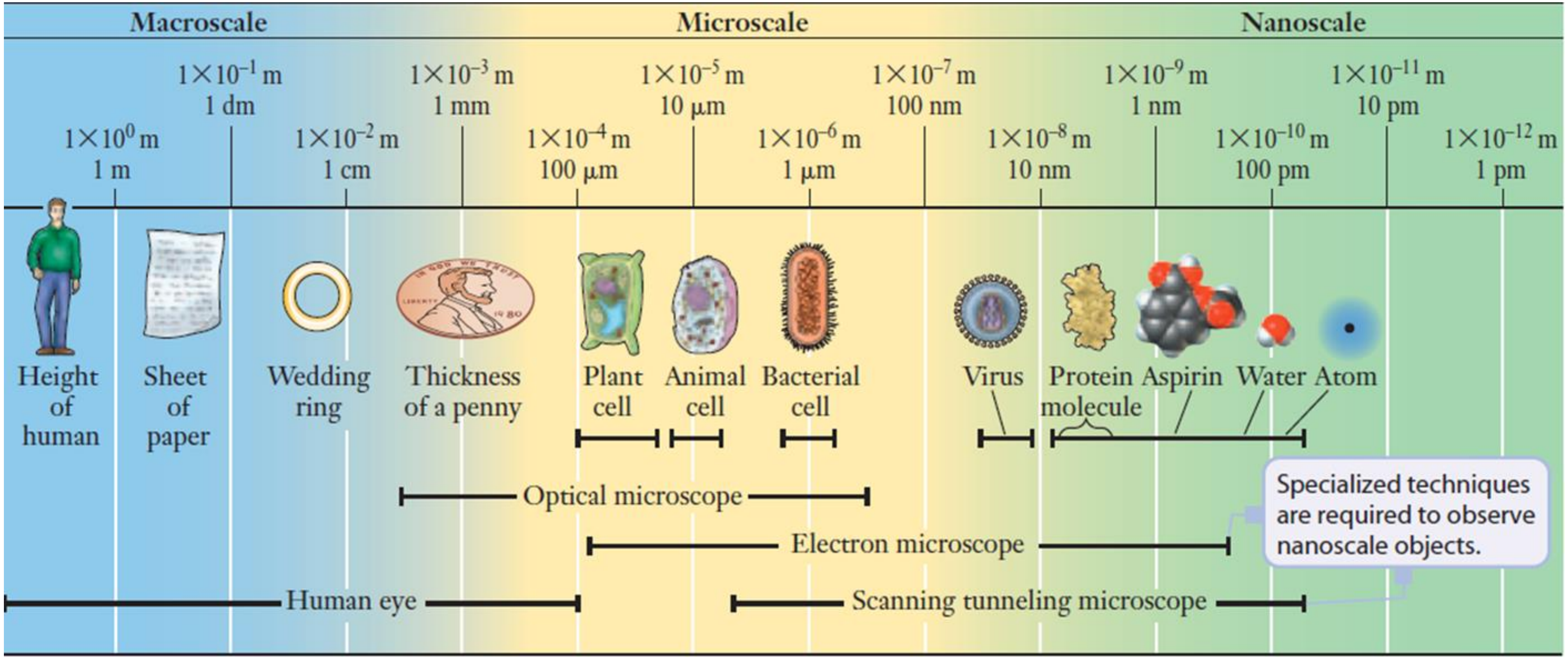
Units

Property	Unit, with Abbreviation
Mass	kilogram, kg
Time	second , s
Distance	meter, m
Electric current	ampere, A
Temperature	Kelvin, K
Number of particles	mole, mol
Light intensity	candela, cd

- Base unit designates the type of quantity being measured
- SI units are the base units of science
- Some units comprise combinations of these base units and are termed derived units
  - $1\,\mathrm{J} = 1\ \mathrm{kg\ m^2\ s^{-2}}$

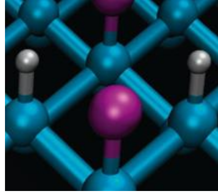
Units





- Prefixes are used with base units to report and understand quantities of any size

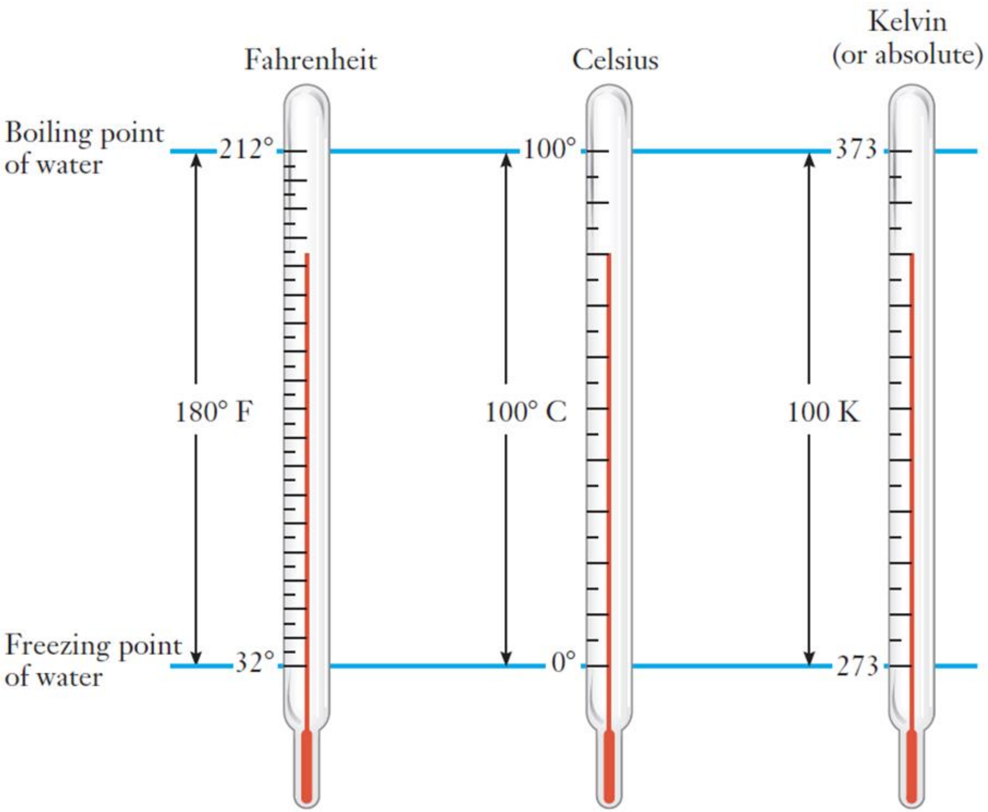
SI Prefixes



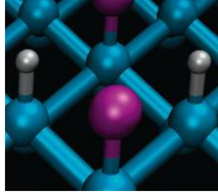
Factor	Name	Symbol	Factor	Name	Symbol
10^{24}	yotta	Y	10^{-1}	deci	d
10^{21}	zetta	Z	10^{-2}	centi	c
10^{18}	exa	E	10^{-3}	milli	m
10^{15}	peta	P	10^{-6}	micro	μ
10^{12}	tera	T	10^{-9}	nano	n
10^{9}	giga	G	10^{-12}	pico	p
10^{6}	mega	M	10^{-15}	femto	f
10^{3}	kilo	k	10^{-18}	atto	a
10^{2}	hecto	h	10^{-21}	zepto	z
10^{1}	deka	da	10^{-24}	yocto	y

- Prefixes are based on multiples of 10

Temperature



- Temperature is measured using the Fahrenheit, Celsius, and Kelvin temperature scales



Temperature Scale Conversions

$$°F = (1.8 \times °C) + 32$$

$$°C = (°F - 32)/1.8$$

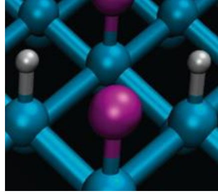
$$K = °C + 273.15$$

$$°C = K - 273.15$$

Numbers and Significant Figures

- All digits reported are considered significant except for certain types of zeros
  - Trailing and Leading zeroes are not significant
    - 51,300 m: 3 significant figures
    - 0.043 g: 2 significant figures
  - A zero is significant when it *follows* a decimal point or when it occurs between other significant figures
    - 4.30 mL: 3 significant figures
    - 304.2 kg: 4 significant figures
  - All numbers are significant when written in correct scientific notation

Numbers and Significant Figures



- Scientific notation is used to easily write very small and very large numbers
  - Numbers written using scientific notation factor out all powers of ten

$$54{,}000 = 5.4 \times 10^{4}$$

$$0.000042 = 4.2 \times 10^{-5}$$

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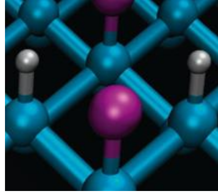
Example Problem 1.2



- An alloy contains 1.05% of some impurity. How many significant figures are reported in this value?

3

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Numbers and Significant Figures (3 of 4)

- For calculated values, the number of significant figures should be consistent with the data used in the calculation
  - For multiplication and division, the number of significant figures in a result must be the same as the number of significant figures in the factor with the fewest significant figures

$$0.24\ \text{kg} \times 4621\ \text{m} = 1100\ \text{kg m or } 1.1 \times 10^3\ \text{kg m}$$

  - For addition and subtraction, the result must have the same number of decimal places as the quantity with the fewest decimal places.

$$\begin{array}{r} 4.882\ \text{m} \\ +\ 0.3\ \text{m} \\ \hline 5.2\ \text{m} \end{array}$$

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Example Problem 1.3

- Report the result for the indicated arithmetic operations using the correct number of significant figures. Assume all values are measurements and not exact numbers.
  - 4.30×0.31
  - $4.033 + 88.1$
  - $5.6 / 1.732 \times 10^4$

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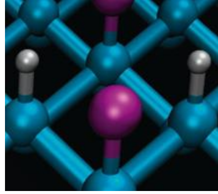
Numbers and Significant Figures



- When counting discrete objects, the result has no ambiguity
  - Such measurements use exact numbers
    - They have infinite significant figures
    - Two pennies would be 2.000000…
    - Exactly defined terms, such as metric prefixes, are also considered exact numbers

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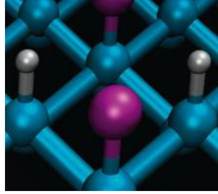
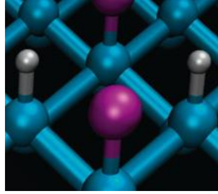
Ratios in Chemistry Calculations



- Mass Density: Ratio of an object's mass to its volume
  - Temperature and compound specific
  - Allows conversion between mass and volume

$$346\ \text{L} \times \frac{1000\ \text{mL}}{1\ \text{L}} \times \frac{0.975\ \text{g}}{1\ \text{mL}} = 3.37 \times 10^5\ \text{g}$$

  - Units of measurement can be used to determine how to write the appropriate ratio by "canceling"out
    - This type of reasoning is called dimensional analysis or the factor-label method



Example Problem 1.5

- What is the wavelength, in meters, of orange light of wavelength 615 nm?

6.15×10^{-7} m

Example Problem 1.6

- The density of water at 25°C is 0.997 g per mL. A child's swimming pool holds 346 L of water at this temperature. What mass of water is in the pool?

$$M = \rho \cdot V$$

$$= 0.997 \times 346 \times 1000$$

$$= 3.44962 \times 10^5 \, g$$