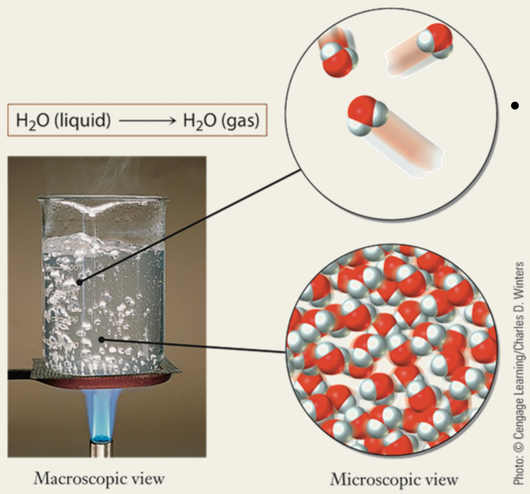
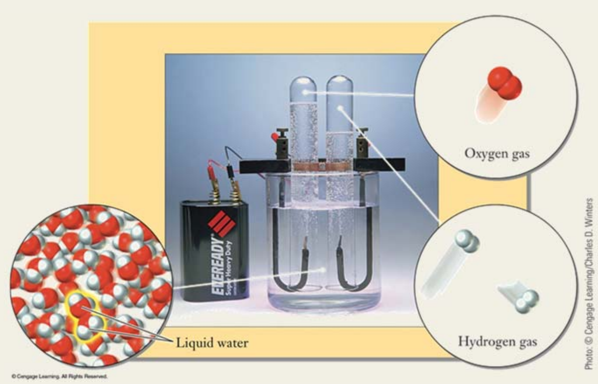
The Microscopic Perspective (continued 1)



- During a physical change, chemical composition does not change
  - ✓ The boiling of water, in which liquid water is converted into a gas

The Microscopic Perspective (continued 2)

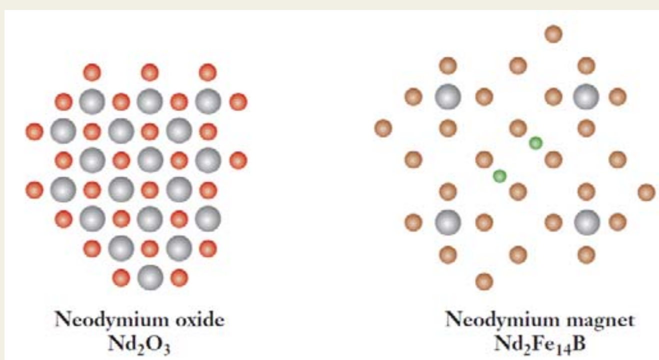


- During a chemical change, a chemical reaction that occurs changes the chemical composition of the matter involved
  - Electrolysis - Uses electricity to convert water into oxygen and hydrogen molecules

The Symbolic Representation

- Symbols are used to represent the atoms, molecules, and reactions
  - Pure aluminum, Al
  - Aluminum oxide, Al_2O_3

The Symbolic Representation (continued)



Particulate-level representation of neodymium oxide, Nd_2O_3

Particulate-level representation of neodymium magnet, $Nd_2Fe_{14}B$

(Q1)

Which property refers to the ability to shape a metal?

- Malleability
- Density
- Hardness

Answer:

Malleability

(Q2)

When a reaction is depicted as a chemical equation, what representation is being used?

- Macroscopic
- Microscopic
- Symbolic

Answer:

Symbolic

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 (continued 1)

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

Observations in Science (continued 2)

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

Observations in Science (continued 3)

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

Observations in Science (continued 4)

- Types of errors in measurements
  - ✓ Random error: May make a measurement randomly too high or too low
    - ❖ Variation associated with equipment limitations
  - ✓ Systematic error: May make a measurement consistently too high or too low
    - ❖ The presence of an impurity

Interpreting Observations

- Inductive and deductive reasoning are used to interpret collected data and observations
  - ✓ Inductive reasoning begins with **a series of specific observations** and attempts to generalize to a larger, more universal conclusion
  - ✓ Deductive reasoning takes **two or more statements or assertions** and combines them so that a clear and irrefutable conclusion can be drawn

Numbers and Measurements in Chemistry

- Chemists quantify data, expressing collected data with
  - ✓ Units
  - ✓ Prefixes
  - ✓ Significant Figures

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Units

SI 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

- Some units comprise combinations of these base units and are termed derived units
  - 1 J = 1 kg m^2 s^{-2}

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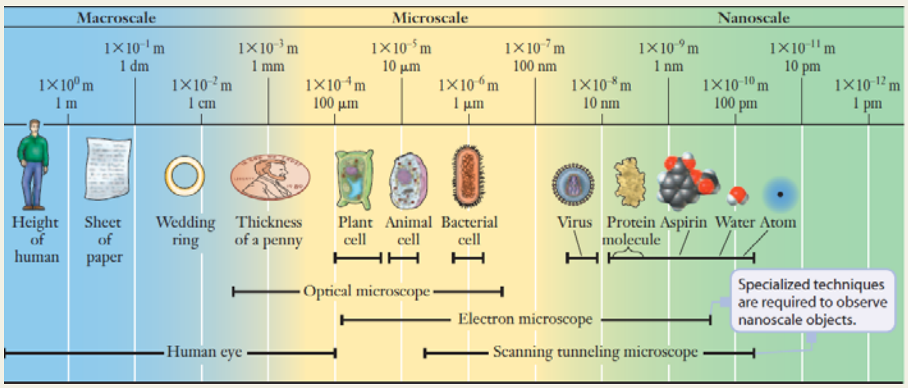
Units (continued)



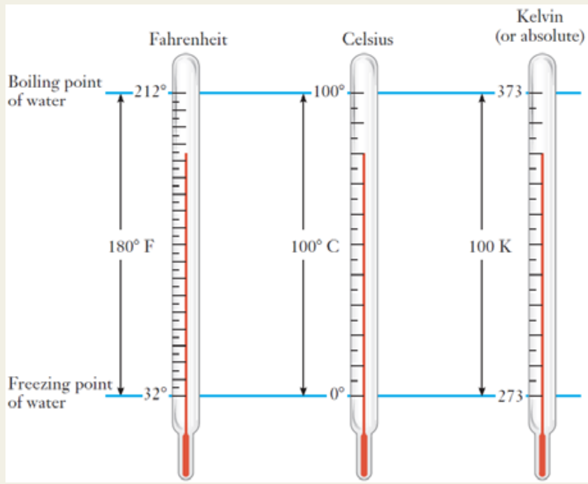
- Prefixes are used with base units to report and understand quantities of any size

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

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Temperature Scale Conversions

$$^{o}F = (1.8 \times {}^{o}C) + 32$$

$$^{o}C = ({}^{o}F - 32)/1.8$$

$$K = {}^{o}C + 273.15$$

$$^{o}C = K - 273.15$$

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Numbers and Significant Figures

- Scientific notation is used to easily write very small and very large numbers

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

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

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Significant Figures

Rules for counting significant figures:

1. Zeros in the middle of a number are like any other digit; they are always significant.

   4.803 cm 4 SF

2. Zeros at the beginning of a number are not significant; they act only to locate the decimal point.

   0.006 61 g 3 SF (or 6.61×10^{-3} g)

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Significant Figures

Rules for counting significant figures:

3. Zeros at the end of a number and after the decimal point are always significant.

55.220 K 5 SF

4. Zeros at the end of a number and before the decimal point may or may not be significant.

34,200 m ? SF

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Significant Figures

Math rules for keeping track of significant figures:

- **Multiplication or division**: The answer can't have more significant figures than either of the original numbers.

$$\underbrace{\frac{278 \text{ mi}}{11.70 \text{ gal}}}_{3 \text{ SF},\ 4 \text{ SF}} = \underbrace{23.8 \text{ mi/gal (mpg)}}_{3 \text{ SF}}$$

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Significant Figures

Math rules for keeping track of significant figures:

- **Addition or subtraction**: The answer can't have more digits to the right of the decimal point than either of the original numbers.

$$\begin{array}{r} 3.18 \\ +\ 0.013\ 15 \\ \hline 3.19 \end{array}$$

3.18 → 2 decimal places

0.013 15 → 5 decimal places

3.19 → 2 decimal places

Significant Figures (continued 3)

Counting discrete objects

✓ Such measurements use exact numbers

- They have infinite significant figures

(Q.4)

Which answer should be reported with 4 sig figs?

- (4.3 + 0.271) / 8.102
- 5.43 × 2.215
- 4.232 – 1.412
- 5.2920 / 4.22

Answer: (4.232 – 1.412)

Converting Measurements from One Unit to Another

Dimensional Analysis Method:

Original quantity × Conversion factor = Equivalent quantity

Relationship: 1 m = 39.37 in.

Conversion factor: $\frac{1 \text{ m}}{39.37 \text{ in.}}$ or $\frac{39.37 \text{ in.}}{1 \text{ m}}$

converts in. to m

converts m to in.

Converting Measurements from One Unit to Another

Q1. Convert 69.5 in. to m, $\frac{1\text{ m}}{39.37\text{ in.}}$ or $\frac{39.37\text{ in.}}{1\text{ m}}$

Incorrect Method

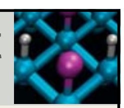
$$69.5\text{ in.} \times \frac{39.37\text{ in.}}{1\text{ m}} = 2740\text{ in.}^2/\text{m}$$

original quantity

conversion factor

?

Calculations: Converting from One Unit to Another



Q1. Convert 69.5 in. to m,

Correct Method

$$69.5\text{ }\cancel{\text{in.}} \times \frac{1\text{ m}}{39.37\text{ }\cancel{\text{in.}}} = 1.77\text{ m}$$

starting quantity

equivalent quantity

conversion factor

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Example Problem 1.5

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

$$1 \text{ m} = 1 \times 10^9 \text{ nm}$$

We can write this as a ratio. Because we want to convert *from* nm *to* m, we'll need m in the numerator and nm in the denominator:

$$\frac{1 \text{ m}}{10^9 \text{ nm}}$$

Then, we just complete the calculation:

$$615 \text{ nm} \times \frac{1 \text{ m}}{10^9 \text{ nm}} = 6.15 \times 10^{-7} \text{ m}$$

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