Key Questions to Consider

- **What is Chemistry?**
- **What do Chemists do?**
- **Why should I care?**

Chemistry: Two key questions:

- Why to materials behave as they do?
  - Color
  - State
  - Overall properties and reactivity?
- How can we take advantage of these properties to do something useful?
  - New materials or improve existing materials
  - Pharmaceuticals, fuels, foodstuffs…

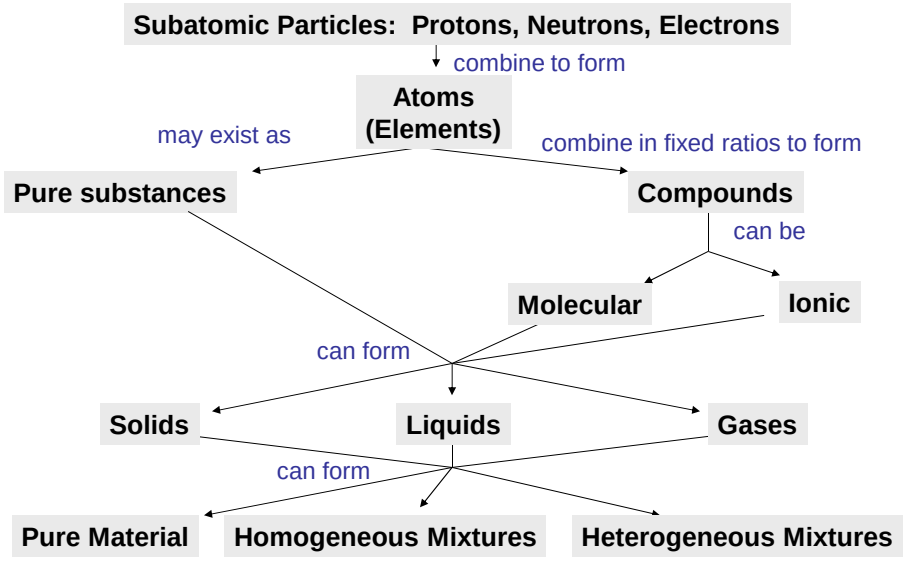
Science is Experimental!

- New knowledge/theories must be confirmed by experimental data.
  - If the theory and experiment (real world) don't match, the theory must be modified!
- Route to experimental problem-solving:

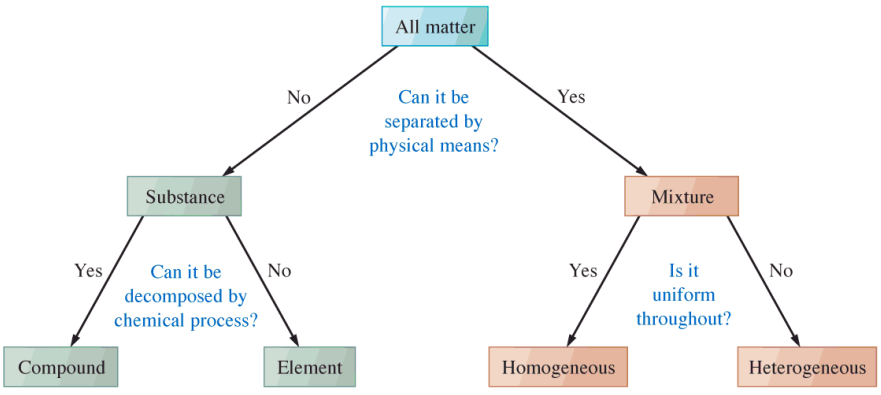
Scientific Laws and Theories

- *Law*: Repeatedly tested hypothesis that has not been contradicted
  - Concise statement of a relation that *seems* to always hold under same conditions
  - Once defined, static
- *Theory*: a unifying principle that explains facts and laws
  - Theories are not hypotheses
  - Continuously revised as new data obtained

Matter: from particulate to macroscopic



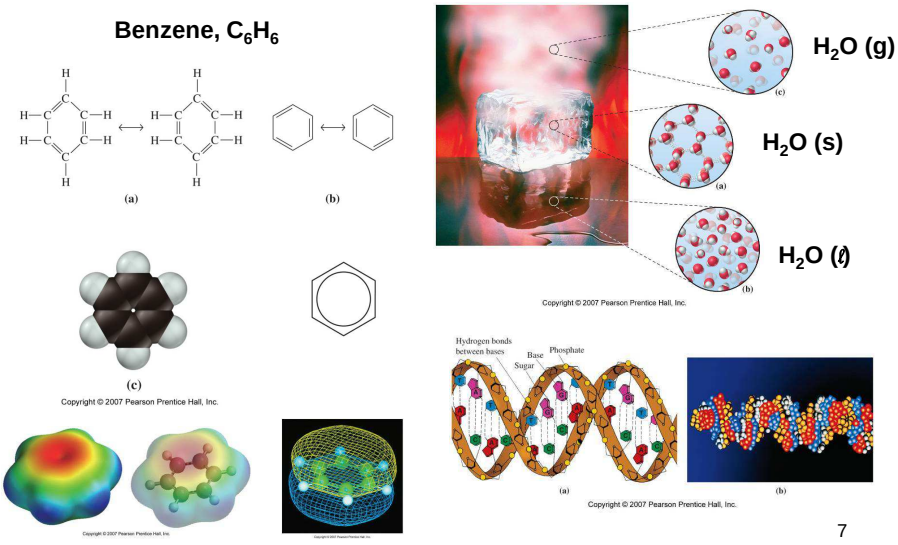
"Top-Down" perspective on matter



▲ FIGURE 1-4
A classification scheme for matter

How do we relate macroscopic to microscopic (nano)?

Representations of matter



Important terms/considerations for describing matter

- Quantitative versus Qualitative descriptions
  - Qualitative
  - Quantitative
    - All quantitative measures have some uncertainty!

- Chemical versus Physical changes
  - Chemical:

  - Physical:

Physical Properties

Table 1.1 Some Examples of Physical Properties

Property	Examples
Temperature	0 °C for ice water, 100 °C for boiling water.
Mass	A nickel weighs 5 g; a penny weighs 2.5 g.
Structure	Ice is crystalline; glass is amorphous.
Color	Sulfur is yellow; bromine is reddish-brown.
Taste	Acids are sour; bases are bitter.
Odor	Benzyl acetate smells like jasmine; hydrogen sulfide smells like rotten eggs.
Boiling point	Water boils at 100 °C; ethyl alcohol boils at 78.5 °C.
Freezing point	Water freezes at 0 °C; methane freezes at −182 °C.
Specific heat	Water has a high specific heat; iron has a low specific heat.
Hardness	Diamond is exceptionally hard; sodium metal is soft.
Conductivity	Copper conducts electricity; diamond does not. Aluminum is a good conductor of heat; glass is a poor heat conductor.
Solubility	Ethyl alcohol dissolves in water; gasoline does not.
Density	1.00 g/mL for water; 19.3 g/cm^3 for gold.

Chemical Properties

Chemical properties are those properties of a substance that can only be studied by forming new substances.

Table 1.2 Some Examples of Chemical Properties

Substance	Typical Chemical Property
Iron	rusts (combines with oxygen to form iron oxide).
Carbon	burns (combines with oxygen to form carbon dioxide).
Silver	tarnishes (combines with sulfur to form silver sulfide).
Nitroglycerin	explodes (decomposes to produce a mixture of gases).
Carbon monoxide	is toxic (combines with hemoglobin, causing anoxia).
Neon	is inert (does not react with anything).

Important terms/considerations for describing matter

- Extensive vs. Intensive properties
  - Extensive
  - Intensive
- How do we relate macroscopic to microscopic?

Quantitative Tools for Describing Chemical and Physical Phenomena

- Size scale can range greatly
- Metric system makes scaling a little easier
  - Know colored prefixes and conversions from Table 1.5
  - Converting between ranges – dimensional analysis

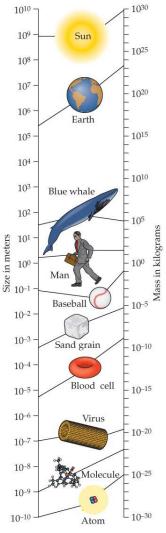


Table 1.5 Approved Numerical Prefixes[a]

Exponential Expression	Decimal Equivalent	Prefix	Pronunciation	Symbol
10^{12}	1,000,000,000,000	*tera-*	TER-uh	T
10^{9}	1,000,000,000	*giga-*	GIG-uh	G
10^{6}	1,000,000	*mega-*	MEG-uh	M
10^{3}	1,000	*kilo-*	KIL-oh	k
10^{2}	100	*hecto-*	HEK-toe	h
10^{1}	10	*deka-*	DEK-uh	da
10^{-1}	0.1	*deci-*	DES-ee	d
10^{-2}	0.01	*centi-*	SEN-tee	c
10^{-3}	0.001	*milli-*	MIL-ee	m
10^{-6}	0.000,001	*micro-*	MY-kro	μ
10^{-9}	0.000,000,001	*nano-*	NAN-oh	n
10^{-12}	0.000,000,000,001	*pico-*	PEE-koh	p
10^{-15}	0.000,000,000,000,001	*femto-*	FEM-toe	f

[a]The most commonly used prefixes are shown in color.

What Does a Number "Mean"?

- Numbers aren't very useful without and idea of how good they are.
  - Precision:
  - Accuracy:
  - How do we determine precision and accuracy?
- Significant figures help us to describe "quality" of a result.
  - "quality" of the result is limited by the quality of the data that goes into it.

Energy and Temperature

Energy is the ability to do work or transfer heat.

Energy exists in two major forms:

- ***Potential energy*** is stored energy.
- ***Kinetic energy*** is energy in motion.

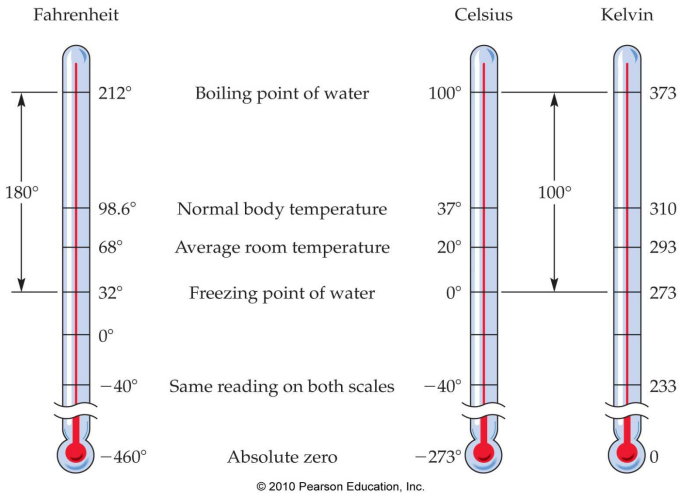
Heat is energy that is transferred from hotter objects to cooler objects.

Temperature is the average kinetic energy of an object.

Heat energy is often measured in **calories** or **joules**.

- One **calorie (cal)** is the amount of heat required to change the temperature of 1.00 g of water 1.00 ^{o}C.
- A calorie is 4.184 **joules (J)**. (1 cal = 4.184 J)
  - Food "calories"

Energy and Temperature



K = °C + 273.15