Ch 100: Fundamentals for Chemistry

Chapter 4: Properties of Matter
Lecture Notes

Physical & Chemical Properties

- **Physical Properties** are the characteristics of matter that can be changed without changing its composition
  - These characteristics are directly observable or measurable
  - Types of Physical Properties:
    1. **Extrinsic** Physical Properties are unique to objects (i.e. size, shape, mass, etc.)
    2. **Intrinsic** Physical Properties are unique to substances (i.e. density, conductivity, color, etc.)
- **Chemical Properties** are the characteristics of a substance that determine the tendency of the matter to transform in composition as a result of the interaction with other substances, the influence of energy or both
  - These are characteristics that describe the behavior of matter

Physical & Chemical Changes

- **Physical Changes** are changes that do not result in a change the fundamental composition of the substance

  Typical Examples:

  1. Physical State Changes: boiling, melting, condensing, etc.
  2. Shape, Size or Texture Changes

- **Chemical Changes** involve a change in the fundamental composition of the matter

  Notes on Chemical Change:

  1. Production of a new substance(s)
  2. Referred to as chemical reactions
  3. The basic representation: **Reactants → Products**

Note: Both physical and chemical changes will likely produce an alteration of appearance, the key is to discern the type of change that has occurred

Energy

Energy is loosely described as the capacity of something to do work (or alter the physical or chemical state of an object or system)

- Common Forms of Energy
  - mechanical, chemical, thermal, electrical, radiant, nuclear
- The SI unit of energy is the Joule (J)
  - Other commonly used units are Calories (cal) and Kilowatt-hours (kW·hr)
- **Types of energy:**
  1. Potential: stored energy
  2. Kinetic: energy associated with motion and vibration
  3. Heat: energy that flows from high to low temperature

Principle of Energy Conservation: energy is never created nor destroyed (but it does change from one type to another!)

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Distinguishing Heat Energy & Temperature

Temperature is _____.

1. How hot or cold something is (an extrinsic physical property), it represents a particular thermal state
2. Related to the <u>average</u> (kinetic) energy of the substance (not the total energy but the average energy)
3. Measured in units of:
   - Degrees Fahrenheit (°F)
   - Degrees Celsius (°C)
   - Kelvin (K)

Heat is _____.

1. Energy that flows from hot objects to cold objects. *Heat is <u>not</u> a physical property.*
2. Energy absorbed or released by an object resulting in its temperature change
3. Measured in units of:
   - Joules (J)
   - Calories (Cal)
   - Kilowatt Hours (kW·hr)

Bottom Line: *Heat energy absorbed or released is <u>measured</u> by changes in temperature but do not confuse heat energy for temperature*

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Temperature Scales

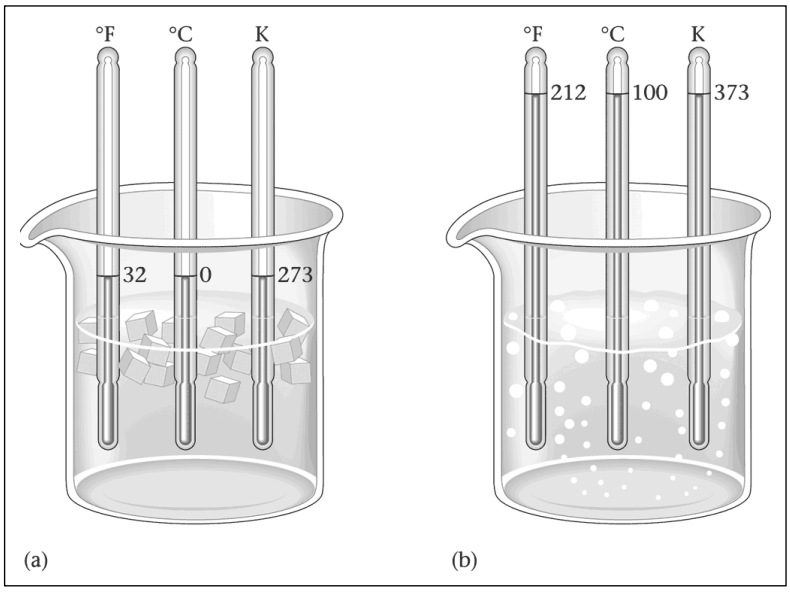
The 2 traditional temperature scales, Fahrenheit and Celsius, were originally defined in terms of the physical states of water at sea level:

1. Fahrenheit Scale, °F
   - For water: freezing point = 32°F, boiling point = 212°F
2. Celsius Scale, °C
   - For water: freezing point = 0°C, boiling point = 100°C
   - 1 Celsius temperature unit is larger than 1 Fahrenheit unit

The SI unit for temperature is a variant of the Celsius scale

3. Kelvin Scale, K
   - For water: freezing point = 273 K, boiling point = 373 K
   - The Kelvin temperature unit is the same size as the Celsius unit

Temperature of ice water and boiling water.



Heat (Energy)

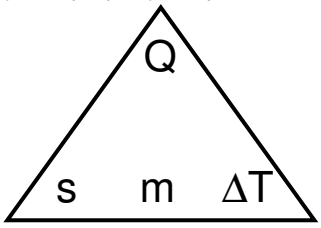
- Heat is energy that flows due to a temperature difference
  - Heat energy flows from higher temperature to lower temperature
- Heat is transferred due to "collisions" between atoms/molecules of different kinetic energy
- When produced by friction, heat is mechanical energy that is irretrievably removed from a system
- Processes involving Heat:
  1. Exothermic = A process that releases heat energy.
     - ***Example:*** *burning paper is an exothermic process because energy is produced as heat (the temperature rises!).*
  2. Endothermic = A process that absorbs energy.
     - ***Example:*** *melting ice to form liquid water is an endothermic process because heat energy must be absorbed to change the physical state (in this case the temperature does not change!).*

Heat (cont.)

- When something absorbs or loses heat energy, 1 of 2 things can occur:
  1. Its temperature will change *(e.g. hot coffee will cool down)*
  2. Its physical state will change *(e.g. ice will melt)*
- For the former case above, the heat energy absorbed or lost by an object is proportional to:
  1. The mass of the object (m)
  2. The change in temperature the object undergoes (ΔT)
  3. The specific heat capacity (s) (a physical property unique to the substance)

To calculate heat gained (Q):

$$Q = s \cdot m \cdot \Delta T$$



Specific Heat Capacity (s)

- Specific heat capacity reflects how absorbed heat energy relates to the corresponding increase in temperature for a given amount of mass, i.e. *energy per unit mass per unit temperature change or*

$$s = \frac{Q}{m \cdot \Delta T}$$

- Specific Heat Capacity is commonly measured in units of:
  1. J/g^{o}C (SI)
  2. cal/g^{o}C (metric & more useful in the lab)
- Specific Heat Capacity is a unique intrinsic physical property of matter. Typically, _____.
  1. Metals have low specific heat capacity
  2. Non-metals have higher specific heat capacity than metals
  3. Water has an unusually large specific heat capacity

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Table 3.2 The Specific Heat Capacities of Some Common Substances

Substance	Specific Heat Capacity (J/g °C)
water (*l*)* (liquid)	4.184
water (*s*) (ice)	2.03
water (*g*) (steam)	2.0
aluminum (*s*)	0.900
iron (*s*)	0.473
mercury (*l*)	0.14
carbon (*s*)	0.71
silver (*s*)	0.24
gold (*s*)	0.13

*The symbols (*s*), (*l*), and (*g*) indicate the solid, liquid, and gaseous states, respectively.

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Table of Specific Heat for Various Substances

Substance	J/g·K	cal/g·K	J/mol·K
Aluminum	0.900	0.215	24.3
Iron	0.473	0.113	26.4
Copper	0.385	0.0921	24.5
Brass	0.380	0.092	...
Gold	0.131	0.0312	25.6
Lead	0.128	0.0305	26.4
Silver	0.233	0.0558	24.9
Tungsten	0.134	0.0321	24.8
Zinc	0.387	0.0925	25.2
Mercury	0.140	0.033	28.3
Alcohol (ethyl)	2.138	0.511	111
Water	**4.184**	**1.000**	**75.2**
Ice (-10 C)	2.059	0.492	36.9
Granite	.790	0.19	...
Glass	.84	0.20	...