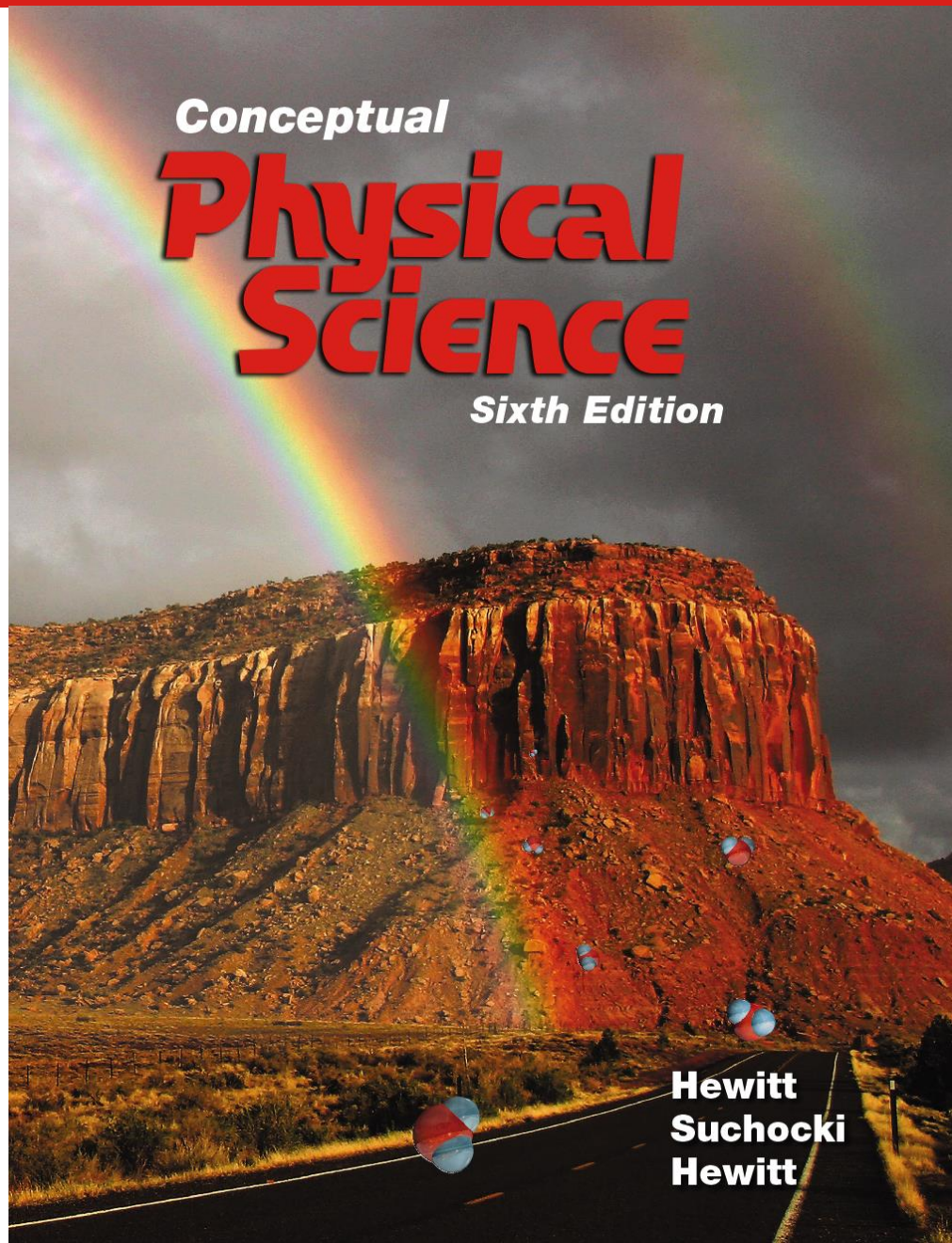
Chapter 7: Thermal Energy and Thermodynamics



This lecture will help you understand:

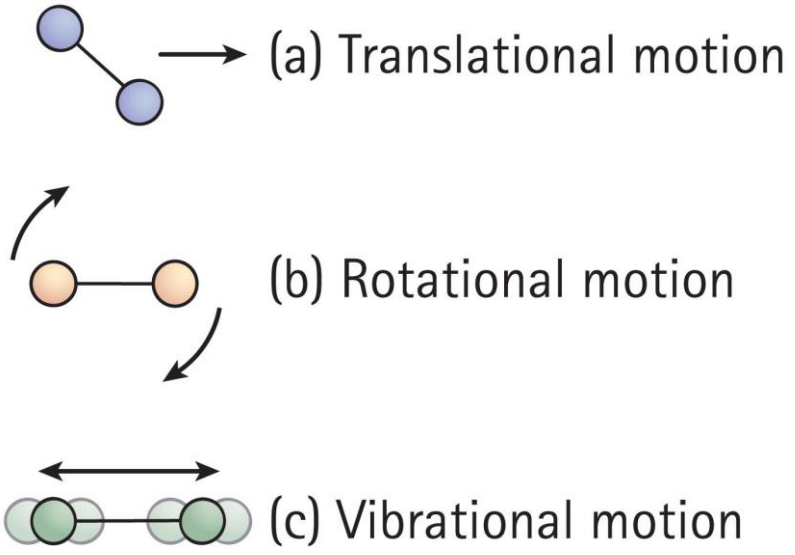
- Temperature
- Absolute Zero
- Heat
- Quantity of Heat

Temperature

- Temperature
  - A number that corresponds to the hotness or coldness of an object
  - Measured by a thermometer
  - A per-particle property
  - No upper limit
  - Definite limit on lower end

Temperature

- Temperature is proportional to the average translational kinetic energy per particle in a substance.
  - Gas—how fast the gas particles are bouncing to and fro
  - Liquid—how fast particles slide and jiggle past one another
  - Solid—how fast particles move as they vibrate and jiggle in place

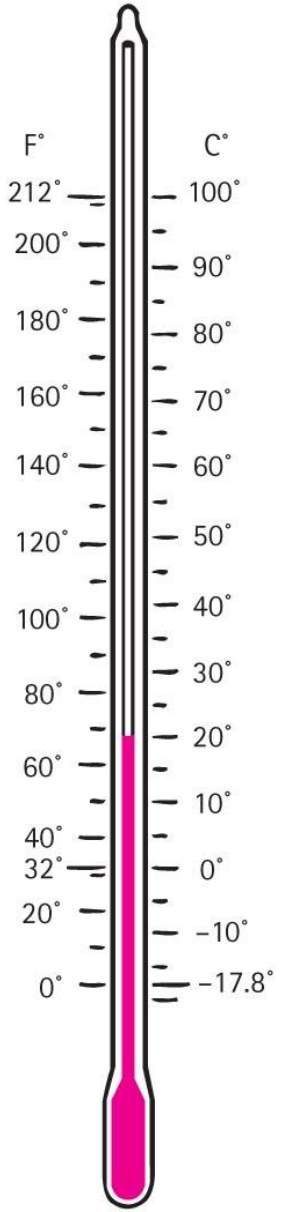


Temperature

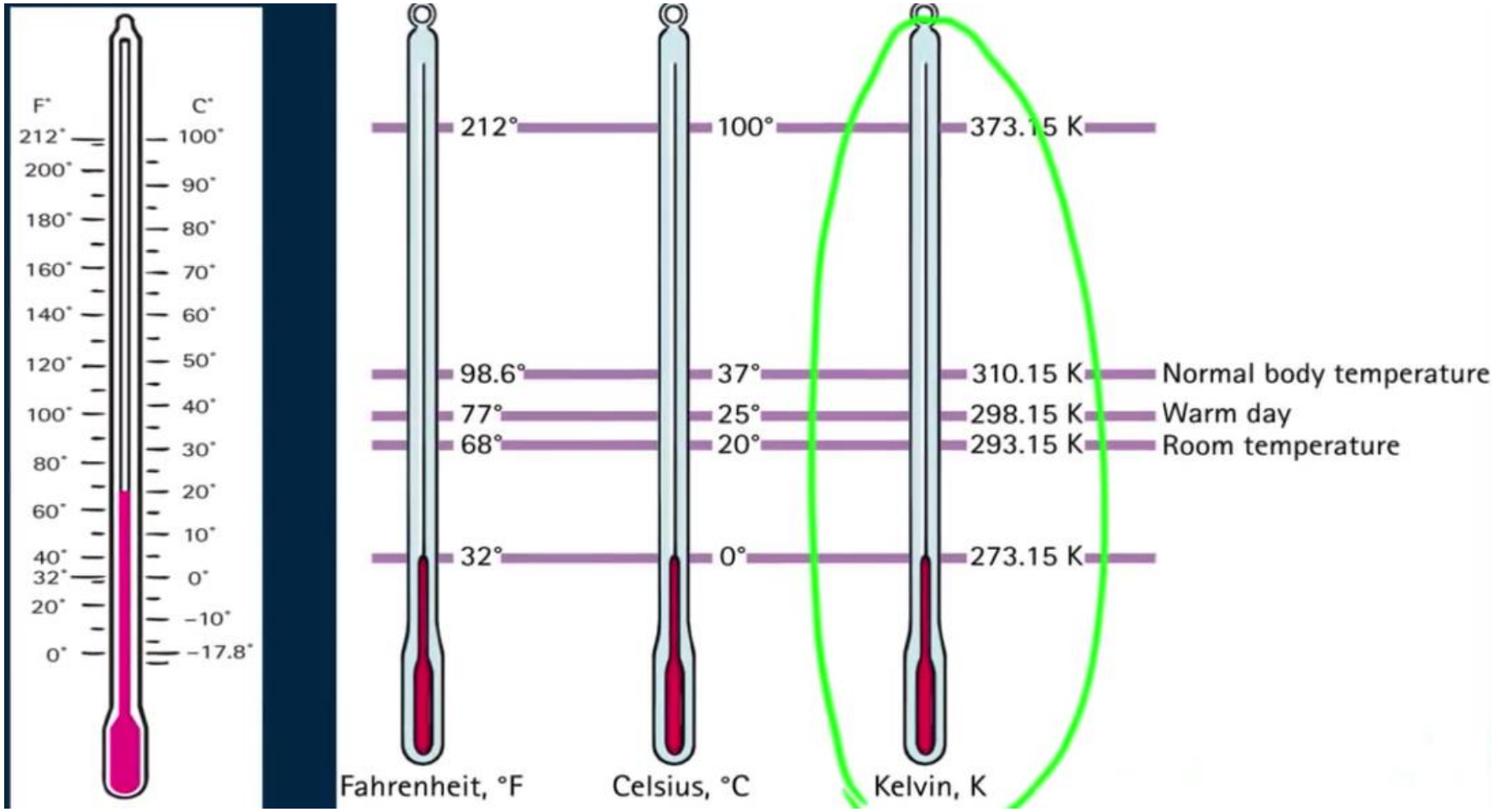
- Thermometer
  - Measures temperature by expansion or contraction of a liquid (mercury or colored alcohol)
  - Reading occurs when the thermometer and the object reach thermal equilibrium (having the same average kinetic energy per particle)
  - Infrared thermometers operate by sensing IR radiation

Temperature

- Temperature Scale
  - Celsius scale named after Anders Celsius (1701–1744)
    - zero ºC for freezing point of water to 100ºC for boiling point of water
  - Fahrenheit scale named after G. D. Fahrenheit (1686–1736)
    - 32ºF for freezing point of water to 212ºF for boiling point of water
  - Kelvin scale named after Lord Kelvin (1824–1907)
  - 273 K for freezing point of water to 373 K for boiling point of water
    - Absolute zero at –273ºC
    - Same size degrees as Celsius scale
    - Kelvins, rather than degrees are used



Temperature

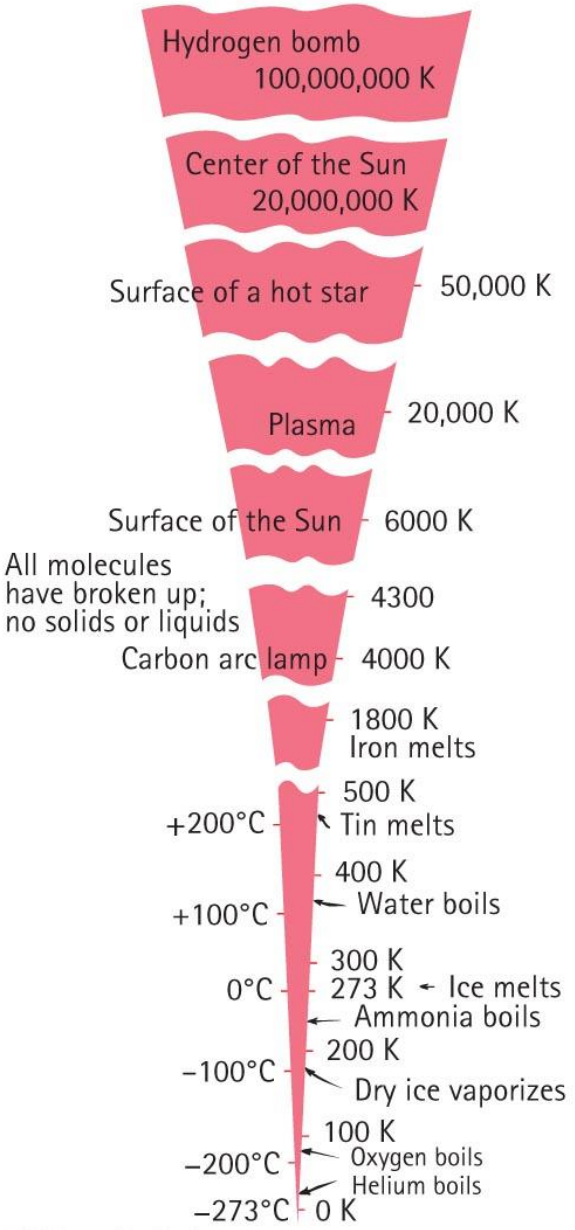


Theory of Temperature

- Kinetic Theory of Matter:
  - Matter is made up of tiny particles (atoms or molecules) that are always in motion.
- Thermal Energy:
  - The total energy (kinetic and potential) of the submicroscopic particles that make up matter.

Absolute Zero

- Absolute zero, or zero K,
  - is the lowest limit of temperature at –273ºC. At this temperature, atoms or molecules have lost all available kinetic energy. A substance cannot get any colder.



Thermal Energy

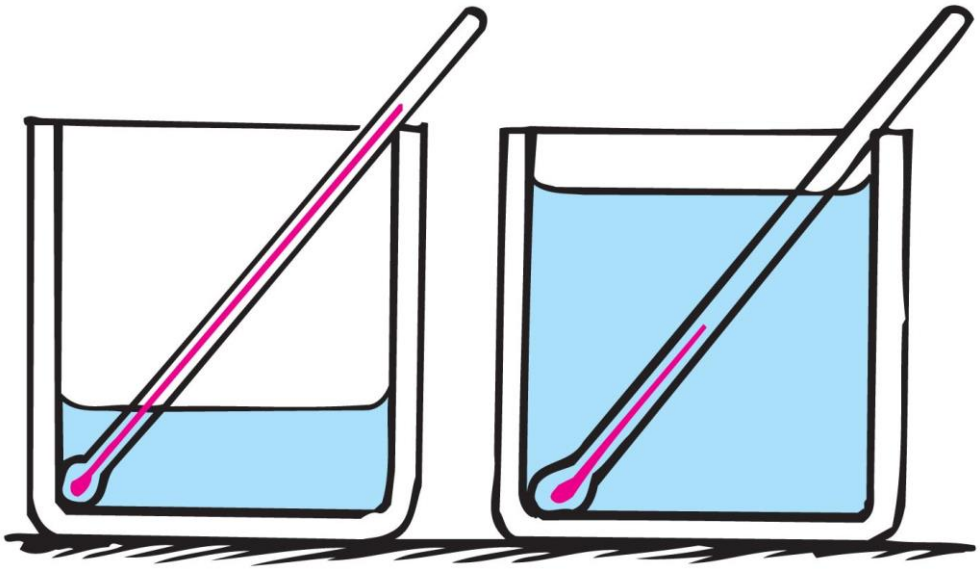
- Thermal energy in a sparkler
  - Temperature of sparks very high (2000ºC)
  - Lot of energy per molecule of spark
  - Total energy is small due to relatively few molecules per spark
  - Low transfer of energy

What Is Heat?

- Heat
  - defined as a flow of thermal energy due to a temperature difference.
  - natural direction of heat flow is from a higher-temperature substance to a lower-temperature substance.

Heat

- 1 liter of water in left pot. 3 liters in right pot.
- both pots absorb the same quantity of heat
- temperature increases three times as much in the pot with the smaller amount of water.

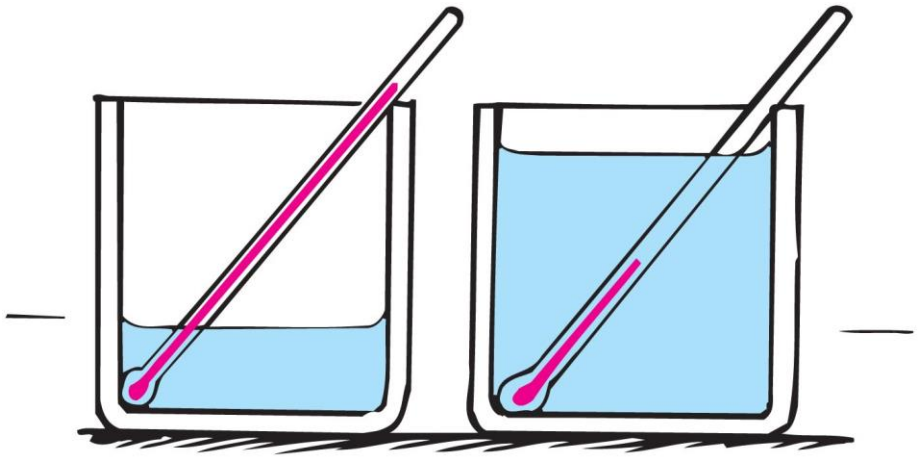


Hot stove

Heat
CHECK YOUR NEIGHBOR

When the same amount of heat is added to each of the two containers of water, the temperature increase in each will

A. be the same.
B. depend on the amount of water in each.
C. be greater for the container with the most water.
D. be less for the container with the smaller amount of water.



Heat
CHECK YOUR ANSWER

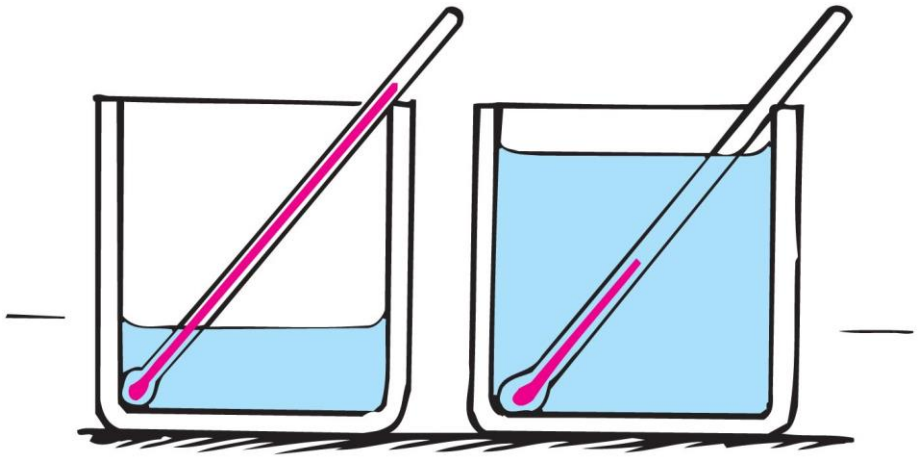
When the same amount of heat is added to each of the two containers of water, the temperature increase in each will

A. be the same.

B. depend on the amount of water in each.

C. be greater for the container with the most water.

D. be less for the container with the smaller amount of water.



Quantity of Heat

- Heat is energy in transit, measured in units of energy—joules or calories.
- **calorie**
  - defined as the amount of heat needed to raise the temperature of 1 gram of water by 1 Celsius degree.
  - 4.19 joules = 1 calorie
  - so 4.19 joules of heat will change that temperature of 1 gram of water by 1 Celsius degree.

Quantity of Heat

- Energy rating of food or fuel
  - measured by energy released when they are metabolized
  - Kilocalorie
    - heat unit in labeling food
    - One kilocalorie or Calorie (with a capital C) is the heat needed to change the temperature of 1 kilogram of water by 1 degree Celsius.