Science: Lesson 8 – Heat and Thermal Energy

Thermal Energy and Temperature

- **Temperature** is the measure of the average kinetic energy of particles.
    - It can also be defined as the measurement of how cold or hot an object is.
- **Thermal Energy:** the constant random motion of particles.

- **Heat:** the transfer of energy between objects at different temperatures.
    - Heat energy always travels from a hotter object to a cooler object.
- **Thermal equilibrium** occurs when there is no difference in temperature.

Note: heat and temperature are not the same. When heat transfer occurs between two objects, the temperature of the objects will change.

Videos:

- Heat transfer | Thermodynamics | High school physics | Khan Academy
- Heat Energy & How We Use It *COOL* Science for Kids!

Sources of Heat

- **The Sun**: the main source of heat on earth.
- Other sources of heat are both naturally occurring and common appliances:
    - Examples: A geyser, furnace, oven/gas cooker, clothes iron.

Video: Sources of Heat

Changes of State

See Lesson 1 under the Phase Changes of State for review.

Remember: Matter exists in three states, solids, liquids, gases

- These states can be changed/transformed into the other states by a change in temperature and/or pressure.

Video: Changes of State | Matter | Physics | FuseSchool (youtube.com)

Thermal Expansion: describes the expansion of most materials when the temperature is increased. It is the increase in the dimensions of a body (area, volume, density, mass) due to the increase in its temperature.

Heat Transfer: Conduction, Convection and Radiation

- Heat transfers can happen in three ways: conduction, convection, and radiation.

Conduction: the transfer of thermal energy between objects that are in direct contact with each other.

- The transfer of kinetic energy between the molecules of a solid object.
    - Example: touching a hot object with your bare hands.

Convection: the transfer of thermal energy through the movement of heated particles in a liquid or gas

- Heat convection occurs when bulk flow of a fluid (gas or liquid) carries heat along with the flow of matter to other parts of the fluid.
    - Example: water starts to boil from the lower parts (bubbles rise from the bottom) and spreads all through the other parts.

Radiation: the transfer of heat through electromagnetic waves and does not require direct contact between two or more bodies.

- the transfer of thermal energy through thermal emission
- Example: you feel hot while walking under the sun.

Videos:

- Thermal conduction, convection, and radiation | Thermodynamics | Physics | Khan Academy
- Heat Transfer - Conduction, Convection, and Radiation

Temperature is measured in degrees using thermometers that are calibrated in Celsius degrees (denoted as $℃$) or Fahrenheit degrees (denoted as $℉$).

- The **metric system** measure temperature using the Celsius and Kelvin scales defined by the relationship:

$$K = ℃ + 273.15$$

    - where K is Kelvin and $℃$ represents Celsius.
- The **imperial system** uses the Fahrenheit and Rankine scales to measure temperature. The relationship between Celsius and Fahrenheit is defined as:

$$℉ = \frac{9}{5}℃ + 32$$

- **Water**:
    - Boiling Point of water: $100℃$
    - Freezing Point of water: $0℃$.
    - Melting point is $0℃$

- **Bimetallic strips** are made up of two metals that expand and contract at different rates, when heated or cooled.
    - They measure a wider range of temperatures compared to thermometers and are commonly used in thermostats.
    - The different expansion rates of the metals to make them causes the bimetallic strip to bend when heated or cooled.
    - When the temperature is increased, the metal with the higher thermal expansion will expand first, causing the bimetallic strip to bend.
    - When the temperature is decreased, the metal with the lower thermal expansion will expand first.

Video: Thermal Expansion Demo: Bimetallic Strip (youtube.com)

Science: Lesson 9 – Heat and Thermal (part 2)

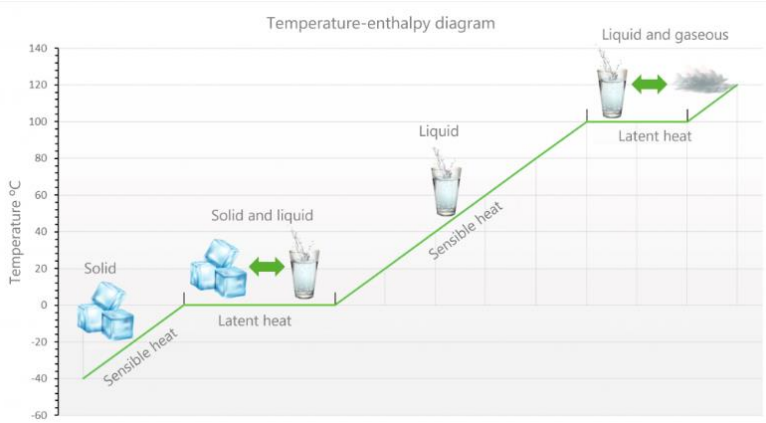
Sensible Heat: refers to the change in temperature of a substance.

- the temperature is increased but no phase change occurs.

Latent Heat: the phase change of that substance to another.

- the temperature is constant while the substance experiences phase change.

Review the figure[1] below to see the difference between sensible and latent heat.



Sensible Heat formula:

$$Q = m\, c\, \Delta t$$

- m is the mass of the body
- c is the specific heat coefficient of the body
- Δt is the change in temperature.

Latent Heat Formula for calculating is:

$$Q = n\, \Delta H$$

- n is the number of moles
- ΔH is the phase change (could be fusion or vaporization).

Conversion between Celsius and Fahrenheit

- Converting Celsius to Fahrenheit, the formula is:

$$°\mathrm{F} = \frac{9}{5}°\mathrm{C} + 32$$

- Converting Fahrenheit to Celsius, the formula is:

$$°\mathrm{C} = \frac{5}{9}(°\mathrm{F} - 32)$$

- **Absolute zero**: the temperature at which atoms in an object stops moving completely and the temperature can't go any lower. It occurs at 0 Kelvin or $-273.15°\mathrm{C}$.

[1] The figure was snipped from Sensible and Latent Heat - Keyter website.

momentum

Videos:

- Sensible and latent heat calculations (stop at 2:28 minutes)
- Heat From Latent and Sensible Heat
- Converting Between Temperature Scales (Celsius, Fahrenheit, and Kelvin)

momentum

Science: Lesson 7 – Classical Mechanics

Classical Mechanics is the field of physics that studies the motion of large objects. It also deals with the motion of bodies under the influence of forces or with the equilibrium of forces when all forces are balanced.

Force: A push or pull action on an object.

- Any action that influences an object to change its velocity. This action on the object tends to maintain or alter the motion of the object.
- Newton's second law of motion: force is defined as the mass of an object multiplied by the acceleration of the object.
    - Mass is a scalar quantity, but acceleration is a vector quantity.
    - This means force is a vector quantity because it has a defined direction.

Two Types of Force: Contact and Non-Contact

- **Contact Forces:** there is physical contact between the objects.
    - Example: friction
- **Non-Contact Force**: there is no contact between the objects.
    - Examples: electrical force, magnetic force, and gravitational force.

Video: Types of Forces

Mechanical Equilibrium: the condition where the balance between opposing forces acting on an object is equal to zero.

Velocity and Acceleration as Vector Quantities

- **Scalar quantities** are quantities that only have magnitude (or size).
- **Vector quantities** are quantities having both magnitude and direction.

Velocity is defined as displacement (not distance) divided by time.

- Since displacement is a vector quantity, velocity is also a vector quantity.
- Acceleration: is the change in velocity divided by time.
    - Acceleration is also a vector quantity.