

# Heat Transfer & Phase Changes

(Chapter 7)

**Student Learning Outcomes:** Recall methods of heat transfer, analyze systems to determine the method of heat transfer and the result, and name contributing factors of global warming.

1. *What are the three methods of heat transfer?*
2. *What is the greenhouse effect & what factors contribute to global warming?*
3. *What happens to temperature and energy during a phase change?*

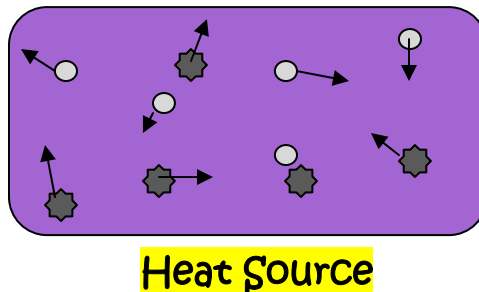
*What are the three methods of heat transfer?*

❖ Heat energy is transported from one place to another in three ways.

- Conduction
- Convection
- Radiation

❖ **Conduction is the transfer of heat energy from one place to another by direct collisions.**

- Energetic atoms and electrons transfer some of their energy to less energetic neighbor particles in collisions.



❖ Solids tend to conduct heat better than liquids or gases. **Why?**

**Example:** Metal spoon

❖ **Thermal conductivity is the ability of a material to transfer heat energy by conduction.**

- The amount of thermal conductivity depends on the mobility of the electrons in the material.
- High thermal conductivity allows heat to be transferred quickly, allows something to change temperature quickly.

**Question:** Does something that has a high thermal conductivity have a high or low specific heat capacity?

❖ **Insulators slow or impede the rate of heat flow through the material.**

- In an insulating material, the electrons are strongly bonded to the nuclei, they are not free to move and have collisions.

**Examples:**

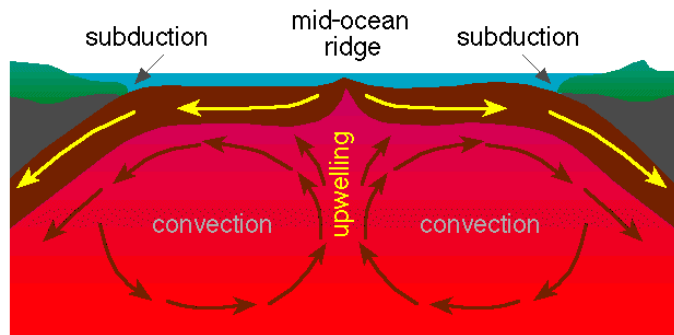
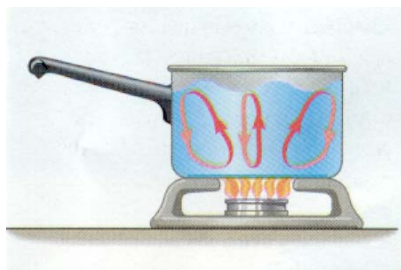
Good Conductors	Good Insulators
Copper	Glass (some)
Silver	Asbestos
Diamond	Wool
Aluminum	Styrofoam

❖ **Convection is the transfer of heat energy from one place to another by the bulk motion of groups of molecules in a fluid.**

- Energy is stored in a moving fluid and is carried from one place to another by the motion of this fluid. Hot fluid rises, cool fluid sinks.

**Question:** Why does hot fluid rise above cool fluid?

**Examples:** Oven, Ceiling Fan, Atmosphere, boiling fluid, Earth



<http://www-hep.phys.unm.edu/gold/phys161/links.html>

❖ **Radiation is the transfer of heat energy from one place to another by electromagnetic waves (light).**

➤ Radiation is the only method of heat transfer that can carry heat through the vacuum of space.

❖ All objects absorb and emit radiant energy in a range of frequencies.

**Examples:**

✚ Burner on a stove

✚ Sun

✚ Fire

**Question:** Why do people tend to wear darker colored clothes in the winter and lighter colored clothes in the summer?

*What is the greenhouse effect & what factors contribute to global warming?*

**Question:** Are day to night temperature changes larger when the sky is clear or cloudy?

❖ **The greenhouse effect traps heat near the surface of a planet.**

➤ Greenhouse gasses in the atmosphere trap heat

❖ The greenhouse effect does not generate heat; it slows heat loss to space.

❖ The substance in our atmosphere that is best at trapping heat is CO<sub>2</sub>.

*Abundances of Greenhouse Gasses*

Gas	% of Total
Carbon Dioxide	82%
Methane	9%
Nitrous Oxide	6%
HFC's, PFC's, & SF <sub>6</sub>	3%

<http://www.eia.doe.gov/bookshelf/brochures/greenhouse/Chapter1.htm>

❖ Greenhouse gas emissions come primarily from the combustion of fossil fuels in energy use.

**Question:** Is the greenhouse effect “bad”?

- ❖ **Global warming is the general increase in planet temperatures.**
- ❖ As the concentration of greenhouse gases grows, more heat is trapped in the atmosphere and less escapes back into space.

**Go To:** <http://www.youtube.com/watch?v=Hi3ERes0h84>

*What happens to temperature and energy during a phase change?*

- ❖ **A substance that has reached the temperature required for a phase change maintains its temperature during the phase change.**
- ❖ All energy lost or gained is used to change the phase of the substance.
- ❖ **Evaporation** (*Liquid to gas*)
  - A molecule with a high average KE gains enough energy through collisions to escape the liquid and change phase to gas.
- ❖ **Sublimation** (*Solid to gas*)
  - A molecule with high KE gains enough energy through collisions to escape the solid and change phase to gas.
- ❖ **Condensation** (*Gas to liquid*)
  - A molecule with low KE loses enough energy through collision to change phase to liquid.
- ❖ The amount of heat energy per kilogram that must be added or removed for a substance to change phase is called **latent heat**.

$$Q = mL$$

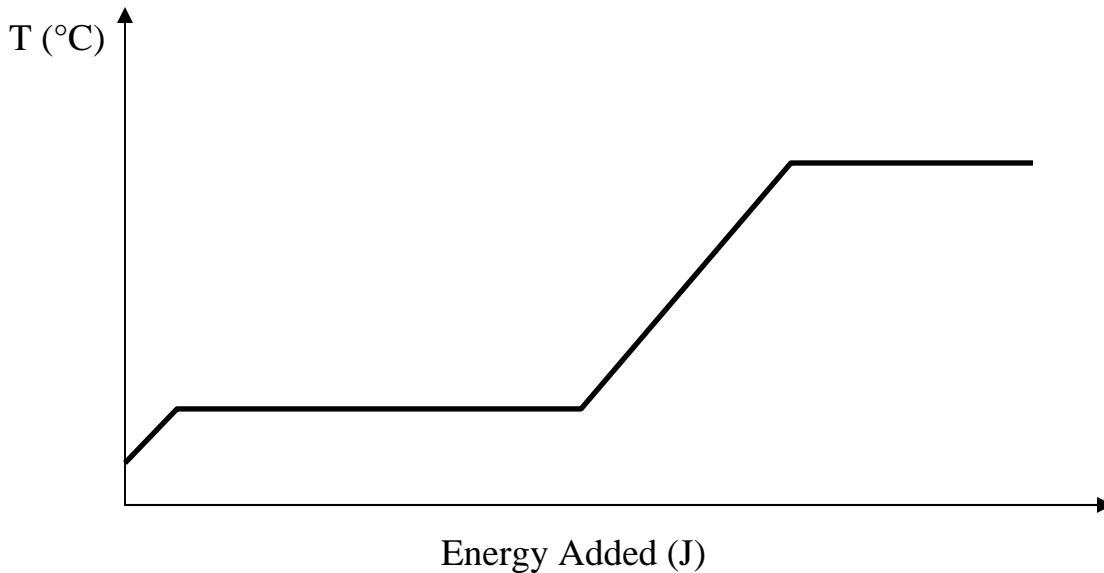
<i>solid ↔ liquid</i>	<i>liquid ↔ gas</i>
Latent heat of fusion ( $L_f$ )	Latent heat of vaporization ( $L_v$ )

❖ Heat is energy and energy can change form.

**Questions:**

1. When heat energy is added to a system, what are the possible results?
2. How much energy is required to melt 1 kg of ice at  $0^{\circ}\text{C}$ ?
3. If a 1 kg piece of  $0^{\circ}\text{C}$  ice is dropped 5 meters, how much ice will melt?
4. A 50 gram piece of steel is brought into full contact with a large piece of  $0^{\circ}\text{C}$  ice. The steel has an initial temperature of  $100^{\circ}\text{C}$ . How much of the ice will melt?

❖ The process of going from an ice cube in your freezer to steam includes both temperature changes and phase changes. All steps require energy.



**Question:** Apply the graph to ice being added to warm soda.