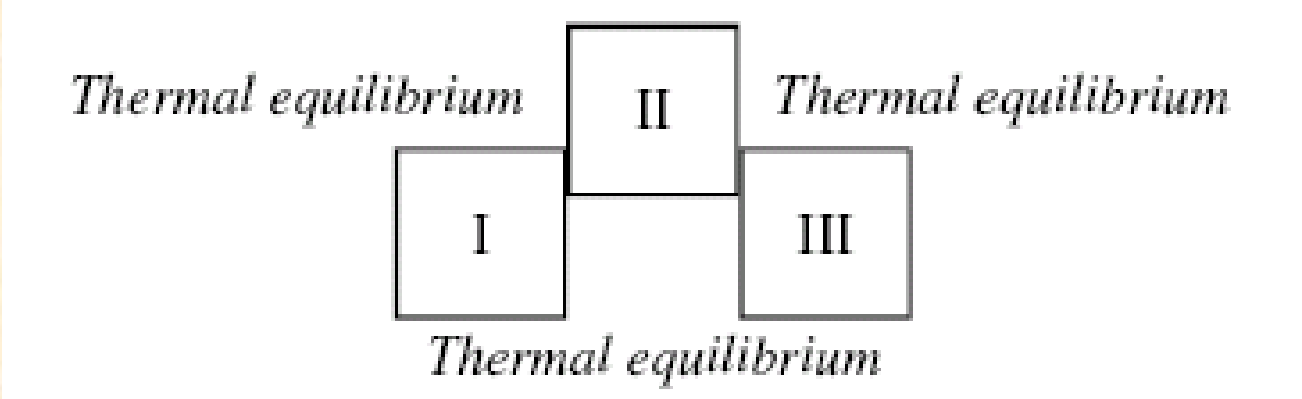
The Laws of Thermodynamics and Heat Transfer

The 0th Law of Thermodynamics

- If object 1 is in thermal equilibrium with two other objects, the other objects are in thermal equilibrium with each other. (Objects at Thermal Equilibrium are at the same temperature.)



The 1st Law of Thermodynamics

- The internal energy of a system can either be increased by adding heat or doing work. (Conservation of Energy.)

First Law of Thermodynamics

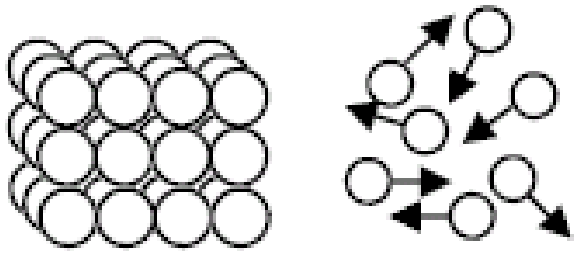
$$\Delta U = Q + W_{on\ system}$$

Internal Energy

+Q → +ΔT

Entropy

- Entropy is the amount of disorder of a system. The more organized a system is, the less entropy it has. Greater entropy usually means less useable energy.

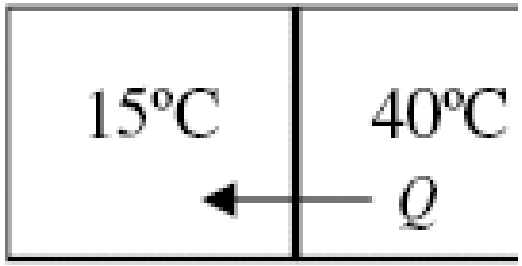


Solids have less positional entropy than liquids or gases because solid molecules are more organized.

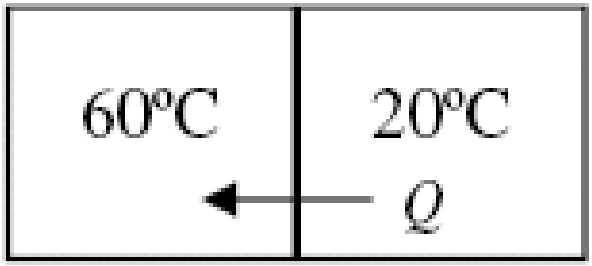
The 2nd Law of Thermodynamics

- Heat will travel from hot to cold on its own and never from cold to hot. **(Direction Heat Flows.)**
- Using entropy: “In any natural process the entropy of a system increases OR the disorder of the system will increase.”

This happens naturally.



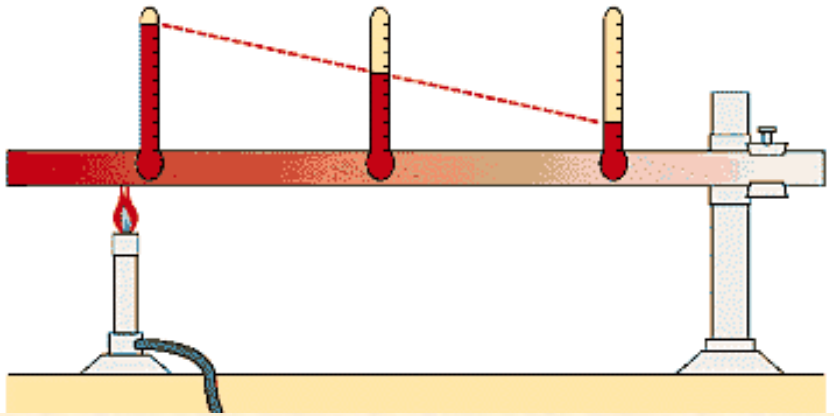
This does not happens naturally.



Heat Transfer

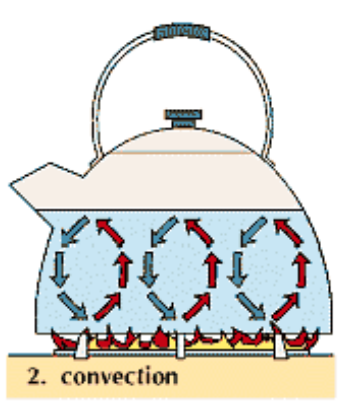
- Thermal energy moves in three different ways.
  - Conduction
  - Convection
  - Radiation

Conduction



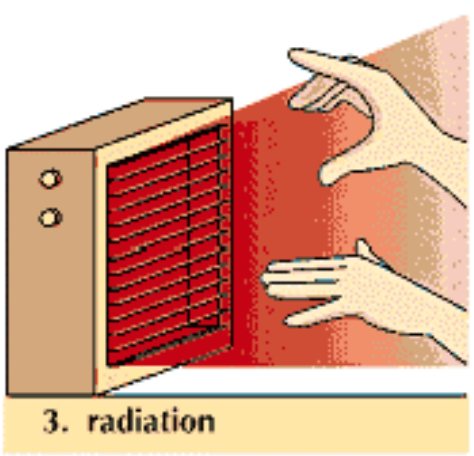
- All particles are moving, the greater the KE the greater the temp. (or energy).
- Energy is transferred when particles moving at different speeds bump into one another making contact.
- Takes place in:
  - Gasses
  - Liquids
  - Solids – Best Conductors
    - Some metals conduct heat better than other do however, Silver, copper, and aluminum are all good heat conductors since there valance electrons are held very loosely
    - Wood, plastic, glass, and fiberglass are all poor conductors of heat due to tightly holding on valance electrons.

Convection



- The transfer of energy by the bulk movement of matter.
- Recall that any material that flows is a fluid, so liquids and gases are both fluids. The most important way thermal energy is transferred in fluids is by convection.
- How is Conduction and Convection different?
- Occurs in Liquids and Gasses.
- Examples of convection would be:
  - How the air moves across the surface of the earths surface.
  - How boiling water comes to a boil in a pan.
  - How ocean currents are heated

Radiation



- The transfer of energy in the form of waves.
- Energy that travels by radiation is often called radiant energy.
- This is how energy from the sun transfers to the earth. Since there is very little matter in space, convection and conduction can not take place.
- Different materials absorb radiant energy differently. Shiny materials reflect radiant energy; while dull materials absorb it. Dark colored materials absorb more energy than lighter colored materials.

All matter that is warmer than 0 K emits radiation.

Insulators

- A material that does not allow heat to move through it easily.
- Some insulators such as wood, plastic and glass we have already identified as poor conductors of heat (or good insulators), however gases such as air and argon are also excellent insulators when placed in the right situation.
- Several types of insulating materials contain many tiny pockets that restrict formation of convection currents, and the trapped gasses do not conduct heat very well so they make good insulators.
- Examples of this is
  - insulation, plastic foam, and picnic coolers

Insulation heat rating system

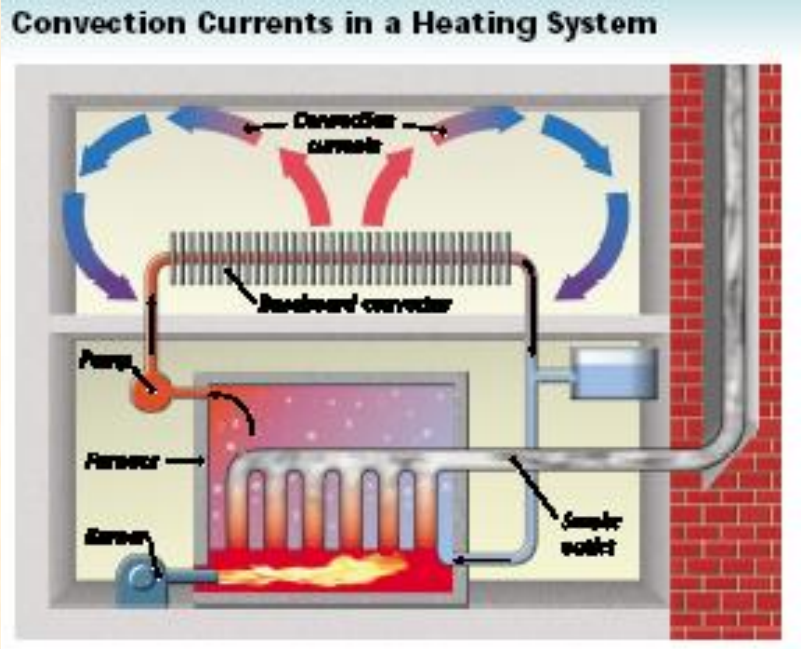
- Insulation heat rating system
  - A rating system has been established in which each material is given an R-value.
  - The R indicates resistance to heat flow, so the higher the R rating the higher resistance it has to heat flow.
  - Example - R-40 is a better insulator then R-20
  - Glass by itself has a R rating of 1, however if the glass is in a double pain window the R value is increased considerably.

Using Heat to Stay Warm

- There is two major types of heating systems
  - Conventional heating systems
    - Radiator Systems
    - Forced Air Systems
    - Electrical Heating Systems
  - Solar Heating systems
    - Passive Solar Heating
    - Active Solar Heating

Radiator Systems

- A device with a large surface area designed to heat the air near it by conduction. Convection currents then circulate the heat to all parts of the room.



Forced Air Systems

- A device that blows heated from a furnace through a system of large pipes, called ducts to openings called vents in each room. In the rooms the warm air circulates by convection. Cool air returns to the furnace through other vents and ducts to be reheated.

Electrical Heating Systems

- These are large heating coils located with in floors or ceilings and are heated by electrical energy. Nearby air is heated by conduction and people and materials in the room are also warmed by radiation. Such systems called radiant electrical heating systems provide even heat, however are very expensive to operate.

Solar Heating

- Energy from the sun is known as solar energy.
- Since solar energy is free it is very appealing as a heating source.

Passive Solar Heating

- Passive Solar Heating
  - Systems that use no fans or mechanical devices to transfer heat from one area to another.
  - Some materials in the system absorb radiant energy during the day, convert it to thermal energy and radiate the thermal energy after dark.

Active Solar Heating

- Active Solar Heating
  - This type of solar heating system as you can guess does use mechanical energy to help transfer heat from one area to another.
  - A solar collector is often used for these applications
  - A solar collector is a device that absorbs radiant energy from the sun. They are generally mounted either on the roof or south side of the building. The radiant energy can be used to heat the house , water, or both.