

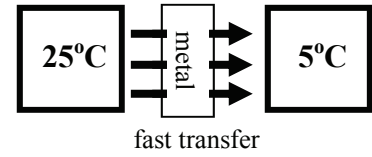
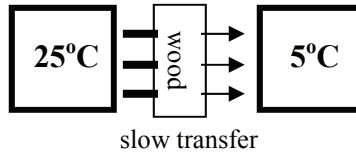
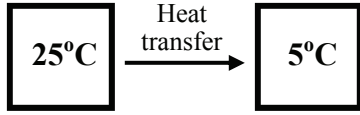
# Thermodynamics

**Thermodynamics is the study of how heat moves.**

Heat always transfers from **hot to cold**. Heat does not rise (hot air rises).

**Insulators** slow down heat transfer. Materials with air pockets are good insulators.

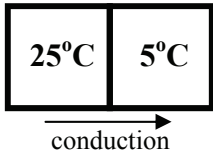
**Conductors** easily allow heat transfer. Most metals are good conductors.



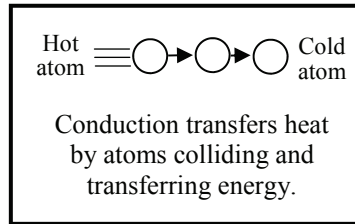
**Thermal energy (heat) is transferred in three ways: Conduction; Convection; Radiation.**

## Conduction

**Conduction transfers heat through objects touching.**



All atoms are vibrating (moving), which means they have kinetic energy. Hot atoms have more  $E_k$ . When hot atoms bump into cold atoms they transfer some energy.



Closer atoms mean more collisions. So solids *tend* to transfer heat better than liquids or gases. Gases tend to make good insulators. Sometimes, though a liquid (water) can speed up conduction with an insulator (your skin).

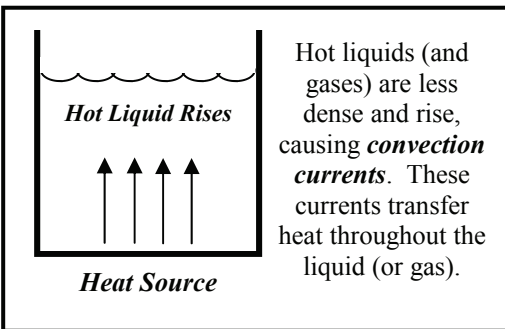
Heat transfer continues until both objects are at **thermal equilibrium**: the same temperature.

High density  $\longleftrightarrow$  Low density  
**Solid      Liquid      Gas**  
 Better conductors  $\longleftrightarrow$  Better insulators

## Convection

**Convection transfers heat through moving currents in gases or liquids.**

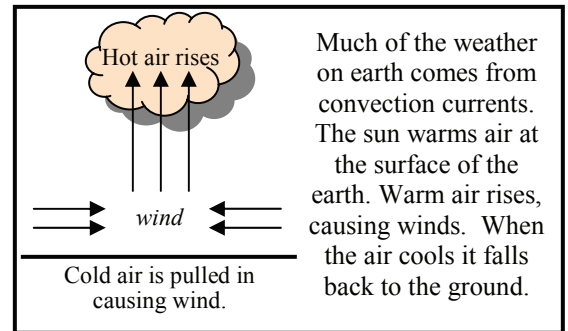
**No currents—No convection**



Hot liquids (and gases) are less dense and rise, causing **convection currents**. These currents transfer heat throughout the liquid (or gas).

Gases transfer heat poorly through conduction. Convection currents speed up thermal transfer.

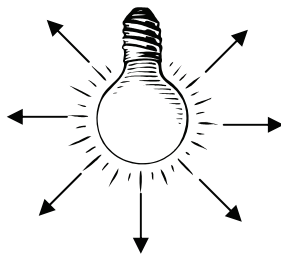
Convection currents can only happen in gases (like air) or liquids (like water), not in solids because solids can't move.



Much of the weather on earth comes from convection currents. The sun warms air at the surface of the earth. Warm air rises, causing winds. When the air cools it falls back to the ground.

## Radiation

**Radiation transfers heat through electromagnetic radiation; occurs even in a vacuum (empty space).**



**Radiation transfers heat in all directions**—even down. Convection currents always rise.

**Radiation requires no contact**—convection and conduction require touching.

**Radiation can go through transparent materials (barriers) like glass.**

Radiation transfers heat through electromagnetic waves — pure thermal energy.

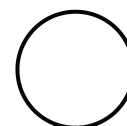


All energy on earth comes originally from the sun. Space is a vacuum (no matter at all). So only radiation can travel through space to the earth.

**Dark objects absorb more radiation than light objects. Dull objects absorb more radiation than shiny objects.**



High absorption of radiation. Heats fast.



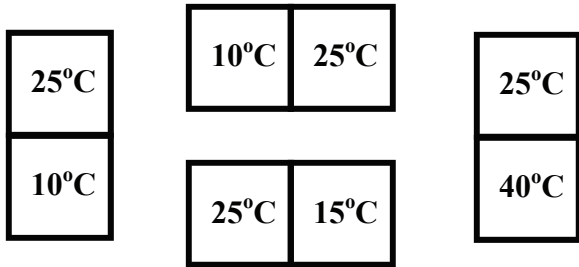
Low absorption of radiation. Heats slowly.

1. Conduction	A. Heat transfer through electromagnetic waves.	1. Insulator	A. A region of space that contains no matter.
2. Thermal Equilibrium	B. Thermal (heat) transfer by the contact (touching) of two objects.	2. Conductor	B. Allows convection, but is a very good insulator.
3. Radiation	C. Transfers heat by moving currents in gases and liquids.	3. Vacuum	C. Any material that easily allows heat to move through it.
4. Wind	D. When two objects are at the same temperature.	4. Solid	D. Allows convection; can be a good conductor of heat.
5. Convection	E. The study of how heat moves.	5. Liquid	E. Any material that resists the movement of heat through it.
6. Thermodynamics	F. Caused by convection currents in the earth's atmosphere.	6. Gas	F. No convection can occur in this.

What Kind of Thermal Transfer?  
1. Conduction; 2. Convection; 3. Radiation

___ When hot air rises.	___ Causes wind.
___ When two objects are touching.	___ Between a stove and a pot.
___ When nothing is touching.	___ Within a pan of water.
___ When atoms collide.	___ More occurs with dark objects.
___ Transfers heat in all directions.	___ Through a car's windows at night.

Draw an arrow for each of the following pair of objects showing the direction of the thermal transfer.



Does heat rise?  
  
Does hot air rise?  
  
Why?

Which of the following are at thermal equilibrium?

A. <table border="1"><tr><td>25°C</td><td>5°C</td></tr></table>	25°C	5°C	C. <table border="1"><tr><td>5°C</td><td>5°C</td></tr></table>	5°C	5°C
25°C	5°C				
5°C	5°C				
B. <table border="1"><tr><td>25°C</td><td>25°C</td></tr></table>	25°C	25°C	D. <table border="1"><tr><td>5°C</td><td>25°C</td></tr></table>	5°C	25°C
25°C	25°C				
5°C	25°C				

Thermal Insulator or Thermal Conductor?

___ Metal	___ Glass	___ A coat
___ Wood	___ A penny	___ Styrofoam
___ Air	___ Water	___ Aluminum

Absorbs heat (heats fast) or Reflects heat (heats slowly)?

___ Dark liquids	___ Dull objects	___ Aluminum
___ Clear liquids	___ White paper	___ Styrofoam
___ Shiny objects	___ Black paper	___ Dark car

Is this diagram correct or incorrect and why?

