

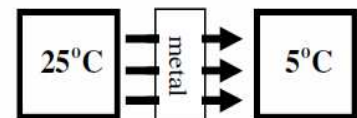
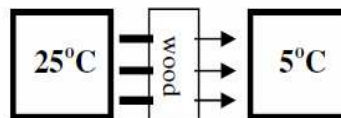
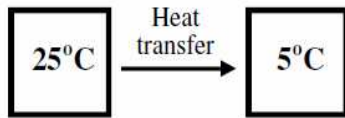
Thermodynamics

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, so they tend to be less dense.

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



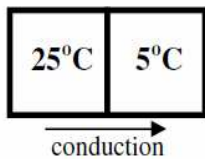
slow transfer

fast transfer

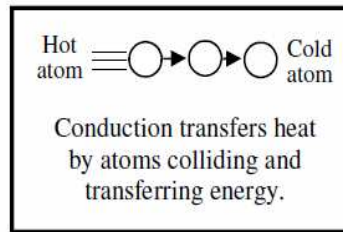
Thermal energy (heat) is transferred in three ways: Conduction; Convection; Radiation.

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.

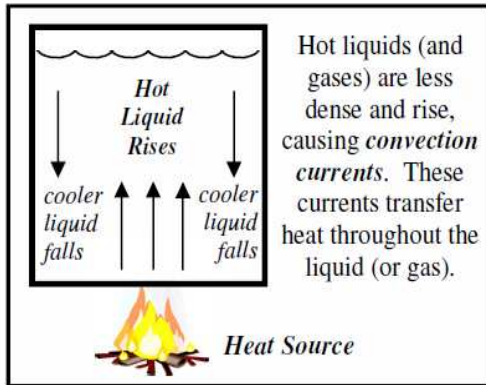
High density ↔ Low density

Solid Liquid Gas

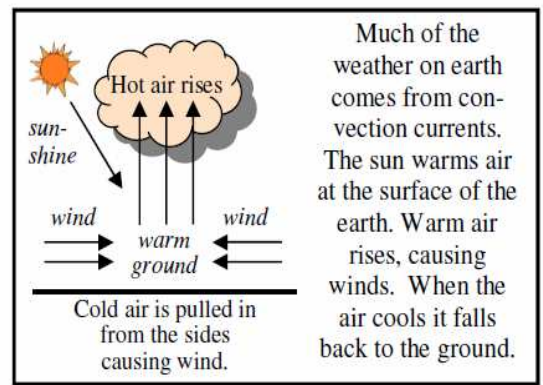
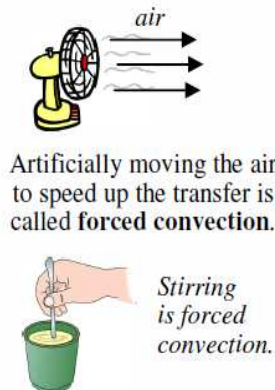
Better conductors ↔ Better insulators

Convection

Convection transfers heat through moving currents in fluids: gases or liquids. Convection cannot occur in solids, because solids can't move.



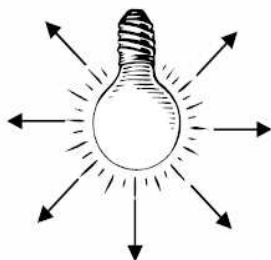
Hot liquids (and gases) are less dense and rise, causing **convection currents**. These currents transfer heat throughout the liquid (or gas).



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 and requires no molecular contact. Radiation can occur 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.



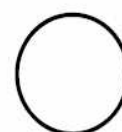
All energy on earth comes originally from the sun. Space is a vacuum (no matter at all). So only radiation can travel through space to the earth.

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

Radiation transfers heat through electromagnetic waves — pure thermal energy.



High absorption of radiation (no reflection). Heats fast.



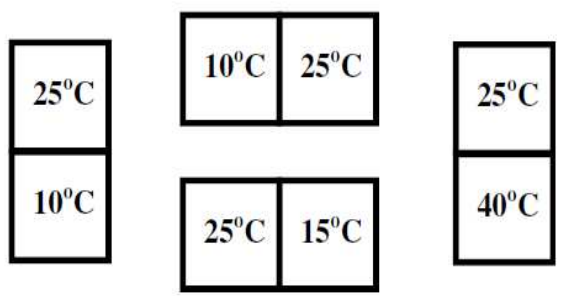
Low absorption of radiation (reflects). Heats slowly.

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 hot car's closed 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 or why not?

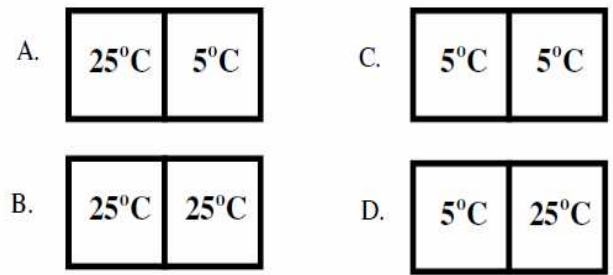
If there is a fireplace on the first floor, after a couple of hours which floor of the house will be warmer? Why?



Fast, Medium, or Slow Molecules?

- | | | |
|-----------------|------------------|------------|
| ___ Liquids | ___ Gases | ___ Solids |
| ___ Water | ___ Cold objects | ___ Ice |
| ___ Hot objects | ___ Steam | ___ Helium |

Which of the following are at thermal equilibrium?



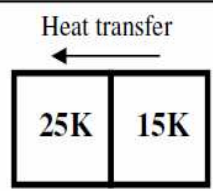
Thermal Insulator or Thermal Conductor?

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

Do the following heat Qickly or Slowly thru radiation?

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

Is this diagram correct or incorrect and why?



Which will stay warm longer: a cup of coffee or a cup of coffee being stirred? Why?

If your student desk has been in the room for many hours, it is at thermal equilibrium with the room?

Which part of your desk is colder: the wood or the metal? Why?