Name: _____

Period: _____

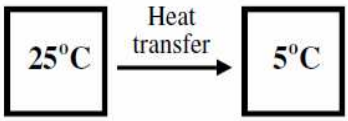
Thermodynamics

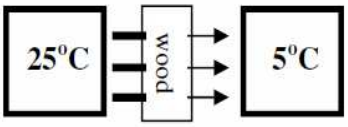
Thermodynamics is the study of how heat moves.

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

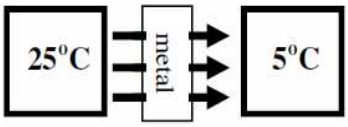
Insulators slow down heat transfer. Materials with air pockets are good insulators, so they tend to be less dense.

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





slow transfer

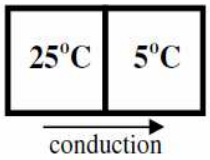


fast transfer

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.

Conduction transfers heat by atoms colliding and transferring energy.

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

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).

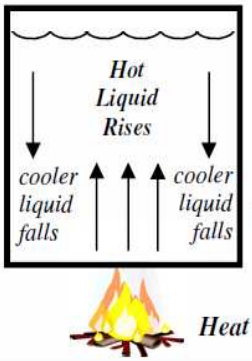
High density ⟷ *Low density*

Solid **Liquid** **Gas**

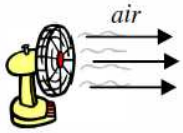
Better conductors ⟷ *Better insulators*

Convection

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

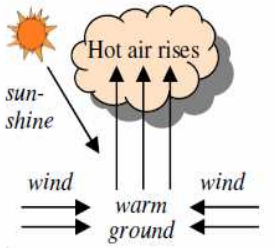


Hot liquids (and gases) are less dense and rise, causing ***convection currents***. These currents transfer heat throughout the liquid (or gas).



Artificially moving the air to speed up the transfer is called **forced convection**.

Stirring is forced convection.

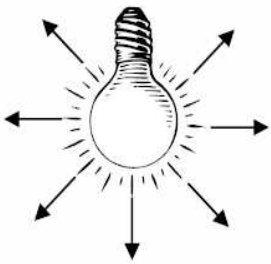


Cold air is pulled in from the sides causing wind.

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 through electromagnetic waves — pure thermal energy.

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

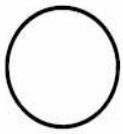
Radiation requires no contact—convection and conduction require touching.

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.

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



Low absorption of radiation (reflects). Heats slowly.

1. Conduction	A. Heat transfer through electromagnetic waves.
2. Thermal Equilibrium	B. Thermal (heat) transfer by the contact (touching) of two objects.
3. Radiation	C. Transfers heat by moving currents in gases and liquids.
4. Wind	D. When two objects are at the same temperature.
5. Convection	E. The study of how heat moves.
6. Thermo-dynamics	F. Caused by convection currents in the earth's atmosphere.

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

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

25°C	10°C	25°C
10°C	25°C	25°C
	15°C	40°C

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

1. Insulator	A. A region of space that contains no matter.
2. Conductor	B. Allows convection, but is a very good insulator.
3. Vacuum	C. Any material that easily allows heat to move through it.
4. Solid	D. Allows convection; can be a good conductor of heat.
5. Liquid	E. Any material that resists the movement of heat through it.
6. Gas	F. No convection can occur in this.

Which of the following are at thermal equilibrium?

A.	25°C	5°C	C.	5°C	5°C
B.	25°C	25°C	D.	5°C	25°C

Thermal Insulator or Thermal Conductor?

____Metal	___ Glass	___ A coat
____Wood	___ A penny	___ Styrofoam
____ Air	___ Water	___ Aluminum

Do the following heat Quickly 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?

Heat transfer ←

25K	15K

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?