Lecture 6.
mperature and Heat

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RECENT HEAT RELATED DEATHS

- Korey Stringer 7-31-01
  - 27 Yrs Old 6’3” 335 lbs
- Eraste Autin 7-25-01
  - 18 Yrs Old 6’2” 250 lbs
- Preston Birdsong 8-13-00
  - 18 Yrs Old 5’11” 190 lbs

The Body's Response to Heat

- The body tries to maintain a constant internal temperature

- When the internal temperature rises, the body attempts to get rid of excess heat by:
  - Increasing blood flow to skin surface
  - Releasing sweat onto skin surface

"TOO HOT RESULTS" How *HEAT* puts Stress on your body

- Excessive sweat loss results in dehydration

- The body loses its ability to cool

- Increased blood flow to skin causes decrease in organ function

HEAT-RELATED ILLNESSES

- HEAT CRAMPS
- HEAT EXHAUSTION
- HEAT STROKE

HEAT CRAMPS

- Caused by excessive loss of electrolytes
- Early warning sign of heat stress
- Painful cramps usually in legs or abdomen
- Stop activity, hydrate, rest in cool place
- Get medical attention if condition continues

HEAT EXHAUSTION

- The body's response to excessive water and electrolyte loss

- Stop activity and seek treatment immediately

HEAT STROKE

- The body's cooling mechanism shuts down
- 50% that reach the heat stroke stage die even with medical attention

COLD STRESS

Hypothermia

Cold Stress (Hypothermia)

- Acute problem resulting from prolonged cold exposure and heat loss
- "Hypo" (too little) "Thermia" (heat)
- 750 deaths/year in USA
- Generally doesn't present the same level of danger as heat stress
  - Does not occur as quickly
  - Workers will simply come in out of the cold

MAJOR CAUSES

- Cold Temperatures
  - 41 degrees F is cold enough with other contributing factors
- Improper clothing and equipment
- Wetness
  - Sweating, contact with water
  - Water conducts heat away from the body 25 Xs faster than air

Contributing Factors

- Fatigue
- Dehydration
- Hunger
- Alcohol intake

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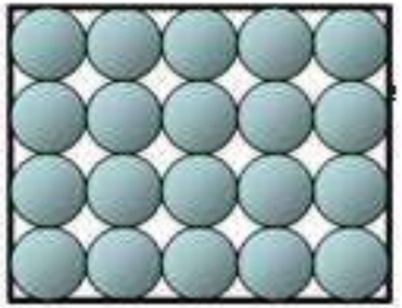
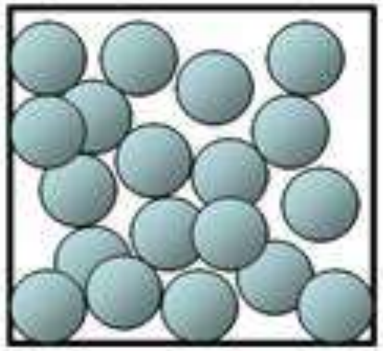
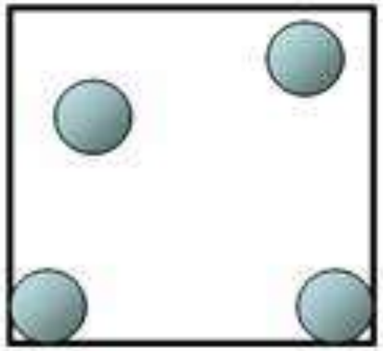
STATES OF MATTER



Solid State
Ordered and dense
Has a definite shape and volume.
Solids are very slightly compressible.



Liquid State
Disordered and usually slightly less dense.
Has a definite volume and takes the shape of the container.
Liquids are slightly compressible.



Gas State
Disordered and much lower density tnan crystal or liquid.
Does not have definite shape and volume.
Gases are highly compressible.

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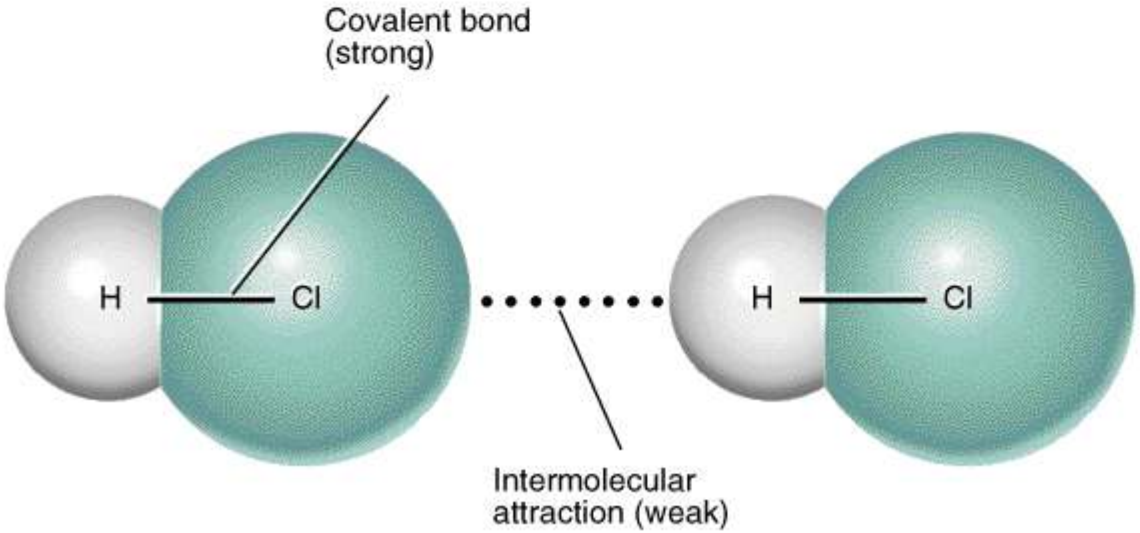
A.Intermolecular Forces

1. the **attractive** forces between molecules
2. states of matter are determined by the **strength** of these forces
   (IMF increase from gas→liquid→solid)



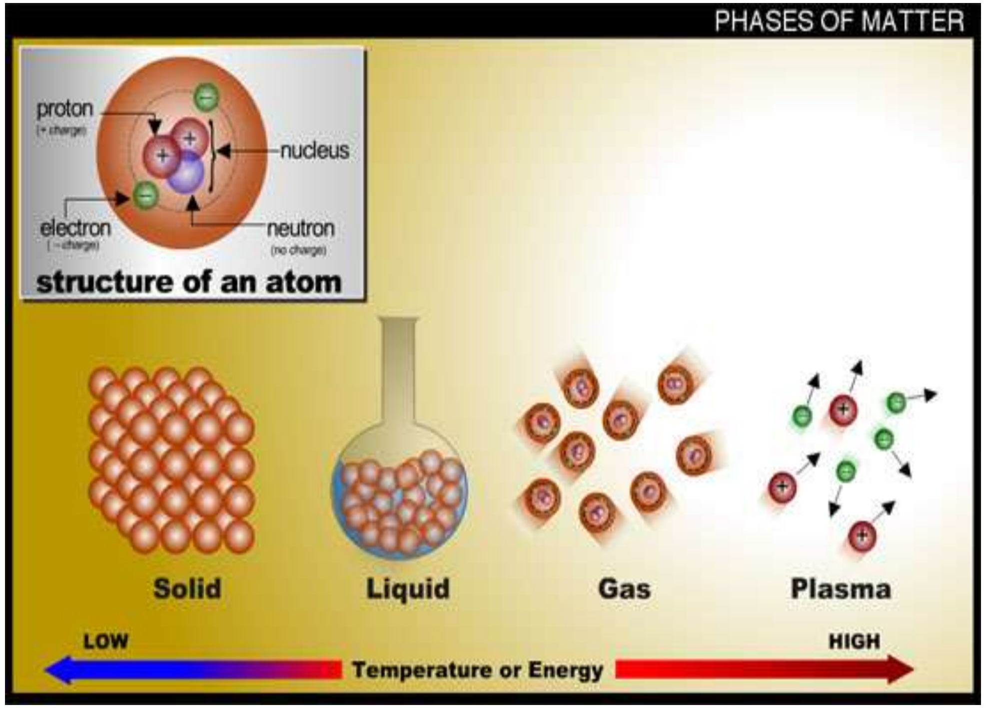
The Kinetic Theory of Matter

- All of the particles that make up matter are constantly in motion

- Solid= vibrating atoms
- Liquid= flowing atoms
- Gas= move freely
- Plasma=

  move incredibly

  fast and freely



www.nasa.gov

Temperature is a measure of the average kinetic energy of the individual particles in a substance.

The atoms in an object are in constant motion.

A When the horseshoe is hot, the particles in it move very quickly.

B When the horseshoe has cooled, its particles are moving more slowly.

WATER AND DYE EXPERIMENT

- Why did the dye in hot water move faster than the dye in cold water?
- The results have to do with the different temperatures of the water.

Back to Experiment

- So what explanation would be given if we heated the cold water.
  - Its particles will start moving faster, so their kinetic energy will increase. This means that the temperature of the water will rise.

Temperature

- is a measure of the average kinetic energy of all particles within an object.

- indicates how warm or cold an object is with regards to the standard.

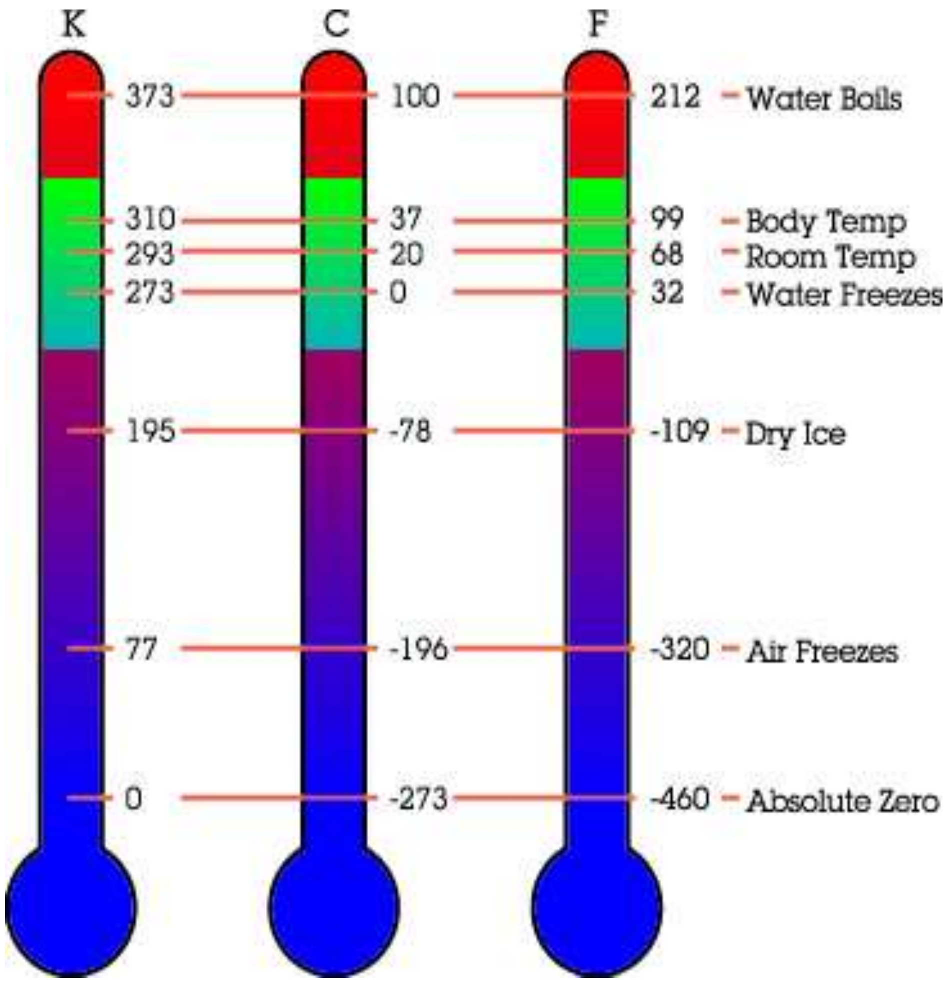
A thermometer is a device that measures temperature.

Temperature

Temperature

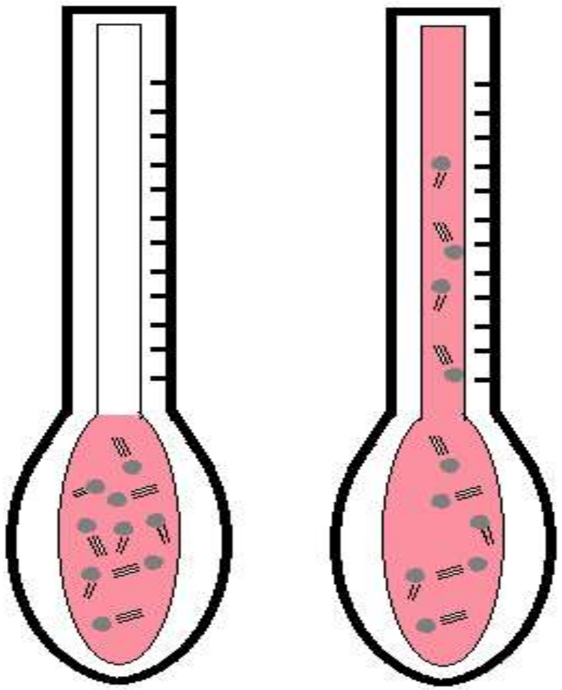
- is measured with a thermometer and can be measured in Kelvin, Celsius, and Fahrenheit

Absolute zero-temperature at which particles stop moving 0°K



A thermometer is used to measure temperature.

When the thermometer is placed in a substance, the heat from that substance may be transferred to the mercury (or alcohol) in the thermometer.



It causes the motion, or kinetic energy of the particles to increase. This rise in temperature is shown by the rising column of mercury or alcohol in the thermometer.

Temperature Conversions

F= 1.8C + 32

C= (F-32)/1.8

Absolute zero

is the lowest possible temperature . An object's energy is zero. There is no possible transfer of energy.

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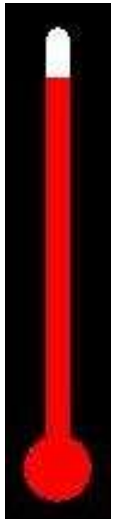
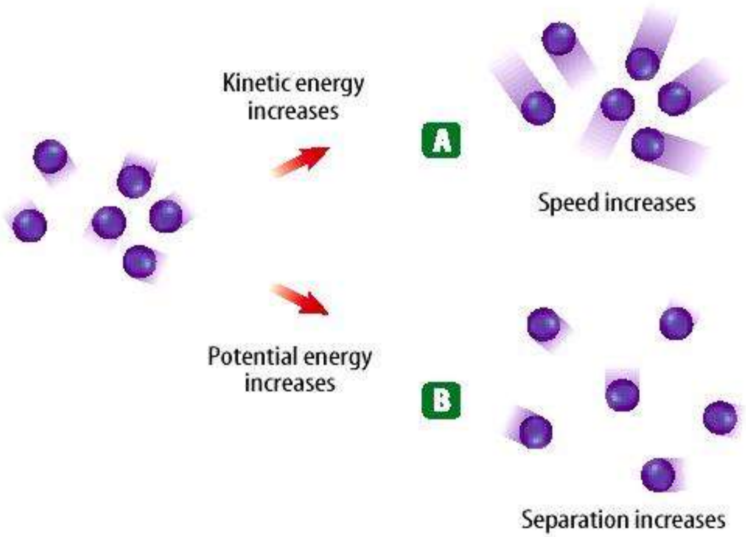
SI unit for temp. is the Kelvin

a. K = C + 273 (10C = 283K)

b. C = K – 273 (10K = -263C)



B. Thermal Energy – the total of all the kinetic and potential energy of all the particles in a substance.



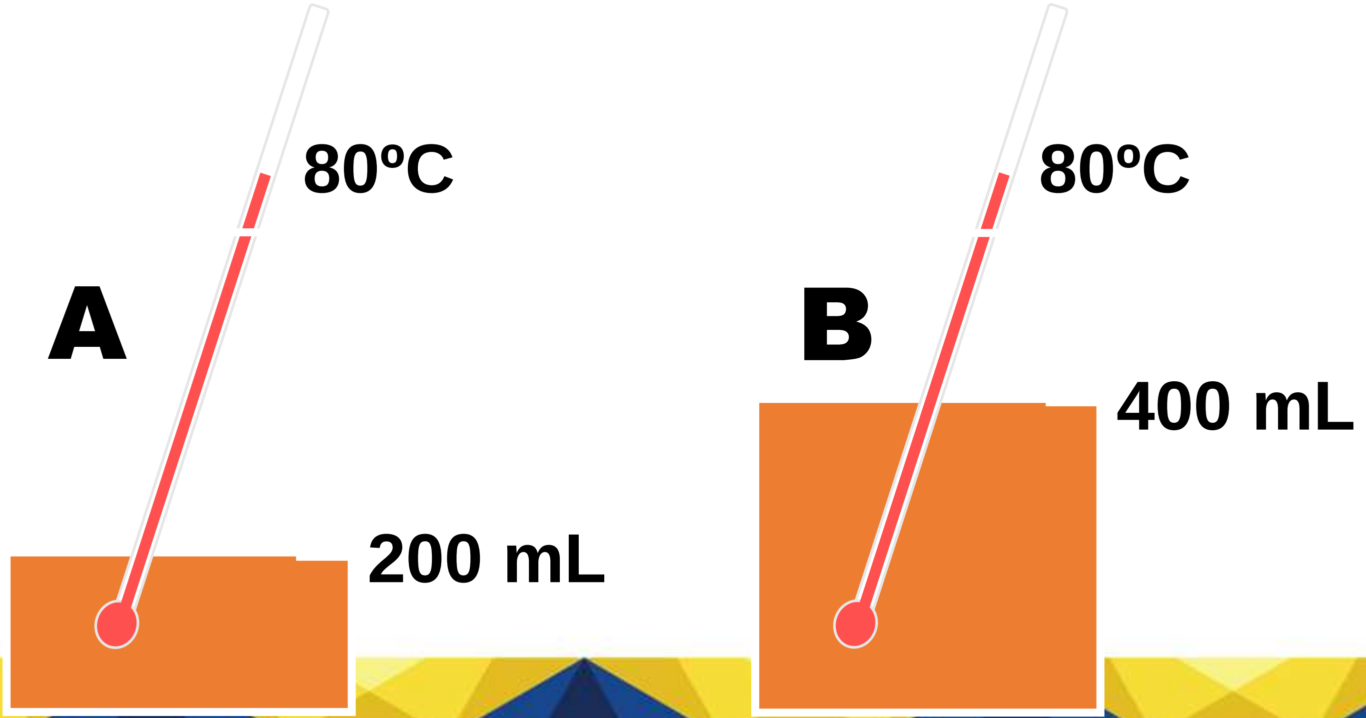
Thermal energy relationships

a. Depends on temperature, mass, and type of substance

b. As temperature increases, so does thermal energy (because the kinetic energy of the particles increased).

c. Even if the temperature doesn’t change, the thermal energy in a more massive substance is higher (because it is a total measure of energy).

- Which beaker of water has more thermal energy?
  - B - same temperature, more mass



Thermal Energy Defined

Thermal energy –

total energy of the particles in a material

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Heat defined

Heat - is the thermal energy that flows from something of a higher temperature to something of a lower temperature.

Units of Heat

THERMAL UNITS AND THEIR VALUES IN JOULES

Heat unit	Equivalent value	Uses
joule (J)	equal to 1 kg$\bullet\left(\frac{m^2}{s^2}\right)$	SI unit of energy
calorie (cal)	4.186 J	non-SI unit of heat; found especially in older works of physics and chemistry
kilocalorie (kcal)	4.186×10^3 J	non-SI unit of heat
Calorie, or dietary Calorie	4.186×10^3 J = 1 kcal	food and nutritional science
British thermal unit (Btu)	1.055×10^3 J	English unit of heat; used in engineering, airconditioning, and refrigeration
therm	1.055×10^8 J	equal to 100 000 Btu; used to measure natural-gas usage

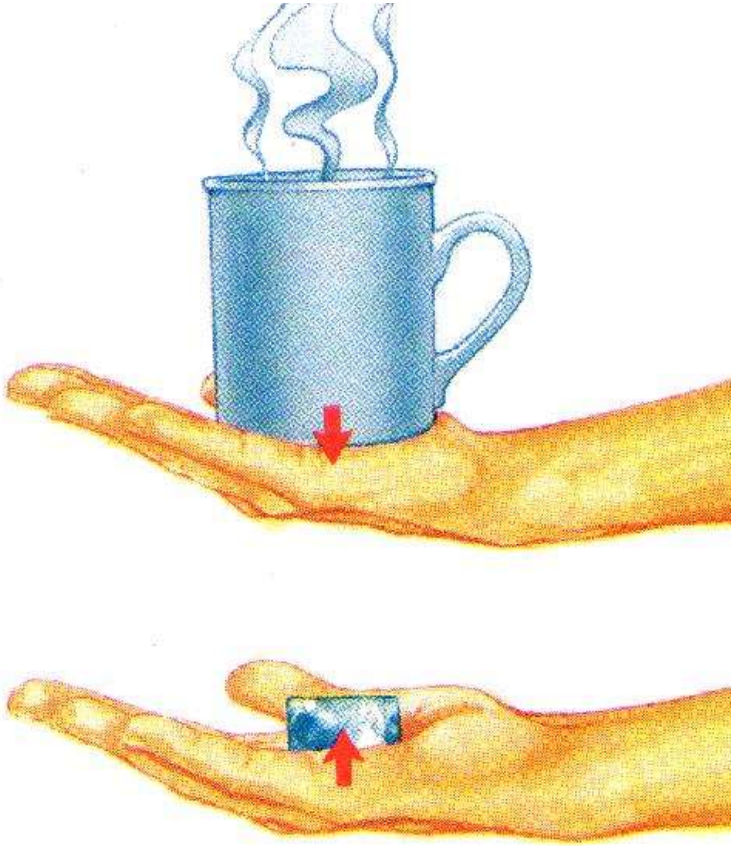
Physics -Serway/Faughn (Holt)

Heat

Cup gets cooler while hand gets warmer

a. The *flow* of thermal energy from one object to another.

b. Heat ***always*** flows from warmer to cooler objects.



Ice gets warmer while hand gets cooler

Dealing with temperature when does an energy transfer occur?

- The feeling associated with temperature difference results from energy transfer.
- Energy is transferred from a hotter object to a cooler object.

- *Example* –Holding a piece of ice.

- The ice is at a lower temperature than your hand, so the molecules of ice move very slowly. Your hand's molecules are moving much faster than the ice because it is at a higher temperature. As a result, the molecules of your hand collide with the ice molecules and energy is transferred so the ice molecules start to move faster causing the ice to melt.

When is there no transfer of energy in regards to temperature?

- If both objects are the same temperature there is no transfer of energy AND

- when the temperature is at absolute zero.

Heat Transfer

1.Specific Heat (C_p)

- amount of energy required to raise the temp. of 1 kg of material by 1 degree Kelvin
- units: J/(kg·K) or J/(kg·°C)

Specific Heat Values (J/(kg·K))	
Water	4184
Alcohol	2450
Aluminum	920
Carbon (graphite)	710
Sand	664
Iron	450
Copper	380
Silver	235

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Heat Transfer

- Which sample will take longer to heat to 100°C?

50 g Al   50 g Cu

Specific Heat Values (J/(kg·K))	
Water	4184
Alcohol	2450
Aluminum	920
Carbon (graphite)	710
Sand	664
Iron	450
Copper	380
Silver	235

- Al - It has a higher specific heat.
- Al will also take longer to cool down.

Heat Transfer

$$\boldsymbol{Q = m \times \Delta T \times C_p}$$

Q: heat (J)

m: mass (kg)

ΔT: change in temperature (K or °C)

C_p: specific heat (J/kg·K)

$\Delta T = T_f - T_i$

– Q = heat loss

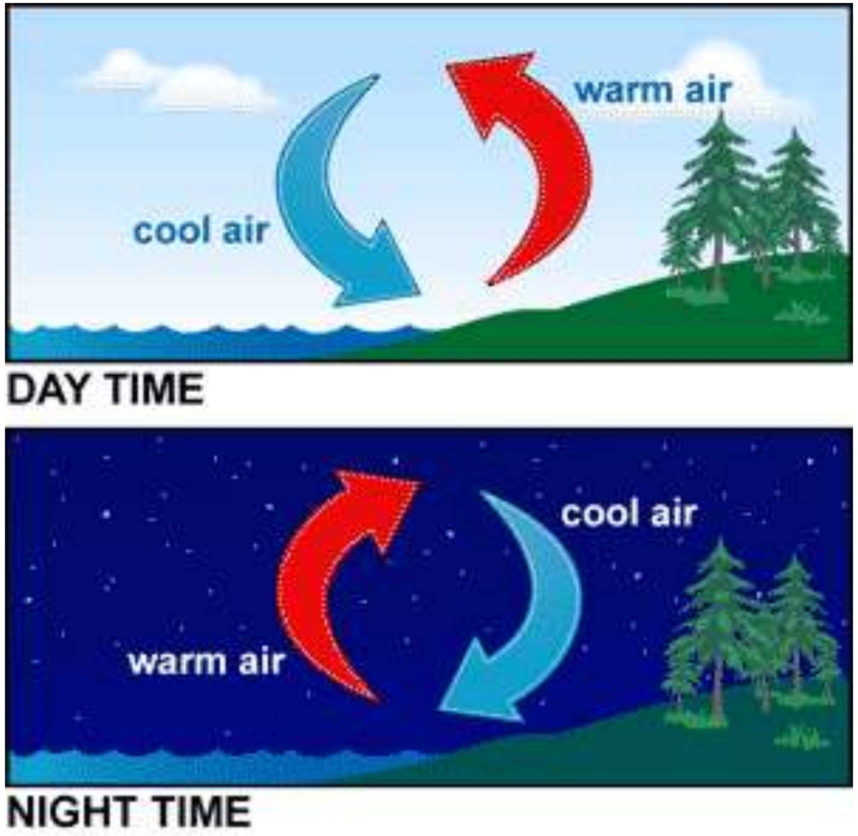
+ Q = heat gain

Specific Heat

2. Some things heat up or cool down faster than others.

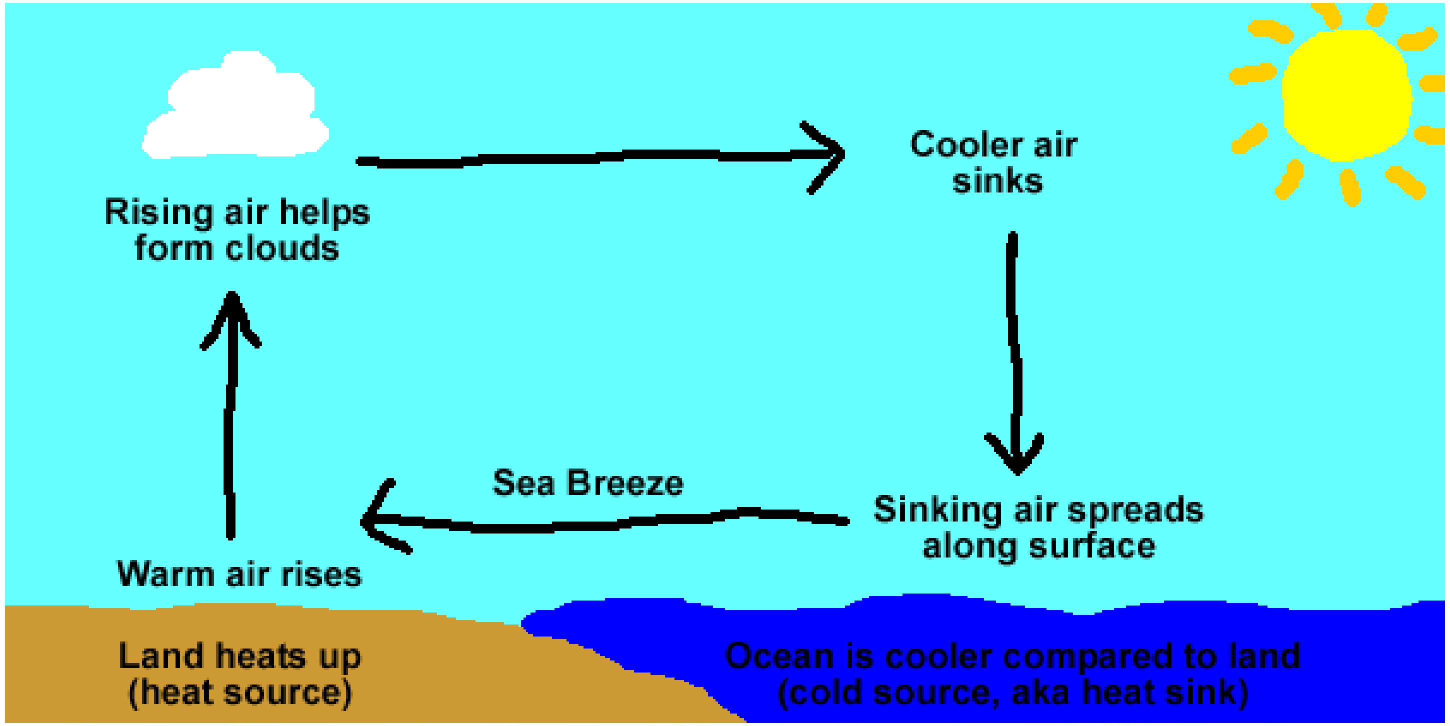
More Convection

- The wind we feel outside is often the result of convection currents. You can understand this by the winds you feel near an ocean. Warm air is lighter than cold air and so it rises. During the daytime, cool air over water moves to replace the air rising up as the land warms the air over it. During the nighttime, the directions change -- the surface of the water is sometimes warmer and the land is cooler.



Heat Transfer: Convection

- Takes place in liquids and gases as molecules move in currents
- Heat rises and cold settles to the bottom



b. Specific heat is the amount of heat required to raise the temperature of 1 kg of a material by one degree (C or K).

1) C_{water} = 4184 J / kg C

2) C_{sand} = 664 J / kg C

This is why land heats up quickly during the day and cools quickly at night and why water takes longer.

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Why does water have such a high specific heat?

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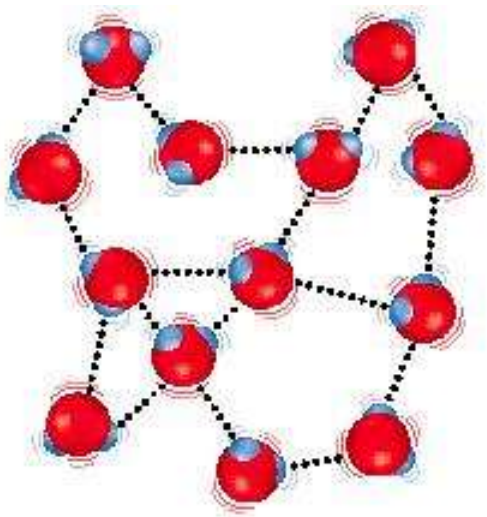
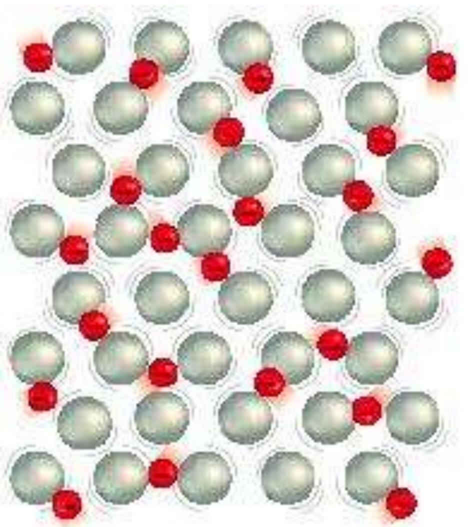
water





metal

Water molecules form strong bonds with each other; therefore it takes more heat energy to break them. Metals have weak bonds and do not need as much energy to break them.

Sample Calculation

A 32.0 g silver spoon cools from 60° C to 20°C. What is the change in thermal energy?

m = 32.0g = 0.0320 kg

C = 235 J/(kg.K) –from table of values for silver

$T_{initial}$ =60°C

T_{final} =20°C Q = (m)(ΔT)(C)

= (0.0320 kg)(-40.0°C)(235J/kg . K)

= -301 J

The spoon loses 301 J of thermal energy as it cools.

Heat Transfer

- A 32-g silver spoon cools from 60°C to 20°C. How much heat is lost by the spoon

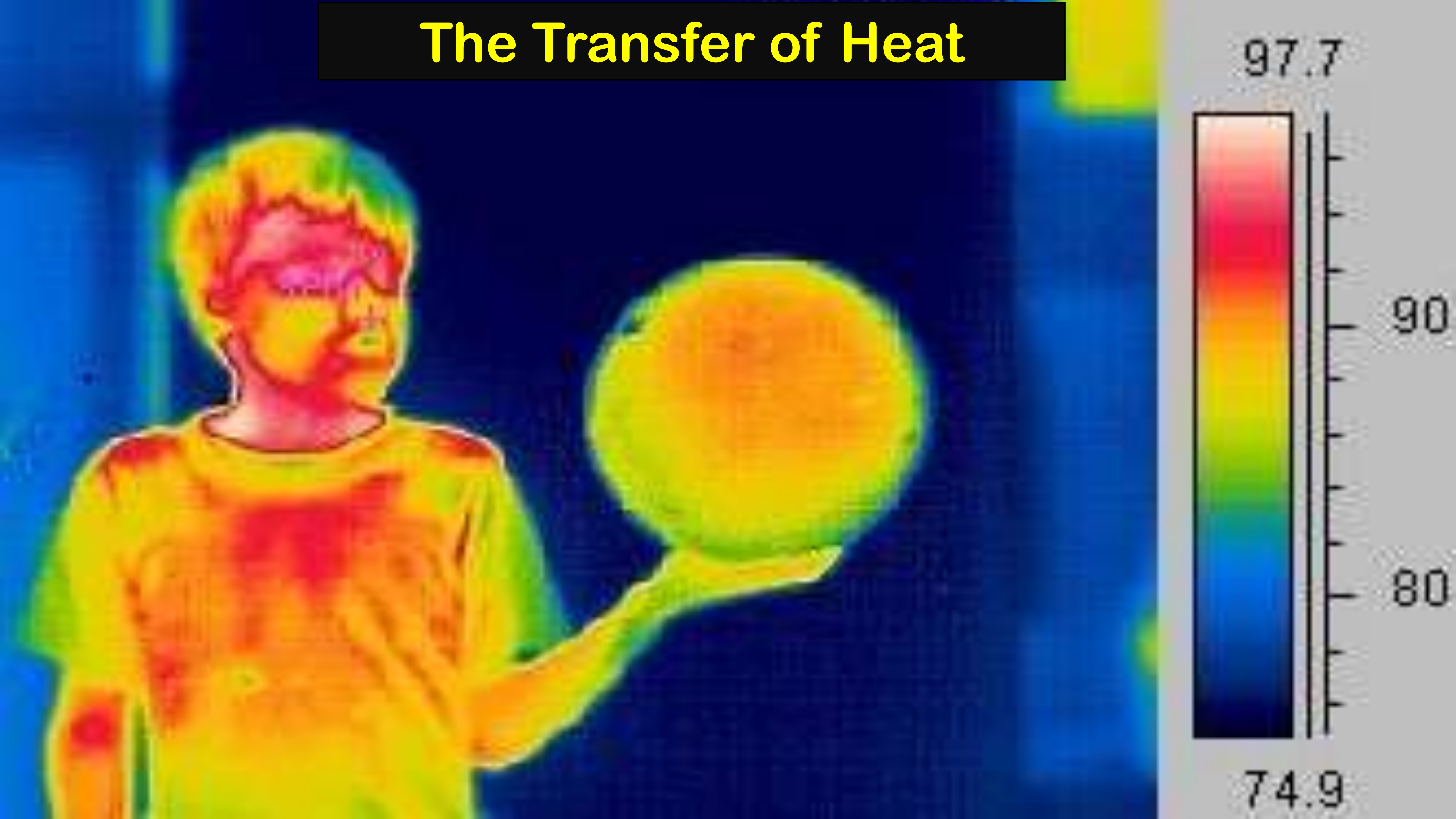
GIVEN:	WORK:
m = 32 g	$Q = m \cdot \Delta T \cdot C_p$
T_i = 60°C	m = 32 g = 0.032 kg
T_f = 20°C	ΔT = 20°C - 60°C = – 40°C
Q = ?	Q = (0.032kg)(-40°C)(235J/kg·K)
C_p = 235 J/kg·K	**Q = – 301 J**

Heat Transfer

- How much heat is required to warm 230 g of water from 12°C to 90°C?

GIVEN:	WORK:
$m = 230$ g $T_i = 12°C$ $T_f = 90°C$ $Q = ?$ $C_p = 4184$ J/kg·K	$Q = m \cdot \Delta T \cdot C_p$ $m = 230$ g $= 0.23$ kg $\Delta T = 90°C - 12°C = 78°C$ $Q = (0.23kg)(78°C)(4184$ J/kg·K$)$ **Q = 75,061 J**

The Transfer of Heat

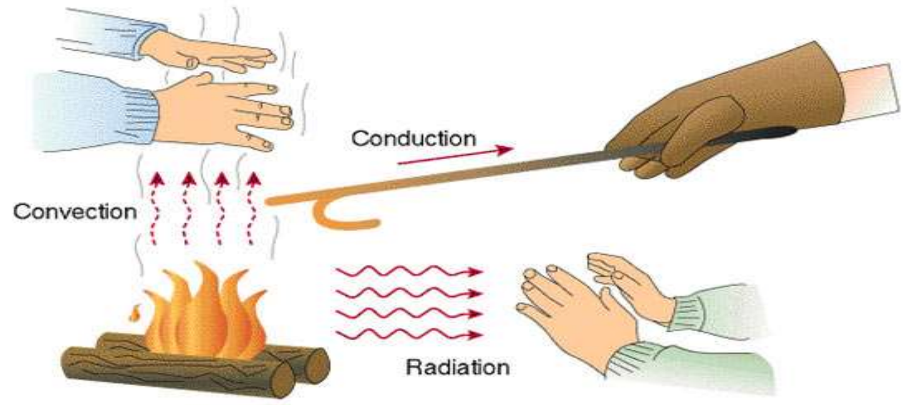


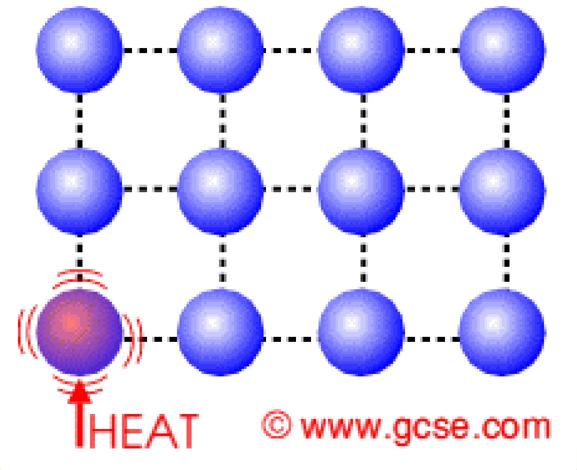
A. How is heat transferred?

- What type of HEAT TRANSFER is occurring in the pictures? Conduction, convection or radiation?

CONDUCTION –

The transfer of thermal energy with no transfer of matter.





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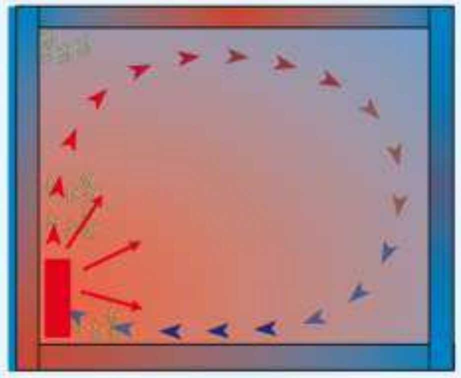
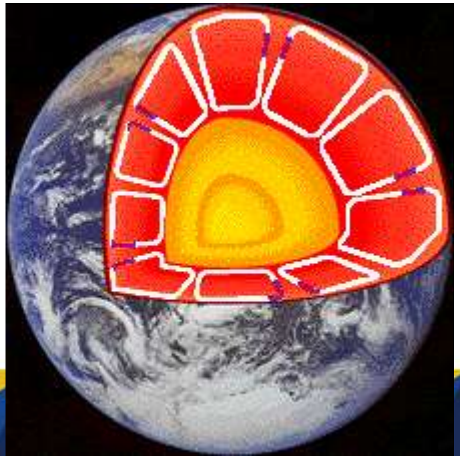
HEAT TRANSFER

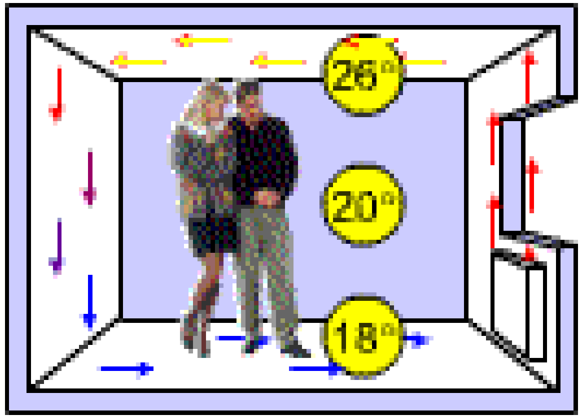


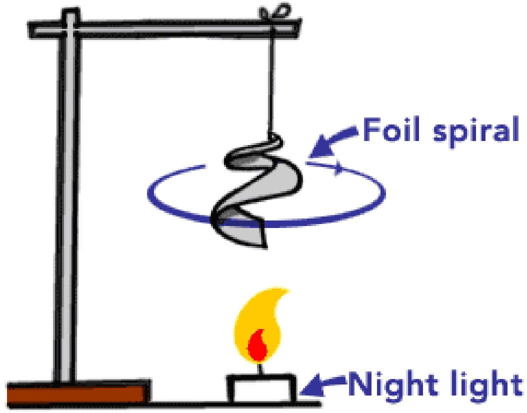
- What type of HEAT TRANSFER is occurring in the pictures? Conduction, convection or radiation?

CONVECTION –

The transfer of thermal energy when particles of a liquid or gas move from one place to another

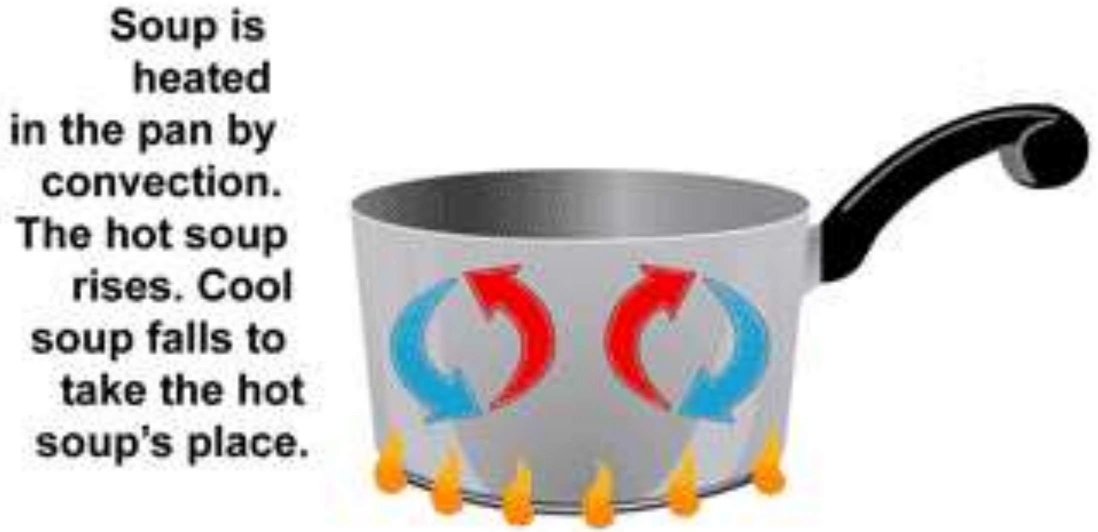




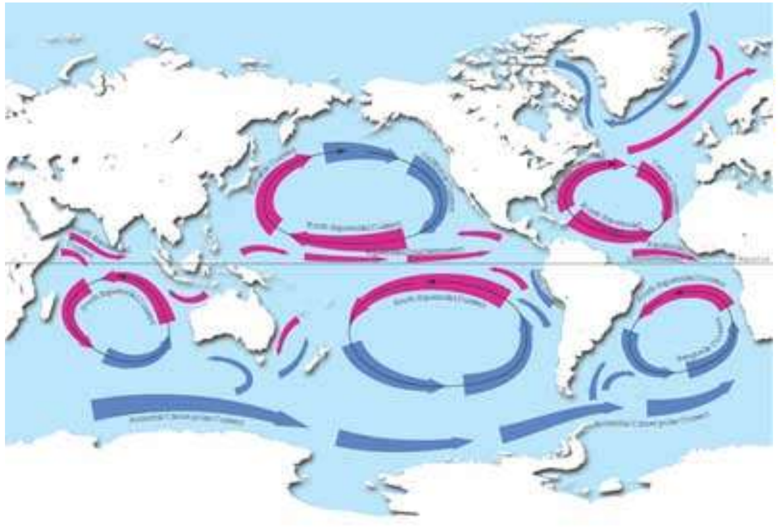


CONVECTION

- Convection is the movement of molecules within fluids (a liquid or a gas); the warm fluid rises and cooler fluids flow in to replace it. This creates a circular flow.

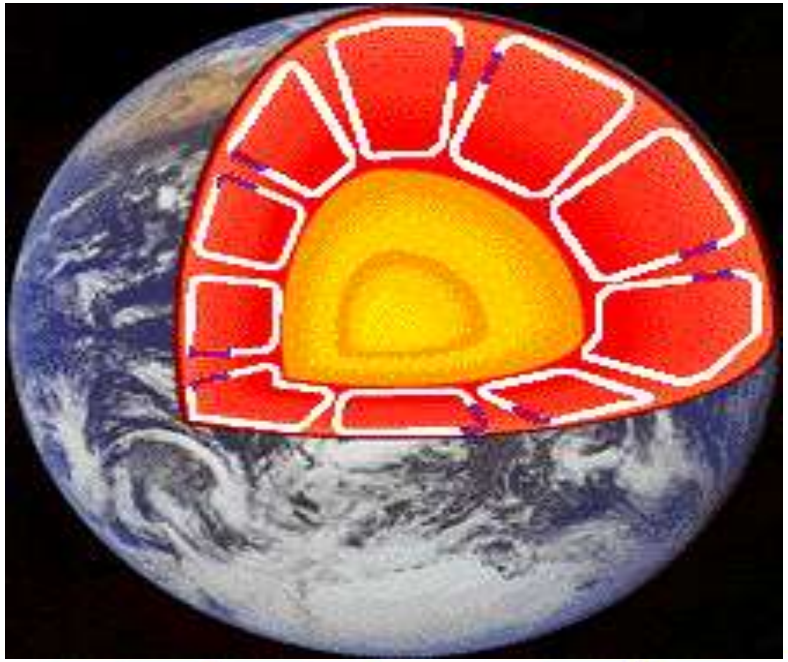


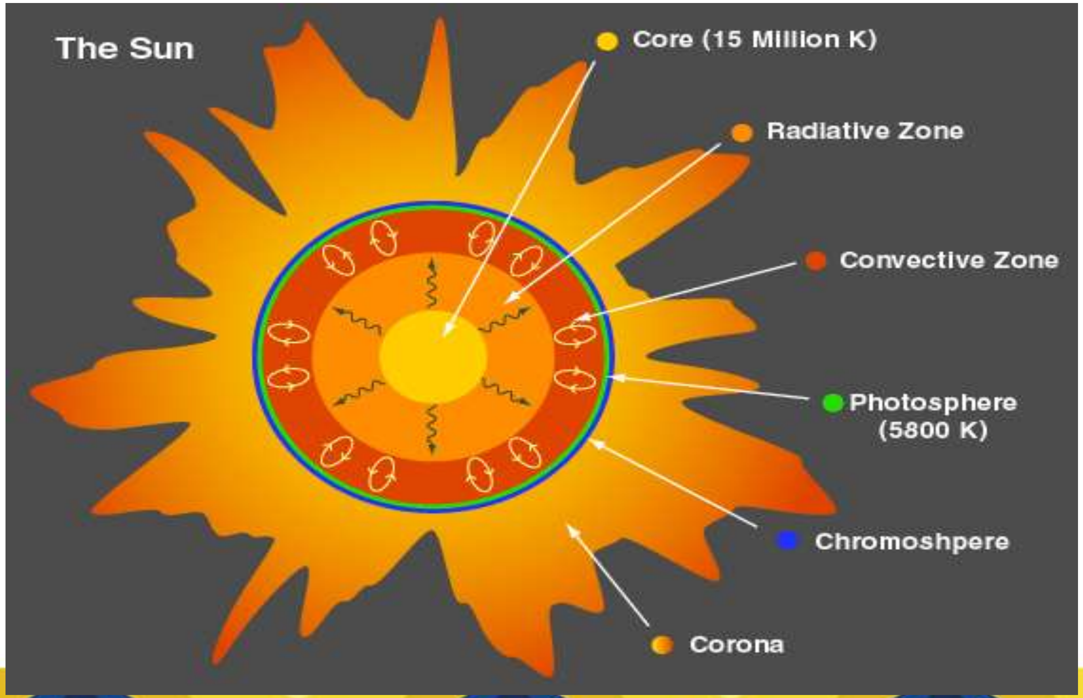
HEAT TRANSFER



CONVECTION – in the earth and sun

The circular flow of hot and cold creates convection currents





How does convection move?

- It is a result from the movement of hotter fluids to colder fluids.

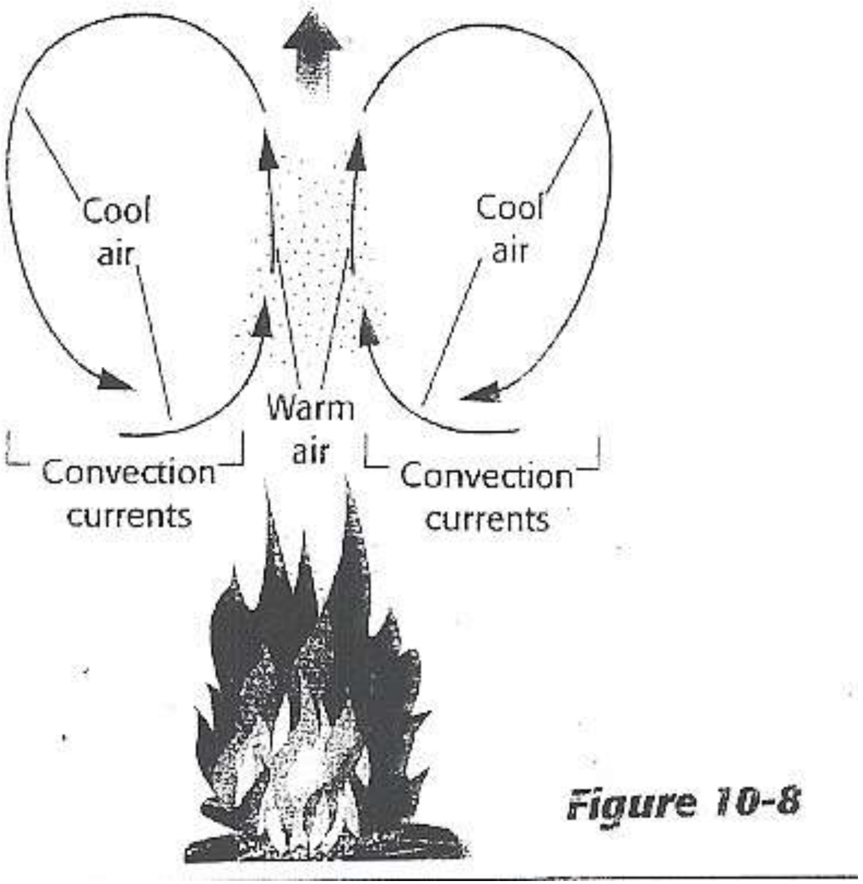


Figure 10-8

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HEAT TRANSFER

- What type of HEAT TRANSFER is occurring in the pictures? Conduction, convection or radiation?

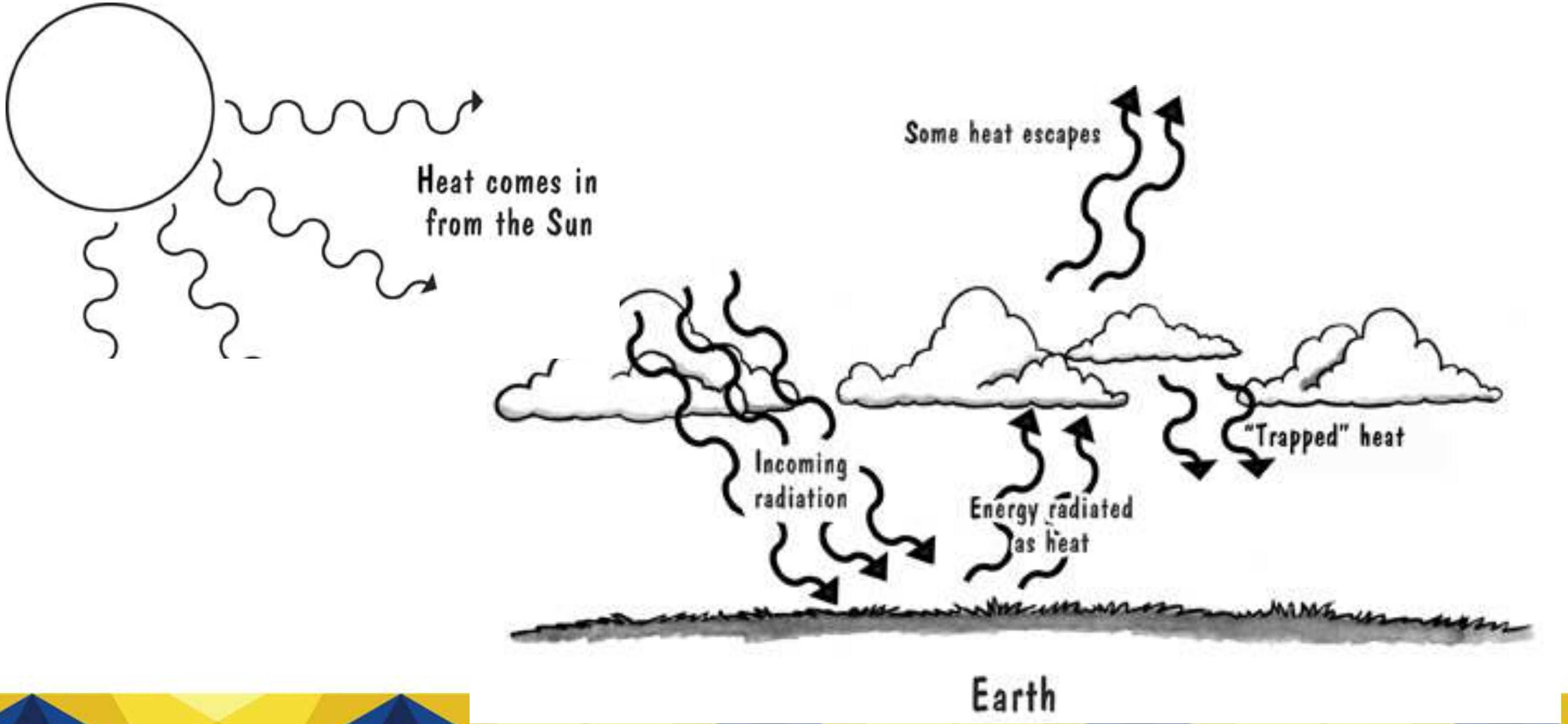
RADIATION –

The transfer of thermal energy by waves moving through space. ALL OBJECTS radiate energy!

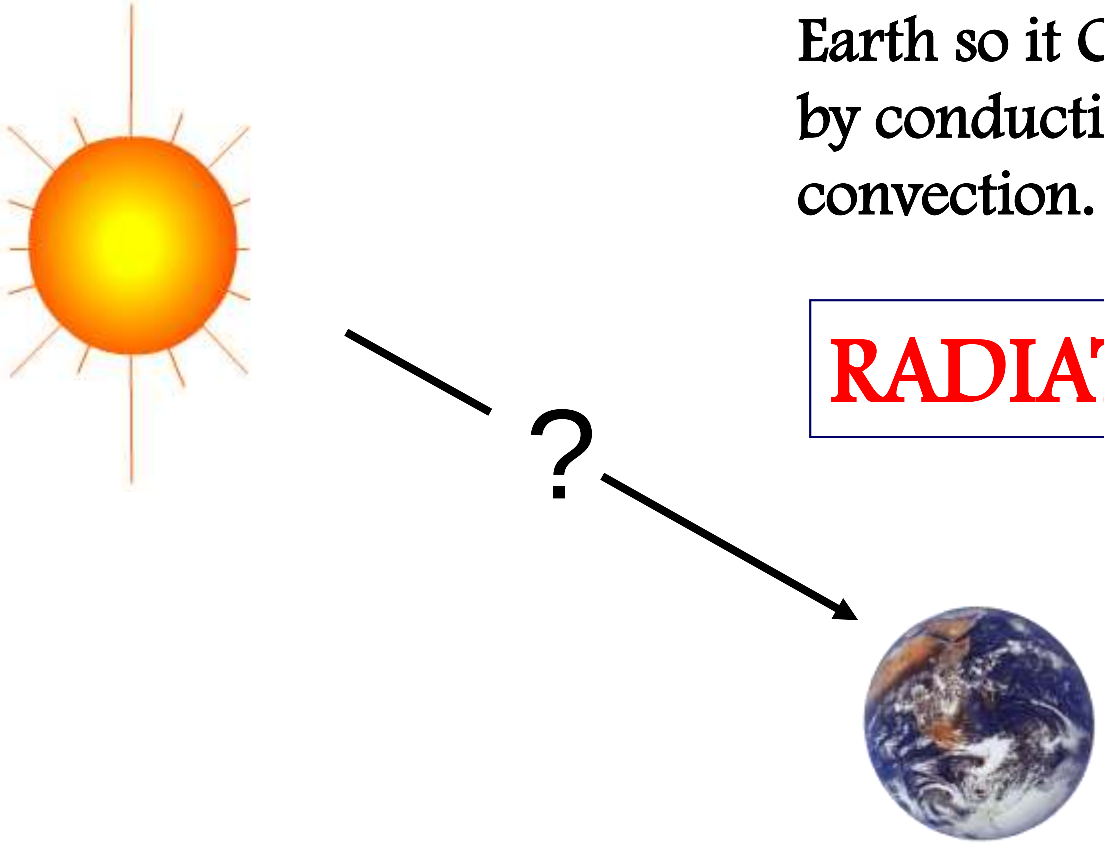
Heat Transfer: Radiation

-Heat is transferred through space

-Energy from the sun being transferred to the Earth



How does heat energy get from the Sun to the Earth?



There are no particles between the Sun and the Earth so it CANNOT travel by conduction or by convection.

RADIATION

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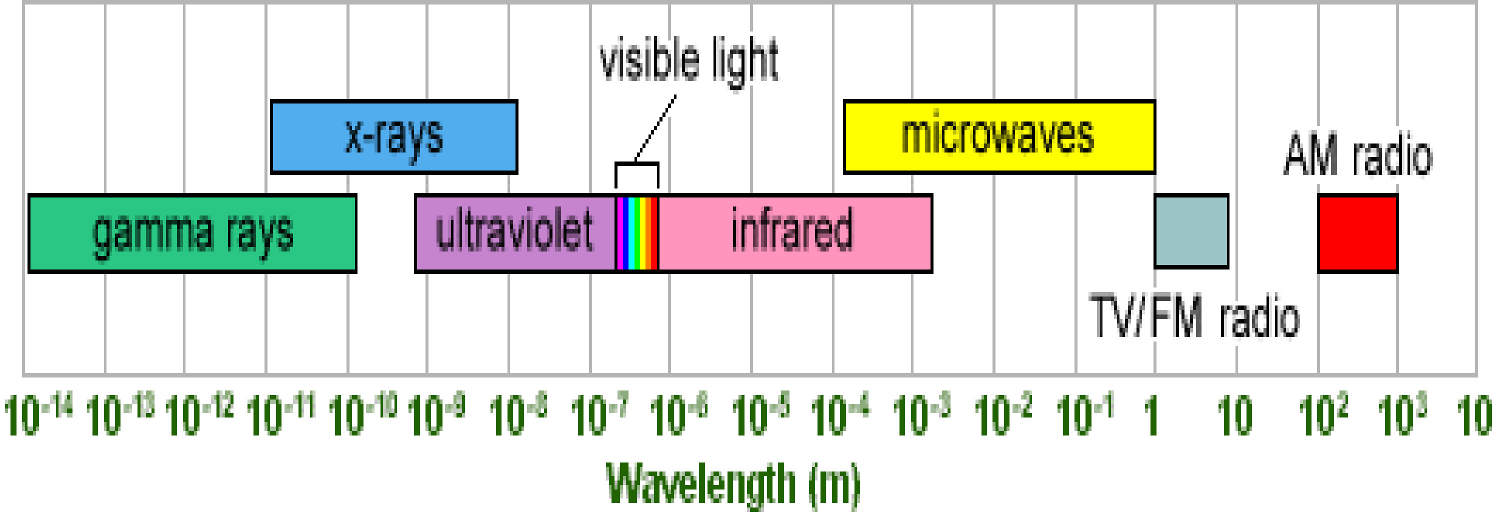
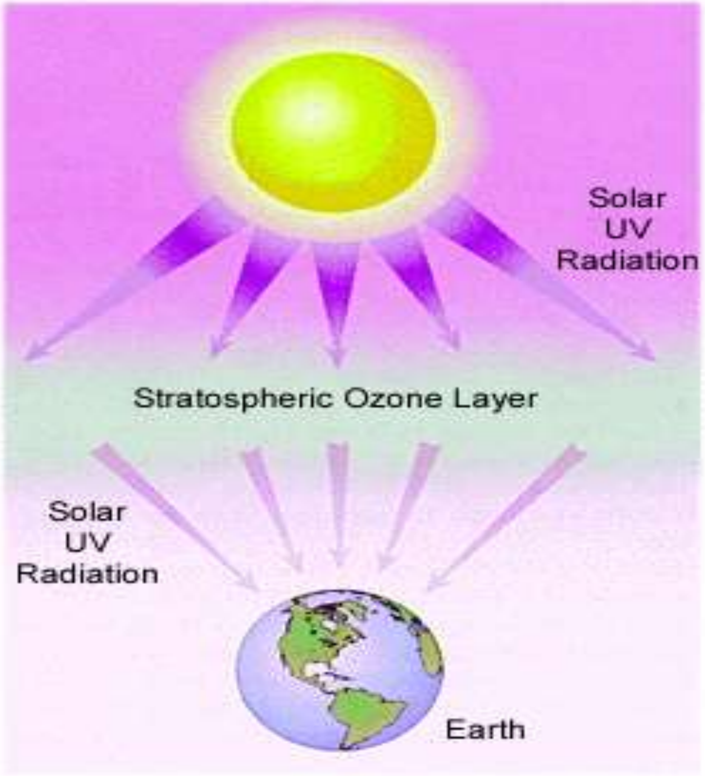
Radiation



- The energy that travels by electromagnetic waves (visible light, microwaves, and infrared light)

- Radiation from the sun strikes the atoms in your body and transfers energy



RADIATION

- The transfer of energy by electromagnetic waves.
- Radiation does not require matter to transfer thermal energy.

How does radiation differ from conduction and convection?

It does not involve or the movement of matter (or physical contact between objects).

So it can travel through a vacuum like space.

B. Conductors and Insulators

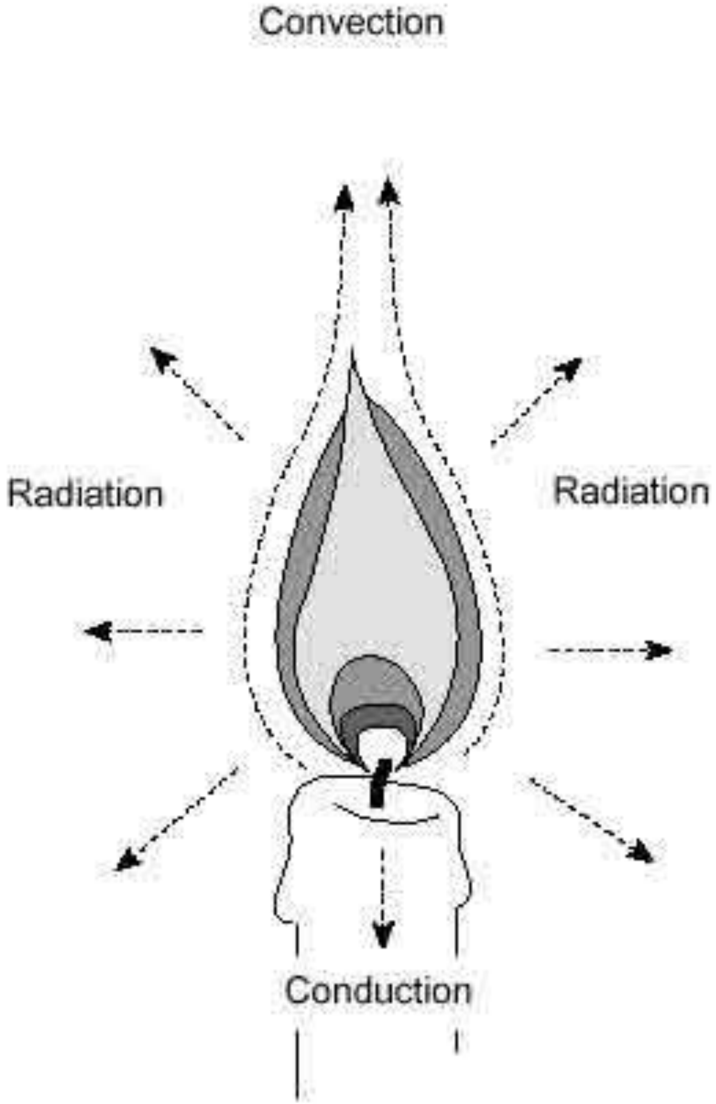
Materials are either conductors or insulators.

A conductor transfers thermal energy

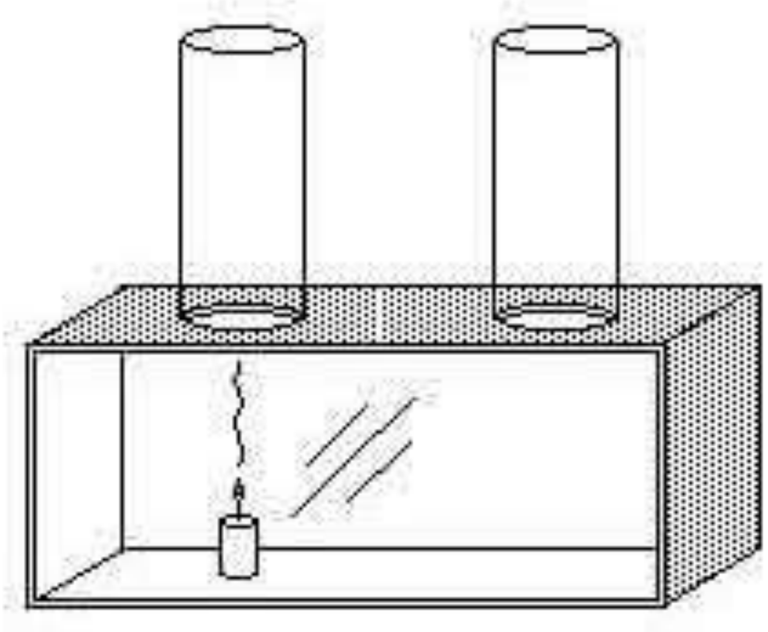
Ex:metals-silver and steel, tile floors takes heat away from your

An insulator does not transfer thermal energy well.

Ex: wood, wool, straw, paper



Candle Flame Energy Flow



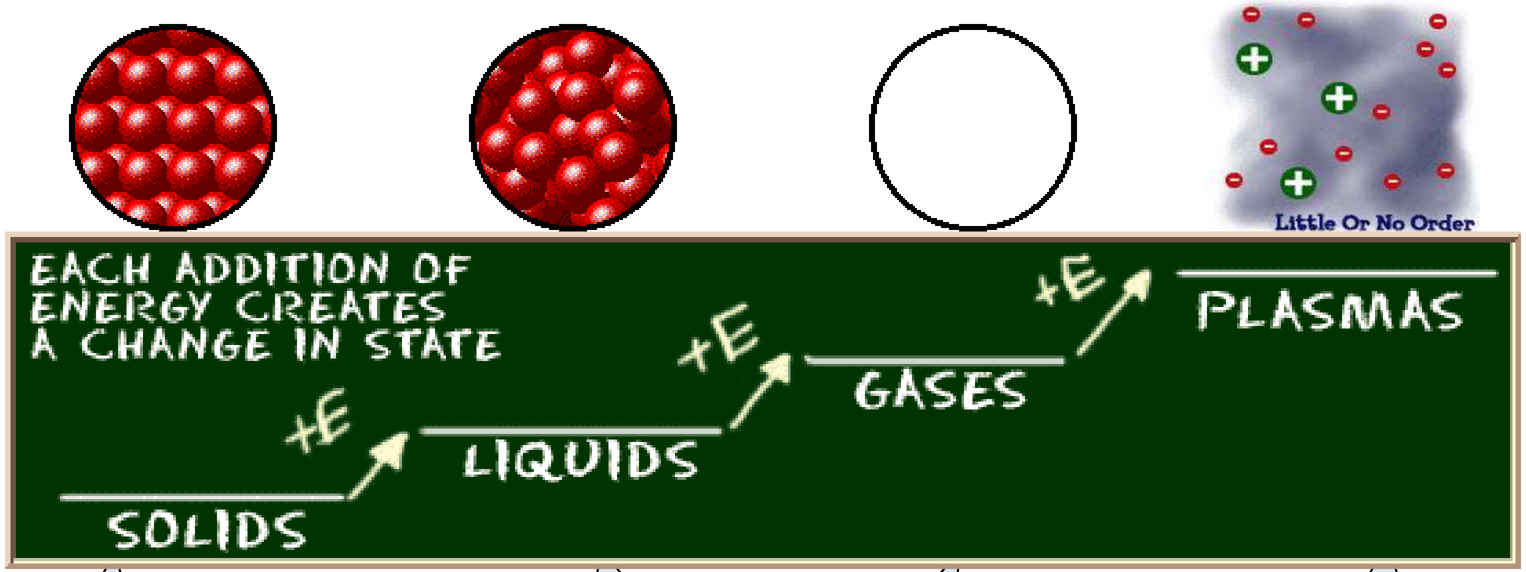
THERMAL ENERGY & MATTER

1. Define Convection, Conduction and Radiation
2. Give an example of each.
3. Write a sentence describing how each is important to our everyday lives.
4. How do we use heat in our everyday lives?

Thermal Energy and States of Matter

- Change of state-physical change from one state to another depends on thermal energy and…….
- particle arrangement
- energy of particles
- distance between particles

STATES OF MATTER



SOLID
Tightly packed, in a regular pattern Vibrate, but do not move from place to place

LIQUID
Close together with no regular arrangement. Vibrate, move about, and slide past each other

GAS
Well separated with no regular arrangement. Vibrate and move freely at high speeds

PLASMA
Has no definite volume or shape and is composed of electrical charged particles

PHASE CHANGES

Description of Phase Change	Term for Phase Change	Heat Movement During Phase Change
Solid to liquid	Melting	Heat goes into the solid as it melts.
Liquid to solid	Freezing	Heat leaves the liquid as it freezes.

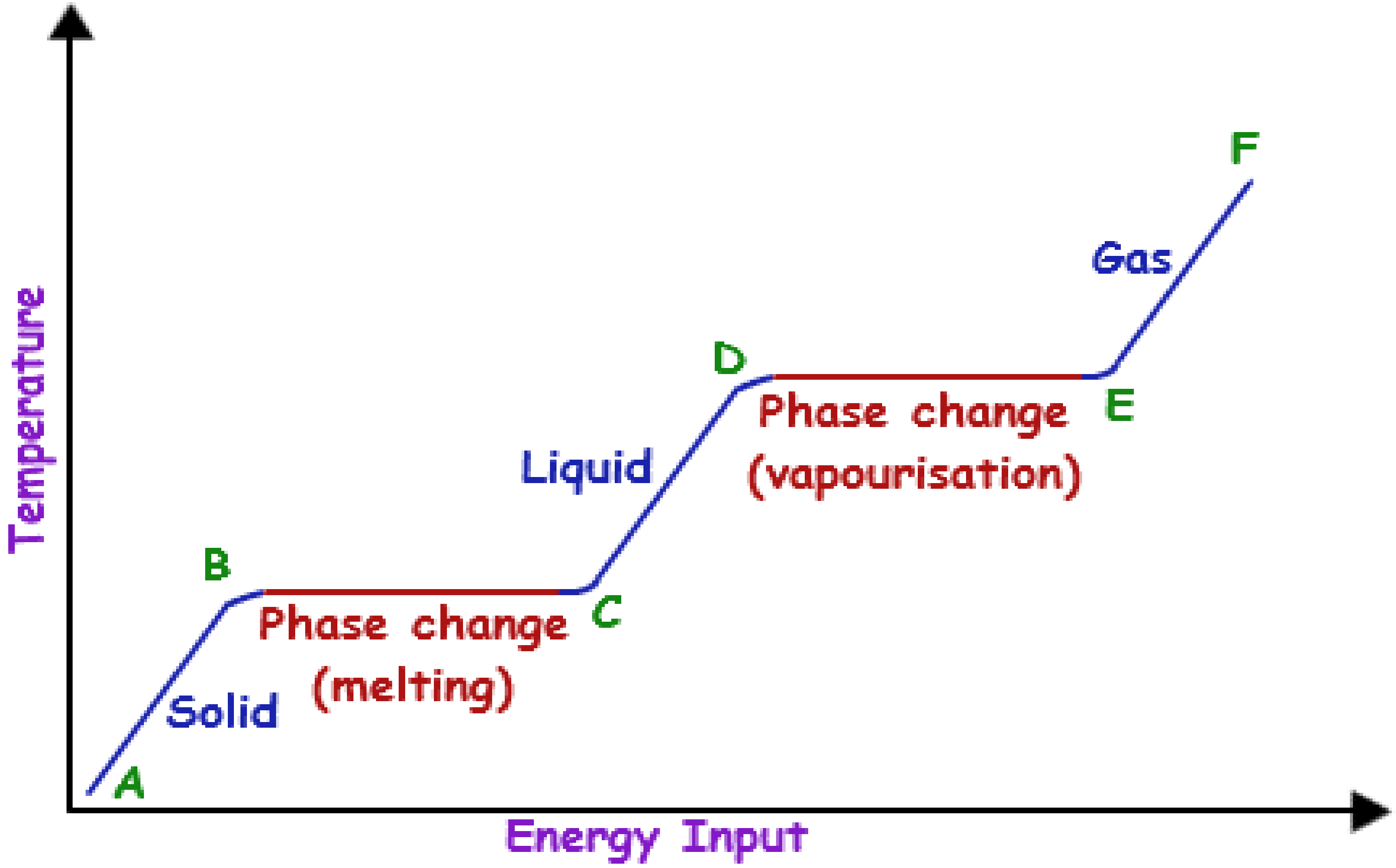
PHASE CHANGES

Description of Phase Change	Term for Phase Change	Heat Movement During Phase Change
Liquid to gas	Vaporization, which includes boiling and evaporation	Heat goes into the liquid as it vaporizes.
Gas to liquid	Condensation	Heat leaves the gas as it condenses.
Solid to gas	Sublimation	Heat goes into the solid as it sublimates.

Vaporization

- Vaporization- changing from a liquid to gas
- If vaporization takes place at the surface of a liquid it is called evaporation
- If vaporization occurs below the surface it is called boiling

Phase Change diagram



Thermal Expansion

- Expansion of matter when it is heated.

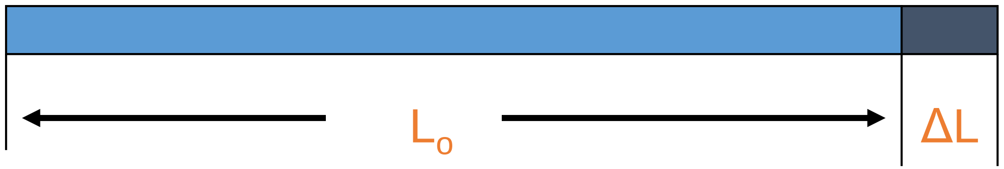
- As matter is heated particles spread out and as it cools particles contract.
- Thermostats work on the properties of thermal expansion.
- How thermostats work:

http://www.youtube.com/watch?v=6r9UAdb2kDo

Thermal Expansion

- Substances expand as they heat and contract as they cool.
- The rate of expansion depends on the substance's coefficient of expansion (α for linear, β for volume)
- The exception to this rule is water. As water is cooled from 4°C to 0°C, it expands which explains why ice floats (it is less dense than water).

Thermal Expansion - Linear



Linear expansion: objects expand along linear dimensions such as length, width, height, diameter, etc.

$$\Delta L = L_o \alpha \Delta T \qquad L_F = L_0 + \Delta L$$

ΔL = change in length measurement, (same units as original length)

L_o = original length, (any length unit – m, cm, in)

ΔT = change in temperature (°C) = $T_f - T_i$

α = coefficient of linear expansion (1 / °C or $°C^{-1}$)

L_F = final length, (same units as original length)

Thermal Expansion (Volume)

Volume expansion: since objects expand in all dimensions, volume also expands.

$$\Delta V = V_o \beta \, \Delta T \qquad V_F = V_O + \Delta V$$

ΔV = change in volume (same units as original volume)

V_o = original volume, (any volume units – L, mL, cm^3)

ΔT = change in temperature (°C) = $T_f - T_i$

β = coefficient of volume expansion (1 / °C or $°C^{-1}$)

V_F = final volume, (same units as original)

Thermal Expansion

- Increasing the temperature of a gas at constant pressure causes the volume of the gas to increase. (Also occurs in solids and liquids)
- **In general, as the temperature of a substance increases, the volume also increases. This is known as thermal expansion.**

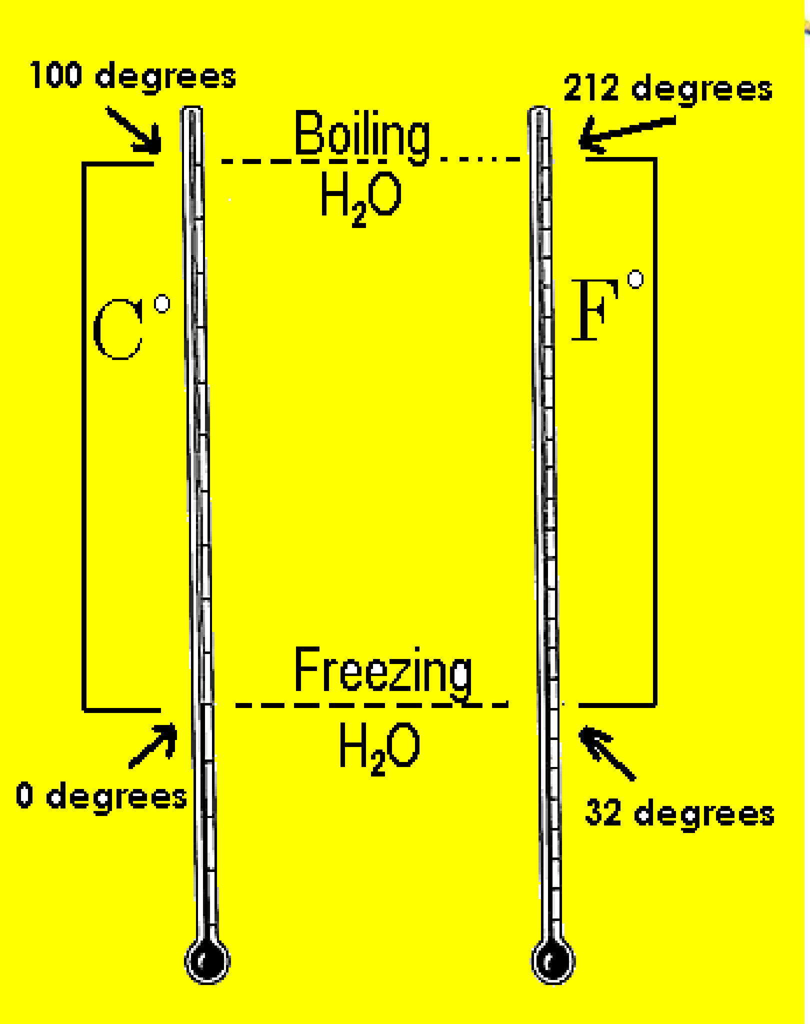
KNOWLEDGE TANK

Daniel Gabriel Fahrenheit

- He discovered, among other things, that water can remain liquid below its freezing point and that the boiling point of liquids varies with atmospheric pressure.
- Fahrenheit temperature scale, scale based on 32 degree for the freezing point of water and 212 degree for the boiling point of water, the interval between the two being divided into 180 parts.
- Fahrenheit originally took as the zero of his scale the temperature of an equal ice-salt mixture and selected the values of 30 degree for the freezing point of water and 90 degree for normal body temperature.

After Fahrenheit died in 1736, scientists calibrated his model of thermometer using 212 degrees, the temperature at which water boils, as the upper fixed point, and 32 degree for water freezing.

When the Fahrenheit thermometer was recalibrated, normal human body temperature registered 98.6 rather than 96.

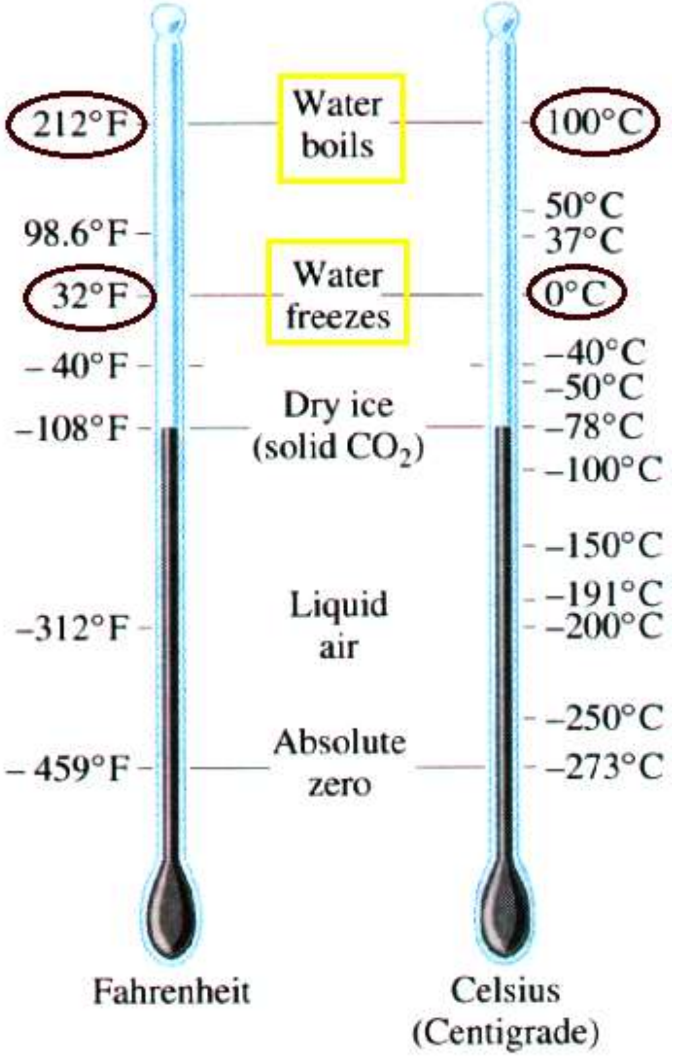


The Celsius temperature scale was invented by Anders Celsius (1701-1744) a Swedish Astronomer

- For his meteorological observations he constructed his world famous Celsius thermometer, with 0 for the boiling point of water and 100 for the freezing point.
- After his death in 1744 the scale was reversed to its present form with zero as water's freezing point.

Celsius Temperature Scale

- The **Celsius scale** often countries system. It i
  freezing point – set at 0° and its boiling point – set at 100°.



Kelvin temperature scale

The temperature scale is named after the British mathematician and physicist **William Thomson** Kelvin (1824 – 1907) who proposed it in 1848.

Kelvin temperature scale, has an absolute zero below which temperatures do not exist.

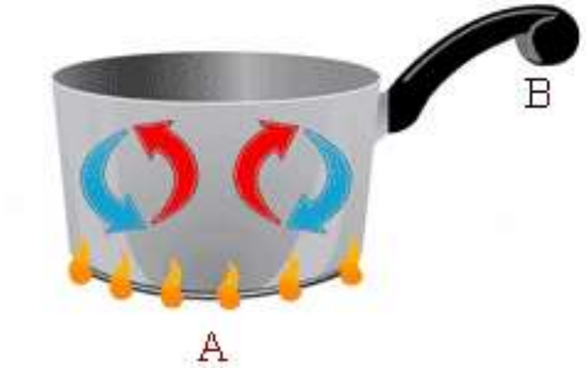
Absolute zero or 0 K, is the temperature at which molecular energy is a minimum, and it is equal to a temperature of -273.15° on the Celsius scale.

The Kelvin degree is the same size as the Celsius degree.

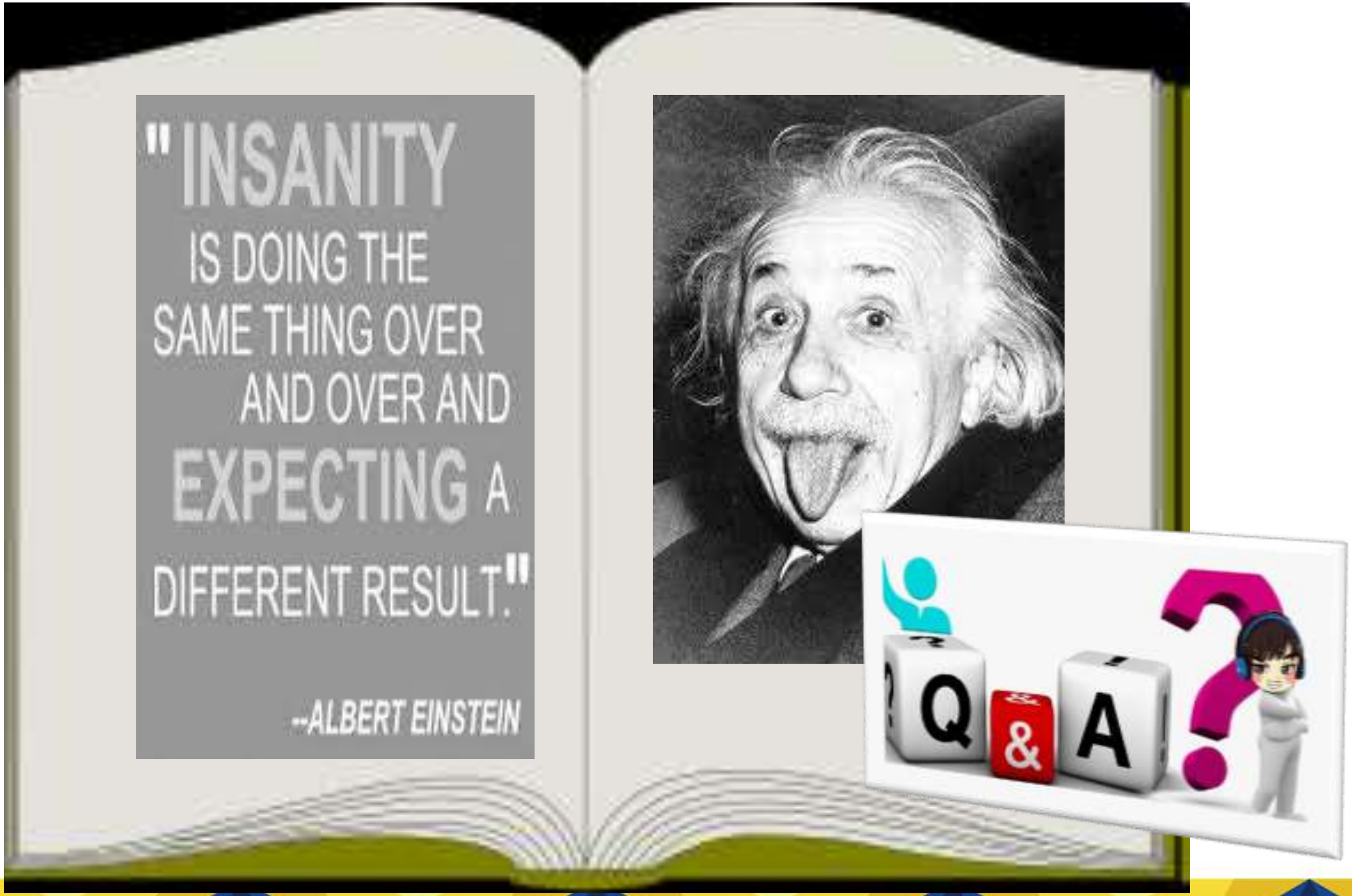
(When writing temperatures in the Kelvin scale, convention the degree symbol is left out and we merely use the letter K.)

ASSESMENT

- What are the 3 ways heat is transferred
- Convection, Conduction, and Radiation
- TRUE or FALSE The transfer of energy by electromagnetic waves is the definition for Convection
- False



- TRUE or FALSE In this picture “B” is representing a heat conductor and “A” is representing heat convection?
- True


"INSANITY
IS DOING THE
SAME THING OVER
AND OVER AND
EXPECTING A
DIFFERENT RESULT."
--ALBERT EINSTEIN
Q & A