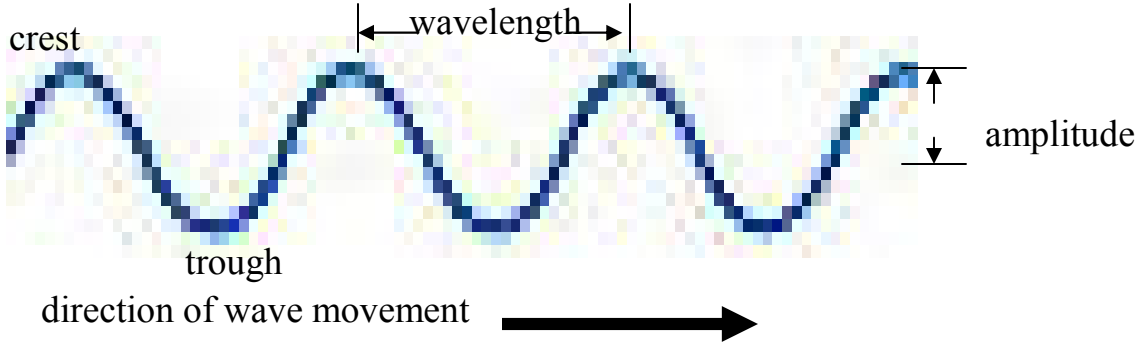
Regents Earth Science – Unit 4: Energy and Heat

Energy

The sun is the major source of energy for the Earth's processes

- the sun radiates energy as **Electromagnetic Energy** - energy given off in the form of transverse waves
- **Parts of a Wave:**

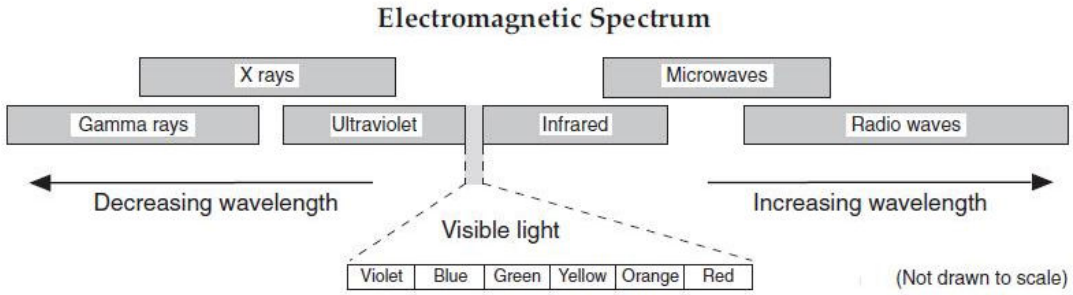


- **wavelength** - distance from one crest to the next
- **frequency** - number of waves that pass a point in one second of time

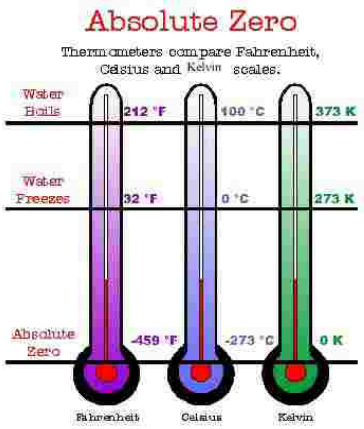
Length of the transverse wave determines the **type** of energy:

Reference Tables p.14

- visible light is a small portion of the entire spectrum

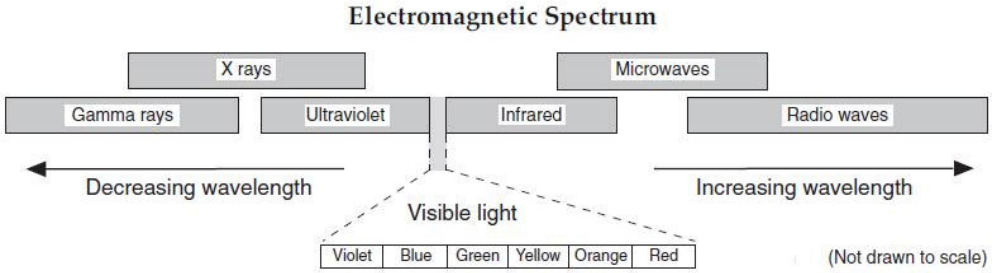


Energy



All matter above absolute zero radiates electromagnetic energy

- **absolute zero** - the coldest an object can get – when particles of matter have no motion
- temperature determines the amount and type of electromagnetic energy given off by an object
- hotter = shorter waves
- hotter = more energy

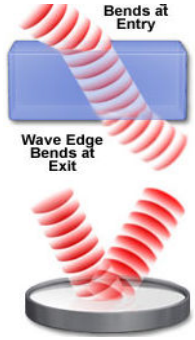


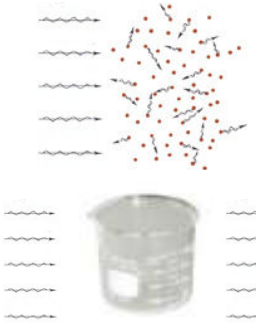
- SHORT waves are powerful - from HOT materials
- LONG waves are weaker - from COLD materials

- the Sun gives off ALL forms of electromagnetic energy (most intense at visible wavelengths)
- Earth re-radiates energy at I.R. wavelengths (heat)

When electromagnetic energy interacts with a material it will be:

1. **Refracted** – waves bend
2. **Reflected** - bounces off at same angle
3. **Scattered** - in various directions
4. **Transmitted** - passes through
5. **Absorbed** - taken into a material – results in heating the material





Factors that Effect the Amount of Radiation Absorbed:

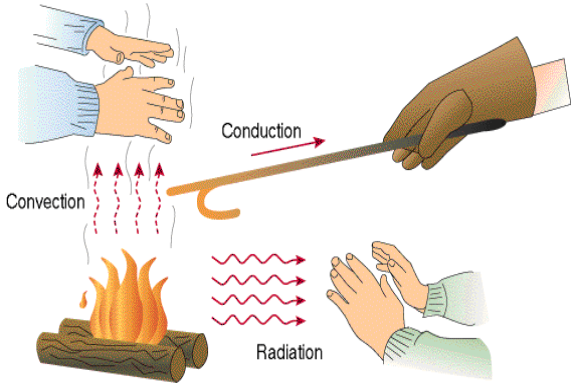
1. **Color** - the darker the color of the surface of a material, the more radiation it will absorb
2. **Texture** - the rougher the surface of a material, the more radiation it will absorb

- good absorbers of energy are also good radiators of energy
- poor absorbers of energy are poor radiators of energy

Transfer of Energy

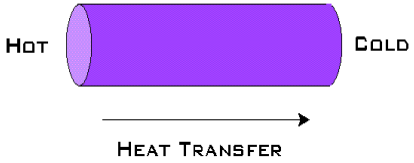
Energy always flows from hot (high potential – **source**) to cold (low potential – **sink**) and is transferred in 3 ways:

1. **Conduction** - the transfer of heat by collisions of molecules (direct contact)
2. **Convection** - the transfer of heat by movement of a hot fluid due to density differences
3. **Radiation** - the transfer of heat by transverse waves (electromagnetic radiation)



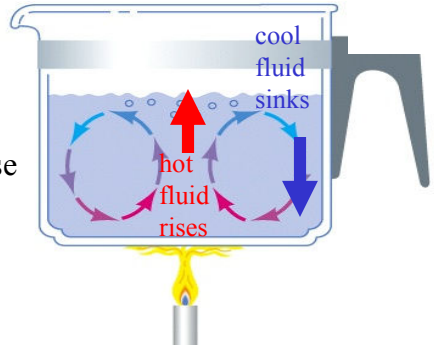
Conduction - occurs best in solids

- molecules are in very close contact in solids
- adding heat to a solid causes the molecules closest to the heat source to vibrate faster
- they in turn cause the molecules next to them to vibrate faster (transfer energy) and this continues through the solid material



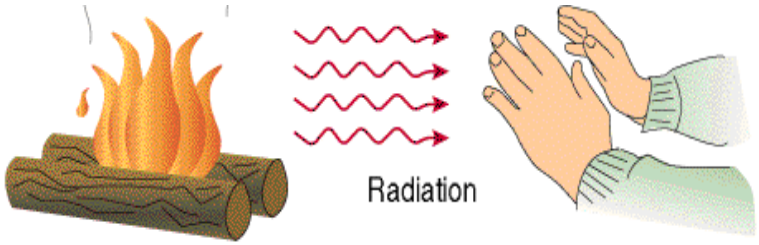
Convection – occurs in fluids (gases and liquids)

- hot materials expand becoming less dense and rise (in fluids)
- cooler, more dense fluids will sink and replaces the risen, less dense fluid
- this creates a circulatory pattern of movement called a **convection current (convection cell)**



Radiation – occurs through a transparent material or vacuum (space)

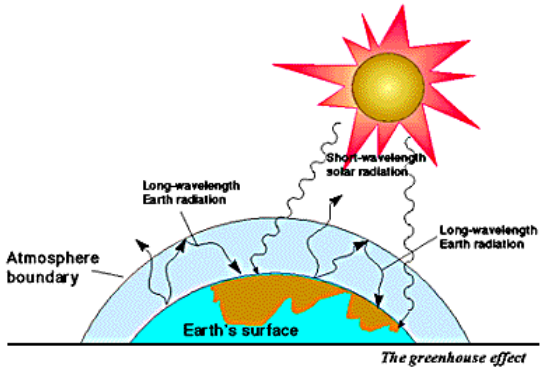
- heat (infrared radiation), light, and all other forms of electromagnetic radiations are transferred by the process of radiation



Transfer of Energy

re-radiated energy – energy radiated back out to the environment or space

- energy from the Sun (visible sunlight) is *short* wavelength radiation
- this radiation is absorbed by the Earth's surface and then re-radiated back out towards space in the form of *longer* wavelengths – infrared radiation (heat)

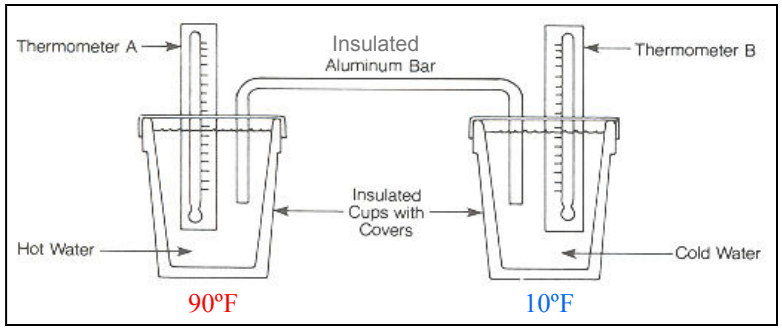


The greenhouse effect

Energy Systems

Closed System – a system that is "cut off" or insulated from its surroundings – no heat/energy enters or leaves the system

- in a closed system, all the heat energy that leaves the hot cup will go to the cold cup – no energy is lost to the environment
- when transferred, both cups will reach equilibrium *with each other* – they will each be 50ºF
- closed systems do not occur in nature



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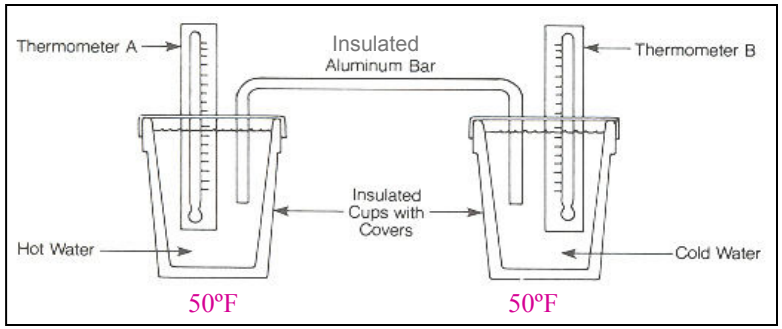
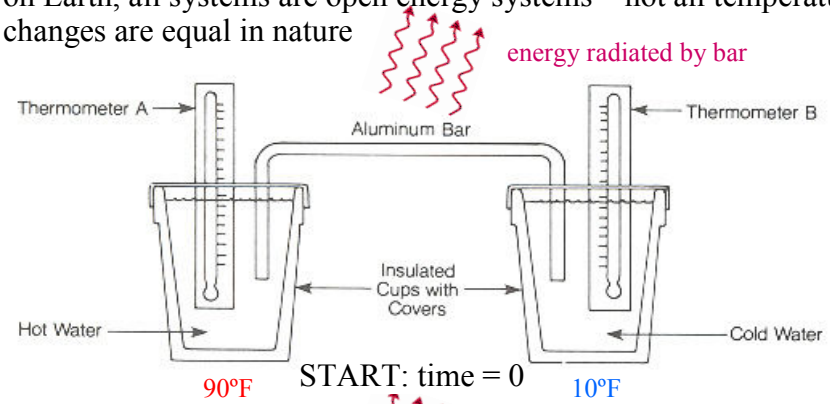


END: time = 20 minutes

Open System – heat/energy can enter/leave the system – not all energy is transferred

- not all of the energy lost by one is transferred to the other, but some energy is *lost to the environment* (in this case by radiation)
- when transferred, the hot cup lost more energy than the cold cup gained
- on Earth, all systems are open energy systems – not all temperature changes are equal in nature



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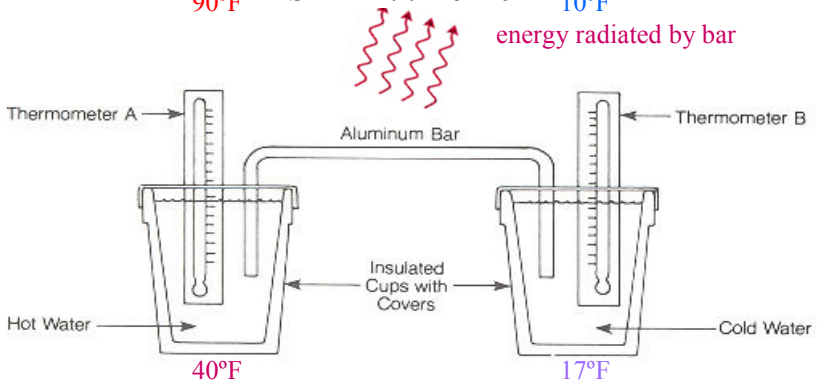
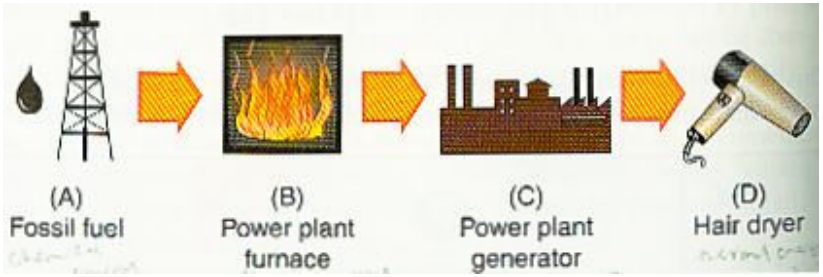


END: time = 20 minutes

Conservation of Energy

Conservation of Energy – energy is neither created nor destroyed – it is converted from one form to another

- the total energy of a system always **remains the same** (energy in = energy out)
- ex. a car needs gasoline to run - most of the energy contained within the gasoline is used to make the car move (fuel ignites in the piston forcing the piston to move)
- some of the gasoline's energy is converted into heat (engine gets hot) and some is converted into electricity used to charge the car's battery

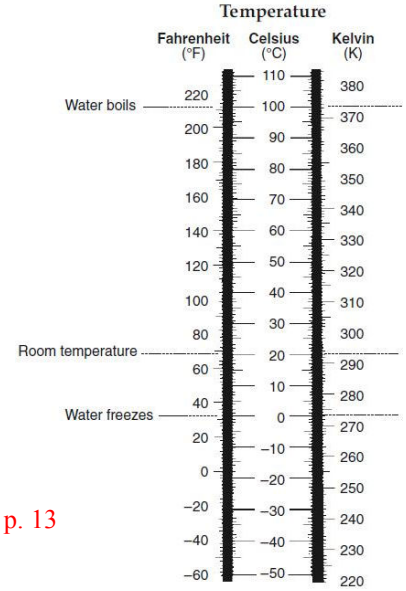


Temperature

Temperature – the average kinetic energy of the particles of a body of matter

- all objects above absolute zero have particles that are in continuous, random motion (kinetic energy)
- the faster the particles are moving, the more kinetic energy they have, and the higher the temperature of the object

Thermometer – instrument used to measure the temperature of an object – indicated on a scale marked in degrees



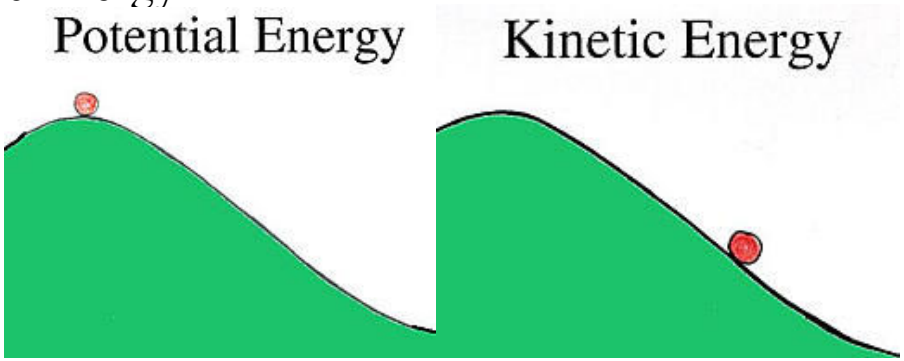
Reference Tables p. 13

Potential/Kinetic Energy

Kinetic Energy – energy of motion

Potential Energy – energy related to position or phase (solid, liquid or gas); energy that is stored

- kinetic and potential energy can be transformed from one to the other
- **Ex**.: a ball at the top of a hill has potential energy (it is high above the center of Earth so it has a great potential to fall) – as the ball rolls down the hill, some of its potential energy is transformed into kinetic energy and the ball rolls faster



Heat

Heat - the **total energy** of a material

- includes: kinetic and potential energy

kinetic heat energy determines the *temperature* of the material

- adding kinetic heat raises the temperature

- potential heat is called **latent heat**

potential heat energy determines the *phase of matter* of the material

- adding potential heat changes the phase

Temperature and Heat

Heat energy is transferred from hot (high potential – source) to cold (low potential – sink) objects

Specific Heat – the amount of heat energy needed to raise the temperature of any substance 1ºC

- the higher the specific heat of a substance, the harder it is to heat it up (or cool it down)
- the lower the specific heat of a substance, the easier it is to heat up (or cool down)
- liquid water has the highest specific heat of all substances

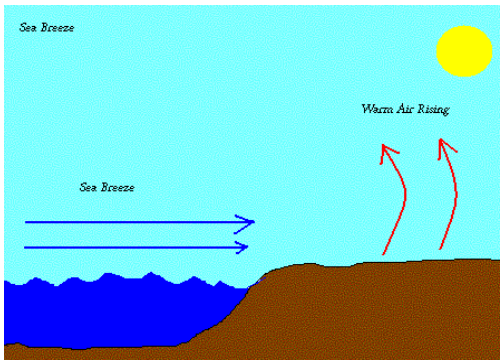
Reference Tables p. 1

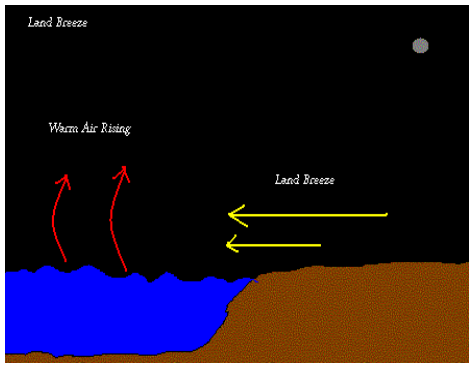
Specific Heats of Common Materials

MATERIAL	SPECIFIC HEAT (Joules/gram • °C)
Liquid water	4.18
Solid water (ice)	2.11
Water vapor	2.00
Dry air	1.01
Basalt	0.84
Granite	0.79
Iron	0.45
Copper	0.38
Lead	0.13

Potential Heat Energy - Changes of State (Latent Heat)

- **water** has a **high specific heat**
- water needs lots of heat to warm (warms slowly)
- water has to loose lots of heat to cool down (cools slowly)

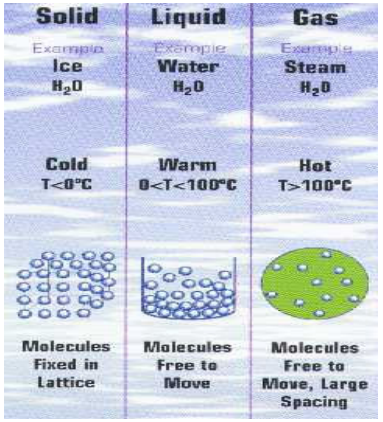




- **land** has a **low specific heat**
- land needs little heat to warm (warms quickly)
- land looses little heat to cool down (cools quickly)

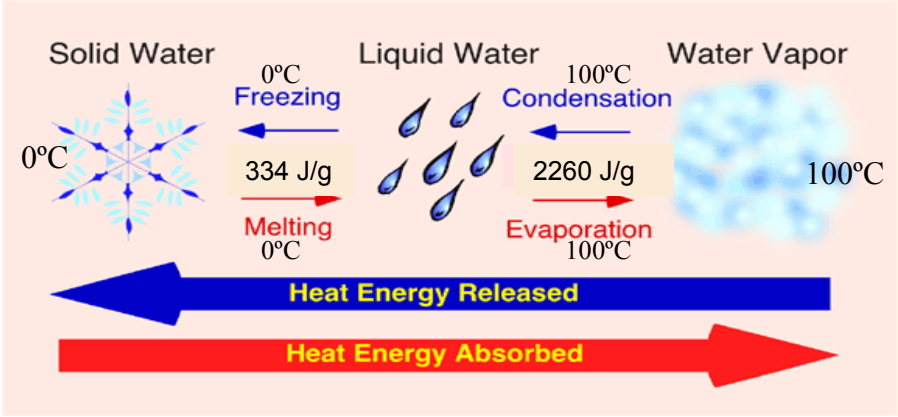
Potential Heat Energy - Changes of State (Latent Heat)

Matter exists in 3 phases: solid, liquid and gas



- **SOLIDS** – cold temperatures, tight bonds holding the molecules together
- **LIQUIDS** – warm temperatures, loose bonds holding the molecules
- **GASES** – hot temperatures, bonds are broken, molecules move freely

When a material changes phase, heat is added but the temperature does NOT change - what happens to the heat?



- phase changes result from a change in the amount of heat
- phase changes are the **PROCESSES** that alter the bonds of molecules

Increasing Heat Phase Changes:

Melting – solid to liquid, adds 80 calories to 1 gram of water
(warms the melting material, cools the environment)

Vaporizing – liquid to gas, adds 540 calories to 1 gram of water
(warms the vaporizing material, cools the environment)

Decreasing Heat Phase Changes

Condensation – gas to liquid, loses 540 calories/gram of water
(cools condensing material, warms environment)

Freezing (Fusion) – liquid to solid, loses 80 calories/gram of water
(cool freezing material, warms the environment)

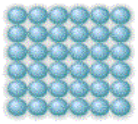
- the heat is used to break bonds holding the molecules - that is why liquids and gases can move more than solids
- Potential Heat (latent heat) changes phases - NOT temperatures

Sublimation – changing from a solid to gas or gas to a solid without going through the liquid phase

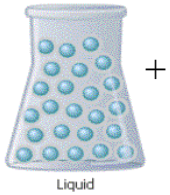
- **Ex.**: frozen carbon dioxide (dry ice)

Potential Heat – Phase Changes

- heat needed to melt is called "*Heat of Fusion*"
- heat needed to vaporize is called "*Heat of Vaporization*"

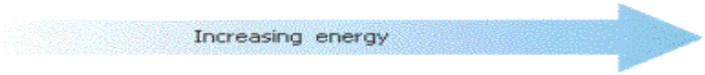


+ 334 J/g



+ 2260 J/g

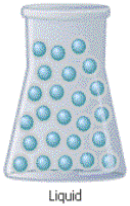
Heat of Fusion *Heat of Vaporization*



- *Heat of Fusion* and *Vaporization* are lost when the processes reverse

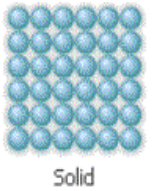
- 2260 J/g (cooling)

Heat of Vaporization



- 334 J/g (cooling)

Heat of Fusion



Phase Change Diagram

Note: there is no temperature change when changing phases – heat energy gained or lost is used to change phase