Ch 4 Heat and Temperature

Physical Science 115

Question:

- What is the difference between a hot cup of coffee and a cold cup of coffee?

  Yes, temperature

But, think small. What else?

- The molecules in the hot cup of coffee are moving faster—they are more energetic.

⇨More **thermal energy**

Internal Energy vs. Temperature

- Internal energy and temperature have to do with kinetic energies of the molecules in substances, but they are different

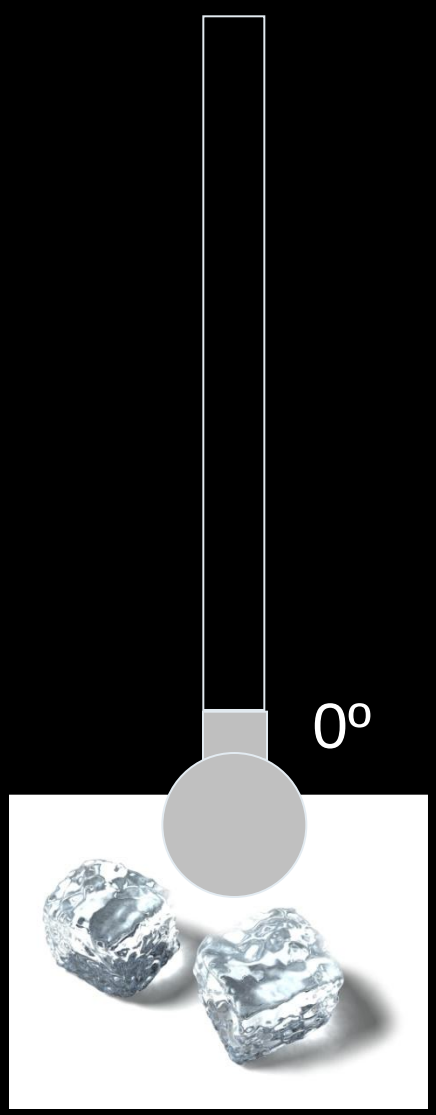
To start with:

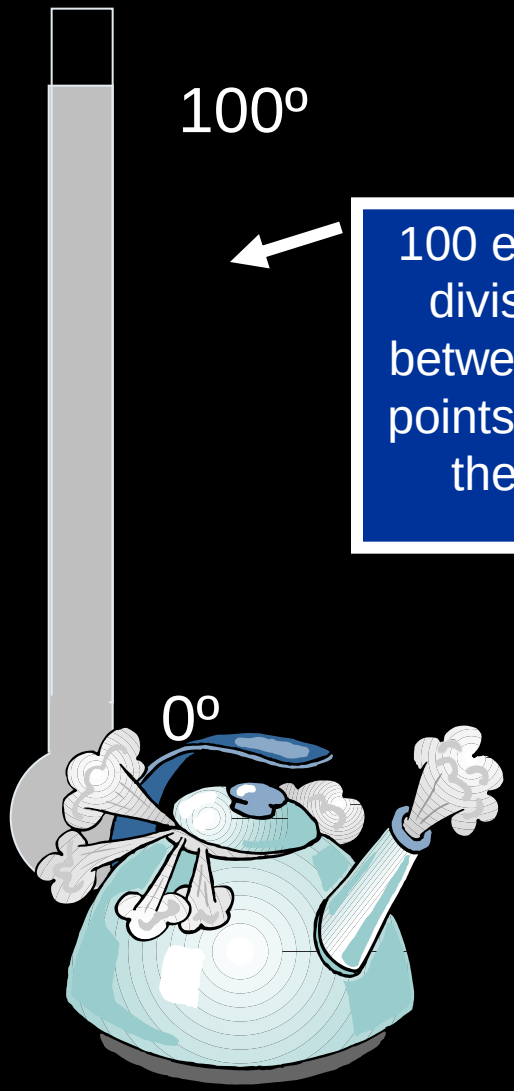
- Internal energy is energy measure in joules, calories.
- Temperature is measured in degrees.

Temperature

- Measuring hot and cold with our body is subjective.
- A thermometer is a reliable and reproducible way to measure “hotness” and “coldness”

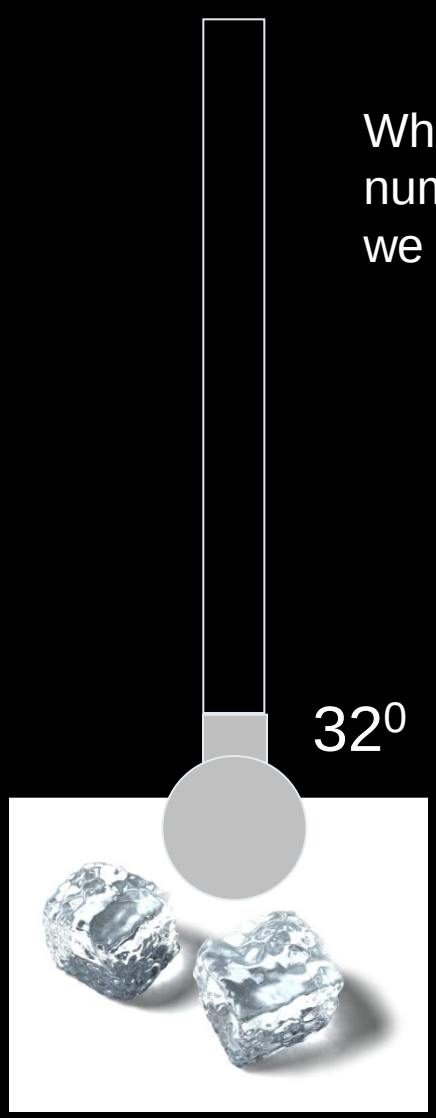
Temperature Scales



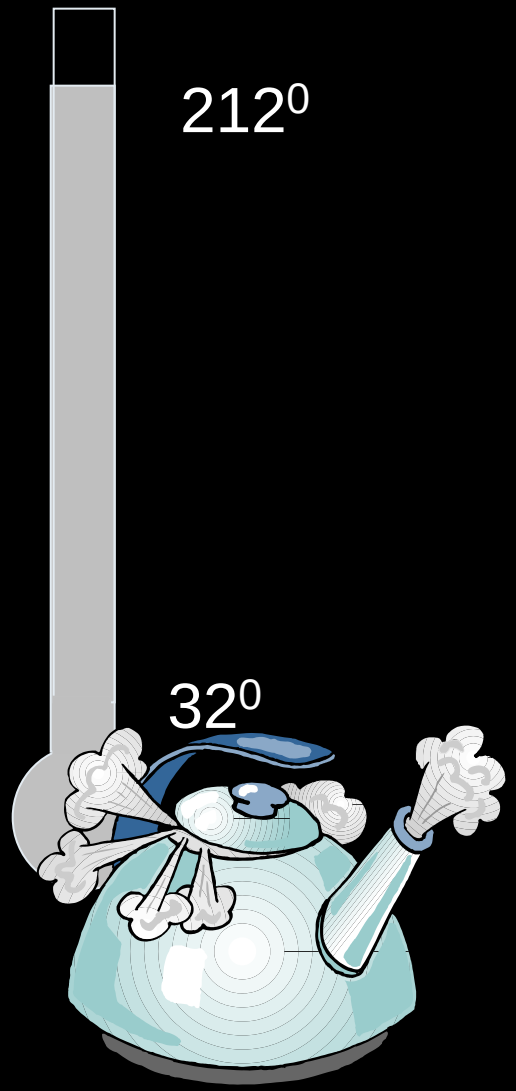


100 equal spaced divisions made between reference points—centigrade thermometer

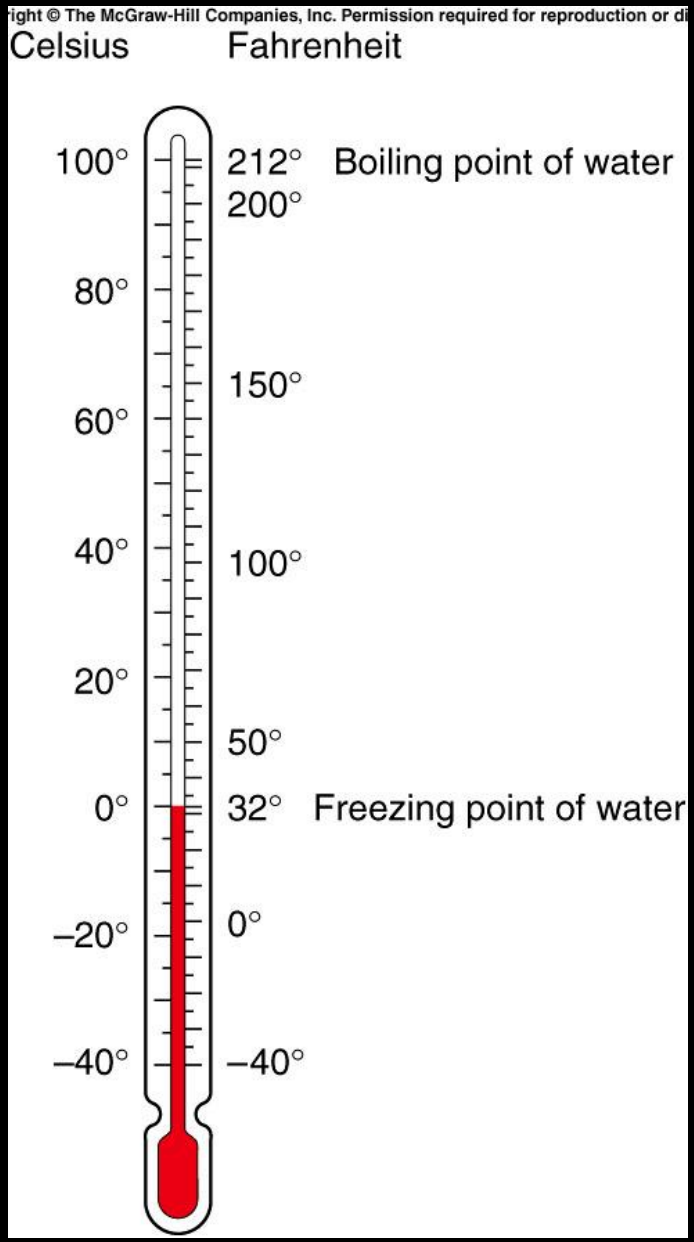
Temperature Scales



What other numbers could we use?



Which has the largest degrees, a Celsius thermometer or a Fahrenheit thermometer?



Hot Cherry Pie

- Suppose you order a hot piece of pie.
- Pie comes from freezer
  ⇨ 0^0 C
- What temperature is twice as hot?
- What if pie was 10^0 C? What would twice as hot be? No! Not 20^0 C

Celsius the Village Tailor

- Measure heights of all customers against the stick, which is against the wall.
- No need for stick to extend to ceiling or to floor.
- Stick has 273 notches between bottom and top.
- The distance above the ground, “absolute zero”, is also 273 notches.
- All tailors use same method, they can communicate amongst themselves.

One Day…

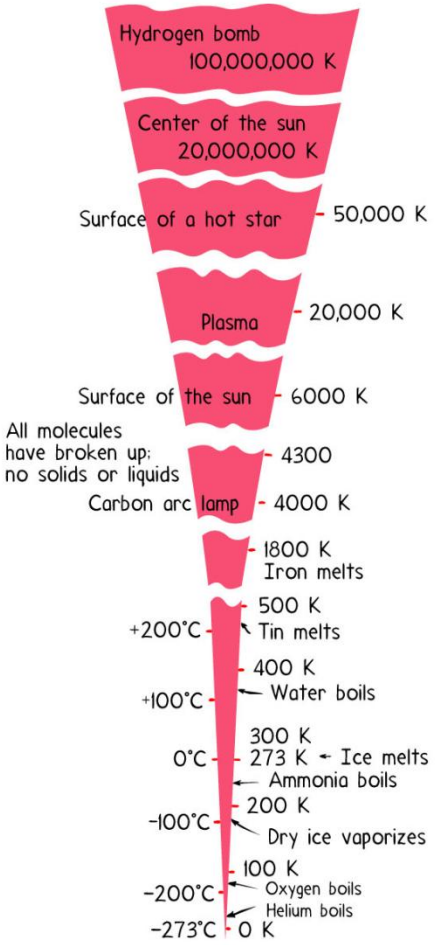
- A very short woman, measures zero on scale.
- She has a brother who is twice as tall, how tall is her brother?
- If 0^0 pie is twice as hot, how hot?
- If 10^0 pie is twice as hot, how hot?

Absolute Zero

- Temperature has no upper limit.

  solid⇨liquid⇨gas⇨plasma
- Lower limit on temperature is absolute zero.

Absolute zero—The temperature at which no more energy can be removed from a substance. It can't get any colder.



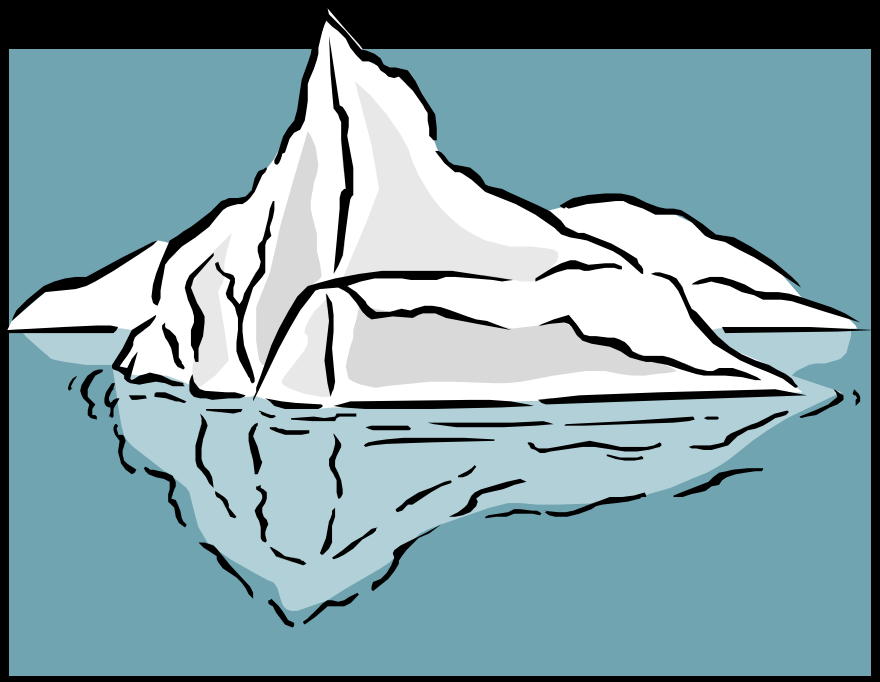
Kelvin Temperature Scale

- K = ºC + 273
- Absolute zero = 0 K
- No negative numbers on Kelvin scale.

Internal Energy

- The total energy stored in the atoms and molecules within a substance.

Compare a giant iceberg to a cup of coffee…



- Which has a higher temperature?
- Which has more internal energy?

Internal Energy vs. Temperature

- Internal energy and temperature have to do with kinetic energies of the molecules in substances, but they are different

To start with:

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Heat

- The energy exchange between objects because of temperature difference is called heat.
- “Heat flow” is redundant.

Calories

- A calorie is the amount of heat required to change the temperature of water by 1 Celsius degree

  1 Calorie = 4.18 J

1 “food calorie” = 1000 cal

4^{th} of July Sparkler

- Temperature = 2000^0C
- If sparks land on face, the heat received is small.
- High temperature ⇨high energy per moleule.
- High ratio doesn't necessarily correspond to high heat.

Comparison:

Temperature, Internal Energy, and Heat

Temperature	Internal Energy	Heat
Measures average kinetic energy.	The energies associated with motion and position within a substance.	The flow of thermal energy

Energy Flow

When you stick a nail into ice, does cold flow from the ice to your hand, or does thermal energy flow from your hand to the ice?

Answer: Thermal energy flows from your hand to the ice.

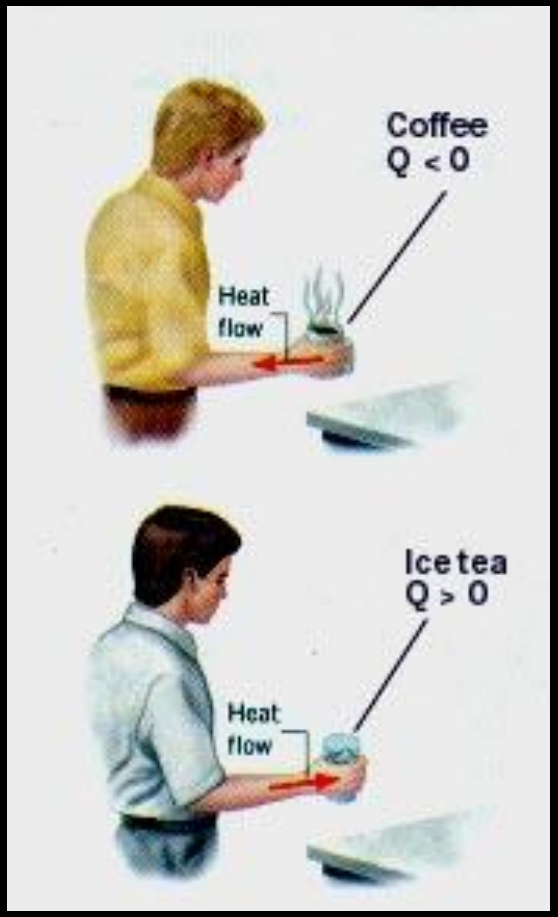
Thermal Equilibrium

Hot Coffee ⇨ “Cold” Hand

“Warm” Hand ⇨Ice Tea

Heat will flow from a hot object to a cold object until they are the same temperature.

When two objects are at the same temperature they are in thermal equilibrium.

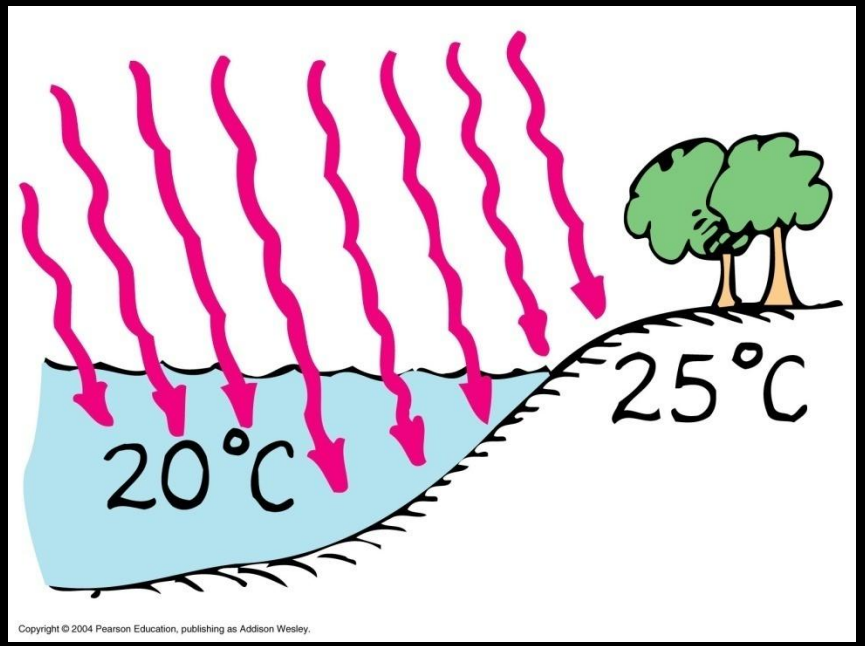


Specific Heat Capacity

- Have you ever noticed that the filling is much hotter than the crust?
- Different substances have different capacities for storing thermal energy.

Specific Heat of Water

- Water has a much higher capacity for storing energy than most all other substances.
- It takes more energy to warm the water than to warm the sand.



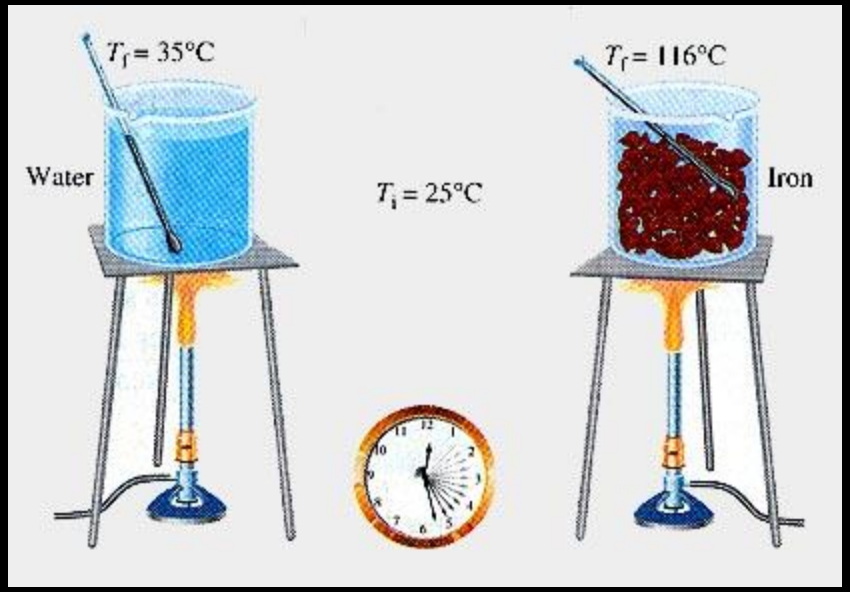
Formula--Specific Heat Capacity

The quantity of heat needed to change a unit mass of the material by a unit amount in temperature.

It is a property of the material.

$$Q = mc\,\Delta T$$

Specific Heat of Water vs. Iron

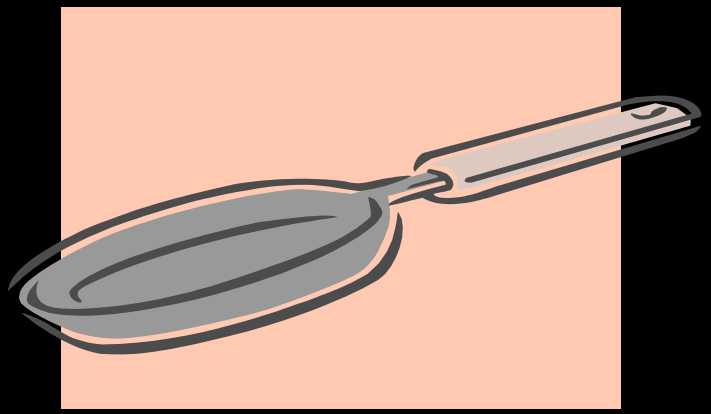


Same heat is absorbed.

Iron's ability to store heat is less than water's.

Iron's temperature rises more than does the water's.

Consider the difference in touching:

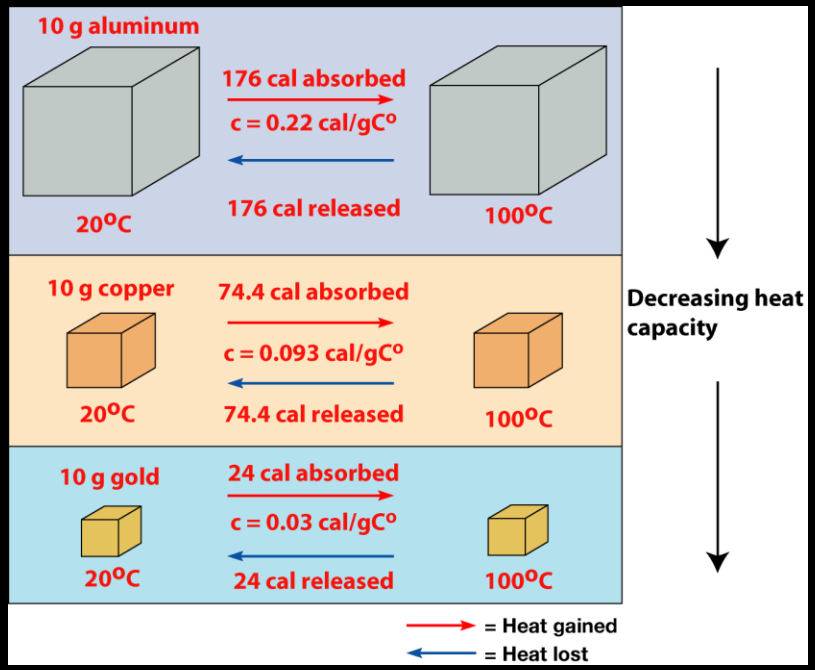


An empty iron frying pan that has been placed on a stove for one minute

A frying pan of water that has been on the stove for several minutes.

- Which pan has the higher temperature?
- Which absorbed the greater amount of energy?

Specific Heat



Variables involved in heating

- Temperature change
- Mass
- Type of material
  - Different materials require different amounts of heat to produce the same temperature change
  - Measure = specific heat

Summarized in one equation

$$Q = mc\Delta T$$

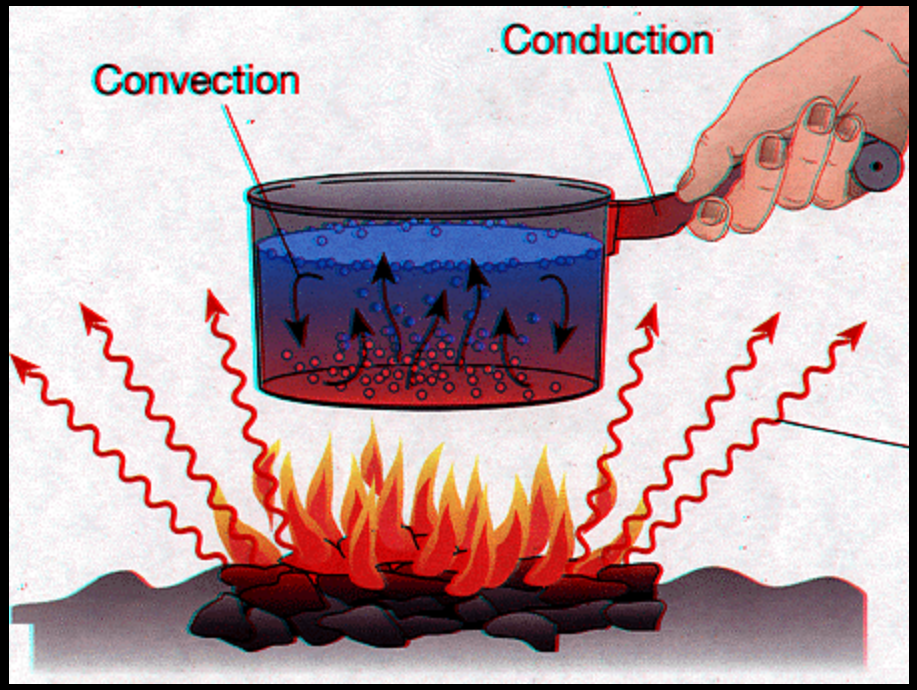
Example

A 0.500 kg piece of metal is heated to 200.0°C and then dropped into a beaker containing 0.400 kg of water that is initially at 20.0°C. If the final equilibrium temperature of the mixed system is 22.4°C, find the specific heat of the metal.

Heat Transfer

Three Types of Thermal Energy Transfer

1. Convection
2. Conduction
3. Radiation



Conduction

- **Conduction** moves heat from one particle to the next.
- It is due to collision between atoms.
- Example: when the stove burner heats a pan and its contents.
- Conduction allows the heat to be transferred inside and throughout a material rather than only heating the surface.

Cold Tile

- Tile floor and wood floor are at the same temperature
- Tile feels colder
- Tile is a better heat conductor
- Thermal energy moves more quickly from your feet.

Glass and Air are poor conductors.

- Long Stem
- Conduction of heat is minimized

- Air is also a poor conductor.
- Hand in pizza oven does not burn unless you touch metal!

Snow is a poor conductor of thermal energy.

- Snowflakes trap air.
- Provides insulation.
- Blanket of snow insulates ground.
- Igloo doesn’t provide thermal energy, it slows down the loss of energy.

Which home has more insulation in the attic?

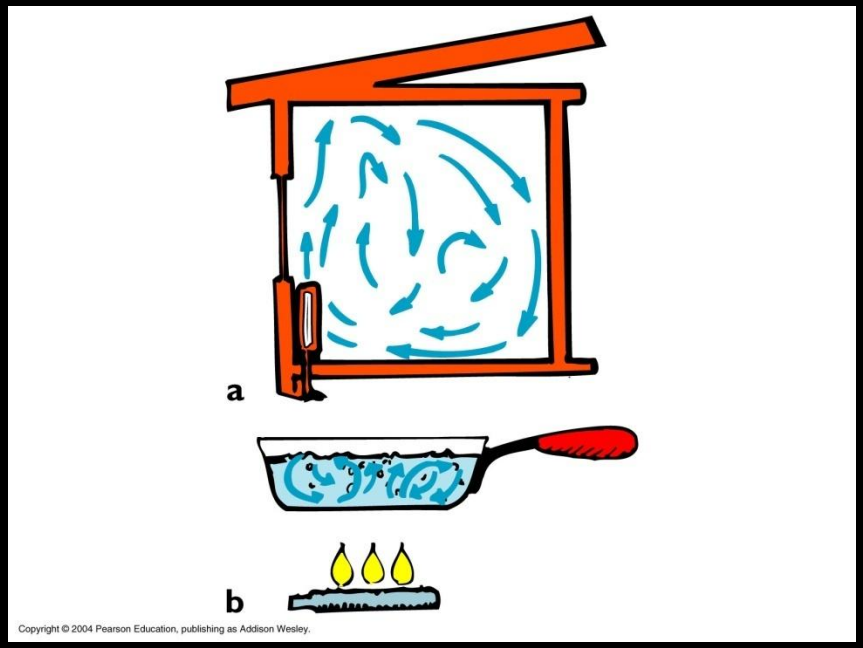
Convection

- is the transfer of heat through the flow of liquids or gases
- The material itself moves from one place to another.
- Examples:
  - Hot air rises through a chimney.
  - House heating

Convection Currents

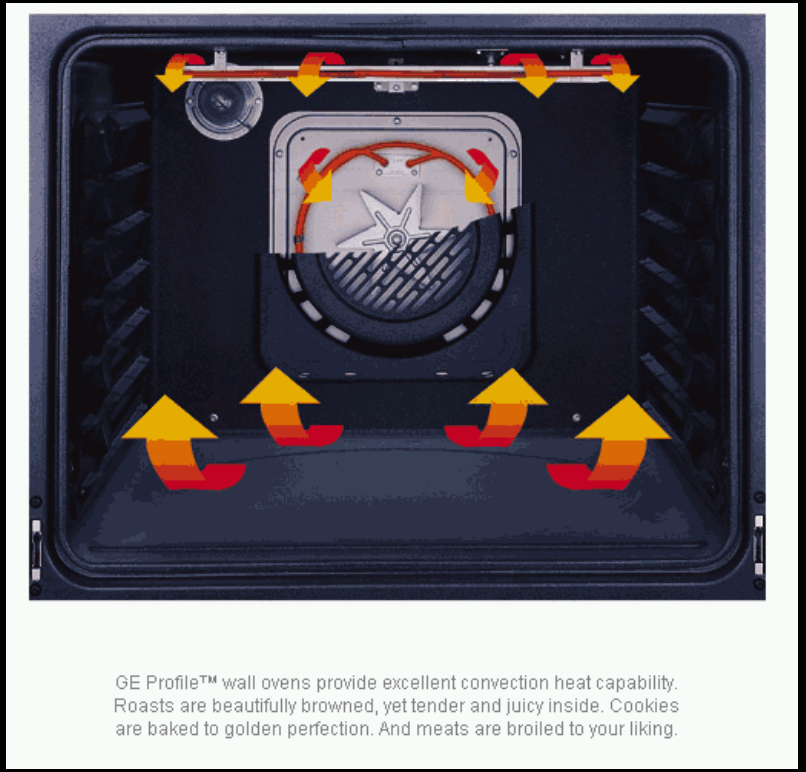
- Convection currents in a gas

- Convection currents in a liquid



Convection Ovens

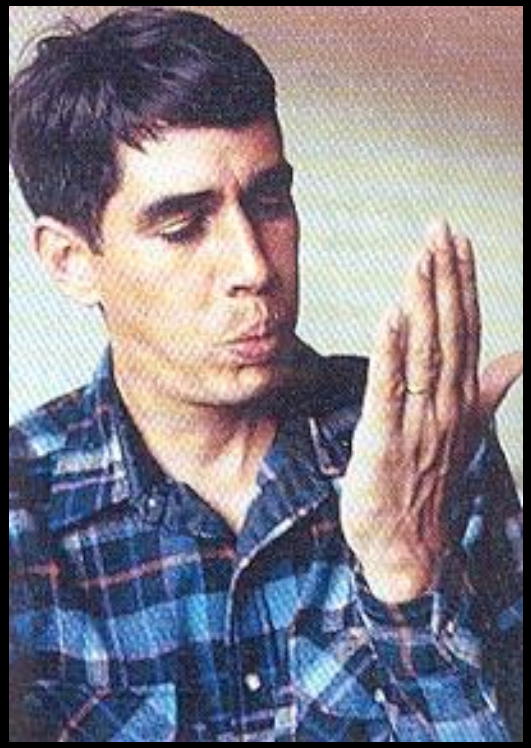
- Ovens with a fan inside.
- Cooking is sped up by the circulation of heated air.



GE Profile™ wall ovens provide excellent convection heat capability. Roasts are beautifully browned, yet tender and juicy inside. Cookies are baked to golden perfection. And meats are broiled to your liking.

Try this.

- Blow on hand with mouth open wide.
- Try again with smaller opening.
- What do you notice? Why?



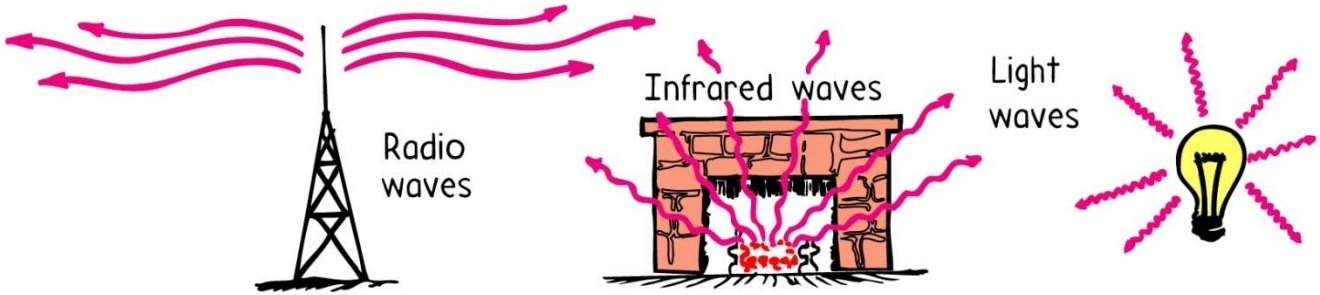
Cooling by Expansion

- As gas expands, energy is spread out over greater area
- Therefore, it cools.

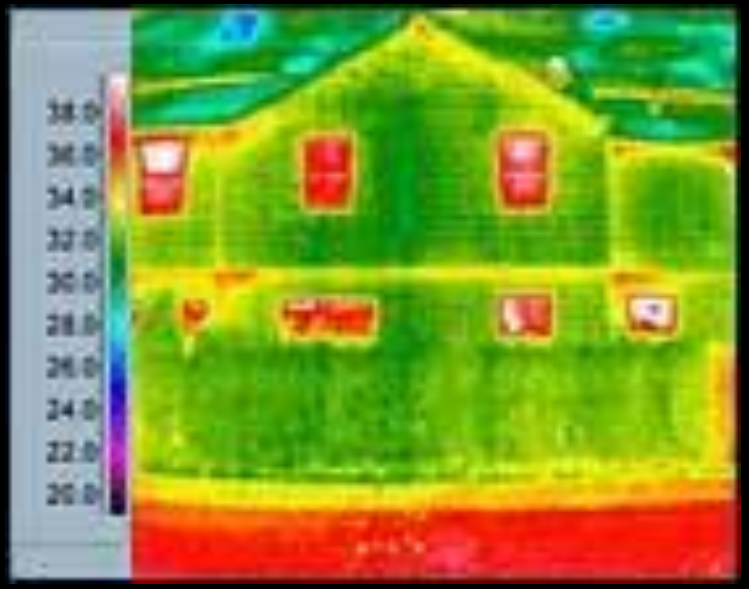
Radiation

- Radiation is heat transfer by the emission of electromagnetic waves which carry energy away from the emitting object.
- For ordinary temperatures (less than red hot"), the radiation is in the infrared region of the electromagnetic spectrum.

Types of Radiation



Infrared Photography



Energy and Change of Phase