

## Objective 5-Heat

Investigate and demonstrate the movement of heat through solids, liquids and gases by convection, conduction and radiation

### Heat

- The heat of an object is the total kinetic energy of its molecules
- temperature of the object is the measurement of the average energy of its molecules.
- Specific heat is a way to compare heat from different materials. Heat energy can cause expansion in many materials.

#### Molecular Theory explains heat

An explanation of what heat is comes from the Molecular Theory of Matter, which states that matter is made up of tiny particles called molecules. These particles are in constant motion within the bounds of the material.

#### *Velocity of molecules*

Since the relationship between kinetic energy of an object and its velocity is:

$KE = \frac{1}{2} mv^2$ , which means that the more energy an object has, the faster it is traveling (or vice versa).

Thus, when you provide extra energy to an object, you cause its molecules to speed up. Those molecules, in turn, can cause other molecules to speed up. The sum effect of the speed or energy of these molecules is the phenomenon we call heat.

#### **Sources of heat energy**

Molecules can go into high-energy motion, causing heat, from various energy sources.

- Light from the sun radiating on an object can transfer energy to the object's molecules, causing them to move faster. In other words, the object heats up.
- Chemical reactions, such as something burning, causes nearby molecules to accelerate and thus produces the effect of heat.
- Electrical resistance can heat a wire, causing its molecules to move faster.
- Friction and nuclear reactions can also produce heat.

#### ***Specific heat***

Since the molecules of various materials have different weights and sizes, the amount of energy required to speed up those molecules will depend on the type of material.

Also, since the amount of heat an object has depends on the total energy of its molecules, that energy is proportional to the mass of the object.

- *The specific heat of a material is the amount of heat (or energy) required to raise the temperature of 1 gram of the substance 1 degree C. Units  $\rightarrow$  J/g K or J/g  $^{\circ}$ C or cal/g  $^{\circ}$ C*
- *Calorie is the amount of heat required to change the temperature of one gram of water one degree C. The specific heat of water is defined as 1.0 calorie/gram-degree.*

Note that this calorie is different than the dieter's Calorie (with a capital "C"). Metals have small specific heats. It does not take much heat to change the temperature of a metal. Water has a relatively high specific heat which is the cause of many of the weather patterns on earth.

### *BTU*

In the English system, specific heat is the amount of heat required to heat 1 pound of water 1 degree F. Its unit of heat is the BTU (British Thermal Unit). Often, you can see heaters and furnaces in the U.S. rated in BTUs.

### *Thermal expansion*

An early observation on the effect of heat is the fact that most substances expand when heated and contract when cooled. One application of this is seen in the several inch separation in sections of freeway overpasses, which are there to account for the expansion of the overpass in the summer, when the heated material expands.

### *Water and ice*

Although water contracts when cooled, the change to ice is an exception to that rule. When water changes to ice, it expands. This is a major cause of potholes in the street in the winter. After it has expanded, ice later contracts slightly as it cools.

### *Gases*

The Law of Charles states that the volume of a gas varies directly with its absolute temperature, if pressure is held constant:  $V$  is proportional to  $T$  (Note the use of absolute temperature).

This means that as you heat a gas, its volume becomes greater. This is seen in the example of the hot air balloon. It also means that if you compress or expand a gas, you can increase or decrease its temperature and heat.

The refrigerator is an application of this law, because it uses the expansion of gas to decrease temperature.

### **In conclusion**

Heat of an object is the total kinetic energy of its molecules. The Molecular Theory of Matter shows when molecules have more energy, they move faster. Specific heat is a way to compare heat from different materials. Heat can cause expansion in many materials.

## **Heat Transfer**

The speed of a material's molecules or atoms determines their kinetic energy. Heat is the total kinetic energy of an object. That heat can be transferred to other materials through conduction, convection and/or radiation.

### **Conduction**

*Conduction --heat transfer from one object to another by direct*

- works best in solids since molecules are touching anyway
- substances that transfer this way well are called **conductors** (metals)
- substances that don't conduct are called **insulators** ( wood, plastic, air

Heat energy can be transferred from one substance to another when they are in direct contact. The moving molecules of one material can increase the energy of the molecules of the other. The heat can also travel through a material as one molecule transfers energy to a neighboring one.

- like when warm air is in contact with your skin.

## **Convection**

*Convection Heat carried from one place to another in a liquid or gas as molecules move in currents caused by density differences.*

Example: Warm air rising)

- this type of transfer takes place in liquids and gases (ex. hot air balloons, oceans)
- this heating causing things to rise in one spot and fall in another is the cause for drafts in your house and winds

Forced air heating and air conditioning are examples of heating (or cooling) by convection.

## **Radiation**

*Radiation -- the transfer of heat energy through empty space (ex. heat from the sun)  
A third method to transfer heat is by radiation.*

Transfer of heat by radiation travels at the speed of light and go great distances, even in a vacuum. We are heated from the Sun through radiation transfer of heat.

## **In conclusion**

### **Three methods of heat transfer:**

#### **Conduction:**

Transfer from one substance to another by direct contact of molecules.

*Example:* When you touch a hot stove.

#### **Convection:**

Heat carried from one place to another in a liquid or gas as molecules move in currents caused by density differences.

*Example:* Warm air rising.

#### **Radiation:**

Heat carried through empty space in the form of infrared rays.

*Example:* When you face the sun and feel warmth on your face