Name: _____ Date: _____ Hour: _____

Exothermic and Endothermic Reactions

6-8.PS1.B.2 - Construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

6-8.PS3.A.3 - Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

Essential Questions:

How do healthcare professionals rely on endothermic reactions after an injury?

I can statements:

I can explain the difference between exothermic and endothermic reactions.
I can explain where the energy comes from when heat is given off or absorbed in a chemical reaction.

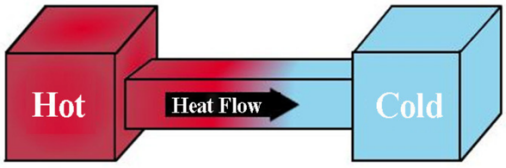
Critical Vocabulary:

Temperature, Heat, Endothermic, Exothermic, Thermal Energy, Energy / Heat Transfer, kinetic theory of matter, kinetic energy, thermal expansion, bond energy,

Energy flows from warmer to cooler objects.

Heat is different from temperature.

Heat and temperature are very closely related. As a result, people often confuse the concepts of heat and temperature. However, they are not the same. Temperature is a measurement of the average kinetic energy of particles in an object. ***Heat is a flow of energy from an object at a warmer temperature to an object at a cooler temperature.***



If you add energy as heat to a pot of water, the water's temperature starts to increase. The added energy increases the average kinetic energy of the water molecules. Once the water starts to boil, however, adding energy no longer changes the temperature of the water. Instead, the heat goes into changing the physical state of the water from liquid to gas rather than increasing the kinetic energy of the water molecules. This fact is one demonstration that heat, and temperature are not the same thing.

STOP AND THINK: Compare and Contrast Heat and Temperature.

Heat and Thermal Energy

Suppose you place an ice cube in a bowl on a table. At first, the bowl and the ice cube have different temperatures. However, the ice cube melts, and the water that comes from the ice will eventually have the same temperature as the bowl. This temperature will be lower than the original temperature of the bowl but higher than the original temperature of the ice cube. The water and the bowl end up at the same temperature because the particles in the ice cube and the particles in the bowl continually bump into each other and energy is transferred from the bowl to the ice.

Heat is always the transfer of energy from an object at a higher temperature to an object at a lower temperature. So energy flows from the particles in the warmer bowl to the particles in the cold ice and, later, the cooler water. If energy flowed in the opposite direction— from cooler to warmer—the ice would get colder and the bowl would get hotter, and you know that never happens.

STOP AND THINK: In which direction does heat always transfer energy?

When energy flows from a warmer object to a cooler object, the thermal energy of both of the object's changes. ***Thermal Energy is the total random kinetic energy of particles in an object.*** Note that temperature and thermal energy are different from each other. Temperature is an average and thermal energy is a total. ***A glass of water can have the same temperature as Lake Superior, but the lake has far more thermal energy because the lake contains many more water molecules.***

After you put ice cubes into a pitcher of lemonade, energy is transferred from the warmer lemonade to the colder ice. The lemonade's thermal energy decreases and the ice's thermal energy increases. Because the particles in the lemonade have transferred some of their energy to the particles in the ice, the average kinetic energy of the particles in the lemonade decreases. As a result, the temperature of the lemonade decreases.

STOP AND THINK: How are heat and thermal energy related to each other?

Endothermic and Exothermic Reactions

Substances react chemically in characteristic ways

If you tested different substances with a particular liquid to see how the substances react, each would react in its own characteristic way. And each substance that reacted would react the same way each time it was tested with the same liquid. Substances react in characteristic ways because every substance is different. Each one is made up of certain atoms bonded in a particular way that makes it different from any other substance. When it reacts with another substance, certain atoms or groups of atoms unbond, rearrange, and rebond in their own way.

Chemical reactions and energy

Chemical reactions involve breaking bonds in the reactants and making new bonds in the products. It takes energy to break bonds in the reactants. Energy is released when new bonds are formed in the products.

The using and releasing of energy in a chemical reaction can help explain why the temperature of some reactions goes up (**exothermic**) and the temperature of other reactions goes down (**endothermic**).

Chemical Reactions release or absorb energy

Chemical reactions involve breaking bonds in reactants and forming new bonds in products. ***Breaking bonds requires energy and forming bonds releases energy***. The energy associated with bonds is called **bond energy**. What happens to this energy during a chemical reaction?

Chemists have determined the bond energy for bonds between atoms. Breaking a bond between carbon and hydrogen requires a certain amount of energy. This amount of energy is different from the amount of energy needed to break a bond between carbon and oxygen, or between hydrogen and oxygen.

Energy is needed to break bonds in reactant molecules. Energy is released when bonds are formed in product molecules. By adding up the bond energies in and the reactants and the products, you can determine whether the energy will be released or absorbed.

If more energy is released when the products form and is needed to break the bonds in the reactants, then energy is released during the reaction. A reaction in which energy is released is called an **exothermic reaction**.

If more energy is required to break the bonds in the reactants then is released when the products form, then energy must be added to the reaction. That is, the reaction absorbs energy. A reaction in which energy is absorbed is called an **endothermic reaction**.

These types of energy changes can also be observed in different to physical changes such as dissolving or changing state. The state change from liquid to a solid, or freezing, releases energy-this is an exothermic process. The state change from a solid to a liquid, or melting, absorbs energy-this is an endothermic process.

STOP AND THINK: How are exothermic and endothermic reactions different?

Exothermic reactions release energy

Exothermic chemical reactions often produce an increase in temperature. In exothermic reactions, the bond energies of the reactants are less than the bond energies of the products. ***As a result, less energy is needed to break the bonds in the reactants then is released during the formation of the products.*** This energy difference between reactants and products is often released as heat. ***The release of heat causes a change in the temperature of the reaction mixture.***

Even though energy is released by exothermic reactions, some energy must first be added to break bonds in reactants. In exothermic reactions, the formation of bonds in the products releases more energy. ***Overall, more energy is released then is added.***

Some reactions are highly exothermic. These reactions produce a great deal of heat in significantly raise the temperature of their surroundings. One example of the reaction of powdered aluminum metal with a type of iron oxide, the reaction known as a thermite reaction.

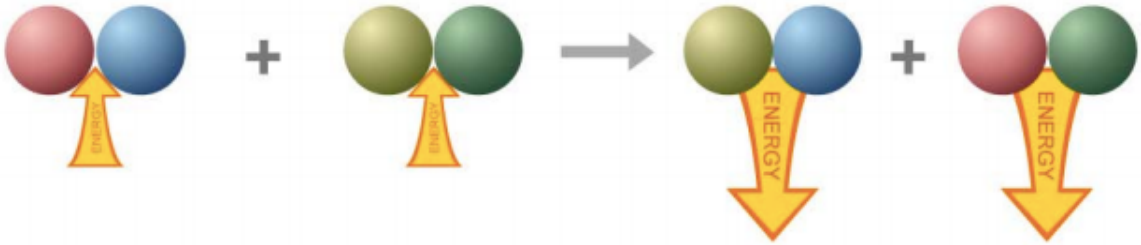
$2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$

This reaction releases enough heat to melt the iron that is produced. In fact, this reaction is used to weld iron rails together.

All common combustion reactions, such as the combustion of methane, are exothermic. The difference in energy is released to the surrounding air as heat. Some chemical reactions release excess energy as light instead of heat. For example, glow sticks work by a chemical reaction that releases energy as light.

Exothermic reaction: Reactants→Products + Energy

If a reaction is exothermic, that means that it takes less energy to break the bonds of the reactants than is released when the bonds in the products are formed. Overall, the temperature increases.



STOP AND THINK: How can you determine if a reaction is exothermic? Include a model.

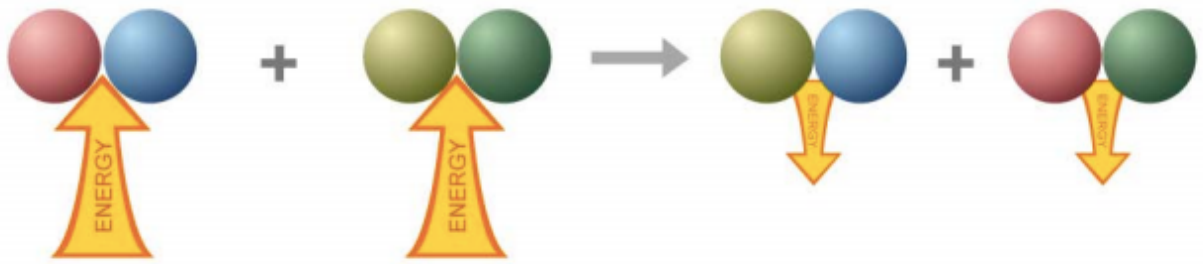
Endothermic reactions absorb energy

Endothermic reactions often produce a decrease in temperature. In endothermic reactions, the bond energies of the reactants are greater than the bond energies of the products. ***As a result, more energy is needed to break the bonds in the reactants then is released during the formation of the products.*** The difference in energy is usually absorbed from the surroundings as heat. ***This often causes a decrease in the temperature of the reaction mixture.***

All endothermic reactions absorb energy. However, they do not all absorb energy as heat.

Endothermic reaction: Reactants + Energy → Products

If a reaction is endothermic, it takes more energy to break the bonds in the reactants than is released when the products are formed. Overall, the temperature decreases.



Probably the most important series of endothermic reactions on earth is photosynthesis. Many steps occur in the process, at the overall chemical reaction is:

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Unlike many other endothermic reactions, photosynthesis does not absorb energy as heat. Instead, during photosynthesis, plants absorb energy from sunlight to turn carbon dioxide and water into oxygen and glucose, which is a type of sugar molecule. The energy is stored in the glucose molecules, ready to be used when needed.

STOP AND THINK: How can you determine if a reaction is endothermic? Include a model.

Exothermic and endothermic reactions work together to supply energy

Went thinking about exothermic and endothermic reactions, it is often useful to consider energy as part of the reaction. An exothermic reaction releases energy, so energy is on the product side of the chemical equation. An endothermic reaction absorbs energy, so energy is on the reactant inside of the chemical equation.

Exothermic reaction: Reactants→Products + Energy

Endothermic reaction: Reactants + Energy → Products

As you can see in the general reactions above, exothermic and endothermic reactions have opposite energy changes. ***This means that if an exothermic chemical reaction proceeds in the opposite direction, it becomes an endothermic reaction that absorbs energy. Similarly, if an endothermic reaction proceeds in the opposite direction it becomes an exothermic reaction that releases energy.***

STOP AND THINK: What happens when an exothermic reaction is reversed? Endothermic reversal?