The Flow of Energy - Heat and Work

Energy Transformations

Energy is the capacity for doing work or supplying heat. It has no mass or volume. It is detected only because of its effects.

Thermochemistry is the study of energy changes that occur during chemical reactions and changes in state.

The energy stored in the chemical bonds of a substance is called **chemical potential energy**.

During a chemical reaction, a substance is transformed into another substance with different amounts of chemical potential energy. When you buy gasoline or groceries, you are actually buying the stored potential energy it contains.

Energy changes occur as either heat transfer or work, or a combination of both.

Heat, represented by *q*, is energy that transfers from one object to another because of a temperature difference between them.

Heat will always flow from a warmer object to a cooler object.

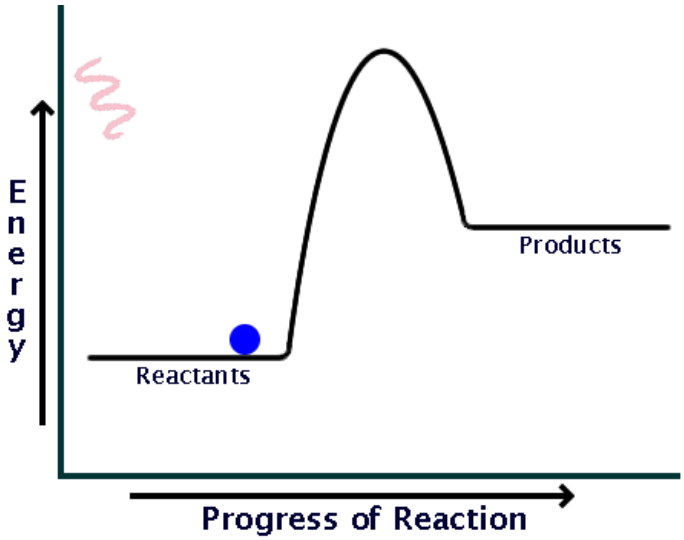
If two object remain in contact, heat will always flow from the warmer to the cooler object until the objects are the same.

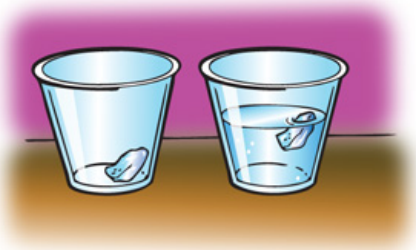
Exothermic and Endothermic Reactions

The **law of conservation of energy** states that in any chemical or physical process, energy is neither created or destroyed.

If the energy in the system decreases, then its surroundings must increase by the same amount. The opposite also holds true.

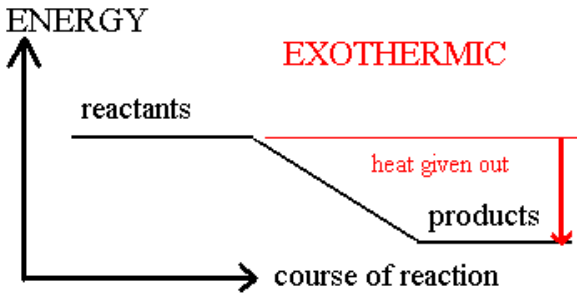
In an **endothermic** process, the system gains heat as the surroundings cool down.





Heat flowing into a system from its surroundings is defined as positive; *q* has a positive value.

In an exothermic process, the system loses heat as the surroundings heat up.



Heat flowing out of a system is defined as negative; *q* would be negative because the system is losing heat.

Example:

On a sunny winter day, the snow on a rooftop begins to melt. As the melting water drips from the roof, it refreezes into icicles. Describe the direction of heat flow as the water freezes. Is this process endothermic or exothermic?

Units for Measuring Heat Flow

Heat flow is measured in two common units, the calorie and the joule.

A calorie (cal) is defined as the quantity of heat needed to raise the temperature of 1 gram (g) of pure water 1°C.

1 Calorie = 1 kilocalorie = 1000 calories

A capital 'C' when referring to calories means the dietary Calorie, the energy in food.

So, the statement "10 g of sugar has 41 Calories" means that 10 g of sugar releases 41 000 calories of heat when completely burned.

The joule (J) is the SI unit of energy.

1 J of heat raises the temperature of 1 g of pure water 0.2390 °C

1 J = 0.2390 °C 4.184 J = 1 cal

Heat Capacity and Specific Heat

The amount of heat needed to increase the temperature of an object exactly 1 °C is the heat capacity of that object. It depends on both its **mass** and its **chemical composition**.

The greater the mass of the object, the greater the heat capacity. Similarly, 10 kg of water will have a different heat capacity to that of 10 kg of concrete.

*Chart of specific heat capacities for common substances. (Pg. 508)

Because it takes a lot of heat to raise the temperature of water, water also releases a lot of heat as it cools.

Moderate temperatures in coastal areas

To calculate the specific heat (C) of a substance:

$$C = \frac{q}{m \times \Delta T} = \frac{\text{heat (J or cal)}}{\text{mass (g)} \times \text{change in T (}^{o}C\text{)}}$$

Example

The temperature of a 95.4-g piece of copper increases from 25.0 °C to 48.0 °C when the copper absorbs 849 J of heat. What is the specific heat of copper?

Try questions #1-11 on pages 507-510