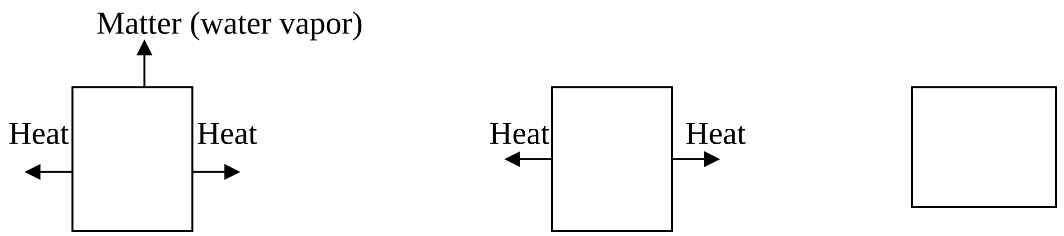
Thermochemisty: Heat

System: The universe chosen for study – a system can be as large as all the oceans on Earth or as small as the contents of a beaker. We will be focusing on a system's interactions – transfer of energy (as heat and work) and matter between a system and its surroundings.

Surroundings: part of the universe outside the system in which interactions can be detected. 3 types of systems:

a) Open – freely exchange energy and matter with its surroundings
b) Closed – exchange energy with its surroundings, but not matter
c) Isolated – system that does not interact with its surroundings



Open System Closed System Isolated system

Examples:

a) beaker of hot coffee transfers energy to the surroundings – loses heat as it cools. Matter is also transferred in the form of water vapor.

b) flask of hot coffee transfers energy (heat) to the surroundings as it cools. Flask is stoppered, so no water vapor escapes and no matter is transferred

c) Hot coffee in an insulated flask approximates an isolated system. No water vapor escapes and little heat is transferred to the surroundings.

Energy: derived from Greek, meaning "work within." Energy is the capacity to do work. Work is done when a force acts through a distance. Energy of a moving object is called kinetic energy ("motion" in Greek).

K.E. = ½ * m (kg) * v^2 (m/s)
Work = force * distance = m (kg) * a (m/s^2) * d (m)

When combined, get the SI units of energy called the joule (J)

1 Joule = 1 $(kg*m^2)/(s^2)$

The kinetic energy that is associated with random molecular motion is called thermal energy.

The more vigorous the motion of the molecules it he system, the hotter the sample and the greater is its thermal energy. Thermal energy for a system also depends on the number of particles present, so that a small sample at a high temperature may have less thermal energy than a larger sample at a lower temperature – temperature and thermal energy must be carefully distinguished.

Heat: the transfer of thermal energy

Heat: the energy transferred between a system and its surrounding as a result of a temperature difference. Energy, as heat, passes from a warmer body (with a higher temperature) to a cooler body (with a lower temperature) Molecules of the warmer body through collisions, lose kinetic energy to those of the colder body. Thermal energy is transferred – heat "flows" – until the average molecular kinetic energies of the two bodies become the same, until the temperatures become equal.

Heat describes the energy in transit between a system and its surroundings. When a solid is heated, the molecules, atoms, or ions of the solid move with greater vigor and eventually break free from their neighbors by overcoming the attractive forces between them, Energy is required to overcome these attractive forces.

Heat is simply the form in which a quantity of energy may be transferred across a boundary between a system and its surroundings.

The quantity of heat required to change the temperature of one gram of water by one degree Celsius is called the **calorie**.

1 Cal = 4.184 J

The quantity of heat required to change the temperature of a system of 1 gram by one degree is called the **specific heat** of the system. Specific heat of water is about

$$4.18 \text{ J} / (\text{g} * {}^{o}\text{C}) = 1 \text{ cal} / (\text{g} * {}^{o}\text{C})$$

Quantity of heat (q) = Specific heat * mass * temperature change
(needed to change temp of substance)

Positive q shows that heat is absorbed/gained by the system. Negative q show that heat is evolved/lost by a system.

Significance: Aluminum has a pretty high specific heat compared with other metals, helps to account for its use in thawing frozen foods rapidly. The aluminum cools slowly as it transfers heat to the frozen food, and the food thaws more quickly. Water has the same effect. Example: heated up lead put into beaker of cold water: the transfer of energy, as heat, from the lead to the colder water causes the temperature of the lead to decrease and that of the water to increase until the lead and the water are at the same temperature – **Law of Conservation of Energy**.

www.udo-leuschner.de/ energie/e06entropie.htm

James Joule (1818-1889) – ran a brewery, precise measurements of quantities of heat formed the basis of the law of the conservation of energy.

Bibliography

1) "General Chemistry: Principles and Modern Applications", Chapter 7, Ralph H. Petrucci, William S. Harwood, F. Geoffrey Herring, Eight Edition, Prentice Hall, Upper Saddle River, NJ, 2002.