Teacher's Tools® Chemistry

Thermochemistry: Overview: Student Review Notes

Thermochemistry is the study of the heat (energy in the form of heat) of chemical reactions.

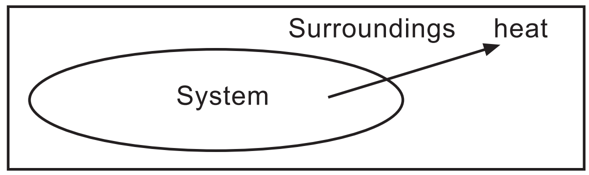
Specifically:

- The direction of heat flow (in to the system (+) or out of the system (-)
- The magnitude of heat flow (kJ/units)
- The experimental determination of both (calorimetry)

Two types of Chemical Reactions as determined by the direction of heat flow:

You need to understand the sign convention for the flow of heat

Heat flow is **negative** when it goes **out of a system** and into the surroundings.

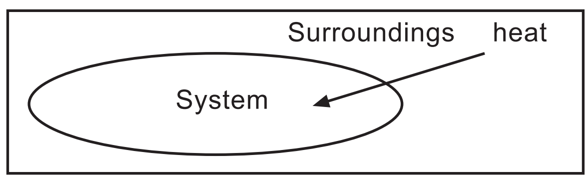


A reaction system that **evolves** heat in the surroundings is called an **EXOTHERMIC** reaction.
For an exothermic reaction, we observe an increase in the termperature of the surroundings.
For example, the combustion of methane is an exothermic reaction:

$$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(l)} + \text{heat}$$

heat energy is given off in an exothermic reaction

Heat flow is **positive** when it comes **into a system** from the surroundings.



A reaction system that **absorbs** heat in the surroundings is called an **ENDOTHERMIC** reaction.
For an endothermic reaction, we observe an decrease in the termperature of the surroundings.
For example, the vaporization of water (the body's natural cooling system):

$$H_2O_{(l)} + \text{heat} \longrightarrow 2H_2O_{(g)}$$

heat energy is absorbed in an exothermic reaction

Exothermic and Endothermic reactions involve an exchange of heat between the system and surroundings. The **amount** of heat energy that flows is related to a basic property of the system called **ENTHALPY.**

Enthalpy, H, is defined as the heat content of the system at constant pressure. During a chemical reaction, we look at the **change in Enthalpy, ΔH**, between the products and reactants:

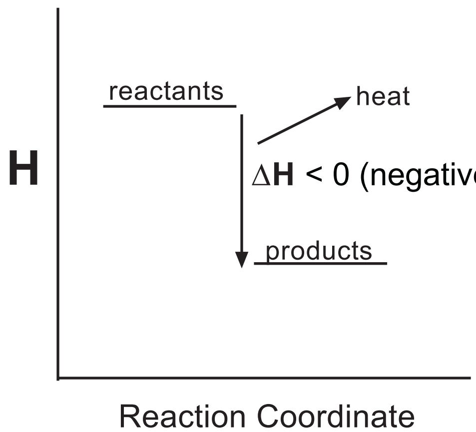
$$\Delta H = H_{products} - H_{reactants}$$

Change in Enthalpy

$$\Delta H = H_{products} - H_{reactants}$$

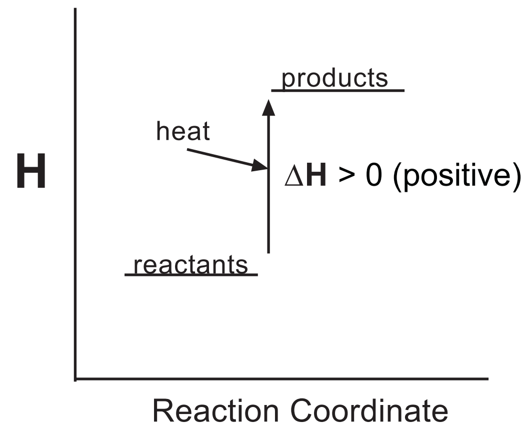
Exothermic Reaction

Heat is evolved
enthalpy of the system decreases



Endothermic Reaction

Heat is absorbed
enthalpy of the system increases



This is consistent with the **Law of Conservation of Energy**. Energy is neither created or destroyed in an ordinary chemical reaction or physical change. The heat absorbed from or evolved to the surroundings is exactly equal to the change in enthalpy of the system

You also need to understand the definitions that go along with thermchemical systems.

An **open system** allows for the transfer of both matter and energy between the system and surroundings. An example of this is a cup of coffee. Evaporation out of the top of the cup transfers matter and the coffee cools down because the styrofoam is not perfectly insulating.

A **closed system** allows for the transfer of energy but not matter. An example of this is a bag of ice. As long that there isn't a hole in it, all that gets transferred across the boundary is heat energy.

An **isolated system** allows neither the transfer of matter or energy. It is perfectly insulated and has a boundary that doesn't allow for matter to go in or out of the system. A perfect thermos would be an example of this type of system.

Phase changes

Phase changes are called **latent heat processes**. Latent heat processes occur at constant temperature. Get that! The temperature of system of mixed phases (like ice and water) will not change until the system goes to a single phase (either all solid or liquid). There are standard amounts of energy required to change a mole of a substance from one phase to another.

ΔH_{fus} is the heat (enthalpy) of fusion. That is the enthalpy change associated with a transition between the solid and liquid phase for a mole of a pure substance.

ΔH_{vap} is the heat (enthalpy) of vaporization. That is the enthalpy change associated with a transition between the liquid and vapor phase for a mole of a pure substance.

ΔH_{sub} is the heat (enthalpy) of sublimation. That is the enthalpy change associated with a transition between the solid and vapor phase for a mole of a pure substance.

A **sensible heat process** is one in whicy you are simply heating up or cooling down a substance while it's all a single phase (solid, liquid or vapor).

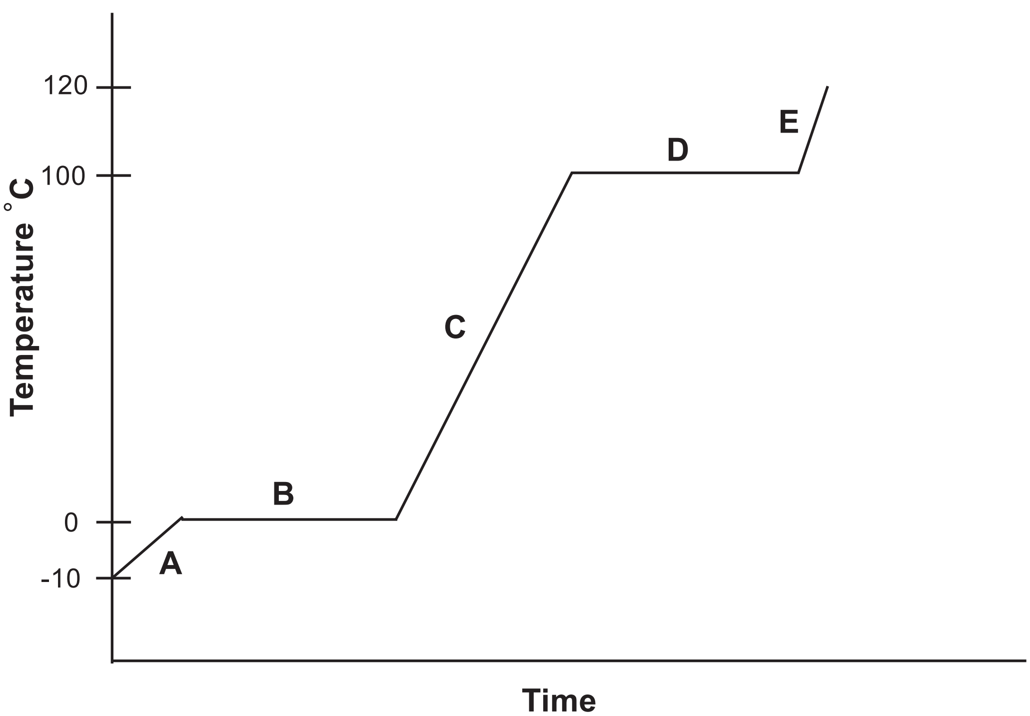
Here the heat energy is equal to the mass of the substance times its specific heat times the temperature change:

$$q = mS\Delta T$$

heat (q), mass (m), Specific Heat (J/g) (S), Temperature change (ΔT)

Heating Curve: know how to calculate the heat energy for each step of the process

Heating a mass of water from -10°C to 120°C



A: Sensible Heat Process. The ice is heated up to its melting point. $q_A = mS_{ice}\,\Delta T$

B: Latent heat process. Melt all the ice at constant temperature. $q_B = n\Delta H_{fus}$

C: Sensible Heat Process. The water is heated up to its boiling point. $q_C = mS_{water}\Delta T$

D: Latent heat process. Evaporate all the water at constant T. $q_D = m\Delta H_{vap}$

E: Sensible Heat Process. The steam is heated up. $q_E = mS_{steam}\Delta T$

For the entire process: $q_{total} = q_A + q_B + q_C + q_D + q_E$