**THERMOCHEMISTRY**

Why do you have to strike a match to start a fire? Why do some chemical reactions give off heat while other reactions absorb heat?

Thermodynamics is the study of energy as it changes from one form to another.

Thermochemistry is the study of energy change in the form of heat associated with chemical reactions. It is an aspect of thermodynamics that focuses on heat evolved or absorbed during a chemical reaction

This is the branch of physical chemistry that studies the heat changes in a reaction. The heat change (enthalpy change) represented as delta-H is usually written alongside the equation. For example,

Heat change is measured in kilo joules per mole

Note: is a state function (i.e. it depends on the initial and final conditions of the reaction).

Actually, a state function such as entropy or enthalpy has a unique value for each given state of a system.

For example, looking at this

If we divide the equation through by 2 (or multiply by half), the delta H will also be divided by 2

And if the reaction is reversed, the heat change also changes

**TERMINOLOGIES USED IN THERMOCHEMISTRY**

System: This is defined as the portion of the universe under study where chemical reactions take place. It is also called a thermodynamic system

Surrounding: This is defined as everything in the universe apart from the thermodynamic system

Boundary: This is defined as the portion or the layer that separates the system from the surrounding

Open System: This is the type of system in which matter and the energy are transferred to the surrounding

Closed System: This is a type of system in which only energy is transferred while matter remains constant

Isolated System: This is a type of system in which both matter and energy remain constant (i.e. they are not transferred to the surrounding

Exothermic (Reaction): This is the reaction in which heat is liberated to the surrounding. It is also defined as a reaction in which the hydration energy is greater than the lattice energy. is negative

Endothermic reaction: This is the reaction in which heat is absorbed from the surrounding into the system

Adiabatic Reaction: This is the reaction in which heat is neither absorbed nor evolved I.e. there is neither heat loss nor heat gain. is equal to zero

Isobaric Reaction: This is a reaction that occurs at constant pressure

Isothermal: Occurs at constant temperature

Isomeric: This is a reaction that occurs at a constant volume. It is also known as an isoconic or an isovolumetric reaction.

Extensive Properties: These are properties that depend on the quantity of matter. The total can be obtained by adding individual constituents together. For example mass, weight, volume, time, heat capacity, energy, work etc.

Intensive Properties: These are properties that are independent on the quantity of matter. The total cannot be obtained by adding the individual constituents. For example temperature, pressure, density, specific heat capacity, refractive index etc.

Hess’ Law OF Constant Heat Summation: This law states that the heat content of a particular reaction is independent on the path taken by the reaction provided that the condition of the initial stage of the reaction is the same as that of the final stage. It could also be said that regardless of the multiple stages or steps of a reaction, the total enthalpy change for the reaction is the sum of all changes. This law is a manifestation that the enthalpy is a state function.

For example,

Enthalpy

This is known as the heat content of a reaction. The standard heat of a reaction is defined as the heat energy absorbed or evolved when the chemical reaction occurs between the molar quantity of a substance as represented under standard conditions

Here, m is the stoichiometric ratio (number of moles or atoms) of the product

Also, n is the stoichiometric ratio of the reactant

is the heat change of the reaction

andare the heat changes of the product and reactant respectively

When

STANDARD HEAT OF COMBUSTION

This is defined as the heat energy evolved when one mole of a substance is completely burned in air. The instrument used to measure the heat of combustion is called the “bomb calorimeter”. For example,

Since in the equation above it’s not one mole of the of C6H6 that is burned, that can’t be the equation of the standard heat of combustion of C6H6

STANDARD HEAT OF FORMATION

This is defined as the heat energy evolved (or absorbed) when one mole of a substance is formed from its constituent elements. This means that for standard heat of formation to occur, the following conditions must be satisfied

One mole of the compound must be formed

The constituents of the product must be the reactants

Only the compound must be the product

The standard heat of formation of all elements in their standard (uncombined) state is zero

Since one mole of wasn’t formed, that can’t be the standard heat of formation of H2O. When modified,

From the reaction above, it can also be deduced that the standard heat of formation of water is also the standard heat of combustion

STANDARD OF NEUTRALIZATION

This is defined as the heat energy evolved (or absorbed) when one of H+ from an acid combines with one mole of OH- from a base to produce one mole of H2O. The standard heat of neutralization of a strong acid and a strong base is constant provided that one mole of H2O is produced

Most standard heats (heat of combustion, formation and neutralization) evolve heat (most especially that of combustion). Therefore

Here, m is the mass, c is the specific heat capacity and Theta is the change in temperature

Just remember that when calculating the standard heat of anything, make sure you calculate the heat energy related to one mole of the substance even if you are not given 1 mole. For example, you might be given the mass of the substance that liberated the heat. You have to first convert that to moles and then you use the concept of mole ratio to solve for the heat evolved for one mole.

THERMODYNAMICS

This is the branch of thermochemistry that studies the relationship between heat energy and other forms of energy. In this system, heat energy is highly pronounced and the other forms of energy are regarded as work

FIRST LAW OF THERMODYNAMICS

This law states that

Energy can neither be created nor destroyed but can be converted from one form to another.

This law is also called the law of conservation of energy

is the change in internal energy

is the heat energy

is the work done

When is positive, the system absorbs heat

When it is negative, the system evolves heat

When is positive, there is work done on the system

When is negative, there is work done by the system

ENTROPY

This is defined as the degree of disorderliness or randomness of a substance. Entropy depends majorly on the temperature of the system. Generally, an increase in temperature increases the entropy of a system and a decrease in temperature decreases the entropy of the system. Entropy change is represented as delta S.

Also, as a substance changes from solid to liquid and from liquid to gas, there is an increase in the entropy of the system and when a substance changes from gas to liquid or liquid to solid, there is a decrease in the entropy of the system.

Generally, the change in entropy is given as

Here, T is the absolute temperature

The SI unit of Spontaneity is

The highest degree of entropy can be gotten from a mixture of two (or more) gases

The higher the electro-negativity of a substance, the higher the entropy value; for example, among the hydrogen halides, hydrogen fluoride has the highest entropy value. Also, fluorine, being the most electronegative element will have the highest entropy while potassium will have the lowest entropy

SPONTANEOUS PROCESS

A reaction is said to be spontaneous if it occurs feasibly (i.e. it takes place without an external influence (mechanical or controlled by man’s influence). For example, the evaporation of a liquid to gas; using a towel to dry the body after a bath; It should be noted that spontaneous reactions are irreversible

SECOND LAW OF THERMODYNAMICS

A reaction is an increase in the entropy of the system and its surrounding.

According to the second law,

Energy Change

If is positive, then the reaction is spontaneous

If is negative, then the reaction is non-spontaneous

GIBBS FREE ENERGY CHANGE ()

This is defined as the energy that brings about a chemical reaction. It is also defined as the driving force in a system. It is represented as

The following should be noted

When is positive, is less than . The will be positive.

If The reaction is non-spontaneous

When is negative, the reaction is spontaneous

When is zero, Here, the reaction is in equilibrium

alone cannot be used to determine the spontaneity of a reaction because (some) reactions that are exothermic at a particular temperature and may be endothermic at a different temperature.

NOTE THE TABLE

|  |  | T |  |
| --- | --- | --- | --- |
| + | + | High | - |
| + | - | Low | - |
| - | + | All | - |
| - | - | All | + |