Enthalpy

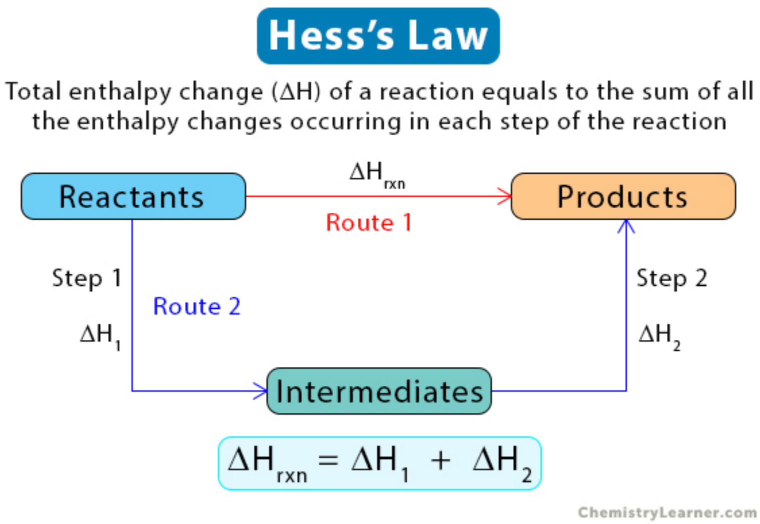
Definitions

Average bond enthalpy: The energy required to break one mole of a particular type of bond between 2 gaseous atoms

Standard enthalpy change of reaction (△H): The heat energy absorbed or released during a chemical reaction in standard conditions.

State Hess' Law

Hess's Law states that the total enthalpy change of a reaction is the same, no matter how the reaction occurs, whether it happens in one step or multiple steps. This means that the enthalpy change of a reaction is path-independent and only depends on the initial and final states of the reactants and products.



Explanation about where energy comes from in chemicals

Energy in chemicals comes from the bonds between atoms. When these bonds are formed, energy is released. When they are broken, energy is absorbed. This bond energy is what drives chemical reactions and changes.

Calculate simple enthalpy changes by applying Hess' Law using bond energies

1. Identify the reactants and products involved in the reaction.
2. Determine the bonds broken and formed in the reaction.
3. Look up the average bond energies for each bond involved. These values can be found in tables.
4. Calculate the total bond energy of the bonds broken (reactants) and formed (products).
5. Subtract the total bond energy of the reactants from the total bond energy of the products to find the change in bond energy (ΔH).
6. This change in bond energy represents the enthalpy change (ΔH) for the reaction.

For example, consider the reaction:

1. $H_2(g)+Cl_2(g) \rightarrow 2HCl(g)$
2. Bonds broken: H-H and Cl-Cl
3. Bonds formed: 2H-Cl
4. Look up the average bond energies (in kJ/mol): H-H=432, Cl-Cl=242, and H-Cl=431.
5. Calculate the total bond energy of bonds broken: 2×H-H+1×Cl-Cl =2×432+1×242=1106 kJ
6. Calculate the total bond energy of bonds formed: 2×H-Cl2×H-Cl =2×431=862 kJ
7. Calculate the change in bond energy (ΔH): ΔH=Energy of bonds broken−Energy of bonds formed =1106 kJ−862 kJ=244 kJ

Calculate the maximum energy produced in chemical reactions

Formula:
Amount of limiting reactant (mol) x enthalpy change = maximum energy produced

Example: Combustion of Methane

Reaction: CH_4 (g) + $2O_2$(g) → CO_2(g) + $2H_2O$(g)

Enthalpy Change (ΔH): Approximately -890 kJ/mol

1. The reaction involves the combustion of methane to produce carbon dioxide and water. The enthalpy change (ΔH) for this reaction is approximately -890 kJ/mol. Lets say in this case, methane (CH_4) is the limiting reactant with 0.5 mols.
2. Max Energy Produced=Amount of limiting reactant consumed×ΔH
   Max Energy Produced= 0.5mol×(−890 kJ/mol)=−445 kJ

Create thermochemical equations for different reactions

Write the balanced chemical equation and include the enthalpy change associated with the reaction

<u>Exothermic and Endothermic</u>

Define the terms exothermic reaction and endothermic reaction and give examples of each (including neutralization reactions, displacement reactions, combustion reactions)

Exothermic: An exothermic reaction is a reaction in which bonds are formed, and where there is a release of energy into the surroundings. Furthermore, an exothermic reaction can be classified as a reaction where the standard enthalpy change is less than 0. e.g. Rusting of iron

Endothermic: An endothermic reaction is a reaction in which bonds are broken, and where energy is absorbed from the surroundings. Furthermore, an endothermic reaction can be classified as a reaction where the standard enthalpy change is greater than 0. e.g. evaporation

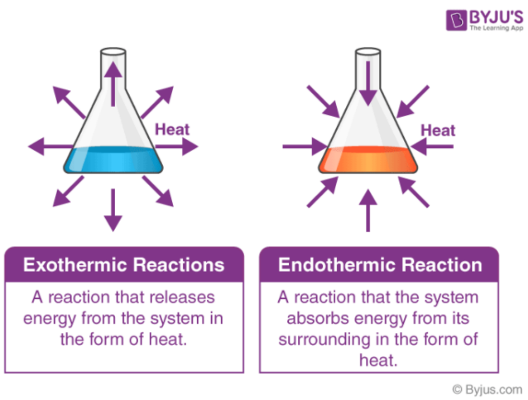
Neutralization reaction: A neutralization reaction is when a base and an acid react to form water and salt. This reaction is exothermic.

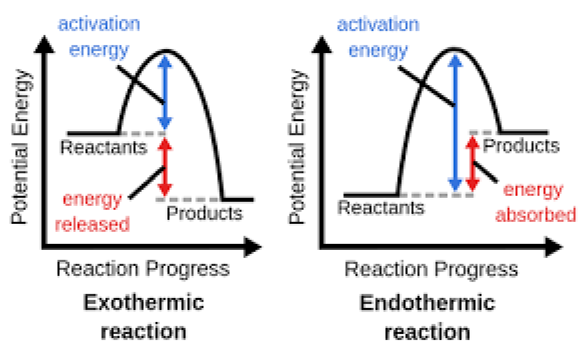
Displacement reaction: A displacement reaction is when a more reactive element replaces a less reactive element from its compound

Combustion reaction: A combustion reaction is when a hydrocarbon fuel reacts with oxygen, forming carbon dioxide and water (in the case of complete combustion). The release of heat energy to the surroundings makes this reaction exothermic.

Decomposition reaction: A decomposition reaction is when a compound is broken down into 2 or more simpler compounds. This reaction is endothermic as there is an absorption of heat energy.

Identify, draw & label diagrams of exothermic endothermic reactions





Apply the relationship between temperature change, enthalpy change and the classification of a reaction as endothermic or exothermic

A reaction is classified as exothermic if:

1. The enthalpy change of the reaction decreases and becomes negative.
2. More energy is released during bond formation than is required for bond breaking.
3. The temperature (energy) of the products is lower than that of the reactants.

A reaction is classified as endothermic if:

1. The enthalpy change of the reaction increases and becomes positive.
2. More energy is required for bond breaking than is released during bond formation.
3. The temperature (energy) of the products is higher than that of the reactants.

Identify the importance of energy changes in chemical reactions, the importance of exothermic reactions and how humans use fuel

During chemical reactions, the enthalpy values of the reactants and products change.

When the enthalpy change is negative or decreases (the enthalpy of the reactants is higher than that of the products), the reaction is classified as exothermic because it releases heat energy.

In the context of fuels, combustion occurs when they burn. The equation for complete combustion is
Fuel + Oxygen → Carbon Dioxide + Water

Combustion reactions are exothermic, as they release energy. This energy is what powers car engines by moving the pistons, demonstrating a practical application of exothermic reactions through fuel combustion.

Decomposition reactions play a role in renewable energy generation, such as in the production of heat and other biofuels. When animal waste decomposes, an endothermic reaction occurs, absorbing heat energy to break down the waste into useful fuels that can be harnessed by humans.

Heat

Define the term specific heat capacity; calorimetry

Specific heat capacity is the energy required to increase a unit mass of a substance by 1 degree celcius/kelvin. Calorimetry is the process of measuring a chemical reactions heat, physical changes and heat capacity

Investigate the use of a simple calorimeter

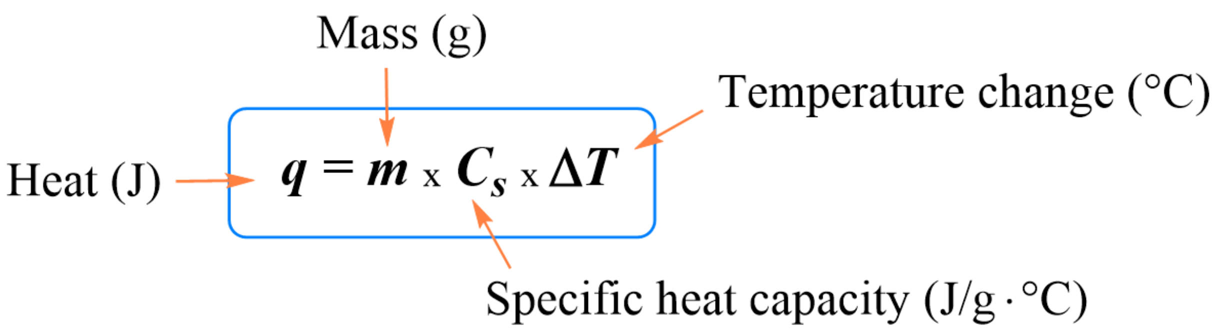
A simple calorimeter can be used to measure the difference in temperature before and after a reaction. This can be used to derive the transfer of heat energy during the reaction.

Evaluate the use of a calorimeter for measuring the energy transferred

What?	How it affects the data?	How can it be improved?
Use of Inappropriate Materials	Poor thermal conductivity materials can result in inaccurate energy transfer measurements.	Use materials with high thermal conductivity suitable for calorimetry, such as copper or aluminum.
Lack of Surrounding Insulation	Absence of external insulation allows heat exchange with the environment, leading to erroneous data.	Add external insulation around the calorimeter to prevent heat loss to the surroundings.

Calculate the heat energy change when the temperature of a pure substance is changed

Heat energy changes can be calculated using the specific heat capacity formula:



__Combustion__

Define the terms flash point; ignition temperature

Flash point: the lowest temperature at which a liquid produces enough vapor to form an ignitable mixture with air near its surface. At this temperature, an external ignition source, such as a spark or flame, can cause the vapor to ignite momentarily.

Ignition temperature: is the minimum temperature at which a substance will spontaneously ignite without the need for an external flame or spark. At this temperature, the heat generated by the chemical reactions within the substance is sufficient to sustain combustion.

Explain incomplete & complete combustion

Complete combustion is when the products of the reaction are carbon dioxide and water. Incomplete combustion is when the products are carbon (soot), carbon monoxide and water.

Incomplete combustion occurs when fuel burns in an insufficient supply of oxygen, leading to the production of soot due to the excess carbon reacting with inadequate oxygen to form carbon monoxide.

State word & balanced chemical equations for incomplete & complete combustion

Complete Combustion - Fuel + Oxygen → Carbon Dioxide + Water

Incomplete Combustion - Fuel + Oxygen → Carbon + Carbon Monoxide + Water

Link combustion equations to exothermic equations

Combustion reactions are considered exothermic because they usually produce heat and light as end products. This mirrors exothermic reactions, where heat is released as a product, similar to combustion. Therefore, combustion equations release heat energy to the surroundings, making them exothermic.