ENERGY AND CHEMICAL CHANGE 26 AUGUST 2014

Lesson Description

In this lesson we:

- Explain energy change in chemical reactions
- Define exothermic and endothermic reactions
- Define bond energy
- Discuss change in enthalpy
- Define activation energy and activated complex
- Discuss potential energy diagrams
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Challenge Question

When sodium bicarbonate dissolves in water the temperature of the solution formed decreases. Is this chemical reaction exothermic or endothermic? Explain your answer.

Summary

Energy Change

Whenever a chemical reactions takes place there is always a change in energy of the system.

An **exothermic** reaction is a reaction in which more energy is released than absorbed.

For example: $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ + **energy**

An **endothermic** reaction is a reaction more energy is absorbed than released

For example: $6CO_2(g) + 6H_2O(l)$ + **energy** $\rightarrow C_6H_{12}O_{22} + 6O_2(g)$ *(photosynthesis)*

Enthalpy (H) is the total amount of chemical potential energy in a chemical system

During a chemical reaction the enthalpy of the system changes. Change in enthalpy is given by the symbol ΔH.

For an exothermic reaction ΔH is negative and for endothermic reactions ΔH is greater than zero.

Bond Energy

During a chemical reaction bonds are broken by energy being taken in and new bond s are formed resulting in energy being given off.

The energy which is absorbed when bonds are broken or released when new bonds are formed is known as **bond energy.**

$$\textit{Energy Change} = \Sigma \textit{energy absorbed}_{(\textit{bond breaking})} - \Sigma \textit{energy released}_{(\textit{bond formation})}$$

Table of Bond Energies

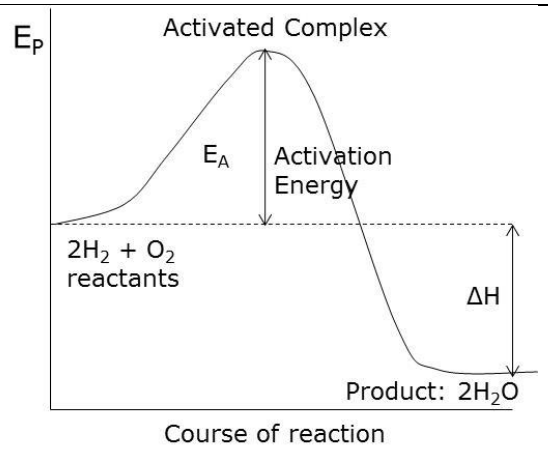
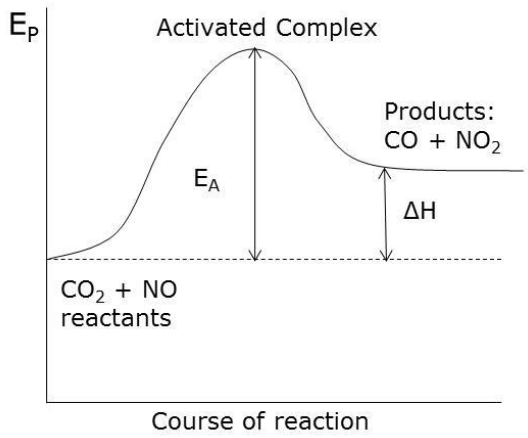
Bond	Bond energy ($kJ \cdot mol^{-1}$)	Bond	Bond energy ($kJ \cdot mol^{-1}$)
H – H	432	F – F	159
H – O	459	Cℓ – Cℓ	243
H – C	414	I – I	151
H – N	390	Br – Br	192
H – F	569	O = O	494
H – S	339	C = O	803
H – Cℓ	431	C – C	348
H – I	299	C – O	258
H – Br	368	C ≡ C	837
F – F	159	N ≡ N	946
		C = C	611

Activation Energy and Activated Complex

For a reaction to happen between two substances, a minimum amount of energy must be absorbed to break the existing bonds of the reactants. This minimum energy is known as the **activation energy.**

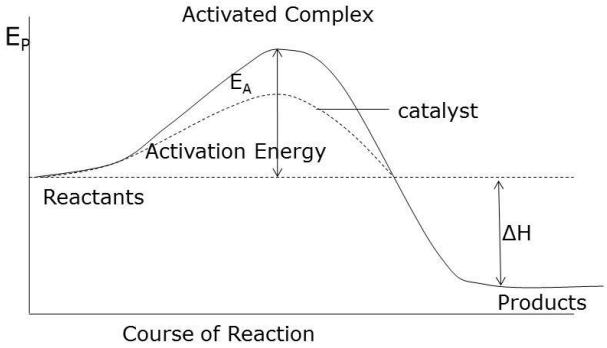
When this minimum energy has been absorbed the reactants form a substance known as the **activated complex.** The activated complex is a temporary, high energy, unstable state between reactants and products.

Potential Energy Diagrams

Exothermic reaction	Endothermic reaction
	
$\Delta H = H_{products} - H_{reactants}$ Exothermic reaction: $\Delta H < 0$	$\Delta H = H_{products} - H_{reactants}$ Endothermic reaction: $\Delta H > 0$
Reactant → product + energy Reactant → product + 20 kJ. mol^{-1} $\Delta H < 0$ $\Delta H = -20\ kJ.mol^{-1}$	Reactant + energy → product Reactant + 20 $kJ.mol^{-1}$ → product $\Delta H > 0$ $\Delta H = -20\ kJ.mol^{-1}$

Catalyst

A catalyst can increase the rate of a reaction without being consumed by the reaction or taking part in the reaction.



A catalyst lowers the activation energy but does not change the change in enthalpy of the reaction.

Test Yourself

Question 1

When a candle burns candle wax reacts with oxygen to form water and carbon dioxide. Select which of the following statements are true. (More than one option can be selected)

A The reaction is endothermic

B The reaction is exothermic

C ΔH =0

D ΔH < 0

Question 2

When a catalyst is added to a chemical reaction,

A the activation energy always increases

B the activation energy always decreases

C ΔH will become smaller

D ΔH will become bigger

Question 3

In a given reversible reaction the forward reaction is exothermic. What statement about the reverse reaction is true

A exothermic

B energy released equal activation energy of forward reaction

C ΔH value for the reverse reaction is larger than for the forward reaction

D ΔH value for the reverse reaction is smaller than for the forward reaction

Question 4

Identify which condition is required for a spontaneous reaction

A. Large activation energy
B. Large enthalpy
C. Small activation energy
D. Small enthalpy

Question 5

Identify which conditions are true for an explosion

A. Very small activation energy
B. Very large activation energy
C. $\Delta H < 0$
D. $\Delta H > 0$

Improve your Skills

Question 1

Use the table of bond energies to calculate ΔH for the following reaction:

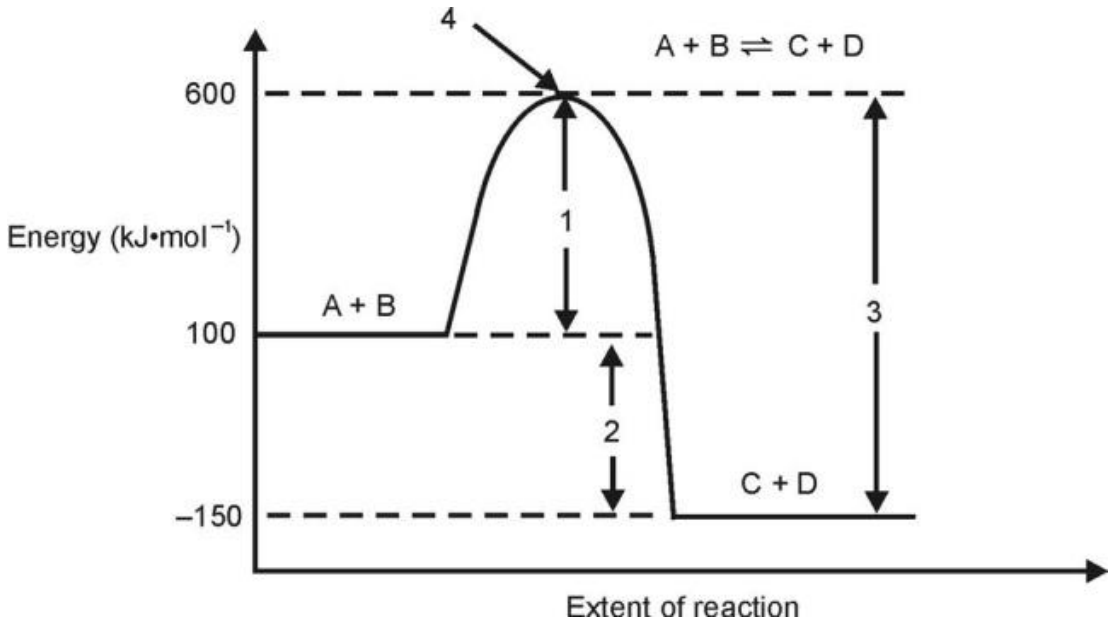
$2HCl(g) + Br_2(g) \rightarrow$

$2HBr(g) + Cl_2(g)$

Is the reaction is exothermic or endothermic?

Question 2

In the following energy profile diagram, the *x*-axis represents the extent of reaction. The *y*-axis represents the energy of the reactants or products.



2.1 Provide names for labels 1 to 4.
2.2 Calculate the activation energy for the forward reaction shown on the graph.
2.3 Calculate the overall enthalpy of this reaction.
2.4 Draw a sketch to show the effect of a catalyst

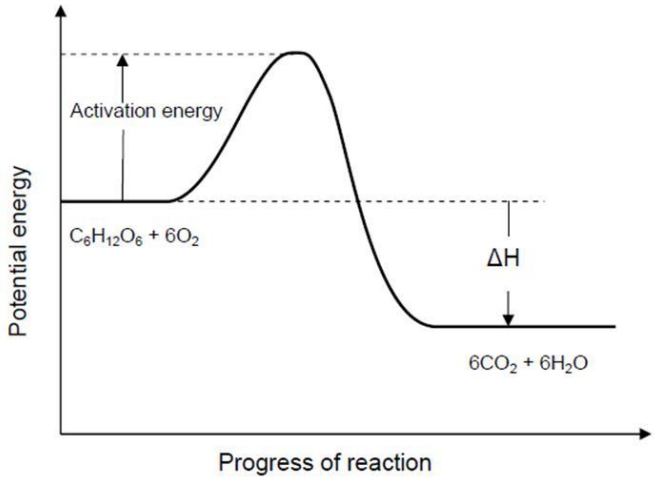
Question 3

(Adapted from Grade 11 Exemplar paper)

During the process of cellular respiration, glucose is broken down to form carbon dioxide and water according to the following equation:

$$C_6H_{12}O_{22} + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

The reaction is catalysed by enzymes. The change in potential energy during this reaction in the human body is illustrated in the graph below:



Use the graph to answer the following questions:

3.1 Is the breakdown of glucose an endothermic or an exothermic reaction? Give a reason for your answer.

3.2 Explain how the enzymes influence the rate of the reaction.