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ENERGY CHANGES IN A REACTION

Learner Note: Energy changes can be used to determine whether a reaction is exothermic or endothermic. These concepts are important for Rates of Reaction and Chemical Equilibrium.

SECTION A: TYPICAL EXAM QUESTIONS

Question 1: 2 minutes

1.1 Consider the reaction



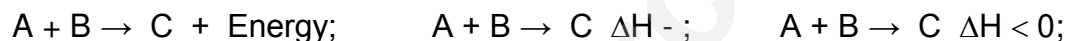
1.1 Is this reaction exothermic or endothermic? (1)

(Make sure the different terminology to indicate the heat of the reaction is understood; it is important to be able to identify whether a reaction is exothermic or endothermic.)

1.2 How does the energy of the products compare to that of the reactants? (1)

(Make sure you know the difference between the reactants and products especially in a reverse reaction.)

Learner Note: A variety of methods are used show the heat of the reaction i.e.



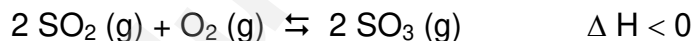
These are all ways to show that the reaction is exothermic.

Question 2: 8 minutes

(Adapted from MDoE Nov 2009)

Learner Note: The contact process is always asked. Make sure it is thoroughly understood. It is examined again in Grade 12.

The contact process is used in the industrial preparation of sulphuric acid. The reaction is given below:



2.1 Draw the potential energy versus reaction coordinate graph for the forward reaction. Indicate the following on the graph:

Activation energy for the forward reaction

Activation energy for the reverse reaction

Activation complex

Heat of the reaction for the forward reaction

Heat of reaction for the reverse reaction

(7)

(Refer to criteria for drawing a graph. Know the different labels for this graph. You will often have to read values off it.)

- 2.2 Is the forward reaction endo or exothermic? (1)
 2.3 Is the reverse reaction endo or exothermic? Give a reason for your answer. (2)
(10)

Question 3: 8 minutes (Adapted from DoE Exemplar 2007)

During cellular respiration glucose is broken down as shown below

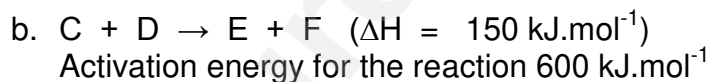
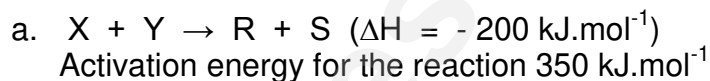


The reaction is catalysed by enzymes.

- 3.1 Is the breakdown of glucose an exothermic or endothermic reaction? Give a reason for your answer. (2)
 3.2 Explain what the effect is of the enzymes on the rate of the reaction. (2)
(The effect of a catalyst is always asked, understand and learn it!)
 3.3 Write a convincing note to your class mate explaining why regular exercise is necessary. (3)
 3.4 In your own words, refer to the reaction and give an explanation of cellular respiration. (3)
(10)

Question 4: 12 minutes (Taken from: The Answer Series.)

Study the following reactions



(Elements may be represented as letters from the alphabet, don't be put off by this)

- 4.1 Are the above reactions endothermic or exothermic? Explain. (4)
 4.2 What is meant by the term activation energy? (2)
 4.3 From the information supplied, what can we deduce about the rate of the reactions? Explain. (5)
 4.4 Give an equation whereby ΔH may be calculated. (2)
 4.5 What can be done to reduce the amount of activation needed in a reaction? (2)
(15)

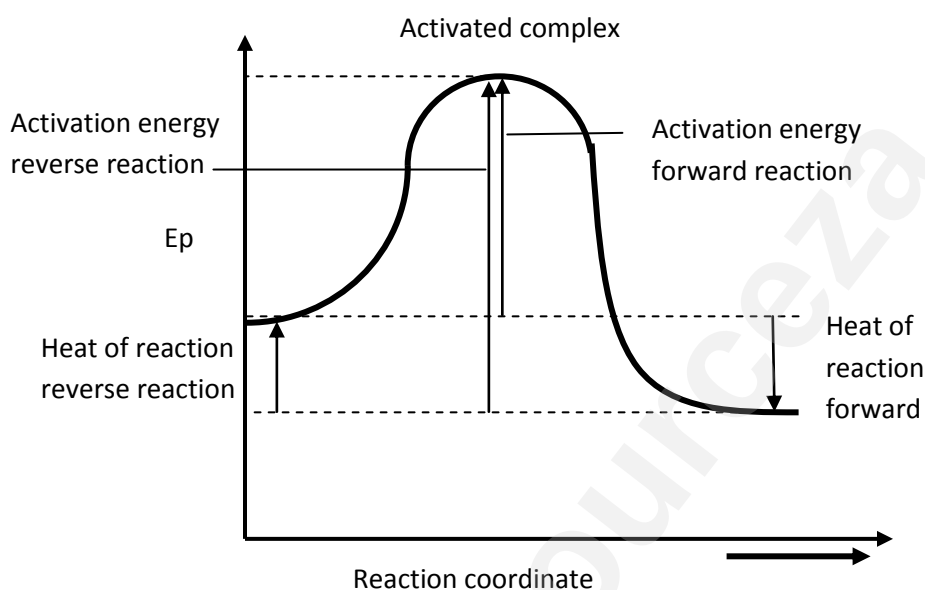
SECTION B: SOLUTIONS AND HINTS

Question 1:

1.1 Exothermic ✓

1.2 $E_{\text{products}} < E_{\text{reactants}}$ ✓

(Make sure you look carefully at the bigger than or smaller than sign, it can easily be confused if you do not concentrate)



Mark allocation

Activation energy for the forward reaction ✓
 Activation energy for the reverse reaction ✓
 Activation complex ✓
 Heat of the reaction for the forward reaction ✓
 Heat of reaction for the reverse reaction ✓
 Axes labelled ✓
 Shape of graph ✓
(Learn the labels – for the forward and reverse)

2.2 Exothermic ✓

2.3 Endothermic, ✓ energy of the products are greater than the energy of the reactants ✓

! Learner Note: It is important to be able to draw the energy curves for forward and reverse reactions. Ensure that you are able to answer questions for both reactions if one of the graphs, i.e. forward or reverse is given. Practise this. Remember to label the axes!

Question 3

3.1 Exothermic, ✓ the heat of the reaction is negative, energy is given off ✓

3.2 Enzymes are catalysts ✓ - catalysts speed the reaction up ✓ and increase the rate of the reaction.

3.3 Glucose is broken up by the body during exercise, ✓ it reduces weight gain ✓ as it uses energy ✓

3.4 Cellular respiration is the reaction of glucose with oxygen (oxidation of glucose) ✓ to produce carbon dioxide, water and energy. ✓ It occurs in the presence of a catalyst ✓

Learner Note: Emphasise the function of a catalyst – it reduces the activation energy for the forward and reverse reaction.

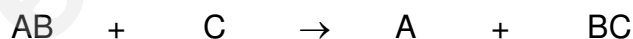
Question 4

- 4.1 a. Exothermic, ✓ heat of the reaction is negative ✓
 b. Endothermic, ✓ heat of the reaction is positive ✓
- 4.2 The minimum amount of energy needed to start a reaction ✓✓
- 4.3 a Has the lowest activation energy ✓ therefore it will have a greater reaction rate ✓ – less energy is needed to start the reaction ✓
 b Has a lower rate of reaction ✓ – more energy is required to get the reaction to take place ✓
- 4.4 $\Delta H = H_{\text{products}} - H_{\text{reactants}}$ ✓✓
- 4.5 By adding a catalyst ✓ the amount of activation energy is reduced ✓

SECTION C: ADDITIONAL CONTENT NOTES

ENERGY CHANGES DURING CHEMICAL REACTIONS

- Most reactions do not begin until an amount of energy (activation energy) has been added to the reaction mixture.
- The **activation energy** is often called the '**energy hill**' which must be 'overcome' by the addition of this amount of energy before a reaction can take place.
- When activation energy is added to the reactants, a so-called **activated complex** is formed.
- Activated complex – temporary, unstable, high-energy composition of atoms, which represents a transition state between reactants and the products.
- When the activated complex is formed during a reaction, this complex can lead either to the formation of new bonds i.e molecules of the products, or to re-formation of the old bonds, thereby returning to being reactants.
- For the reaction



The formation of an activated complex as a transitional step can be represented as follows:



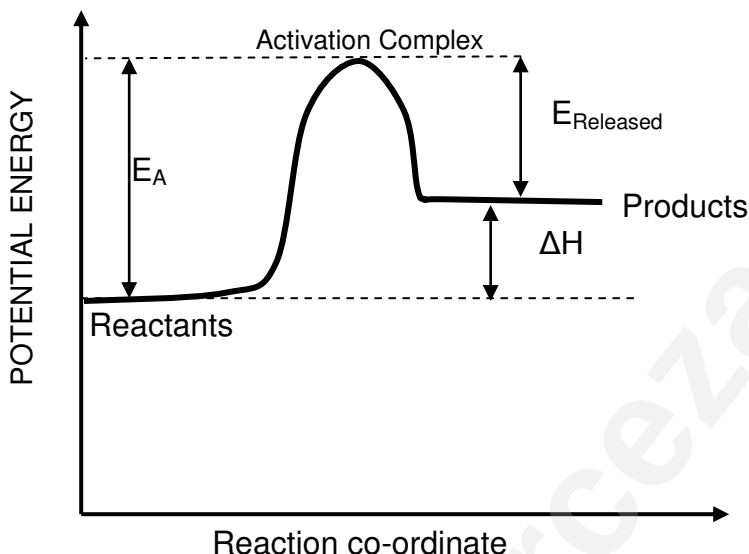
- The peak of the energy hill indicates the energy of the activated complex.
- When an activated complex is formed during a reaction, this complex can lead either to the formation of new bonds, i.e. molecules of the products or to the re-formation of the old bonds, thereby returning to being the reactants. This is **reversibility for the reaction**.

HEAT OF REACTION (ENTHALPY)

- Heat of the reaction (ΔH) is the difference between the energy of the products and the energy of the reactants.

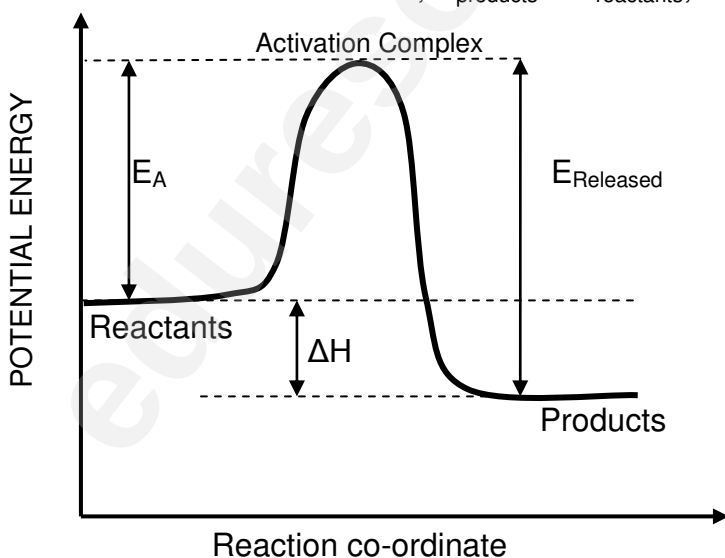
$$\Delta H = E_{\text{products}} - E_{\text{reactants}}$$

- For an **endothermic reaction**, $E_{\text{products}} > E_{\text{reactants}}$, therefore **ΔH is positive**.



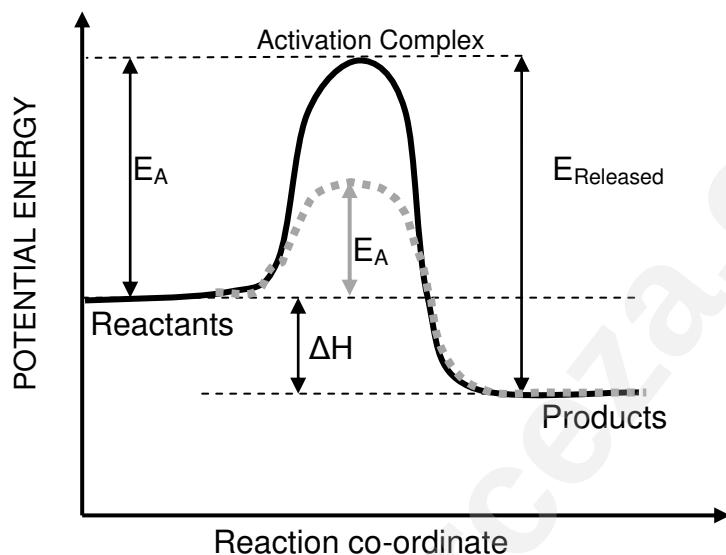
Note: In a reversible reaction, the energy released in forming the products in the forward reaction is the same as the activation energy (E_A) of the reverse reaction.

- For an **exothermic reaction**, $E_{\text{products}} < E_{\text{reactants}}$, **ΔH is negative**.



The Mechanism of a Catalyst

- A catalyst mechanism: the function of a catalyst is to provide an alternate route for the reaction to take place. This route has a lower activation energy and the rate of the reaction increases. A catalyst forms part of the activated complex and when this decomposes the catalyst is released, unchanged.



- The function of a catalyst is to provide an alternate route for the reaction to take place. This route has a lower activation energy and the rate of the reaction increases.
- A catalyst forms part of the activated complex and when this decomposes the catalyst is released, unchanged.
- Two kinds of catalysis:
 - Homogenous – catalyst is the same phase as the reactants.
 - Heterogeneous – catalyst in different phase as the reactants.
- Catalysts cannot cause a reaction to occur, they can only affect the rate of the reaction.

SECTION D: HOMEWORK

Learner Note: Use the homework to practise this section. Attempt all questions, remain within the time frame.

Question 1: 5 minutes

1. Explain the following terms:

- 1.1. Heat of reaction (2)
 - 1.2. Endothermic reaction (2)
 - 1.3. Activation energy (2)
- (6)**

Question 2: 5 minutes

Classify each of the following as either endothermic or exothermic.

- 2.1 $\text{CO} + \text{NO}_2 \rightarrow \text{CO}_2$ $\Delta H = -226 \text{ kJ/mol}$
- 2.2 $2\text{HI} \rightarrow \text{H}_2 + \text{I}_2$ $\Delta H = +40 \text{ kJ/mol}$
- 2.3 $\text{H}_2 + \text{F}_2 \rightarrow 2\text{HF}$ $\Delta H = -536 \text{ kJ/mol}$ (6)

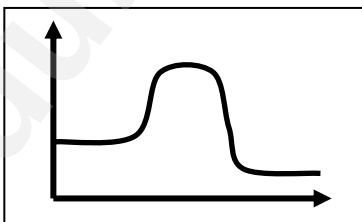
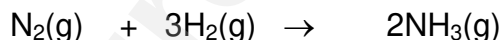
Question 3: 5 minutes

What provides activation energy for the following chemical changes?

- 3.1 Paint on a roof fades
- 3.2 A Bunsen burner is lit
- 3.3 A bush fire starts (6)

Question 4: 5 minutes

The graph in the diagram alongside represents the change in energy that occurs during the reaction...



- 4.1 Provide labels for the x and the y-axes. (2)
- 4.2 Compare the energy of the products to that of the reactants. (2)
- 4.4 What is an activated complex? (2)
- 4.5 Is ΔH for this reaction positive or negative? (1)
- 4.6 Is this reaction endothermic or exothermic? (1) **(8)**