Chapter 8

Energetics

Short Questions (Exercise)

1. Define exothermic and endothermic reactions:

- Exothermic Reaction: A chemical reaction that releases heat energy to the surroundings. Example: Combustion of methane ($CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ + heat).
- Endothermic Reaction: A chemical reaction that absorbs heat energy from the surroundings. Example: Photosynthesis ($6CO_2 + 6H_2O$ + light energy $\rightarrow C_6H_{12}O_6 + 6O_2$).

2. Define enthalpy of a chemical reaction:

Enthalpy (ΔH) is the heat change during a chemical reaction at constant pressure. It is positive for endothermic reactions ($\Delta H > 0$) and negative for exothermic reactions ($\Delta H < 0$).

3. What is anaerobic respiration?

Anaerobic respiration is the process of energy production in the absence of oxygen. It involves the breakdown of glucose into energy, producing by-products like lactic acid or ethanol. Example: Fermentation.

4. Define activation energy:

Activation energy is the minimum energy required for reactants to undergo a chemical reaction. It determines how fast a reaction occurs.

5. What is the role of a catalyst in a chemical reaction?

A catalyst speeds up a chemical reaction by lowering its activation energy without being consumed in the reaction.

6. Differentiate between aerobic and anaerobic respiration:

Feature	Aerobic Respiration	Anaerobic Respiration
Oxygen Requirement	Requires oxygen	Does not require oxygen
Energy Yield	High (36-38 ATP per glucose molecule)	Low (2 ATP per glucose molecule)
By-Products	Carbon dioxide and water	Lactic acid (in animals) or ethanol (in yeast)
Location	Occurs in mitochondria	Occurs in cytoplasm

7. How can you determine the enthalpy of a chemical reaction?

Enthalpy change (ΔH) is determined by:

ΔH = (Sum of bond energies of reactants) - (Sum of bond energies of products).

8. Explain how the process of respiration provides us energy:

Respiration involves the breakdown of glucose in the presence of oxygen (aerobic respiration) or absence of oxygen (anaerobic respiration) to produce ATP (adenosine triphosphate), which is the energy currency of the cell. This energy powers cellular processes like muscle contraction, metabolism, and growth.

9. Draw labeled reaction pathway diagrams for exothermic and endothermic reactions:

Exothermic Reaction:

- Reactants have higher energy than products. Energy is released as heat.

Endothermic Reaction:

- Products have higher energy than reactants. Energy is absorbed.

10. Calculate the enthalpy of reaction between hydrogen and chlorine to form hydrogen chloride:

Reaction: $H_2 + Cl_2 \rightarrow 2HCl$

Given bond energies:

- H-H = 436 kJ/mol
- Cl-Cl = 243 kJ/mol
- H-Cl = 432 kJ/mol

ΔH = (Sum of bond energies of reactants) - (Sum of bond energies of products)

ΔH = [436 + 243] - [2 × 432]

ΔH = 679 - 864 = -185 kJ/mol

Answer: The reaction is exothermic, with ΔH = -185 kJ/mol.

11. Justify the statement that the process of respiration is crucial for us:

Respiration is vital because it provides ATP, the primary source of energy for all cellular activities. This energy drives essential processes such as:

- Muscle contraction for movement.
- Cellular repair and regeneration.
- Active transport of molecules across cell membranes.
- Synthesis of biomolecules like proteins.

Pathway Diagrams for Exothermic and Endothermic Reactions

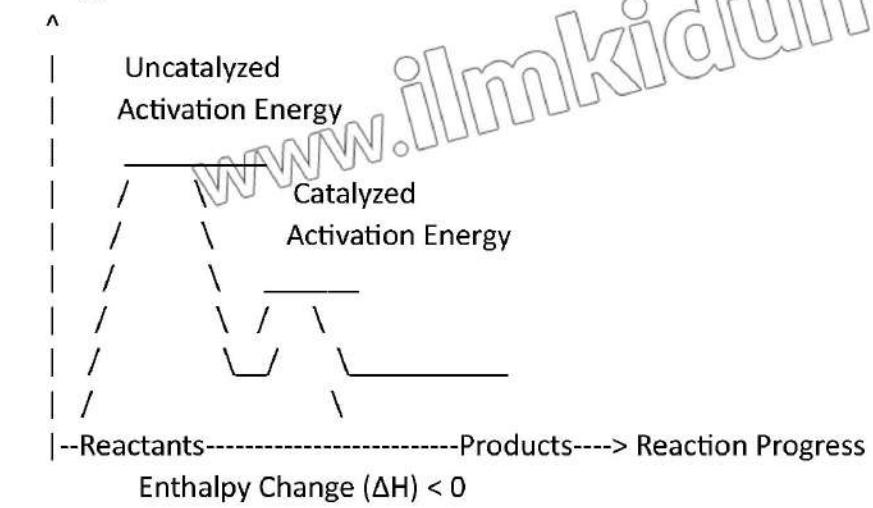
1. Exothermic Reaction Pathway

- Characteristics:
  - Reactants have higher energy than products.
  - Energy is released during the reaction (ΔH < 0).
  - A catalyst reduces the activation energy.

Diagram Description:

The energy pathway for an exothermic reaction shows the following:
- The activation energy required for the reaction to proceed (uncatalyzed).
- A catalyzed reaction reduces the height of the activation energy barrier.
- Enthalpy change (ΔH) is negative, as energy is released.

Diagram (Description for Exothermic Reaction):



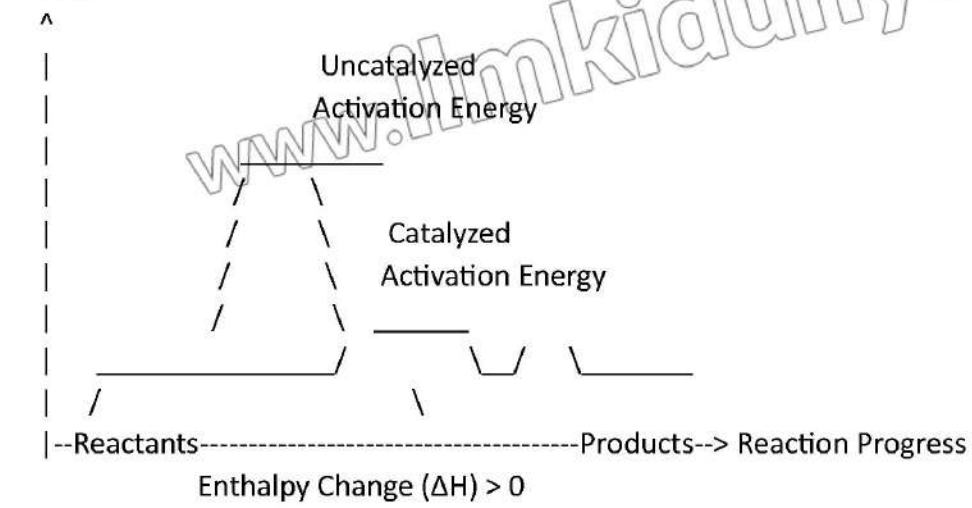
2. Endothermic Reaction Pathway

- Characteristics:
  - Products have higher energy than reactants.
  - Energy is absorbed during the reaction (ΔH > 0).
  - A catalyst reduces the activation energy.

Diagram Description:

The energy pathway for an endothermic reaction shows the following:
- The activation energy required for the reaction to proceed (uncatalyzed).
- A catalyzed reaction reduces the height of the activation energy barrier.
- Enthalpy change (ΔH) is positive, as energy is absorbed.

Diagram (Description for Endothermic Reaction):



Explanation of Terms in the Diagram:

1. Reactants: The starting materials in the chemical reaction.
2. Products: The final substances formed in the reaction.
3. Activation Energy: The minimum energy required to start the reaction:
   - Uncatalyzed: Higher activation energy.
   - Catalyzed: Lower activation energy due to the catalyst.
4. Enthalpy Change (ΔH): The difference in energy between reactants and products:
   - Exothermic Reaction: $\Delta H < 0$, energy is released.
   - Endothermic Reaction: $\Delta H > 0$, energy is absorbed.

Extera Short Questions (Topic Wise)

8.1: Energy in Chemical Reactions

What is energy in chemical reactions?

Energy is involved in breaking and forming bonds during chemical reactions. It is either absorbed (endothermic) or released (exothermic). Example: The combustion of methane releases energy: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ + Energy.

What is an exothermic reaction?

An exothermic reaction releases energy, usually in the form of heat or light, as products have lower energy than reactants. Example: Combustion of wood releases heat and light.

What is an endothermic reaction?

An endothermic reaction absorbs energy, as reactants require more energy to form products. Example: Photosynthesis absorbs sunlight: $6CO_2 + 6H_2O$ + Energy $\rightarrow C_6H_{12}O_6 + 6O_2$.

What happens to energy during bond formation?

Energy is released when bonds are formed because the system becomes more stable. Example: The formation of water from hydrogen and oxygen releases energy.

8.2: Thermochemical Reactions

What are thermochemical reactions?

Thermochemical reactions are chemical reactions accompanied by changes in heat energy.

What is a thermochemical equation?

A thermochemical equation shows the heat change (ΔH) along with the reactants and products. Example: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$, ΔH = -890 kJ indicates the reaction is exothermic.

What does a negative ΔH indicate?

A negative ΔH means the reaction releases heat and is exothermic.

What does a positive ΔH indicate?

A positive ΔH means the reaction absorbs heat and is endothermic. Example: Dissolution of ammonium nitrate in water (ΔH = +25.7 kJ/mol).

8.3: Enthalpy of Reaction

What is enthalpy of reaction?

Enthalpy of reaction is the heat energy change at constant pressure during a chemical reaction.

How is enthalpy change represented?

It is represented by ΔH, which can be positive (endothermic) or negative (exothermic).

What is standard enthalpy change?

Standard enthalpy change is the enthalpy change when all reactants and products are in their standard states (1 atm pressure, 298 K temperature).

What is the unit of enthalpy?

The unit of enthalpy is kilojoules per mole (kJ/mol). Example: The standard enthalpy of combustion of methane is -890 kJ/mol.

8.4: Bond Energy and Bond Dissociation Energy

What is bond energy?

Bond energy is the average energy required to break one mole of a bond in gaseous molecules.

What is bond dissociation energy?

Bond dissociation energy is the energy required to break a specific bond in a molecule. Example: The bond dissociation energy of H_2 is 435 kJ/mol.

Why is bond energy important?

It helps predict the energy changes in chemical reactions by comparing the energy required to break bonds in reactants and form bonds in products.

Which bonds have higher bond energy?

Triple bonds have the highest bond energy, followed by double and single bonds. Example: The bond energy of N_2 (triple bond) is 945 kJ/mol.

8.5: Activation Energy

What is activation energy?

Activation energy is the minimum energy required for reactants to collide and form products, initiating a reaction.

What does activation energy determine?

Activation energy determines the speed of a reaction; lower activation energy leads to faster reactions.

What happens if activation energy is high?

A reaction occurs more slowly because fewer molecules have sufficient energy to overcome the barrier.

How can activation energy be reduced?

Activation energy can be reduced by using a catalyst. Example: Enzymes reduce activation energy in biological processes like digestion.

8.6: Catalyst

What is a catalyst?

A catalyst is a substance that increases the rate of a chemical reaction without being consumed in the process. Example: Catalase breaks down hydrogen peroxide into water and oxygen.

How does a catalyst work?

A catalyst lowers the activation energy of a reaction, allowing more reactants to form products faster.

What is an example of a catalyst?

Enzymes in biological systems act as catalysts. Example: Catalase breaks down hydrogen peroxide.

Does a catalyst affect equilibrium?

No, a catalyst speeds up both the forward and reverse reactions equally and does not change the equilibrium position.

Extera Long Questions (Topic Wise)

Explain the difference between exothermic and endothermic reactions with examples.

Exothermic reactions release energy to the surroundings, usually in the form of heat or light. The energy released during bond formation in the products is greater than the energy required to break the bonds in the reactants. ΔH is negative.
Example: Combustion of methane releases energy: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$, $\Delta H = -890$ kJ/mol.

Endothermic reactions absorb energy from the surroundings. The energy required to break the bonds in the reactants is greater than the energy released during bond formation in the products. ΔH is positive.
Example: Photosynthesis absorbs sunlight: $6CO_2 + 6H_2O + \text{Energy} \rightarrow C_6H_{12}O_6 + 6O_2$.

What is bond energy, and how does it relate to the energy changes in chemical reactions?

Bond energy is the amount of energy required to break one mole of a specific bond in gaseous molecules. It helps predict energy changes in chemical reactions by comparing the energy required to break bonds in reactants and form bonds in products.

Example: Breaking the H_2 bond requires 435 kJ/mol (endothermic), while forming water releases 483.6 kJ/mol (exothermic). Reactions with more energy released during bond formation than required for bond breaking are exothermic.

What is activation energy, and how do catalysts affect it? Provide examples.

Activation energy is the minimum energy required for reactants to collide and form products. It represents the energy barrier that must be overcome for a reaction to proceed.

Catalysts lower activation energy, allowing the reaction to occur faster. They provide an alternate pathway without being consumed in the reaction.
Example: Enzymes in biological systems speed up reactions by reducing activation energy, such as catalase decomposing hydrogen peroxide: $2H_2O_2 \rightarrow 2H_2O + O_2$.

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8.1: Energy in Chemical Reactions

1. **What happens during an exothermic reaction?**
   a) Energy is absorbed
   b) Energy is released ☑
   c) No energy change occurs
   d) Energy remains constant

2. **What is an endothermic reaction?**
   a) A reaction that releases energy
   b) A reaction that absorbs energy ☑
   c) A reaction with no energy change
   d) A reaction that emits light

3. **Which of the following is an example of an exothermic reaction?**
   a) Photosynthesis
   b) Combustion of methane ☑
   c) Melting of ice
   d) Dissolution of ammonium nitrate

4. **What happens to energy during bond formation?**
   a) Energy is released ☑
   b) Energy is absorbed
   c) Energy is unchanged
   d) Energy is transferred

5. **What happens to energy during bond breaking?**
   a) Energy is released
   b) Energy is absorbed ☑
   c) Energy is stored
   d) Energy is unchanged

8.2: Thermochemical Reactions

6. **What does a thermochemical equation show?**
   a) Mass of reactants
   b) Energy absorbed by reactants
   c) Energy change (ΔH) during a reaction ☑
   d) Only products formed

7. **What does a negative ΔH indicate?**
   a) Endothermic reaction
   b) Exothermic reaction ☑

c) No energy change
d) Energy loss to surroundings

8. **What does a positive ΔH indicate?**
   a) Energy is absorbed by the system ☑
   b) Energy is released by the system
   c) Energy remains constant
   d) The system does no work

9. **Which of the following reactions is exothermic?**
   a) Dissolution of ammonium nitrate
   b) Freezing of water ☑
   c) Melting of ice
   d) Decomposition of calcium carbonate

10. **What type of energy change occurs during combustion reactions?**
    a) Exothermic ☑
    b) Endothermic
    c) Neutral
    d) Isothermal

8.3: Enthalpy of Reaction

11. **What is enthalpy of reaction (ΔH)?**
    a) Energy required to break bonds
    b) Heat energy change at constant pressure ☑
    c) Total energy in a reaction
    d) Energy lost to surroundings

12. **What is the standard unit of enthalpy?**
    a) Joules (J)
    b) Kilojoules per mole (kJ/mol) ☑
    c) Watts (W)
    d) Calories (cal)

13. **What is standard enthalpy change?**
    a) Enthalpy change measured at any temperature
    b) Enthalpy change in gaseous state only
    c) Enthalpy change when reactants and products are in standard states ☑
    d) No enthalpy change

14. **Which reaction involves a positive ΔH?**
    a) Combustion of wood
    b) Condensation of water
    c) Melting of ice ☑
    d) Freezing of water

15. **What does ΔH = -890 kJ/mol signify?**
    a) Endothermic reaction

b) Exothermic reaction ☑
c) Reaction in equilibrium
d) No heat change

8.4: Bond Energy and Bond Dissociation Energy

16. **What is bond energy?**
    a) Energy required to break one mole of a bond in gaseous molecules ☑
    b) Energy released during bond formation
    c) Energy stored in a bond
    d) Total energy in a molecule

17. **What type of bond has the highest bond energy?**
    a) Triple bond ☑
    b) Double bond
    c) Single bond
    d) Ionic bond

18. **Which bond requires 435 kJ/mol to break?**
    a) H_2 bond ☑
    b) O_2 bond
    c) N_2 bond
    d) C-C bond

19. **Why is bond energy important?**
    a) It determines atomic mass
    b) It explains why bonds break
    c) It helps predict energy changes in reactions ☑
    d) It measures stability of ionic compounds

20. **What happens during bond dissociation?**
    a) Energy is absorbed ☑
    b) Energy is released
    c) Bonds are formed
    d) No energy change

8.5: Activation Energy

21. **What is activation energy (Ea)?**
    a) Energy released in a reaction
    b) Minimum energy required to start a reaction ☑
    c) Energy at equilibrium
    d) Total energy in reactants

22. **What happens if activation energy is high?**
    a) The reaction is slow ☑
    b) The reaction is fast

c) No reaction occurs
d) Energy remains constant

23. **How can activation energy be reduced?**
a) By adding more reactants
b) By using a catalyst ☑
c) By heating the reactants
d) By cooling the system

24. **Which graph peak represents activation energy?**
a) The energy barrier before products are formed ☑
b) The energy level of reactants
c) The energy level of products
d) The transition point

25. **What is an example of a reaction requiring activation energy?**
a) Combustion of wood ☑
b) Freezing of water
c) Dissolution of salt
d) Photosynthesis

8.6: Catalyst

26. **What is a catalyst?**
a) A substance that slows down a reaction
b) A substance that speeds up a reaction without being consumed ☑
c) A product of a reaction
d) An energy barrier

27. **How does a catalyst work?**
a) By increasing the energy of reactants
b) By lowering activation energy ☑
c) By absorbing energy
d) By changing equilibrium

28. **Which is an example of a biological catalyst?**
a) Acid
b) Base
c) Enzyme ☑
d) Metal

29. **Does a catalyst affect equilibrium?**
a) Yes, it shifts the equilibrium position
b) No, it slows down equilibrium
c) No, it only speeds up the attainment of equilibrium ☑
d) Yes, it changes the reactants

30. **What happens to a catalyst after a reaction?**
a) It is consumed

b) It becomes part of the products

c) It remains unchanged ☑

d) It loses its activity