



Chapter # 5 Energetics



Student Learning Outcomes

After studying this chapter, students will be able to:

- Explain the idea of a chemical system and its connection with its surroundings influences energy transfer during a chemical reaction.
- Differentiate between exothermic and endothermic reactions by giving examples.
- State that thermal energy is called enthalpy change and recognize its sign as negative for exothermic and positive for endothermic reactions.
- Define activation energy as the minimum energy that colliding particles must have a successful collision.
- Explain that activation energy depends on reaction pathway which can be changed using catalysts or enzyme (detailed pathways not required).
- Draw, label and interpret reaction pathway diagram for exothermic and endothermic reaction which includes enthalpy change, activation energy (uncatalyzed and catalyzed), reactants and products.
- Recognize that bond breaking is endothermic and bond making is exothermic processes.
- Explain that enthalpy change is sum of energies absorbed and released in bond breaking and bond forming.
- Calculate enthalpy change of a reaction given bond energy values.
- Explain how respiration (aerobic and anaerobic), an exothermic process, provide energy for biological systems and lipids as reserve stores of energy.

Subject Questions & Answers

Q1. What is meant by energetics?

Ans. The branch of chemistry which deals with the energy changes during a chemical reaction is called energetics.

Q2. Why the energy changes take place during a chemical reaction?

Ans. The energy changes take place during a chemical reaction due to breaking and making of chemical bonds during a chemical reaction.

Q3. Define energy. How it exists?

Ans. Energy: The ability of a body to do work or to produce change is called energy.

Existence of energy: Energy exists in different forms (potential, kinetic, chemical, heat, electrical, nuclear etc.) which are often interconvertable.

Q4. Which two forms of energy are mainly concerned in chemical energetics?

Ans. In chemical energetics we are mainly concerned with following two forms of energy:

1. Chemical energy
2. Heat energy

Q5. What is meant by heat when it is absorbed or released during a chemical reaction?

Ans. Heat: Heat is a form of energy which is associated with molecular motion. It flows from hotter to colder body.

Q6. When heat is absorbed or released during a chemical reaction?

Ans. During a chemical reaction, heat is absorbed when bonds are broken and released when bonds are formed.

Q7. Define chemical energy.

Ans. Chemical energy: The energy which is stored in the bonds of molecules in which atoms are bonded to each other is called chemical energy.

Q8. What are thermochemical reactions? Write down their types.

Ans. Thermochemical reactions: The chemical reactions which occur with the evolution or absorption of heat are called thermochemical reactions.

Types: There are two types of thermochemical reactions.

1. Exothermic reactions
2. Endothermic reactions

Q9. What is meant by system and surrounding? Explain with the help of an example.

Ans. System: Any physical or chemical change under study is called system.

Surrounding: Everything else which does not fall in this system is called surrounding.

OR The environments containing the system are called the surrounding.

Example: If you are boiling water in the beaker, the water molecules will be called a system while everything surrounding thus like beaker, burner etc. will be called the surrounding.

Similarly a cup of ice cream has melt, the ice cream acting as a system, while the wall of cup and the air around it is surrounding.

Q10. What we study in energetics?

Ans. In energetics, we study the flow of energy in a chemical reaction.

Q11. Define thermodynamics.

Ans. Thermodynamics: The branch of science which deals how energy changes during chemical reaction affect the properties of a chemical system.

Q12. Write a note on enthalpy and heat content.

Ans: Enthalpy (H): "The enthalpy or heat content, is defined as the total amount of thermal energy stored in a compound." Enthalpy is the measurement of energy in a thermodynamics system. The quantity of enthalpy is equal to the total heat content of a

system.

Heat Content: The total amount of heat energy present in molecule under standard conditions (0°C temperature and 760 mmHg) is called heat content.

Representation of enthalpy: The enthalpy of a system is represented by H.

Change in enthalpy: The change in enthalpy which a system undergoes is represented by ΔH .

Units of enthalpy: The unit of its measurement is KJ/mole.

Measurement of enthalpy: The total enthalpy of a system can not be measured directly however, the change in enthalpy ΔH brought about in a system can be measured comparatively easily.

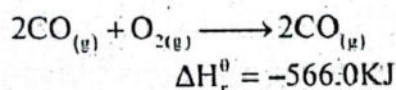
$$\Delta H = H_2 - H_1$$

$$\text{Change in enthalpy} = \text{Enthalpy of product} - \text{Enthalpy of reactant}$$

Q13. What is meant by standard enthalpy change of reaction (ΔH_r°).

Ans. Standard enthalpy change of reaction (ΔH_r°): It is the enthalpy change when reactants in their standard states under go reaction to produce products in their standard states. This quantity is called the standard enthalpy change or heat of reaction at constant pressure.

Examples:



Q14. How can you differentiate enthalpy from heat?

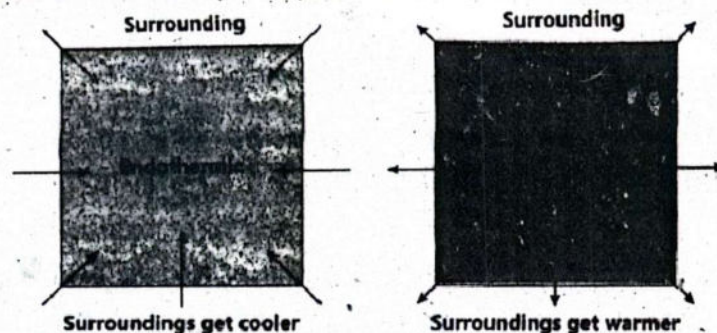
Ans.	Enthalpy	Heat
	Enthalpy is the total heat content of a body. Enthalpy is an essential part of a system. It depends upon the number of molecule present in system, its chemical composition and its structure. Enthalpy is change when heat enters or leaves the system.	Heat is a form of energy that flows from hot body to a cold body because of a difference in temperature. Unit: We measure heat in joules. Heat is transfer of thermal energy. Heat is not an essential part of a system. It just comes and goes.

Q15. What is meant by exothermic reaction? Explain with examples.

Ans. Exothermic Reactions: ["Exo means out and therm means heat"]

"The chemical reactions in which heat energy is given out are called exothermic reactions.

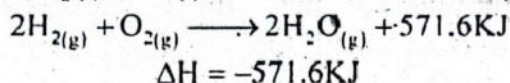
During exothermic reactions, The surrounding becomes hot.



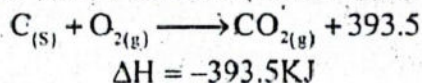
Enthalpy change H , for exothermic reactions is always negative.

Examples:

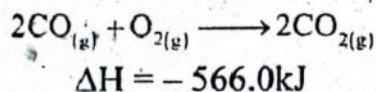
- i. Hydrogen gas burns in oxygen to give water is an example of exothermic reaction.



- ii. Carbon burns in oxygen to give carbon dioxide gas.



- iii. Carbon monoxide reacts with oxygen to give carbon dioxide.



- iv. All the combustion reactions are exothermic in nature.

Exercise

1. Does boiling water in a beaker endothermic or exothermic change? Which form of energy is being transferred in this system?

Ans. Boiling water in a beaker is endothermic because it absorbs energy from surrounding.

Form of energy: The form of energy is transferred in thermal energy.

2. Can energy be transferred in a form other than heat during a chemical reaction?

Ans. Yes, energy can be transferred in other than heat during a chemical reaction, such as light, electricity or mechanical.

3. Why it is not possible to calculate the enthalpy of a system?

Ans. We can not measure the enthalpy because, enthalpy is an extensive property, meaning it depends on the amount of substance present. It is not something we can measure directly like temperature or pressure. We measure change in enthalpy (ΔH) during a chemical reaction.

4. Why the chemical reaction between sodium metal and water proceeds violently?

Ans. Sodium reacts violently with water because it is a very reactive alkali metal which donates an electron to hydrogen ion in water causing a rapid release of energy in the form of heat. This amount of heat is enough to ignite hydrogen gas and causes a violent reaction (explosion).

5. Is melting of ice an exothermic or endothermic change?

Ans. Yes, the melting of ice is an endothermic change because it absorbs energy from surrounding.

Q16. What is meant by endothermic reactions? Explain with examples.

Ans. **Endothermic Reactions:** [Endo means inside and Therm means heat]

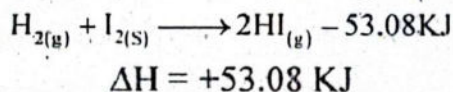
"The chemical reactions in which heat energy is absorbed are called endothermic reactions."

During endothermic reactions, the enthalpy change (ΔH) is always positive.

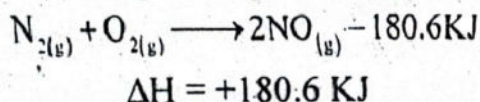
Examples:

- i. Photosynthesis is an endothermic in nature.

- ii. Hydrogen gas reacts with solid iodine only at high temperature.



- iii. Formation of NO in air due to lightening in the clouds.



Q17. Discuss the importance of exothermic reaction in daily life.

Ans. Importance (uses) of exothermic reactions: Our present-day living conditions depend heavily on the availability of energy in its various forms. Exothermic chemical reactions are extensively used to fulfill this requirement. In such reactions, chemical energy is converted into heat energy.

Home and industry: We burn fuels like gas, oil and coal to cook food and for other heating purposes in our homes and industry. During this burning process called combustion, substances present in fuels react with oxygen of the air to produce a certain amount of heat.

Biological fuels: Foods such as fats and carbohydrates are important biological fuels. During metabolism, the chemical energy present in this food is converted to heat to keep us warm.

Generation of electricity: A large portion of electricity is produced at power stations by burning fuels such as natural gas, oil and coal. The heat which comes out from their combustion is used to produce steam at high pressure. This high pressure steam is then used to rotate turbines, which in turn generate electricity.

Driving vehicle: While driving a vehicle, it is the combustion of petrol or diesel that gives off energy and drives it forward.

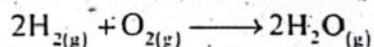
Fireworks: The one example of exothermic reactions people seem to enjoy the most is that of fireworks. Fireworks are the result of combustion reactions that yield heat, light and sound. Different metal salts along with oxidising agents produce a variety of colours when burnt.



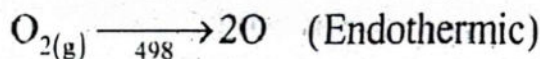
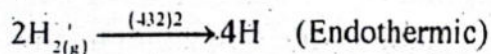
Q18. Why the chemical reactions are either exothermic or endothermic? Explain with an example.

Ans. A chemical reaction mainly involves the processes which involve bond breaking and bond formation.

Explanation with example: Formation of water from hydrogen and oxygen.



Bond breaking: The chemical bonds between the atoms present in the molecules of H_2 and O_2 first break to give their atoms.



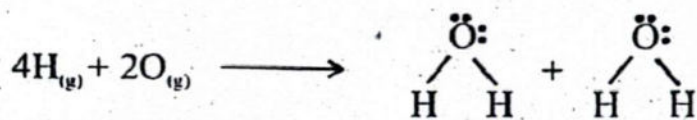
Total amount of energy absorbed during bond breaking.

$$= (435)2 + 498 \quad = 870 + 498$$

$$= 1368\text{KJ} \quad = +1368 \text{ KJ/mol}$$

Bond formation: These atoms of hydrogen (4H) and oxygen (2O) form bonds to give

two water molecules:



Number of "O — H" bonds formed = 4 bonds
 Bond formation energy of one O — H bonds = 484 KJ/mol
 Bond formation energy of 4(O — H) bonds = 4×484
 = -1936 KJ/mol

Total amount of energy released during bond formation = 1936 KJ/mol

Conclusion: Weaker bond are broken and less energy (1368 KJ) is absorbed in the system. Stronger bonds are formed in water molecule and more energy (-1936 KJ) is released. The overall reaction is exothermic.

Amount of energy released = $1368 - 1936 = -568\text{KJ/mol}$

Amount of energy released for 2 moles of water = -568 KJ/mol

Amount of energy released for 1 mole of water = $\frac{-568}{2}$ KJ/mol
 = -284 KJ/mol

Q19. How does a chemical reaction take place? Explain with the help of energy profile diagrams of exothermic and endothermic reactions.

Ans. A chemical reaction takes place when the reactant molecules collide with each other to give a transition state.

Explanation: Consider the following hypothetical reactions:



Before mixing: Before mixing, the molecules of reactants "A" and "B" are in a state of random motion, separately colliding with each other and with walls of container.

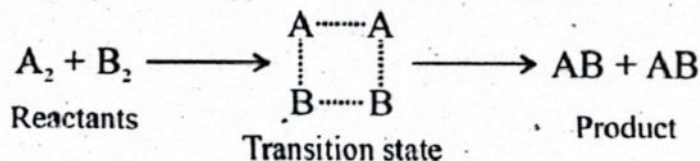
Kinetic energies possessed by these molecules are not same. Majority of these molecules possess average kinetic energy but a few possess more than average energy while others possess less than average kinetic energy.

Excited molecules: The molecules which possess more than average kinetic energy are called excited molecules.

After mixing: When the two reactant molecules are mixed together, all these molecules start *colliding* with each other.

The collisions which result by colliding molecules having average or less than average kinetic energies may not be able to produce any result.

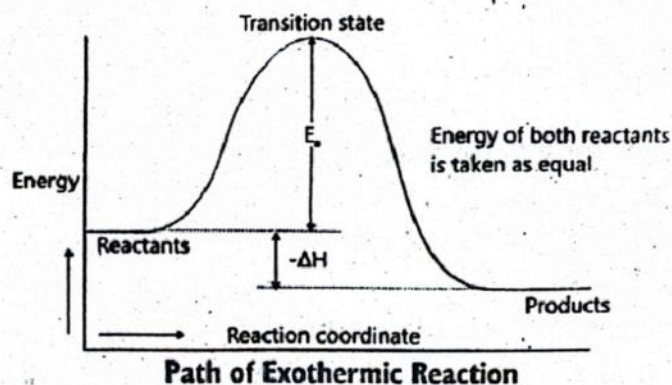
Collision of excited molecules: When excited molecules from both the reactants collide with each other they may be able to produce transition state.



The transition state is shown at the peak of curve.

After a very short period of time, the transition state either returns to the reactants

and the products.

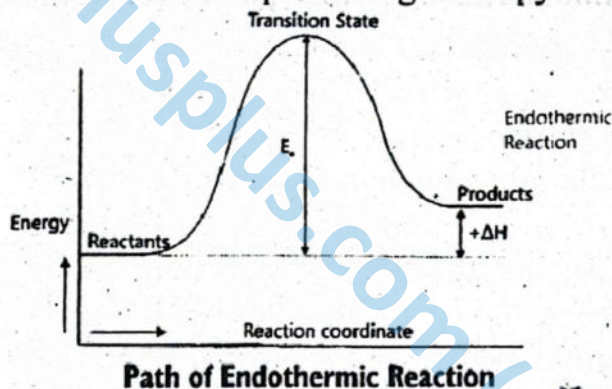


Progress of reaction: The progress of reaction is shown in the diagram above.

Energy of transition state: The energy of the transition state is higher than that of reactants or products because the bonds between the reactant or product molecules are being cleaved progressively.

Activation energy: The energy absorbed by the reactant or product molecules in order to be converted into transition state is called activation energy (E_a).

Enthalpy Change (ΔH): The difference between the energy of reactants and that of products comes out in the form of heat representing enthalpy change (ΔH) of reactions.



Q20. What is meant by catalyst. How it increases the rate of reaction?

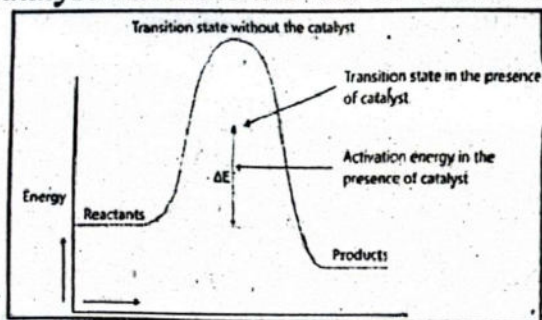
Ans. Catalyst: The substance which can change (increase) the rate of a reaction but chemically remains unchanged at the end of reaction is called catalyst.

Examples:

- i. Nickel (Ni) acts as a catalyst in the hydrogenation of oil to give banaspati ghee.
- ii. Platinum acts a catalyst in the production of H_2SO_4 .
- iii. Chlorine acts as a catalyst promoting the breakdown of ozone.

How catalyst increases the rate of reaction: The catalyst increases the rate of reactions by decreasing its activation energy.

Addition of the catalyst in a reaction increases the rate of reaction because it changes the path adopted by the reactants where by the activation energy value of reaction in decreased, as a result, more reactants are able to be converted into products molecules hence the rate of reaction will increase.



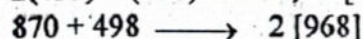
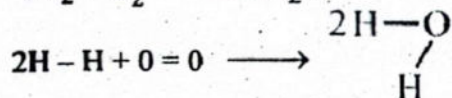
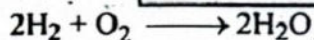
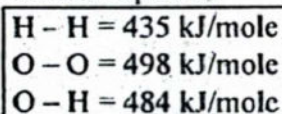
Exercise

1. Can exothermic reaction be reversed?

Ans. Yes, an exothermic reaction can be reversed, and the reverse will be endothermic.

2. Calculate the enthalpy change for the formation of one mole of liquid water.

Ans. Balanced chemical equation



Enthalpy change = - 568 kJ/mol

Enthalpy change for 2 moles of water = - 568 kJ pule

Enthalpy change for 1 mole of water = $\frac{-568}{2} = 284 \text{ kJ/mole}$

Result: Enthalpy change of formation of one mole of liquid water = - 284 kJ/mole

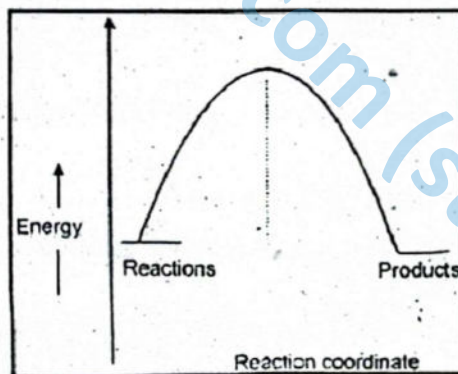
3. Are energy diagrams useful?

Ans. Yes, energy diagrams are very useful because these diagrams provide useful tool for understanding the energy changes that occur during chemical reactions.

These diagrams help us to visualize the energy of reactants and products, the activation energy required for the reaction to occur.

4. Draw an energy profile diagram for a hypothetical reaction which does not evolve or absorb heat.

Ans.

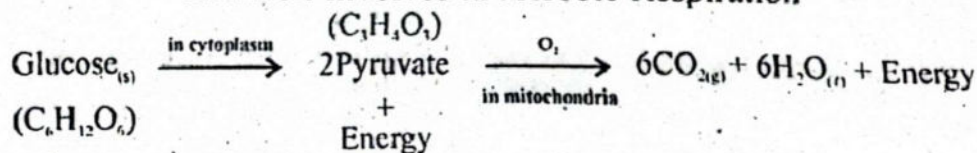


Q21. Discuss the aerobic and anaerobic respiration.

Ans. **Aerobic respiration:** The process of respiration in human beings takes place in the presence of oxygen is called aerobic respiration.

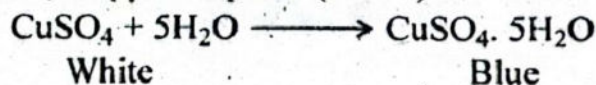
Aerobic respiration is an exothermic process.

Reaction Involves in Aerobic Respiration

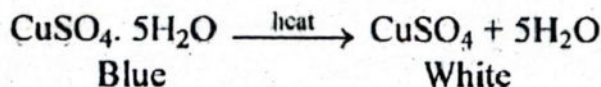


Example: The hydrations of anhydrous copper sulphate is an example of an exothermic reaction which can be reversed.

When crystals of anhydrous copper sulphate (White) are added to water, they turn blue.



This is forward reaction which is exothermic. When hydrated copper sulphate crystals are heated they form white powder. This is reverse reaction which is endothermic.



3. Can energy be transferred in a form other than heat?

Ans. Yes, energy can be transferred in a form other than heat in a chemical reaction.

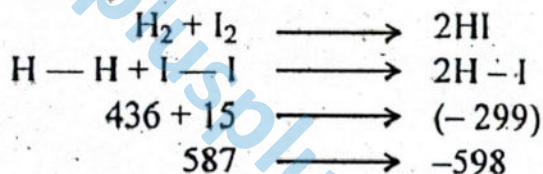
Examples: i. Chemical reactions can be transferred energy in the form of light.

ii. Chemical energy can be converted into electrical energy as in battery.

4. Calculate the enthalpy change of the following chemical reactions. $\text{H}_{2(g)} + \text{I}_{2(g)} \rightarrow 2\text{HI}_{(g)}$

Bond energies of H_2 - I_2 and HI are 436, 151 and -299 KJ/mol. respectively.

Ans. Balanced chemical equation:

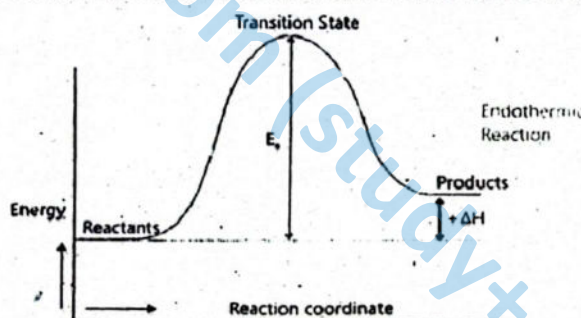


$$\therefore \text{Enthalpy change} = 587 - 598$$

$$= -11 \text{ KJ/mol.}$$

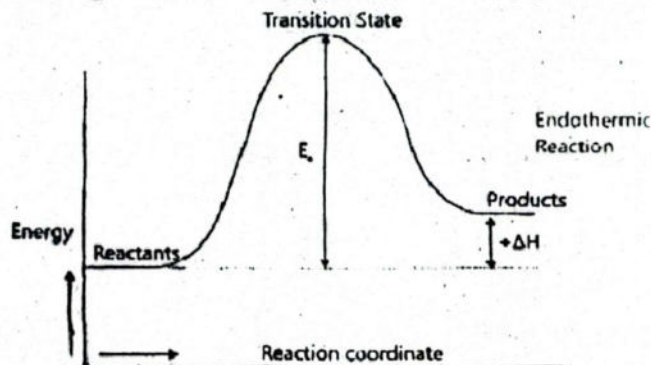
5. Draw the energy profile diagrams for exothermic and endothermic reactions.

Ans. Energy profile diagram for exothermic reaction.



6. Energy profile diagram for endothermic reaction.

Ans.



Additional MCQs

5.1 + 5.2

System and Surrounding + Enthalpy

- The energy stored in a molecule in which atoms are bonded to each other is called:**
 - Chemical energy
 - Heat energy
 - Electrical energy
 - Mechanical energy
- The energy which is released when bond is formed and absorbed when it is broken is called:**
 - Chemical energy
 - Heat energy
 - Potential energy
 - Kinetic energy
- The branch of chemistry which deals with the energy changes that takes place during a chemical reaction is called:**
 - Biochemistry
 - Organic chemistry
 - Physical chemistry
 - Chemical energetics
- The reactions which are accompanied by evolution of heat are called:**
 - Endothermic reactions
 - Chemical reactions
 - Exothermic reactions
 - Slow reactions
- The chemical reactions which are accompanied by absorption of heat are called:**
 - Endothermic reactions
 - Exothermic reactions
 - Chemical reactions
 - None of these
- The total heat content of a body is called:**
 - Chemistry
 - Enthalpy
 - System
 - Surrounding
- The form of energy which flows from hot body to a cold body is called:**
 - Heat
 - Kinetic energy
 - Potential energy
 - Both b and c

5.3

Exothermic and Endothermic Reaction

5.4

How does a Reaction take place

- Heat evolved or absorbed during a chemical reaction is called:**
 - Heat of reaction
 - Heat capacity of a reaction
 - Nature of reaction
 - None of these
- The energy absorbed by the reactant or product molecules in order to be converted into the transition state is called:**
 - Potential energy
 - Kinetic energy

- (c) Activation energy (d) Mechanical energy
10. The substance which increases the speed of reaction but without itself undergoing any permanent chemical change is called:
 (a) Activated complex (b) Catalyst
 (c) Transition complex (d) None of these
11. The breaking of bonds of H_2 and O_2 absorb energy, the process is known as:
 (a) Endothermic process (b) Exothermic process
 (c) Activated process (d) Distributive process
12. The making of bonds between H and O evolve energy, the process is known as:
 (a) Endothermic process (b) Exothermic process
 (c) Explosive process (d) None of these
13. The ΔH for exothermic reaction is always:
 (a) +ve (b) -ve (c) both +ve and -ve (d) None of these

5.5

Aerobic and Anaerobic Respiration

14. The process of respiration in human beings takes place in the presence of oxygen is called:
 (a) Aerobic respiration (b) Anaerobic respiration
 (c) Constructive respiration (d) None of these
15. The respiration in certain organisms like bacteria and algae which occurs in the absence of oxygen is called:
 (a) Aerobic respiration (b) Anaerobic respiration
 (c) Distributive respiration (d) None of these
16. Aerobic respiration is:
 (a) Endothermic in nature (b) Exothermic in nature
 (c) Neither exothermic nor endothermic in nature
 (d) Both a and b
17. During glycolysis of glucose it splits into two molecules of:
 (a) Water (b) Carbon dioxide (c) Sodium (d) Pyruvate
18. Anaerobic respiration is:
 (a) Exothermic in nature (b) Endothermic in nature
 (c) Neither exothermic nor endothermic (d) Both a and b

ANSWERS:

1. (a) 2. (b) 3. (d) 4. (c) 5. (a) 6. (b) 7. (a)
 8. (a) 9. (c) 10. (b) 11. (a) 12. (b) 13. (b) 14. (a)
 15. (b) 16. (b) 17. (d) 18. (a)

Conceptual MCQs

1. The reactions in which surrounding become warmer are called:
 (a) Endothermic reactions (b) Exothermic reactions
 (c) Neither exothermic nor endothermic (d) Both a and b

2. **The part of universe which is under consideration is known as:**
 - (a) System
 - (b) Surrounding
 - (c) Neither system nor surrounding
 - (d) Both a and b
3. **When energy is transferred from surrounding to the system, the change is called:**
 - (a) Exothermic
 - (b) Endothermic
 - (c) Progressive
 - (d) None of these
4. **When the energy is transferred from system to surrounding, the change is called:**
 - (a) Endothermic
 - (b) Exothermic
 - (c) Both a and b
 - (d) None of these
5. **The word 'energy' was the first used in the field of physics by:**
 - (a) Bohr
 - (b) Thomas Young
 - (c) Rutherford
 - (d) None of these
6. **During endothermic reactions, the surrounding becomes:**
 - (a) Warmer
 - (b) Cooler
 - (c) Neither warmer nor cooler
 - (d) Both a and b
7. **Boiling of water in a beaker is:**
 - (a) Exothermic process
 - (b) Endothermic process
 - (c) Neither endothermic nor exothermic process
 - (d) Both a and b
8. **The burning of sui gas in houses is an example of:**
 - (a) Exothermic process
 - (b) Endothermic process
 - (c) Symbolic process
 - (d) All of these
9. **The enthalpy change for endothermic reactions is always:**
 - (a) Positive
 - (b) Negative
 - (c) Zero
 - (d) None of these
10. **When energy is evolved during a reaction, the total enthalpy of the system:**
 - (a) Increases
 - (b) Reviewing same
 - (c) Decreases
 - (d) None of these
11. **The units used to measured the enthalpy change of a reaction are:**
 - (a) m/sec
 - (b) g/cm³
 - (c) KJ/mol.
 - (d) Kg/cm³
12. **When energy is transferred from surrounded to system, the change is called endothermic and it has a:**
 - (a) Positive sign
 - (b) Negative sign
 - (c) Zero sign
 - (d) None of these
13. **The Thomas Young was the first to use the word energy to the field of physics in:**
 - (a) 1902
 - (b) 1702
 - (c) 1802
 - (d) 1602
14. **The units used to measure the heat are:**
 - (a) m/sec.
 - (b) Kg/cm³
 - (c) Joules
 - (d) m³
15. **Combustion of petrol in driving a vehicle is an example of an:**
 - (a) Exothermic reaction
 - (b) Endothermic reaction
 - (c) Corrosive reactions
 - (d) Both a and b
16. **The freezing of water into ice is:**
 - (a) Endothermic process
 - (b) Exothermic process
 - (c) Neither exothermic nor endothermic process
 - (d) Both a and b
17. **During exothermic reactions the enthalpy of reactants is always:**
 - (a) Greater than products
 - (b) Smaller than products

- (c) Equal to that of products (d) Zero
18. The catalyst used in hydrogenation of oil to give banaspati ghee is:
 (a) Na (b) Zn (c) Ni (d) Fe
19. The energy of the transition state is higher than that of reactants or products because the bond between the reactant and product molecule are being:
 (a) Cleaved progressively (b) Formed progressively
 (c) Neither formed nor cleaved progressively (d) All of these
20. The primary storage form of glucose is:
 (a) Glycogen (b) Glycoside (c) Hydrolysis (d) All of these

ANSWERS:

1. (b) 2. (a) 3. (b) 4. (a) 5. (b) 6. (b) 7. (b)
 8. (a) 9. (a) 10. (c) 11. (c) 12. (a) 13. (c) 14. (c)
 15. (a) 16. (b) 17. (a) 18. (c) 19. (a) 20. (a)

Additional Short Questions

5.1 + 5.2

System and Surrounding + Enthalpy

1. What is meant by system?

Ans. Any physical or chemical change under study is called system.

2. Define surrounding.

Ans. Every thing else which does not fall in this system is called surrounding.

3. What is meant by enthalpy?

Ans. The total heat content of a body is called enthalpy of body. It is represented by H.

4. What do you know about chemical energy?

Ans. The energy stored in a molecule in which atoms are bonded to each other is called chemical energy.

5. What is heat?

Ans. The energy released when a bond is formed and absorbed when a bond is broken is called heat.

6. What is meant by standard enthalpy of reaction?

Ans. It is the enthalpy change when reactants in their standard states undergo reaction to produce products in their standard states. This quantity is called the standard enthalpy change.

7. What is chemical energetic?

Ans. The study of energy changes that take place during a chemical reaction is called chemical energetic.

8. Define exothermic reaction.

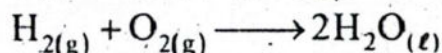
Ans. The reactions in which heat energy is given out are called exothermic reactions.

9. What is meant by endothermic reaction?

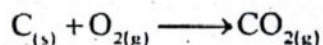
Ans. The reactions in which heat energy is absorbed are called endothermic reactions.

10. Give two examples of exothermic reaction.

Ans. i. Formation of water from hydrogen and oxygen.

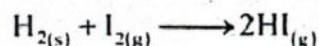


ii. Production of carbon dioxide from carbon and oxygen.



11. Give one example of endothermic reaction:

Ans. Formation of hydrogen iodide from hydrogen and iodine

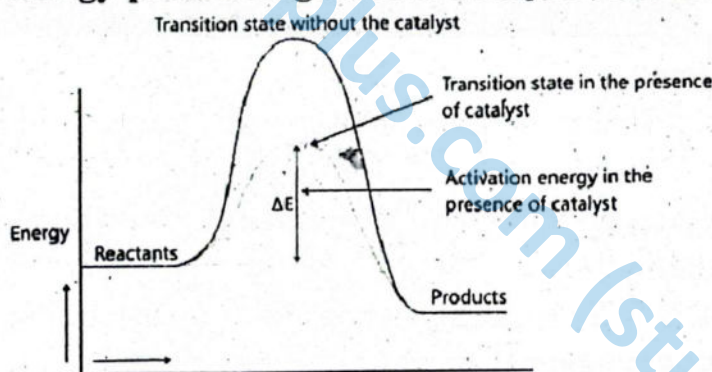


12. Define catalyst.

Ans. The substance which increases the rate of a reaction but chemically remains unchanged at the end of reaction is called catalyst.

13. Draw the energy profile diagram for catalysed and uncatalysed reaction.

Ans.



14. Define aerobic respiration.

Ans. The respiration which takes place in human beings in the presence of oxygen is called aerobic respiration.

15. What is glycolysis?

Ans. The process during which one molecule of glucose is split into two molecules of pyruvate is called glycolysis.

16. What are lipids?

Ans. Lipids are a group of organic compounds which include fats, waxes, sterols etc.

17. What is meant by activation energy (E_a)?

Ans. **Activation energy (E_a):** The energy absorbed by the reactant or product molecules in order to be converted into the transition state is called activation energy. It is represented by E_a .

Conceptual Short Questions

1. Which we encounter in energetics?

Ans. In energetics we not only encounter heat which comes out of a chemical reaction but also another quantity which is called enthalpy.

2. What happens to the enthalpy of a system when energy is absorbed or released?

Ans. When the energy is absorbed during a reaction, the total enthalpy of the system increases. When energy is evolved during a reaction, the total enthalpy of the system decreases.

3. What we study in thermodynamics?

Ans. Thermodynamics deals with how the energy changes during chemical reactions affect the properties of a chemical system.

4. What is the importance (uses) of energy evolved during chemical reaction?

Ans. Energy evolved during a chemical reaction is used in everyday life for cooking, heating, lighting, transportation, communication, entertainment and much more.

5. Is boiling water in a beaker an endothermic or exothermic change? Which form of energy is being transferred in this system?

Ans. Boiling water in a beaker is an endothermic change. The energy being transferred in this system is heat energy.

6. Why is heat transferred from hot to cold body?

Ans. Heat is a form of energy that flows from hot body to cold body because of a difference in temperature.

7. In melting of ice an exothermic or endothermic change?

Ans. The melting of ice is an endothermic change.

8. Write down the name of catalyst used in the production of H_2SO_4 .

Ans. The catalyst used in the production of H_2SO_4 is platinum.

9. Name the catalyst used in promoting the breakdown of ozone.

Ans. Chlorine acts as a catalyst promoting the breakdown of ozone.

10. Name the catalyst used in the hydrogenation of oil to give banaspati ghee.

Ans. Ni acts as a catalyst in the hydrogenation of oil to give banaspati ghee.

Key Points

1. Any physical or chemical change under study is called a system. Everything else which does not fall in this system is called surrounding.
2. The total amount of heat present in a system at standard conditions is called its heat content. The quantity of enthalpy of a system is also called its total heat content.
3. The standard enthalpy of a reaction is the enthalpy change that occurs when reactants in their standard states undergo reaction to produce products in their standard states.

4. Chemical reactions which take place with the evolution of heat are called exothermic reactions while those which proceed with the absorption of heat are called endothermic reactions.
5. A chemical reaction always involves breaking and formation of chemical bonds.
6. When weaker bonds are broken while stronger bonds are formed, the reaction is overall exothermic and vice versa.
7. A reaction takes place when the reactant particles collide to give a transition state which then change into the products.
8. The energy needed by the reactant particles to change into transition state is called activation energy.
9. The difference between the energy of reactants and that of products is called enthalpy change of the reaction.
10. The reaction is exothermic if the energy of the products is less than that of reactants and endothermic if the energy of the products is more than that of reactants.
11. A catalyst increases the rate of reaction by decreasing its activation energy.
12. The process of respiration in human beings takes place in the presence of oxygen and it is called an aerobic respiration. In some organisms, the respiration occurs in the absence of oxygen which is called anaerobic respiration.

Exercise Questions

1 Tick (✓) the Correct answer.

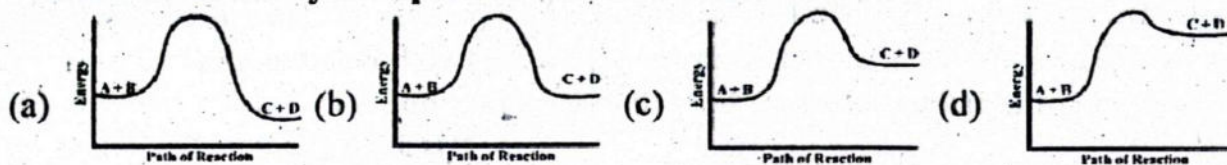
- (i) The following reaction is an exothermic reaction:



From where does the energy come to break the bonds of H_2 and Cl_2 ?

- (a) By collisions between the molecules
 - (b) From sunlight
 - (c) From the surrounding
 - (d) By collisions of the molecules with the walls of the container
- (ii) Which of the following reactions has the least value of activation energy?
- (a) $\text{H}_{2(g)} + \frac{1}{2}\text{O}_{2(g)} \longrightarrow \text{H}_2\text{O}_{(g)}$
 - (b) $\text{C}_{(s)} + \text{O}_{2(g)} \longrightarrow \text{CO}_{2(g)}$
 - (c) $\text{NaCl}_{(aq)} + \text{AgNO}_3_{(aq)} \longrightarrow \text{AgCl}_{(s)} + \text{NaNO}_3_{(aq)}$
 - (d) $\text{H}_{2(g)} + \text{I}_{2(s)} \longrightarrow 2\text{HI}_{(g)}$
- (iii) Formation of which hydrogen halide from the elements is an endothermic reaction?
- (a) HCl
 - (b) HF
 - (c) HBr
 - (d) HI
- (iv) What are the products of anaerobic respiration?
- (a) $\text{ATP} + \text{CO}_2 + \text{H}_2\text{O}$
 - (b) $\text{CO}_2 + \text{H}_2\text{O}$
 - (c) $\text{ATP} + \text{Ethanol} + \text{H}_2\text{O}$
 - (d) $\text{Ethanol} + \text{H}_2\text{O}$

(v) Which reaction do you expect to be a reversible reaction?



(vi) What does it show when a chemical reaction is exothermic?

- (a) It shows the bonds which break are weaker than those are formed.
- (b) It shows the bonds which break are stronger than those are formed.
- (c) Exothermic nature of the reaction is not concerned with bond formation or bond breakage.
- (d) It shows that the reactants are more stable than the products.

(vii) When NaOH and HCl are mixed the temperature increases. The reaction is:

- (a) endothermic with a positive enthalpy change.
- (b) endothermic with a negative enthalpy change.
- (c) exothermic with a positive enthalpy change.
- (d) exothermic with a negative enthalpy change.

(viii) The average bond dissociation energy for the C-H bond is 412 kJ mol^{-1} . Which of the following process will have enthalpy change close to 41 kJ mol^{-1} ?

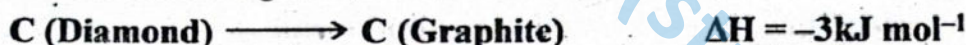
- (a) $\text{CH}_{4(g)} \longrightarrow \text{C}_{(g)} + 2\text{H}_{2(g)}$
- (b) $\text{CH}_{4(g)} \longrightarrow \text{C}_{(g)} + 2\text{H}_{2(g)}$
- (c) $\text{CH}_{4(g)} \longrightarrow \text{C}_{(g)} + 4\text{H}_{2(g)}$
- (d) $\text{CH}_{4(g)} \longrightarrow \text{CH}_{3(g)} + \text{H}_{(g)}$

(ix) The average bond energies for O - O and O = O are 146 and 496 kJ mol^{-1} respectively. Find the enthalpy in kJ for the following reaction?



- (a) -102 kJ
- (b) $+102 \text{ kJ}$
- (c) $+350 \text{ kJ}$
- (d) $+394 \text{ kJ}$

(x) Why does the following exothermic reaction not occur?



- (a) Structure of diamond is more stable than that of graphite.
- (b) Diamond has strong covalent bonds than does the graphite.
- (c) The change from diamond to graphite has high activations energy.
- (d) Density of graphite is less than that of diamond.

ANSWERS:

- (i) (b)
- (ii) (c)
- (iii) (d)
- (iv) (c)
- (v) (b)
- (vi) (a)
- (vii) (d)
- (viii) (d)
- (ix) (a)
- (x) (c)

2 Questions for Short Answers

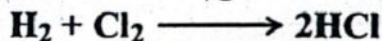
i. What is the difference between enthalpy and enthalpy change?

Ans. Enthalpy is the total heat content of a system, while enthalpy change is the amount of the heat that passes into or out of a system during a reaction.

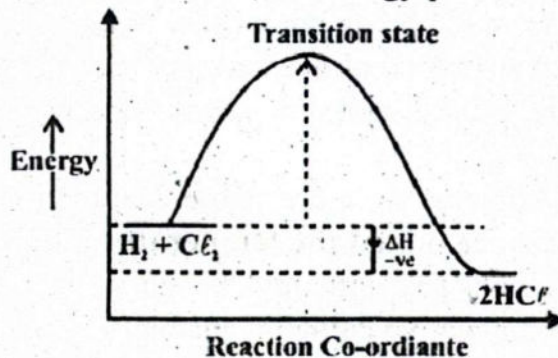
ii. Why breaking of a bond an endothermic process?

Ans. The breaking of a bond is an endothermic process because it requires energy to break the forces of attraction present between two bonded atoms.

iii. Depict the transition state for following reaction.



Ans. The above reaction exothermic hence its energy profile diagram is:



iv. Draw the reaction profiles for two exothermic reactions one of which moves faster than other.

Ans. Slower reaction Faster reaction



v. What is the role of glycogen in our body?

Ans. Role of glycogen: The glycogen is the primary storage form of glucose. It serves as a source of carbohydrates in the body. It serves as an energy reservoir.

3 Constructed Response Questions

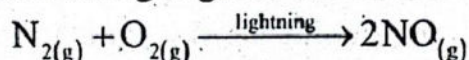
i. Physical changes which usually occur around us are given in the table. Write down whether they are exothermic or endothermic.

Physical change	Exothermic or Endothermic	Physical change	Exothermic or Endothermic
Conversion of hydrated salt into anhydrous salt	Endothermic	Conduction of electricity by metals	Neither (No heat change)
Burning of paper	Exothermic	Dissolving ammonium chloride in water	Endothermic
Vapourizing liquid nitrogen	Endothermic	Formation of rain from clouds	Exothermic
Evaporation of dry ice	Endothermic	Dissolving sodium carbonate in water	Exothermic

ii. Explain why the reaction between atmospheric gases oxygen and nitrogen does not take place under normal conditions? But in the presence of lightning these gases react to give NO. The reaction stops as soon as the lightning stops.

Ans. Nitrogen gas is the main unreactive gas in air. The lack of reactivity of nitrogen gas is due to the strong triple covalent bond between two nitrogen atoms ($N \equiv N$). Its bond dissociation energy is almost 958.38 kJ/mole. This bond is difficult to break. Nitrogen dilutes the effects of the reactive oxygen gas, so nitrogen gas does not react with oxygen gas under normal conditions.

Nitrogen gas only reacts with oxygen gas under extreme conditions i.e. in the presence of lightning. The lightning provides the high activation energy needed for the oxidation of unreactive nitrogen gas to form NO.



The reaction stops as soon as lightning stops because high activation energy cannot be provided without lightning.

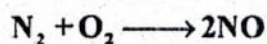
iii. A reaction between natural gas (CH_4) and atmospheric oxygen does not take place when you mix them. As soon as you show a burning match stick, the reaction starts immediately and then it continues until one or both of reactants is/are used up. Explain.

Ans. The reaction between natural gas (CH_4) and atmospheric oxygen does not take place when you mix them because there is not enough energy to overcome the activation energy required for the reaction.

A burning match stick starts the reaction between natural gas (CH_4) and atmospheric oxygen by providing the necessary activation energy, which will continue until one or both reaction is/are used up.

4 Descriptive Questions

i. Find out the enthalpy change of the following reaction using the given data.

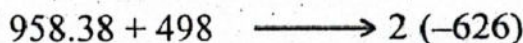
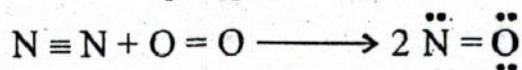
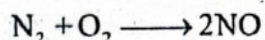


Bond dissociation energy of $N_2 = 958.38$ kJ/mol

Bond dissociation energy of $O_2 = 498$ kJ/mol

Bond formation energy of NO = -626 kJ/mol

Ans. Balanced chemical equation:



Enthalpy change = 204.38 kJ/mol.

ii. Explain the difference between the terms heat and enthalpy.

Ans. For Answer See Q. No.14

iii. Explain why formation of a bond is always an exothermic process.

Ans. The bond formation is always exothermic because energy is released to the surrounding when atoms form a chemical bond.

iv. Explain the role of lipids in our body.

Ans. For Answer See Q. No.23

v. Explain the following terms:

Activation energy, Transition state, Aerobic respiration.

Ans. For Answer See Q. No.19, 21

5 Investigative Questions

i. Why is it essential to cook some of the food items while others we can eat without cooking?

Ans. Cooking of some food items is essential because it kills harmful bacteria and parasite that can cause food borne diseases, making them safe to eat.

While others are naturally safe to consume raw due to their protective outer skin and low risk of contamination.

Cooking improves digestibility and nutrient availability in food, while other provide necessary vitamins and fibers without cooking.

ii. Why do fireworks look spectacular? What types of chemical compounds undergo chemical reactions during this activity?

Ans. The fireworks are the result of combustion reactions that yield heat, light and sound. Different metal salts along with oxidizing agents produces a variety of colours when they are burnt.

