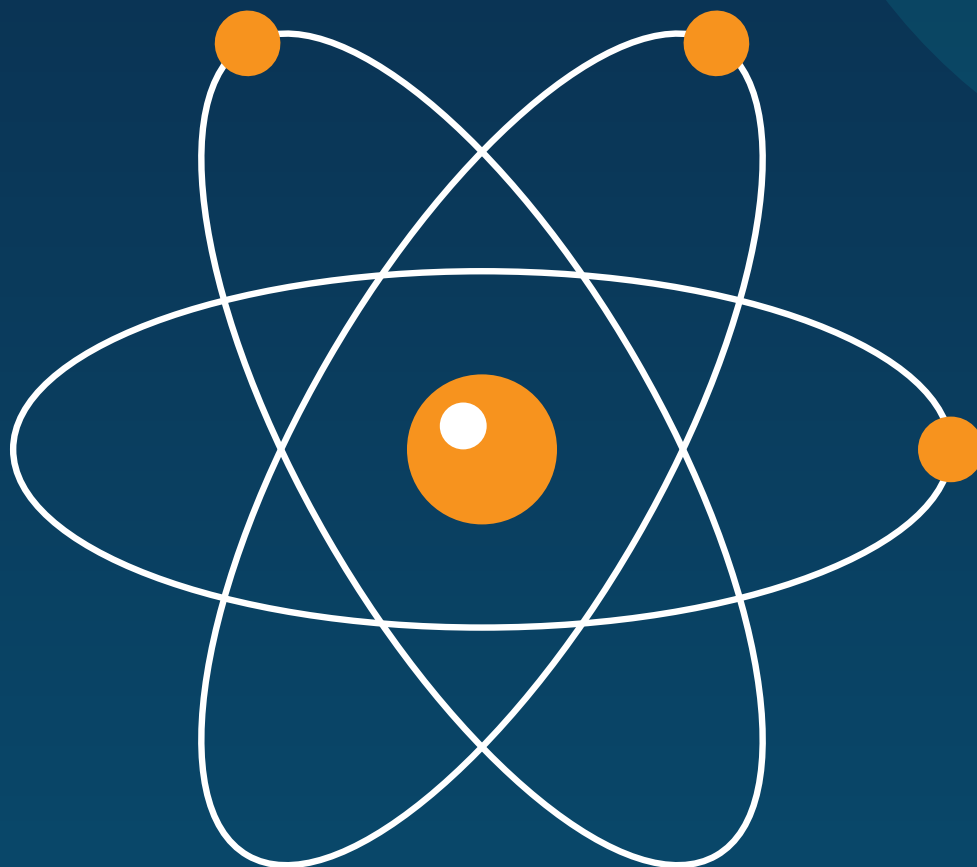


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9th CLASS CHEMISTRY - CHAPTER 5

ENERGETICS

Complete Exercise Solutions

- ✓ Solved MCQs with Explanations
- ✓ Short Questions
- ✓ Constructed Response
- ✓ Descriptive Questions
- ✓ Investigative Questions

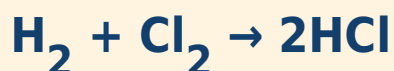
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1. Tick (✓) the correct answer

10 MCQs - correct option highlighted with an explanation

Q1

The following reaction is an exothermic reaction.



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

(a)

✓ (b)

(c)

(d)

✓ **Correct Answer: (b)** From sunlight

Explanation: This is a **photochemical reaction**.

The energy required to break the strong H-H and Cl-Cl bonds (activation energy) is provided by sunlight.

Without sunlight the reaction does not occur at room temperature, because the thermal energy is insufficient to overcome the activation barrier.

Q2

Which of the following reactions has the least value of activation energy?

(a)

(b)

✓ (c)

(d)

✓ **Correct Answer: (c)** $\text{NaCl(aq)} + \text{AgNO}_3\text{(aq)} \rightarrow \text{AgCl(s)} + \text{NaNO}_3\text{(aq)}$

Explanation: This is an **ionic reaction** taking place in aqueous solution.

The reactants are already dissociated into free-moving ions, so they need very little energy to react; they simply collide and react almost instantly.

Reactions (a), (b) and (d) involve breaking covalent bonds (H-H, C=O, etc.), which require much higher activation energies.

Q3

Formation of which hydrogen halide from the elements is an endothermic reaction?

(a)

(b)

(c)

✓ (d)

✓ **Correct Answer: (d)** HI

Explanation: The formation of HI is **endothermic**: the energy released in forming the H-I bond is less than the energy absorbed to break the H-H and I-I bonds.

In contrast, the formation of HF, HCl and HBr is exothermic because the energy released on forming the H-X bond is greater than the energy absorbed to break the reactant bonds.

Q4

What are the products of anaerobic respiration?

(a)

(b)

✓ (c)

(d)

✓ **Correct Answer: (c)** ATP + Ethanol + H₂O

Explanation: Anaerobic respiration occurs in the **absence of oxygen**.

In yeast, glucose is broken down into ethanol, carbon dioxide and a small amount of ATP.

Option (c) captures the key products (ATP and ethanol) usually associated with this process in standard textbook contexts (note: CO₂ is also a by-product, but it is not listed in the option).

Q5

Which reaction do you expect to be a reversible reaction?

(a)

(b)

✓ (c)

(d)

✓ **Correct Answer: (c)** Graph (c) – low activation energy, with products lower than reactants

Explanation: Reversible reactions typically have **relatively low activation energies**.

Graph (c) shows the smallest energy hump (activation energy) compared with the other graphs, making it the most likely candidate for a reaction that can easily proceed in both the forward and reverse directions.

Q6

What does it show when a chemical reaction is exothermic?

✓ (a)

(b)

(c)

(d)

✓ **Correct Answer: (a)** It shows the bonds which break are weaker than those which are formed.

Explanation: In an exothermic reaction, energy is **released** to the surroundings.

This happens because the total energy stored in the bonds of the products (newly formed, stronger bonds) is less than the energy stored in the bonds of the reactants (broken, weaker bonds).

The excess energy is released as heat.

Q7

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

(a)

(b)

(c)

✓ (d)

✓ **Correct Answer: (d)** exothermic with a negative enthalpy change.

Explanation: An increase in temperature means heat is being **released** into the surroundings.

By definition, a reaction that releases heat is exothermic, and by convention exothermic reactions have a negative enthalpy change ($\Delta H < 0$).

Q8

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

(a)

(b)

(c)

✓ (d)

✓ **Correct Answer: (d)** $\text{CH}_4(\text{g}) \rightarrow \text{CH}_3(\text{g}) + \text{H}(\text{g})$

Explanation: The bond dissociation energy of 412 kJ mol^{-1} is the energy required to break exactly **one mole of one specific C-H bond** in a gaseous molecule.

Option (d) shows the breaking of a single C-H bond to give a methyl radical (CH_3) and a hydrogen atom.

Options (a) and (b) would need roughly 2 times this energy, and (c) roughly 4 times.

Q9

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)

(b)

(c)

(d)

✓ **Correct Answer: (a) -102 kJ**

Explanation: $\Delta H = (\text{energy required to break bonds}) - (\text{energy released on forming bonds})$.

The O-H bonds are the same on both sides and cancel out.

Net bond changes: break 1 O-O bond = 146 kJ ; form $\frac{1}{2}$ O=O bond = $\frac{1}{2} \times 496 = 248 \text{ kJ}$.

$\Delta H = 146 - 248 = -102 \text{ kJ}$.

Q10

Why does the following exothermic reaction not occur?



(a)

(b)

✓ (c)

(d)

✓ **Correct Answer: (c)** The change from diamond to graphite has high activation energy.

Explanation: Although the conversion of diamond to graphite is thermodynamically favourable (it is exothermic), it does not happen at room temperature because of **kinetic hindrance**: a very high activation energy is required to break the rigid, three-dimensional covalent network of diamond.

2. Questions for Short Answers

5 questions - step by step answers

i

What is the difference between enthalpy and enthalpy change?

Enthalpy (H) is the total heat content of a system at constant pressure. It is a **state function**, meaning it depends only on the current state of the system.

Enthalpy change (ΔH) is the difference in enthalpy between the products and the reactants during a chemical reaction: $\Delta H = H_{\text{products}} - H_{\text{reactants}}$. It represents the heat absorbed or released during a reaction at constant pressure.

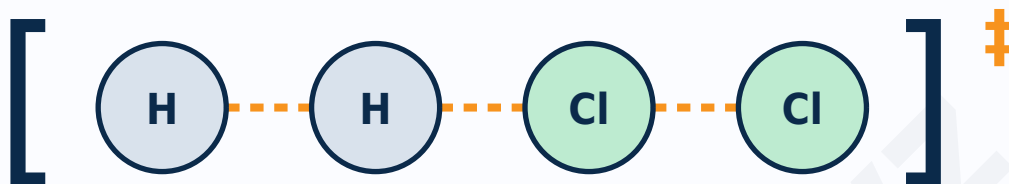
ii

Why is breaking of a bond an endothermic process?

Breaking a bond requires an **input of energy** to overcome the electrostatic attractive forces holding the atoms together. Because the system must absorb energy from its surroundings to achieve this separation, the process is **endothermic** ($\Delta H > 0$).

iii

Depict the transition state for the following reaction. $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$



dashed lines = partially broken / partially formed bonds

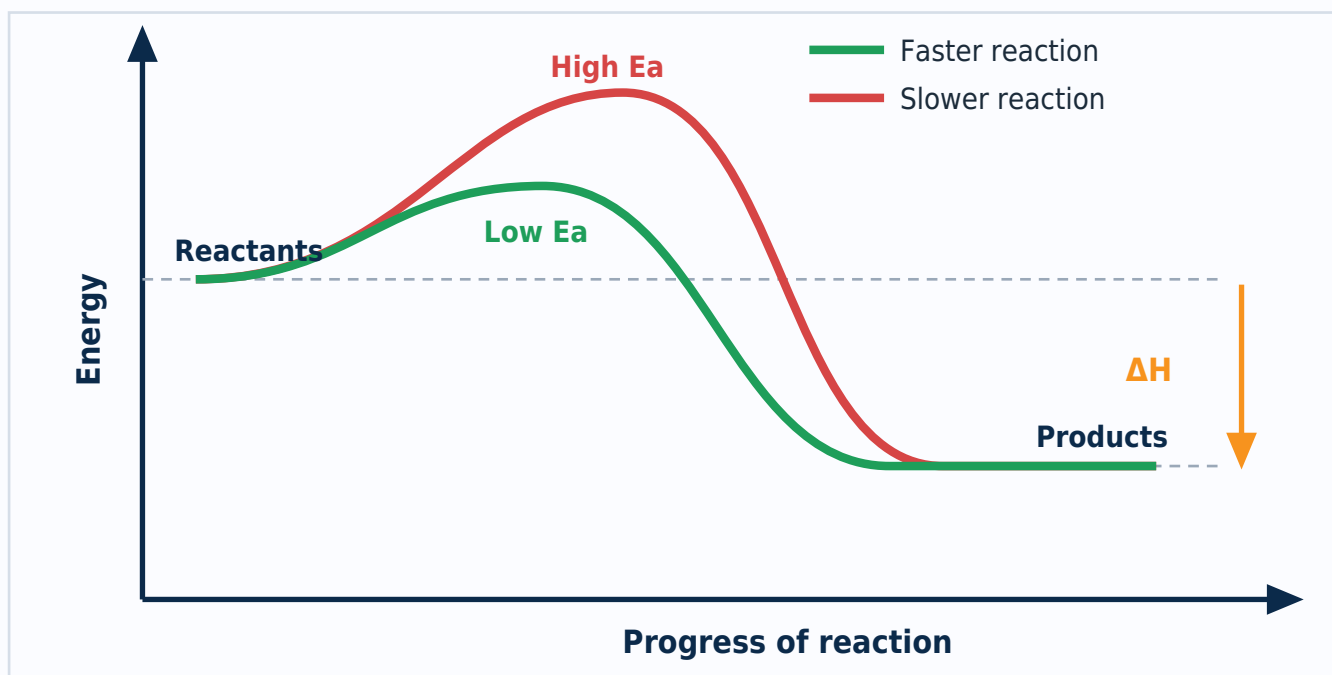
The **transition state** is a temporary, high-energy, unstable arrangement of atoms in which old bonds are partially broken and new bonds are partially formed. For this reaction it can be depicted as:



The H-H and Cl-Cl bonds are stretched while the H-Cl bonds are beginning to form, at the peak of the energy barrier.

iv

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



Both profiles start with **reactants at a higher energy** and end with **products at a lower energy** (exothermic).

Faster reaction: a curve with a **small hump** (low activation energy, E_a).

Slower reaction: a curve with a **taller hump** (high activation energy, E_a), keeping the starting and ending energy levels exactly the same as the faster reaction.

v

What is the role of glycogen in our body?

Glycogen is a highly branched **polysaccharide** that serves as a form of **energy storage** in animals and humans. It is stored primarily in the liver and muscles.

When blood glucose levels drop, glycogen is broken down into glucose to provide immediate energy for cellular respiration, especially during physical activity or between meals.

3. Constructed Response Questions

3 questions - explain and apply

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
Conversion of hydrated salt into anhydrous salt	Endothermic
Burning of paper	Exothermic
Vapourizing liquid nitrogen	Endothermic
Evaporation of dry ice	Endothermic
Conduction of electricity by metals	Neither (physical process)
Dissolving ammonium chloride in water	Endothermic
Formation of rain from clouds	Exothermic
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.

N_2 and O_2 are very stable molecules because of the strong triple ($N \equiv N$) and double ($O = O$) bonds. Under normal conditions the **activation energy** required to break these bonds is too high, so no reaction occurs.

Lightning provides a massive amount of energy (heat) that overcomes this activation energy, allowing N_2 and O_2 to react and form NO.

Once the lightning stops, the energy source is removed and the reaction ceases, because the ambient conditions cannot overcome the activation energy barrier.

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 continues until one or both of the reactants is/are used up. Explain.

The mixture of CH_4 and O_2 needs an **initial input of energy** to overcome the activation energy barrier. The burning match provides this initial energy (ignition).

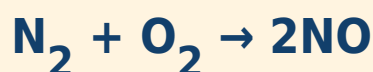
Once started, the reaction is **highly exothermic** and releases a large amount of heat. This heat supplies the activation energy for the next molecules, so combustion becomes **self-sustaining** until one of the reactants is completely consumed.

4. Descriptive Questions

5 questions - detailed answers

i

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



Given:

Bond dissociation energy of $\text{N}_2 = 958.38 \text{ kJ mol}^{-1}$

Bond dissociation energy of $\text{O}_2 = 498 \text{ kJ mol}^{-1}$

Bond formation energy of $\text{NO} = -626 \text{ kJ mol}^{-1}$

Calculation:

$\Delta H = \Sigma(\text{bond energies of reactants}) - \Sigma(\text{bond energies of products})$

Bonds broken (reactants): 1 mol $\text{N}\equiv\text{N}$ + 1 mol $\text{O}=\text{O}$
 $= 958.38 + 498 = \mathbf{1456.38 \text{ kJ mol}^{-1}}$

Bonds formed (products): 2 mol N-O . Energy released
 $= 2 \times 626 = \mathbf{1252 \text{ kJ mol}^{-1}}$

$\Delta H = 1456.38 - 1252$

✓ **Answer: $\Delta H = +204.38 \text{ kJ mol}^{-1}$** (the reaction is endothermic)

ii

Explain the difference between the terms heat and enthalpy.

Heat (q) is the transfer of thermal energy between a system and its surroundings due to a temperature difference. It is a **path function** (it depends on the process).

Enthalpy (H) is the total heat content of a thermodynamic system. The change in enthalpy (ΔH) equals the heat absorbed or released at constant pressure. Enthalpy is a **state function**: its change depends only on the initial and final states, not on the path taken.

iii

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

When atoms come together to form a bond, they move to a **lower, more stable energy state**. The excess energy is released into the surroundings as heat.

Therefore the system loses energy, making the process **exothermic** ($\Delta H < 0$). The stronger the bond formed, the more energy is released.

iv

Explain the role of lipids in our body.

Lipids serve several crucial roles:

- 1. Energy storage:** highly reduced molecules that store more than twice the energy per gram compared with carbohydrates, kept as triglycerides in adipose tissue.
- 2. Structural components:** phospholipids and cholesterol are essential parts of cell membranes.
- 3. Insulation and protection:** fat deposits insulate the body against heat loss and protect vital organs.
- 4. Hormone synthesis:** steroid hormones (e.g. testosterone, estrogen) are derived from lipids.
- 5. Vitamin absorption:** they help absorb the fat-soluble vitamins A, D, E and K.

v

Explain the following terms: Activation energy, Transition state, Aerobic respiration.

Activation Energy: the minimum amount of energy required by reactant molecules to undergo a chemical reaction and form products. It is the energy barrier that must be overcome.

Transition State: the temporary, highest-energy, unstable arrangement of atoms at the peak of the activation energy barrier. Bonds are partially broken and partially formed.

Aerobic Respiration: cellular respiration that requires oxygen to break down glucose and produce ATP, carbon dioxide and water. It yields much more ATP than anaerobic respiration.

5. Investigative Questions

2 questions - think and explain

i

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

Cooking applies heat to cause **chemical changes** (such as denaturation of proteins and gelatinization of starch) that make food easier to digest, safer to eat (pathogens are killed) and more palatable.

Foods like **meat, eggs and grains** contain complex proteins and starches that are hard for the human digestive system to break down raw; cooking breaks them down.

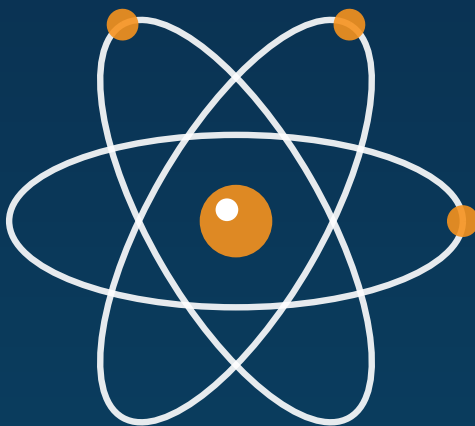
Fruits and vegetables contain simple sugars, vitamins and minerals that are easily digestible and heat-sensitive. Cooking may destroy vitamins, so they are better eaten raw.

ii

Why does fireworks look spectacular? What type of chemical compounds undergo chemical reactions during this activity?

Fireworks look spectacular because of the **emission of light from excited atoms**. When heated, metal salts absorb energy and their electrons jump to higher energy levels. When the electrons fall back to the ground state, they release energy as visible light of specific wavelengths (colours).

The compounds used are typically **metal salts** – strontium salts for red, barium salts for green, copper salts for blue and sodium salts for yellow – mixed with an **oxidizer** (like potassium nitrate) and a **fuel** (like charcoal or sulfur).



Well Done!

You have completed the Energetics exercise.

Quick Recap

- ✓ Breaking bonds is **endothermic**; forming bonds is **exothermic**.
- ✓ ΔH = energy of bonds broken – energy of bonds formed.
- ✓ Activation energy is the barrier every reaction must cross.