9th Class Chemistry Chapter # 5 Exercise Solutions – Punjab Board

Energetics

Multiple Choice Questions (MCQs)

(i) The following reaction is an exothermic reaction.

$H_2 + Cl_2 \rightarrow 2HCl$
From where does the energy come to break the bonds of H_2 and Cl_2?

Options:

- (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

Correct Answer: (a) By collisions between the molecules

Explanation:
Reactant molecules gain energy by colliding with each other. These collisions, if effective (having enough energy and correct orientation), can break bonds and lead to a chemical reaction. This is part of **collision theory**.

(ii) Which of the following reactions has the least value of activation energy?

Options:

- (a) $H_2(g) + ½O_2(g) \rightarrow H_2O(g)$
- (b) $C(s) + O_2(g) \rightarrow CO_2(g)$
- (c) $NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$
- (d) $H_2(g) + I_2(g) \rightarrow 2HI(g)$

Correct Answer: (c) $NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

Explanation:
This is a **precipitation reaction** between two aqueous solutions and occurs

almost **instantaneously** without needing much energy. Hence, it has the **lowest activation energy**.

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

Options:

- (a) HCl
- (b) HF
- (c) HBr
- (d) HI

Correct Answer: (d) HI

Explanation:
Formation of **HI (hydrogen iodide)** is **endothermic**, meaning it absorbs heat. This is because the bond dissociation energy of I_2 is low, and less energy is released on bond formation in HI than is needed to break H_2 and I_2 bonds.

(iv) What are the products of anaerobic respiration?

Options:

- (a) ATP + CO_2 + H_2O
- (b) CO_2 + H_2O
- (c) ATP + Ethanol + H_2O
- (d) Ethanol + H_2O

Correct Answer: (c) ATP + Ethanol + H_2O

Explanation:
In **anaerobic respiration** (especially in yeast), **glucose is converted into ethanol, a small amount of ATP, and water**. Oxygen is not required in this process.

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

(*Two graphs were given: A and B, both showing energy vs path of reaction. Graph B has a lower peak (activation energy) than Graph A.*)

Correct Answer: Graph A (most likely)

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

Options:

- (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.

Correct Answer: (a)

Explanation:
In an **exothermic reaction**, more energy is released when **new bonds form** than is required to **break old bonds**. This means the **bonds formed are stronger** (release more energy) than those broken.

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

Options:

- (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.

Correct Answer: (d)

Explanation:
Mixing **NaOH + HCl** gives heat → **exothermic reaction**, and such reactions have **negative enthalpy change (ΔH < 0)** because energy is released to surroundings.

(viii) The average bond dissociation energy for the C–H bond is 412 kJ/mol. Which of the following process will have enthalpy change close to 412 kJ/mol?

Options:

- (a) $CH_4(g) \rightarrow C(g) + 2H_2(g)$
- (b) $CH_4(g) \rightarrow C(g) + 2H$
- (c) $CH_4(g) \rightarrow C(g) + 4H(g)$
- (d) $CH_3(g) \rightarrow CH_2(g) + H(g)$

Correct Answer: (d)

Explanation:
The bond energy of **one C–H bond** is ~412 kJ/mol.
Only **option (d)** represents **breaking one C–H bond** (from CH_3 to CH_2 + H), so its enthalpy change will be close to **412 kJ/mol**.

Other options involve **breaking all 4 C–H bonds**, or are duplicates.

(ix) The average bond energies for O=O and O–O are 496 and 146 kJ/mol respectively. Find the enthalpy for this reaction:

Reaction:
H–O–H(g) → H–O(g) + ½ O=O(g)**

Options:

- (a) –102 kJ
- (b) +102 kJ
- (c) +350 kJ
- (d) +394 kJ

Correct Answer: (b) +102 kJ

Why does the following exothermic reaction not occur?
C (Diamond) → C (Graphite) $\Delta H = -3$ kJ mol^{-1}

Options:

- (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 activation energy.
- (d) Density of graphite is less than that of diamond.

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

Explanation:
Although the conversion of **diamond to graphite** is **exothermic** (ΔH = –3 kJ/mol), the reaction doesn't happen spontaneously because the **activation energy is very high**.

This means the atoms in the diamond's **strong, rigid 3D lattice** would require a **large amount of energy** to rearrange into the planar structure of graphite — even though graphite is thermodynamically more stable.

So the reaction is **kinetically hindered**, not thermodynamically.

Short Answer Question

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

Answer:
Enthalpy (H) is the total heat content of a system at constant pressure.
Enthalpy change (ΔH) is the difference in enthalpy between the products and reactants during a chemical reaction.

- ΔH = H(products) – H(reactants)

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ii. Why is breaking of a bond an endothermic process?

Answer:
Bond breaking requires energy to overcome the attractive forces between atoms. Since energy is **absorbed** from the surroundings during this process, it is called **endothermic**.

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iii. Depict the transition state for the following reaction:

$H_2 + Cl_2 \rightarrow 2HCl$

Answer:
The **transition state** is a high-energy, unstable arrangement where old bonds are partially broken and new bonds are partially formed. For this reaction:

[H–H ··· Cl–Cl] → [H···Cl]‡ → HCl + HCl

Where ‡ denotes the transition state with partial bonds between atoms.

Or diagrammatically (symbolic):

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H–H + Cl–Cl → [H···H···Cl···Cl]‡ → 2HCl
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iv. Draw the reaction profiles for two exothermic reactions, one of which moves faster than the other.

Answer (Description):
Draw **two curves** on an energy vs. reaction path graph:

- Both curves start at same reactant energy and end at the same product energy (since both are exothermic).
- The **faster reaction** will have **lower activation energy** (smaller hump).
- The **slower reaction** will have **higher activation energy** (taller hump).

Label axes:

- **Y-axis**: Energy
- **X-axis**: Reaction progress / path
- Indicate **ΔH** as negative for both.

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

Answer:
Glycogen is the **stored form of glucose** in our body, mainly found in the **liver and muscles**. It acts as an **energy reserve**, supplying glucose when blood sugar levels are low or during physical activity.

Constructed Response Questions

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

Physical Change	Exothermic / Endothermic
Conversion of hydrated salt into anhydrous salt	**Endothermic** (heat is absorbed to remove water of hydration)
Burning of paper	**Exothermic** (combustion releases heat and light)
Vapourizing liquid nitrogen	**Endothermic** (energy is required for phase change from liquid to gas)
Evaporation of dry ice (solid CO_2)	**Endothermic** (sublimation needs heat from surroundings)

Physical Change	Exothermic / Endothermic
Conduction of electricity by metals	**Neither clearly exo nor endo** (this is a physical property, not a heat-related change, but if forced to choose — **neutral**)
Dissolving ammonium chloride in water	**Endothermic** (absorbs heat, solution becomes cold)
Formation of rain from clouds	**Exothermic** (condensation releases latent heat)
Dissolving sodium carbonate in water	**Exothermic** (releases heat when ions interact with water molecules)

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

Answer:
Under **normal conditions**, oxygen (O_2) and nitrogen (N_2) do not react because both gases are **very stable** and the **activation energy** required to break their strong triple and double bonds is **very high**.

During a **lightning strike**, an enormous amount of energy is released in the form of **heat and electrical energy**, which provides the **activation energy** needed for the reaction to occur:

$N_2(g) + O_2(g) \rightarrow 2NO(g)$

Once the **lightning stops**, this external energy is no longer available, so the reaction **cannot continue**. The formation of nitric oxide (NO) is therefore **limited to high-energy conditions** like lightning.

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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 the reactants is/are used up. Explain.

Answer:
When methane (CH_4) and oxygen (O_2) are mixed, no reaction occurs because the mixture lacks the **activation energy** needed to initiate the reaction. Methane and oxygen are both **stable** under normal conditions.

When a **burning matchstick** is brought near, it provides **heat energy** that serves as the **activation energy**. This starts the **combustion reaction**:

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) + Energy$

After the reaction starts, it becomes **self-sustaining**, meaning the heat released by the combustion provides enough energy to keep it going — this is why the reaction **continues until one or both reactants are used up**.

Descriptive Questions

. Find out the enthalpy change (ΔH) of the following reaction using the given data:

Reaction:
$N_2 + O_2 \rightarrow 2NO$

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**

Solution:
Step 1: Bonds Broken (Reactants):

- 1 mol N≡N bond = **958.38 kJ**
- 1 mol O=O bond = **498 kJ**

Total energy absorbed (bonds broken) = 958.38 + 498 = 1456.38 kJ

Step 2: Bonds Formed (Products):

- 2 mol N–O bonds = 2 × (–626) = **–1252 kJ**

Step 3: Enthalpy Change (ΔH):
ΔH = Bonds Broken – Bonds Formed
ΔH = 1456.38 – 1252 = **+204.38 kJ/mol**

Answer:
ΔH = **+204.38 kJ/mol** → The reaction is **endothermic**.

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

Answer:

- **Heat** is the energy that flows due to a temperature difference between a system and its surroundings. It is **not a state function** and depends on the path taken.
- **Enthalpy (H)** is the total heat content of a system at constant pressure. It is a **state function** and reflects the internal energy plus pressure–volume work.

In simple terms, **heat is energy in transit**, while **enthalpy is the stored heat energy** in a substance under constant pressure.

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

Answer:
When a bond is formed between atoms, they move to a **more stable, lower-energy state**. The extra energy is **released to the surroundings**, usually as heat.
Hence, bond formation **always releases energy**, making it an **exothermic process**.

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iv. Explain the role of lipids in your body.

Answer:
Lipids play several important roles in the body:

- Act as **long-term energy storage** molecules.
- Form a major part of **cell membranes** (phospholipids).
- Serve as **insulation** to maintain body temperature.
- Protect vital organs by forming **cushions**.
- Help in the **absorption of fat-soluble vitamins** (A, D, E, K).

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v. Explain the following terms:

1. Activation Energy:
It is the **minimum amount of energy** required to start a chemical reaction by breaking the bonds of reactants.

2. Transition State:
A high-energy, unstable state where **reactant bonds are partially broken** and **product bonds are partially formed**. It exists **momentarily** during the reaction path.

3. Aerobic Respiration:
It is a biological process in which **glucose is broken down using oxygen** to release **energy (ATP)**, with **carbon dioxide and water** as by-products.
Equation:
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy (ATP)}$

Investigative Questions

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

Answer:
Some food items contain **harmful microorganisms**, **toxins**, or **complex molecules** (like starches or proteins) that are **difficult to digest** in raw form. Cooking:

- **Kills bacteria and viruses**
- **Softens food**, making it easier to chew and digest
- **Improves taste and flavor**
- **Enhances nutrient absorption**

On the other hand, foods like **fruits and some vegetables** can be eaten raw because they are already **safe, soft, and nutritious** in their natural form and may **lose nutrients** when cooked (like vitamin C).

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

Answer:
Fireworks look spectacular because of the **bright colors, loud sounds, and light flashes** they produce. This happens due to **rapid exothermic chemical reactions** that:

- Release **heat, light, and sound**
- Excite **metal salts**, which emit **colored light** when they return to ground state

Types of chemical compounds involved:

- **Oxidizers** (e.g., potassium nitrate, potassium chlorate) — supply oxygen
- **Reducing agents** (e.g., sulfur, charcoal) — fuel the combustion
- **Metal salts** for color:
  - Strontium salts → red
  - Barium salts → green
  - Copper compounds → blue
  - Sodium compounds → yellow

These compounds **react rapidly**, releasing energy and creating colorful explosions in the sky.