GRADEUP

AQA (GCSE Notes)

Chapter 5: Energy Changes

Q1. What happens to the energy in the universe during a chemical reaction?
Answer: The total energy in the universe stays the same during a chemical reaction. Energy is conserved, meaning it cannot be created or destroyed. It can only be transferred between the system and the surroundings or change from one form to another, but the total amount remains constant before and after the reaction.

Q2. Why do the products of an exothermic reaction have less energy than the reactants?
Answer: The products have less energy because energy is released to the surroundings during the reaction. This energy release means the final substances (products) contain less stored energy than the starting substances (reactants), as the excess energy is given out, usually as heat.

Q3. What is an exothermic reaction?
Answer: An exothermic reaction is a chemical process that releases energy to the surroundings. This usually results in a temperature increase of the surrounding area, as heat is given out. Examples include combustion and neutralisation reactions.

Q4. How does the temperature of the surroundings change during an exothermic reaction?
Answer: The temperature of the surroundings increases because the reaction releases energy, usually as heat, into the environment. This makes the surroundings feel warmer during or after the reaction.

Q5. Give two examples of exothermic reactions.
Answer: Combustion (burning of fuels) and neutralisation (acid reacting with alkali) are two examples. Both release energy to the surroundings, causing an increase in temperature.

Q6. Name two everyday items that use exothermic reactions.
Answer: Self-heating cans and hand warmers use exothermic reactions. Self-heating cans often contain chemicals that react to release heat when activated, and hand warmers use reactions like iron oxidation to produce warmth.

Q7. What is an endothermic reaction?
Answer: An endothermic reaction is one that absorbs energy from the surroundings, usually in the form of heat. This causes the temperature of the surroundings to decrease because energy is taken in by the reaction.

Q8. How does the temperature of the surroundings change during an endothermic reaction?
Answer: The temperature of the surroundings decreases because energy is absorbed from the environment into the reacting substances, making the surroundings feel colder.

Q9. Give an example of an endothermic reaction.
Answer: The reaction between citric acid and sodium hydrogencarbonate is endothermic. Another example is the thermal decomposition of calcium carbonate, where heat is absorbed to break down the compound.

Q10. Why does the temperature of the surroundings decrease in an endothermic reaction?
Answer: The temperature drops because the reaction absorbs heat energy from the surroundings. As this energy is taken in, the surroundings lose heat, resulting in a noticeable cooling effect.

Q11. What is the role of energy in an endothermic reaction?
Answer: In an endothermic reaction, energy is required for the reaction to proceed. The reacting particles absorb energy to break bonds or cause changes, making the surroundings cooler as energy is drawn in.

Q12. Why are sports injury packs based on endothermic reactions?
Answer: Sports injury packs are designed to absorb heat and provide a cooling effect. The endothermic reaction inside the pack takes in energy from the surroundings, making it feel cold and helping reduce swelling or pain.

Q13. What kind of energy transfer occurs in a neutralisation reaction?
Answer: A neutralisation reaction is exothermic, meaning it transfers energy to the surroundings. When an acid reacts with an alkali, heat is released, increasing the surrounding temperature.

Q14. What kind of energy transfer occurs in a thermal decomposition reaction?
Answer: Thermal decomposition is an endothermic process. It involves breaking down a compound using heat, so energy is absorbed from the surroundings, causing a temperature drop.

Q15. How can you identify whether a reaction is exothermic or endothermic by measuring temperature?
Answer: Measure the temperature of the surroundings before and after the reaction. If the temperature increases, the reaction is exothermic. If it decreases, the reaction is endothermic. The direction of temperature change tells you the type of energy transfer.

Q16. Why do some reactions warm up the surroundings?
Answer: These reactions are exothermic and release energy, usually as heat. This heat is transferred to the surroundings, causing the temperature to rise and making the environment feel warmer.

Q17. Why do some reactions cool down the surroundings?
Answer: These are endothermic reactions that absorb energy from the surroundings. As the surroundings lose heat, their temperature drops, resulting in a cooling effect.

Q18. What type of reaction occurs in self-heating cans?
Answer: Self-heating cans use exothermic reactions. When activated, the chemicals inside react and release heat, warming the contents of the can for consumption.

Q19. What can you measure to determine if a reaction is exothermic or endothermic?
Answer: You can measure the temperature change of the surroundings. A rise in temperature indicates an exothermic reaction, while a drop in temperature indicates an endothermic one.

Q20. What is the minimum amount of energy needed for a reaction to take place?
Answer: The minimum energy required is called the activation energy. It is the energy needed to start breaking bonds in the reactants so that a reaction can occur.

Q21. What is activation energy?
Answer: Activation energy is the smallest amount of energy that particles need to collide successfully and cause a reaction. Without this energy, the reaction will not happen.

Q22. Why is activation energy needed for a reaction to start?
Answer: Activation energy is needed to break the bonds in the reactants. It gives the particles enough energy to overcome repulsion and start forming new bonds to create products.

Q23. What does a reaction profile show?
Answer: A reaction profile shows the energy of the reactants and products during a chemical reaction. It includes the activation energy and the overall energy change, helping to visualise whether a reaction is exothermic or endothermic.

Q24. How can reaction profiles help identify if a reaction is exothermic?
Answer: In a reaction profile, if the energy level of the products is lower than that of the reactants, it shows that energy has been released. This drop indicates an exothermic reaction.

Q25. How can reaction profiles help identify if a reaction is endothermic?
Answer: In an endothermic reaction profile, the energy level of the products is higher than that of the reactants. This rise means energy has been absorbed, confirming the reaction is endothermic.

Q26. What does the curved line in a reaction profile represent?
Answer: The curved line in a reaction profile represents the energy pathway that the reaction follows from reactants to products. It shows how the energy of the system changes during the course of the reaction. The curve starts at the energy level of the reactants, rises to show the activation energy needed to begin the reaction, and then falls (in exothermic) or rises further (in endothermic) to the final energy level of the products.

Q27. In a reaction profile, what does the peak represent?
Answer: The peak of the reaction profile represents the maximum energy point during the reaction, also known as the transition state. This point is where the reactants have absorbed enough energy to overcome the activation barrier and begin transforming into products. The height of this peak above the reactants indicates the amount of activation energy required for the reaction to occur.

Q28. How is the activation energy shown in a reaction profile?
Answer: In a reaction profile, the activation energy is shown as the vertical distance between the energy level of the reactants and the highest point on the curve (the peak). It is usually marked with a

vertical arrow. This distance represents the amount of energy the reactant particles must gain for the reaction to proceed.

Q29. How is the overall energy change shown in a reaction profile?
Answer: The overall energy change is shown by the vertical distance between the energy levels of the reactants and the products. If the products are at a lower energy level, the reaction is exothermic, and energy has been released. If the products are at a higher energy level, the reaction is endothermic, and energy has been absorbed from the surroundings.

Q30. What is meant by the term 'overall energy change' in a chemical reaction?
Answer: Overall energy change is the difference in energy between the reactants and the products. It tells you whether energy is released or absorbed during the reaction. A negative energy change means energy is released (exothermic), and a positive energy change means energy is absorbed (endothermic). It reflects the net gain or loss of energy during the entire reaction process.

Q31. What are the relative energy levels of reactants and products in an exothermic reaction?
Answer: In an exothermic reaction, the energy level of the products is lower than that of the reactants. This is because energy is released to the surroundings as the reaction occurs. The drop in energy level from reactants to products on a reaction profile diagram confirms that energy has been lost from the chemical system.

Q32. What are the relative energy levels of reactants and products in an endothermic reaction?
Answer: In an endothermic reaction, the energy level of the products is higher than that of the reactants. This is because energy is taken in from the surroundings to make the reaction happen. On a reaction profile, this appears as a rise in energy from reactants to products, showing that energy has been absorbed into the chemical system.

Q33. Why is it useful to draw reaction profiles?
Answer: Drawing reaction profiles helps to understand how energy changes during a chemical reaction. They show the activation energy needed, the energy levels of reactants and products, and whether the reaction is exothermic or endothermic. These diagrams are visual tools that help students and scientists compare different reactions and predict how they might behave.

Q34. What is the purpose of conducting experiments to measure temperature change in reactions?
Answer: The purpose is to determine whether a reaction is exothermic or endothermic by observing the change in temperature of the surroundings. Measuring temperature changes allows us to see if energy is being released or absorbed, which helps identify the type of energy transfer taking place. This provides useful data for understanding the reaction's behaviour.

Q35. How can dissolving a substance in water help investigate energy changes?
Answer: When a substance dissolves in water, it may release or absorb energy, causing a temperature change. By measuring the temperature before and after dissolving, we can observe

whether the process is exothermic (temperature increases) or endothermic (temperature decreases). This simple test provides insight into the energy involved in dissolving that substance.

Q36. Why is it important to control variables in a temperature change experiment?
Answer: Controlling variables ensures that the temperature change measured is only due to the reaction itself and not other factors. If variables like volume, concentration, or starting temperature are not controlled, results may be inaccurate or misleading. Consistency in these variables leads to reliable, repeatable, and fair results in scientific experiments.

Q37. What variables could affect the temperature change in a reaction between acid and metal?
Answer: Variables that could affect the temperature change include the type of metal, the concentration and volume of the acid, the surface area of the metal, and the starting temperature of the solution. Each of these factors can influence how much energy is released or absorbed, and therefore affect the observed temperature change.

Q38. How would you set up an experiment to investigate temperature change during neutralisation?
Answer: To set up this experiment, use a polystyrene cup to reduce heat loss, measure fixed volumes of acid and alkali, and record their starting temperatures. Mix them and monitor the temperature until it stops rising or falling. Stir gently and record the highest or lowest temperature reached. Repeat the experiment for accuracy and ensure fair testing by keeping variables constant.

Q39. What observations would show a displacement reaction is exothermic?
Answer: If the temperature of the solution increases after the more reactive metal displaces a less reactive one, the reaction is exothermic. You may also feel heat coming from the container or see steam if the reaction is very energetic. These signs show that energy has been released into the surroundings.

Q40. How would you measure the temperature change in a reaction safely?
Answer: Use a thermometer and insulated container, such as a polystyrene cup, to reduce heat loss. Wear safety goggles and gloves. Measure the temperature before the reaction starts and monitor it regularly during and after the reaction. Ensure that all solutions are handled with care, and avoid splashing when mixing substances.

Q41. Why is it important to repeat the experiment when measuring temperature changes?
Answer: Repeating the experiment helps to confirm the accuracy of your results. It allows you to identify any anomalies and calculate an average temperature change for more reliable data. Repeats also improve the reliability of your conclusion about whether the reaction is exothermic or endothermic.

Q42. What is the significance of comparing temperature changes in different reactions?
Answer: Comparing temperature changes helps you understand how much energy different reactions absorb or release. This comparison can identify which reactions are more energetic and

whether they are exothermic or endothermic. It also helps in evaluating the practical uses of these reactions in real-life situations, such as heating or cooling.

Q43. How does the reaction between citric acid and sodium hydrogencarbonate demonstrate an endothermic process?

Answer: When citric acid and sodium hydrogencarbonate react, the temperature of the solution drops. This shows that the reaction absorbs energy from the surroundings, a clear sign of an endothermic process. The cooling effect can be felt and measured, confirming that energy is taken in during the reaction.

Q44. What conclusion can be drawn if the temperature rises after a reaction?

Answer: A rise in temperature means the reaction is exothermic. It has released energy to the surroundings in the form of heat. This energy transfer causes the surrounding materials to heat up, which is detected as a temperature increase using a thermometer.

Q45. What conclusion can be drawn if the temperature drops after a reaction?

Answer: If the temperature drops, the reaction is endothermic. It has absorbed energy from the surroundings to make the reaction happen. As a result, the surroundings lose heat and feel cooler, which is recorded as a decrease in temperature.

Q46. How would you identify the activation energy from a reaction profile diagram?

Answer: On a reaction profile, the activation energy is the vertical distance between the reactants' energy level and the highest point on the curve. It is often shown with an arrow pointing from the reactant level to the peak. This value tells us how much energy is needed for the reaction to start.

Q47. What would a reaction profile look like for a highly exothermic reaction?

Answer: In a highly exothermic reaction profile, the energy of the products is much lower than that of the reactants. The curve rises sharply from the reactants to the peak (activation energy), then drops steeply to a low energy level for the products, showing a large release of energy to the surroundings.

Q48. What would a reaction profile look like for a reaction with high activation energy?

Answer: A reaction profile for a reaction with high activation energy would have a tall peak. The curve would rise significantly from the reactants before reaching the top, showing that a lot of energy is needed to start the reaction. The size of the rise reflects the high activation barrier.

Q49. Why might a reaction with high activation energy not happen at room temperature?

Answer: If the particles at room temperature don't have enough energy to reach the activation energy level, they won't react when they collide. Without enough energy, even frequent collisions won't lead to a successful reaction. This is why some reactions need heating or a catalyst to begin.

Q50. How does temperature influence whether a reaction will occur or not?

Answer: Higher temperatures give particles more energy, making them move faster and collide more often and more forcefully. This increases the chances that collisions have enough energy to overcome the activation energy barrier, leading to more successful reactions. At low temperatures, fewer particles reach the needed energy level, so reactions happen more slowly or not at all.

Q51. What happens to energy when bonds in the reactants are broken during a chemical reaction?

Answer: Energy is absorbed when bonds in the reactants are broken. This is because energy is required to overcome the attraction between atoms in a chemical bond. Breaking bonds is an endothermic process, meaning it takes in energy from the surroundings. The stronger the bond, the more energy is needed to break it.

Q52. Why is energy released when new bonds are formed in the products?

Answer: Energy is released when new bonds are formed in the products because the atoms move to a more stable, lower energy state. When atoms bond, they release energy as they become more stable. This process is exothermic, and the amount of energy released depends on the strength of the bonds formed.

Q53. How can bond energies be used to calculate the energy change in a chemical reaction?

Answer: Bond energies can be used to calculate the energy change in a chemical reaction by subtracting the total bond energy of bonds formed (products) from the total bond energy of bonds broken (reactants). The formula is:

Energy change = Energy to break bonds − Energy to form bonds.

If the result is positive, the reaction is endothermic; if negative, it is exothermic.

Q54. What is meant by the term "overall energy change" in a chemical reaction?

Answer: The overall energy change is the net amount of energy absorbed or released in a chemical reaction. It is calculated by comparing the energy needed to break the bonds in the reactants with the energy released when bonds are formed in the products. This determines whether a reaction is exothermic or endothermic.

Q55. In an exothermic reaction, which is greater: energy released or energy needed?

Answer: In an exothermic reaction, the energy released during bond formation is greater than the energy needed to break the bonds in the reactants. This results in a release of heat energy to the surroundings and often causes an increase in temperature.

Q56. In an endothermic reaction, which is greater: energy needed or energy released?

Answer: In an endothermic reaction, the energy needed to break the bonds in the reactants is greater than the energy released when new bonds form in the products. This means the reaction absorbs energy from the surroundings, often leading to a drop in temperature.

Q57. What kind of energy change occurs when the bonds formed in products release more energy than the energy required to break reactant bonds?

Answer: This kind of energy change is called an exothermic change. In such a reaction, the total energy released during bond formation in the products is more than the energy absorbed to break the bonds in the reactants, resulting in a net release of energy.

Q58. How does bond breaking affect the energy profile of a reaction?

Answer: Bond breaking increases the energy level in the energy profile of a reaction. This is shown

as a rise from the energy level of the reactants to the peak of the curve, representing the activation energy. It is an endothermic step and requires energy input for the reaction to proceed.

Q59. What does a positive energy change mean in a chemical reaction?
Answer: A positive energy change in a chemical reaction means that the reaction is endothermic. It indicates that more energy was absorbed to break the bonds in the reactants than was released when forming the bonds in the products. This results in energy being taken in from the surroundings.

Q60. What does a negative energy change indicate in terms of exothermic or endothermic?
Answer: A negative energy change indicates that the reaction is exothermic. This means that more energy was released in forming product bonds than was absorbed in breaking the reactant bonds. The reaction gives off energy to the surroundings, usually as heat.

Q61. Describe how you would calculate the energy change of a reaction using bond energies.
Answer: To calculate the energy change of a reaction using bond energies, first list all the bonds broken in the reactants and add up their bond energies. Then list all the bonds formed in the products and add up their bond energies. Subtract the total bond energy of the products from the total bond energy of the reactants:
Energy change = Bonds broken − Bonds formed
This tells you whether the reaction is endothermic or exothermic.

Q62. Why is it important to consider both bond breaking and bond forming when calculating energy changes?
Answer: It is important to consider both bond breaking and bond forming because both processes involve energy changes that affect the overall result. Bond breaking requires energy (endothermic), while bond forming releases energy (exothermic). To find the net energy change, both must be taken into account.

Q63. What is the significance of bond energy values in predicting reaction types?
Answer: Bond energy values help predict whether a reaction is exothermic or endothermic. By comparing the energy needed to break bonds with the energy released when new bonds form, you can determine if a reaction releases or absorbs energy. Higher bond energy means a stronger bond and more energy required to break it.

Q64. How can bond energy calculations help identify whether a reaction is exothermic or endothermic?
Answer: Bond energy calculations help identify reaction types by comparing the total energy used to break bonds in the reactants with the total energy released when new bonds form in the products. If the energy released is greater, the reaction is exothermic. If the energy absorbed is greater, it is endothermic.

Q65. If more energy is released in forming bonds than is absorbed in breaking them, what type of reaction is it?
Answer: It is an exothermic reaction. When the energy released during the formation of new bonds

is greater than the energy absorbed to break existing bonds, the excess energy is given off to the surroundings, making the reaction exothermic.

Q66. If a reaction absorbs more energy in breaking bonds than it releases in forming them, what type of reaction is it?
Answer: It is an endothermic reaction. In this case, the reaction needs a continuous input of energy from the surroundings to proceed because the energy required to break bonds is higher than the energy released when new bonds form.

Q67. What are the typical units used when calculating bond energy changes?
Answer: The typical units used for bond energy changes are kilojoules per mole (kJ/mol). This unit expresses the amount of energy required to break one mole of a particular bond in a substance.

Q68. Why are bond energies considered average values?
Answer: Bond energies are considered average values because the actual energy needed to break a specific bond can vary depending on the chemical environment. The values used in calculations are averaged from many different compounds to give a general estimate.

Q69. Give a reason why the calculated energy change may differ from experimental results.
Answer: The calculated energy change may differ from experimental results because bond energies are average values and do not account for specific conditions like temperature, pressure, or state of matter. Heat losses to surroundings and measurement errors can also affect experimental results.

Q70. How does the strength of chemical bonds relate to the energy required to break them?
Answer: The strength of a chemical bond is directly related to the amount of energy required to break it. Stronger bonds have higher bond energies and need more energy to break, while weaker bonds require less energy to be broken.

Q71. How does the number of bonds broken or formed affect the total energy change?
Answer: The more bonds that are broken or formed, the greater the total energy change in the reaction. If many strong bonds are broken, a lot of energy is absorbed. If many strong bonds are formed, a lot of energy is released. The balance between these determines the overall energy change.

Q72. How would you explain the energy changes involved in a neutralisation reaction?
Answer: In a neutralisation reaction between an acid and a base, energy is released as the hydrogen ions from the acid and hydroxide ions from the base form water molecules. This is an exothermic reaction because the bond formation in water releases more energy than is used to break the original bonds.

Q73. What energy change would you expect in a combustion reaction and why?
Answer: A combustion reaction typically results in an exothermic energy change. This is because combustion involves the reaction of a fuel with oxygen, breaking weak bonds and forming strong bonds in products like CO_2 and H_2O. The energy released in forming these strong bonds is greater than the energy absorbed.

Q74. Why do stronger bonds usually require more energy to break?
Answer: Stronger bonds involve a greater attraction between atoms and are more stable. Therefore, more energy is needed to overcome the attraction and separate the atoms, making the bond-breaking process more energy-demanding compared to weaker bonds.

Q75. What information do you need to calculate the energy transferred in a chemical reaction?
Answer: To calculate the energy transferred, you need the bond energies of all bonds broken and formed, the number of moles of each substance involved, and a balanced chemical equation. This allows you to determine the total energy absorbed and released to find the overall energy change.

Q76. What is the purpose of using bond energies in energy change calculations?
Answer: The purpose of using bond energies in energy change calculations is to estimate how much energy is absorbed or released during a chemical reaction. By knowing the energies required to break the bonds in the reactants and the energies released when new bonds form in the products, we can calculate the overall energy change. This helps predict whether a reaction is exothermic or endothermic.

Q77. How does the energy needed to break a triple bond compare to a single bond?
Answer: The energy needed to break a triple bond is much greater than the energy needed to break a single bond. This is because triple bonds are stronger and involve more shared electrons between atoms, which increases the bond strength. As a result, more energy is required to overcome the forces holding the atoms together.

Q78. Why might a chemical reaction with a positive energy change feel cold to the touch?
Answer: A chemical reaction with a positive energy change is endothermic, meaning it absorbs energy from the surroundings. If you touch the container where such a reaction is taking place, it may feel cold because the reaction is taking in thermal energy from your hand and the surroundings, lowering the temperature around it.

Q79. Describe what happens to energy during the breaking of O=O bonds in a reaction.
Answer: When O=O bonds are broken during a reaction, energy is absorbed. This is because the double bond between the oxygen atoms is strong and requires energy input to break it. The energy absorbed goes into overcoming the attractive forces between the atoms in the oxygen molecule.

Q80. How do different elements affect the bond energy values in compounds?
Answer: Different elements affect bond energy values because each element has a different electronegativity, atomic size, and bonding ability. These properties influence the strength and length of the bond, which in turn changes how much energy is needed to break or form that bond in different compounds.

Q81. What type of bond energy data is used for polyatomic molecules?
Answer: For polyatomic molecules, average bond energy values are used. These values represent an average taken from similar bonds in different compounds. This is because the same type of bond (like C-H) can have slightly different energies depending on the chemical environment within the molecule.

Q82. How would you identify whether a reaction has high or low activation energy using bond energies?

Answer: You can estimate activation energy by looking at how much energy is needed to break the initial bonds in the reactants. If strong bonds must be broken first, the reaction likely has high activation energy. If the initial bonds are weak and easy to break, the activation energy is low.

Q83. Can bond energy values help in designing energy-efficient reactions? Explain how.

Answer: Yes, bond energy values can help design energy-efficient reactions. By selecting reactants and conditions that require less energy to break bonds and result in the formation of strong bonds in the products, chemists can minimise energy input and maximise energy output, leading to more efficient reactions.

Q84. What does a large overall energy change suggest about a reaction?

Answer: A large overall energy change suggests that the reaction is either highly exothermic or highly endothermic. In a highly exothermic reaction, a lot of energy is released to the surroundings. In a highly endothermic one, a large amount of energy is absorbed from the surroundings, often requiring continuous energy input.

Q85. In a reaction where energy change is zero, what can you say about the bond energies of reactants and products?

Answer: If the energy change is zero, it means the total energy needed to break the bonds in the reactants is exactly equal to the total energy released when forming the bonds in the products. The bond energies of the reactants and products are balanced.

Q86. How does the conservation of energy apply to chemical reactions involving bond energies?

Answer: The conservation of energy means that energy cannot be created or destroyed in a chemical reaction. In terms of bond energies, the total energy absorbed in breaking bonds and the total energy released in forming bonds must account for all energy changes. The energy is only transferred, not lost.

Q87. Why might experimental temperature change data not exactly match bond energy calculations?

Answer: Experimental temperature changes might not match bond energy calculations because bond energies are average values and do not reflect specific conditions. Additionally, heat loss to the surroundings, measurement inaccuracies, or incomplete reactions can cause differences between theoretical and practical results.

Q88. What assumptions are made when using bond energy values in calculations?

Answer: Assumptions include that the bond energies are constant and not affected by the molecular environment, and that all bonds of the same type have the same energy. It is also assumed that the reaction goes to completion and that there is no energy loss to the surroundings.

Q89. How can bond energies be used to compare the stability of two chemical reactions?

Answer: Bond energies can be used to compare stability by analysing how much energy is required

to break bonds and how much is released during bond formation. A reaction that releases more energy (is more exothermic) tends to form more stable products, indicating greater stability overall.

Q90. What safety precautions should be taken when conducting experiments involving exothermic reactions?
Answer: Safety precautions include wearing safety goggles and gloves, conducting the experiment in a well-ventilated area or fume hood, using heat-resistant containers, and keeping flammable materials away. It is also important to be prepared for sudden temperature changes or releases of gases.

Q91. Describe a method to calculate the energy change of a reaction using bond energy data for $H_2 + Cl_2 \rightarrow 2HCl$.
Answer: First, identify the bonds broken: one H–H and one Cl–Cl. Then, identify the bonds formed: two H–Cl. Use bond energies (e.g., H–H = 436 kJ/mol, Cl–Cl = 243 kJ/mol, H–Cl = 431 kJ/mol).
Energy in = 436 + 243 = 679 kJ
Energy out = 2 × 431 = 862 kJ
Energy change = 679 − 862 = −183 kJ
The reaction is exothermic.

Q92. What conclusion can you draw if bond energy calculations predict an exothermic reaction but no reaction occurs?
Answer: If a reaction is predicted to be exothermic but does not occur, it may be due to a high activation energy barrier or lack of proper conditions such as temperature, pressure, or a catalyst. Bond energy calculations do not account for these kinetic factors.

Q93. What factors other than bond energies can affect whether a chemical reaction occurs?
Answer: Other factors include activation energy, presence of a catalyst, temperature, pressure, concentration of reactants, and physical state. Even if a reaction is energetically favourable, it may not proceed without the right conditions or enough energy to start.

Q94. How might bond energy calculations differ for reactions in solution versus gas phase?
Answer: In solution, interactions with the solvent can affect bond breaking and forming, which alters the energy changes. Solvation energy, ionisation, and hydrogen bonding can all affect the reaction. Bond energies used for gas phase calculations may not accurately represent these effects.

Q95. What are the limitations of using bond energy values for reactions with intermediate steps?
Answer: For reactions with intermediate steps, bond energy calculations may not be accurate because they do not consider the energies of the intermediates or transition states. The overall reaction might involve steps with different bond energies that are not reflected in a single calculation.

Q96. Why is it useful to understand energy changes in everyday chemical reactions like cooking or combustion?
Answer: Understanding energy changes helps explain temperature changes, fuel efficiency, and safety in everyday reactions. For example, knowing how much energy a fuel releases helps in

selecting efficient heating sources. In cooking, energy understanding helps control cooking times and outcomes.

Q97. How can energy profile diagrams be supported with bond energy data?
Answer: Energy profile diagrams show how energy changes during a reaction. Bond energy data can be used to calculate the activation energy (energy needed to break bonds) and the overall energy change, which are then used to label the graph accurately and explain reaction energetics.

Q98. What role does enthalpy play in bond energy calculations?
Answer: Enthalpy represents the heat content of a system and is directly related to the energy change in a reaction. Bond energy calculations help estimate the change in enthalpy (ΔH), allowing us to predict whether a reaction is endothermic or exothermic.

Q99. In what situations would bond energy calculations be most accurate?
Answer: Bond energy calculations are most accurate for reactions involving simple molecules in the gas phase and with no intermediate steps. In such cases, the average bond energies closely match the actual bond energies involved, and environmental effects are minimal.

Q100. Why might two reactions with similar bond energy changes differ in reaction rates?
Answer: Reaction rates depend on activation energy, not just bond energy change. Two reactions may release or absorb similar energy overall, but if one has a higher activation energy or lacks a catalyst, it will proceed slower than the other despite having similar bond energy values.

Q101. What is a simple cell and how can it be constructed using two different metals and an electrolyte?
Answer: A simple cell is a device that produces electricity through a chemical reaction between two different metals placed in an electrolyte. To construct it, take two different metal electrodes (like copper and zinc), insert them into a solution (electrolyte) such as saltwater or dilute acid, and connect the metals with wires. The difference in reactivity of the metals causes a flow of electrons through the wire, producing electricity.

Q102. Why does the voltage of a cell depend on the type of metal used for the electrodes?
Answer: The voltage depends on how reactive each metal is. When two metals with different reactivities are used, electrons flow from the more reactive metal to the less reactive one. The bigger the difference in reactivity, the greater the potential difference (voltage) between them. So, using metals with a larger reactivity gap gives a higher voltage.

Q103. How does the choice of electrolyte affect the voltage of a cell?
Answer: The electrolyte affects how easily ions move between the electrodes. If the electrolyte allows ions to move freely and supports the chemical reactions well, it helps maintain a good flow of current and voltage. A poor choice of electrolyte can reduce the efficiency of the reaction and lower the voltage.

Q104. What happens at the electrodes in a simple electrochemical cell?
Answer: At the electrodes, chemical reactions occur. The more reactive metal loses electrons (oxidation) and becomes positively charged ions. These electrons flow through the wire to the less

reactive metal, where reduction happens (gaining electrons). This movement of electrons generates an electric current.

Q105. Explain why using metals with a greater difference in reactivity produces a higher voltage in a cell.
Answer: A greater difference in reactivity means there is a stronger driving force for electrons to move from one metal to the other. The more reactive metal wants to lose electrons, and the less reactive one gains them. This difference increases the energy (or voltage) released by the cell.

Q106. What is the function of the electrolyte in a simple cell?
Answer: The electrolyte allows ions to move between the two electrodes, which completes the circuit inside the cell. This movement of ions balances the flow of electrons in the outer circuit and keeps the chemical reaction going, which is necessary to keep producing electricity.

Q107. Describe what is meant by a non-rechargeable battery.
Answer: A non-rechargeable battery is one that cannot be reused once its chemical reactants are used up. The chemical reactions inside these batteries are one-way, so once the materials are fully reacted, the battery stops producing electricity and cannot be recharged.

Q108. Why do chemical reactions in a non-rechargeable cell eventually stop?
Answer: The reactions stop because the reactants are used up. When one or both of the chemicals needed to keep the reaction going run out, the chemical process stops, and so does the production of electricity. At that point, the battery is considered "dead."

Q109. What are alkaline batteries and why are they classed as non-rechargeable?
Answer: Alkaline batteries are a common type of non-rechargeable battery. They use an alkaline electrolyte, often potassium hydroxide, and cannot be recharged because the chemical reactions inside them are not reversible under normal conditions. Once the materials are used, the battery cannot work again.

Q110. Describe what happens during the recharging of a rechargeable battery.
Answer: During recharging, an external electric current is applied to the battery, which forces the chemical reactions inside the battery to go in reverse. This regenerates the original reactants from the products and allows the battery to be used again. Energy is stored in the chemicals during this process.

Q111. Why can rechargeable batteries be used multiple times?
Answer: Rechargeable batteries can be used multiple times because the chemical reactions they use are reversible. When an external current is applied, it reverses the reaction, restoring the original chemicals. This process can be repeated many times, making the battery reusable.

Q112. What is the role of an external electrical current in recharging a cell?
Answer: The external electrical current provides the energy needed to reverse the chemical reaction inside the cell. This forces the electrons and ions to move in the opposite direction, converting the products of the reaction back into the original reactants, and storing energy again.

Q113. What are the advantages of using rechargeable batteries over non-rechargeable ones?
Answer: Rechargeable batteries are more cost-effective in the long run since they can be used many times. They also reduce waste and are better for the environment. Additionally, they are ideal for devices that need frequent or long-term use, as they can be charged and reused instead of replaced.

Q114. Why is it important to use batteries with care, especially those containing liquids?
Answer: Batteries containing liquids may leak harmful chemicals if damaged or misused. These chemicals can be corrosive or toxic, posing safety and environmental risks. Proper handling ensures safety during use and disposal, and also helps prevent damage to devices and surroundings.

Q115. How can you safely test a simple cell in the classroom?
Answer: To safely test a simple cell, use small, safe amounts of electrolyte such as saltwater or dilute acid, wear safety goggles and gloves, and ensure the setup is stable and away from electrical sockets. Use a low-voltage voltmeter to measure the output and avoid short circuits.

Q116. What precautions should be taken when handling electrolytes during experiments?
Answer: When handling electrolytes, always wear gloves and goggles, work in a well-ventilated area, and follow teacher instructions. Use small quantities and avoid contact with skin or eyes. Clean spills immediately and dispose of solutions properly according to safety guidelines.

Q117. Why is it important to compare the voltage of different metal combinations in cells?
Answer: Comparing voltages helps us understand which combinations of metals produce the most energy. This is useful in designing better and more efficient batteries. It also helps explain how the reactivity of metals influences the voltage, aiding in understanding electrochemistry.

Q118. How can data on metal reactivity be used to predict the voltage of a cell?
Answer: The greater the difference in reactivity between two metals, the higher the voltage the cell can produce. By knowing the reactivity series, we can predict which combinations will give more voltage, allowing better planning and testing in experiments or real battery design.

Q119. What evidence from an experiment would show that one metal is more reactive than another?
Answer: In a cell, if one metal always gives electrons and the other receives, the one giving electrons is more reactive. A higher voltage also shows a greater difference in reactivity. Observing which metal corrodes or reacts faster in the electrolyte is another sign of higher reactivity.

Q120. Describe a method for testing the voltage produced by different metal pairs in a cell.
Answer: Place two different metals into an electrolyte solution and connect them with wires to a voltmeter. Record the voltage reading. Repeat the process with different metal pairs, keeping the same electrolyte each time. Compare the voltage readings to see which pair gives the highest output.

Q121. What is meant by connecting cells in series?
Answer: Connecting cells in series means joining them end-to-end so that the positive terminal of one cell connects to the negative terminal of the next. This adds up their voltages, allowing a higher total voltage output from the combined cells in the circuit.

Q122. How does connecting cells in series affect the overall voltage?
Answer: When cells are connected in series, their voltages add together. For example, if two cells each produce 1.5 volts, the total voltage in series would be 3 volts. This is useful when a higher voltage is needed than what a single cell can provide.

Q123. What might happen if you connect cells in the wrong way in a circuit?
Answer: If cells are connected the wrong way, their voltages may cancel each other out or reduce the total voltage. This can cause the device to not work properly or at all. In some cases, it might damage the cells or the device by causing a short circuit or reverse current.

Q124. How can you increase the voltage output of a battery using simple cells?
Answer: You can increase the voltage by connecting multiple simple cells in series. Also, using metals with a larger difference in reactivity or choosing a more effective electrolyte can increase the voltage output of each cell, raising the total voltage from the battery.

Q125. Why do batteries eventually run out of energy?
Answer: Batteries run out of energy when the chemical reactions that produce electricity are completed. Once the reactants are fully converted into products, the battery can no longer generate a current. In non-rechargeable batteries, this means they are finished. In rechargeable ones, they need to be recharged.

Q126. What does it mean when a battery is said to be 'flat'?
Answer: A battery is said to be 'flat' when it can no longer produce electricity because the chemical reactions that generate the flow of electrons have stopped. This usually happens when one or more of the reactants inside the battery have been used up. As a result, the voltage drops and the battery is no longer able to power a device. In simple terms, a flat battery has run out of usable energy.

Q127. What factors can affect how long a battery lasts?
Answer: Several factors affect battery life, including the type of battery, the materials used in the electrodes, the efficiency of the chemical reactions, the temperature at which the battery operates, and how the battery is used (e.g., continuous use vs. occasional use). Also, storing batteries at high temperatures or in humid conditions can reduce their lifespan. Rechargeable batteries degrade over repeated charge cycles, affecting their long-term performance.

Q128. How can the reactivity series help in designing more efficient cells?
Answer: The reactivity series helps in designing efficient cells by allowing us to choose two metals with a large difference in reactivity. The greater the difference in reactivity between the two metals used as electrodes, the greater the voltage the cell can produce. This knowledge enables engineers to select metal pairs that give higher energy outputs and make cells more effective and longer-lasting.

Q129. Why is it important to evaluate the environmental impact of different types of batteries?
Answer: Batteries contain chemicals and metals that can harm the environment if not disposed of properly. Some batteries, like non-rechargeable alkaline ones, contribute to more waste, while others, like lithium-ion, can be hazardous if they leak. Evaluating environmental impact helps us choose

safer, more sustainable options, encourage recycling, and reduce pollution and energy waste during production and disposal.

Q130. How do different combinations of metals influence the energy output of a cell?
Answer: Different combinations of metals create different voltage outputs due to their relative positions in the reactivity series. Metals that are far apart on the series produce a larger potential difference (voltage) when used in a cell. This results in a stronger flow of electrons and more electrical energy being produced, making the cell more powerful. The more reactive metal acts as the negative electrode, releasing electrons more readily.

Q131. What is the purpose of using two different metals in a cell rather than two of the same metal?
Answer: Using two different metals creates a potential difference (voltage) between them, which is necessary for generating an electric current. If the same metal is used for both electrodes, no voltage is produced because there's no difference in their ability to lose or gain electrons. Different metals react differently with the electrolyte, leading to electron flow from the more reactive metal to the less reactive one.

Q132. Why does the flow of electrons only occur when the two metals have different reactivities?
Answer: The flow of electrons happens because one metal loses electrons more easily than the other. This occurs when the two metals have different reactivities. The more reactive metal releases electrons, which then flow through an external circuit to the less reactive metal. If the metals have the same reactivity, there's no difference in their tendency to lose electrons, so no current flows.

Q133. What is meant by the term ‘cell voltage’?
Answer: Cell voltage is the potential difference between the two electrodes in a cell. It represents the amount of energy transferred per unit of charge as electrons move through the external circuit. The voltage depends on the types of metals used as electrodes and their positions in the reactivity series. A higher difference in reactivity usually means a higher cell voltage.

Q134. What practical uses are there for batteries made from multiple simple cells?
Answer: Batteries made from multiple simple cells are used to provide greater voltage than a single cell can produce. This is useful in devices that need more power, such as remote controls, flashlights, electric toys, and medical equipment. By connecting cells in series, the voltages add up, making the battery suitable for a wide range of everyday applications where a stronger current is needed.

Q135. Why might one battery be better suited to a device than another?
Answer: Different devices require different voltages and power capacities. Some batteries last longer, provide higher current, or can be recharged, making them more suitable for high-drain devices like smartphones or cameras. Others may be cheaper or smaller, ideal for low-power items like clocks or remotes. The best battery for a device depends on its energy demand, size, and frequency of use.

Q136. How would you set up an experiment to compare different cells safely?
Answer: To compare different cells, you would select various pairs of metals and place them in

identical containers with the same electrolyte. Connect each setup to a voltmeter to measure voltage output. Ensure all wires and connections are secure, and handle chemicals with gloves and goggles. Use the same conditions for each test to ensure fair comparison and avoid touching metals with bare hands to prevent contamination.

Q137. What could cause errors when measuring the voltage of a cell?
Answer: Errors in measuring voltage can be caused by poor electrical connections, corroded or dirty electrodes, inconsistent electrolyte volumes, or using impure materials. External factors like temperature changes or faulty voltmeters can also affect readings. Human error, such as misreading the voltmeter or connecting the wires incorrectly, can lead to inaccurate results. Ensuring consistent experimental conditions helps reduce these errors.

Q138. Why must we handle battery chemicals with care?
Answer: Battery chemicals can be corrosive, toxic, or reactive. Contact with skin or eyes may cause burns or irritation. Inhaling fumes or accidentally ingesting battery components can be harmful or fatal. Leaked chemicals can also damage surfaces and the environment. Therefore, safety measures like gloves, goggles, and proper disposal are essential when handling battery chemicals to prevent accidents and health hazards.

Q139. What are some safety risks when using or making electrochemical cells?
Answer: Safety risks include chemical burns from acidic or alkaline electrolytes, electric shocks from improperly connected circuits, and fires or explosions if reactive materials are mishandled. Short circuits can cause overheating. Also, breaking open commercial batteries can release toxic fumes. To minimise risks, use protective equipment, avoid direct contact with chemicals, and follow proper lab procedures.

Q140. Why do rechargeable batteries have a limited number of charge cycles?
Answer: Rechargeable batteries degrade over time because repeated charging and discharging gradually reduces their chemical efficiency. The materials inside wear out, and side reactions may form unwanted compounds that reduce capacity. Eventually, the battery cannot hold a charge effectively. Most batteries are designed for a certain number of cycles, after which performance significantly drops and replacement is needed.

Q141. How can temperature affect the performance of a battery?
Answer: Temperature influences the rate of chemical reactions inside the battery. At low temperatures, reactions slow down, reducing the battery's ability to provide current. At high temperatures, reactions may speed up but can also cause damage, leading to leakage, reduced lifespan, or even fire. Batteries work best within a recommended temperature range for safety and efficiency.

Q142. What is the environmental advantage of using rechargeable batteries?
Answer: Rechargeable batteries reduce waste because they can be used many times, unlike non-rechargeable batteries that are thrown away after a single use. This decreases the number of batteries ending up in landfills, where they could leak harmful chemicals. Rechargeables also reduce

the demand for raw materials and energy used in manufacturing, making them a more sustainable choice.

Q143. How is the energy transfer in a battery different from that in a mains-powered circuit?
Answer: In a battery-powered circuit, energy is stored chemically and converted into electrical energy as needed. In a mains-powered circuit, electrical energy comes directly from the power grid, typically generated in power stations. Batteries are portable and self-contained, while mains electricity provides a continuous supply but requires a connection to an external source.

Q144. Why is it important to interpret data correctly when evaluating metal combinations?
Answer: Correct interpretation of data ensures the right conclusions are made about which metal combinations produce the highest voltage. This helps in designing efficient cells. Misinterpreting results may lead to poor choices of materials, wasted resources, or unsafe setups. Understanding trends and anomalies also improves reliability and safety in experiments and real-life applications.

Q145. What can voltage measurements tell you about the reactivity of two metals?
Answer: The voltage produced by a cell made from two metals gives an indication of the difference in their reactivities. A higher voltage means a bigger gap between the metals in the reactivity series. This helps us rank metals and predict how they will behave in chemical reactions. It's a practical way to explore and confirm theoretical reactivity data.

Q146. Why should you never short-circuit a battery?
Answer: Short-circuiting a battery causes a large current to flow directly from one terminal to the other with little or no resistance. This can lead to overheating, damage, leaks, fire, or even explosions. It can also permanently damage the battery or reduce its lifespan. For safety, circuits should always include proper resistive loads or devices.

Q147. In a classroom setup, how can students safely dispose of used battery chemicals?
Answer: Students should never pour used battery chemicals down the sink or into the bin. Instead, they should follow school guidelines for chemical disposal. Usually, this involves placing chemicals in clearly labelled hazardous waste containers. Teachers or lab technicians then arrange for proper disposal through licensed waste handlers to prevent environmental harm and ensure safety.

Q148. How does the internal resistance of a cell affect its voltage output?
Answer: Internal resistance reduces the voltage that is available to the external circuit. As current flows, some energy is lost inside the cell due to resistance, especially if the cell is old or poorly made. Higher internal resistance means more voltage is wasted as heat, leading to lower efficiency and performance. Good quality cells are designed to minimise internal resistance.

Q149. Why is it useful to understand how cells and batteries work in everyday life?
Answer: Understanding cells and batteries helps us choose the right type for different devices, maintain them properly, and use them safely. It also helps us make environmentally responsible decisions and troubleshoot problems when devices stop working. Knowledge of how batteries function is valuable in an increasingly battery-powered world, from phones to cars.

Q150. What would you expect to happen if the electrolyte in a cell dries up or leaks?

Answer: If the electrolyte dries up, the chemical reactions inside the cell can no longer take place, so the battery stops working. If it leaks, it can damage the device, harm users, or cause corrosion. In both cases, the battery becomes unsafe or unusable. The electrolyte is essential for ion movement, so any issue with it seriously affects performance.

Q151. What is the role of hydrogen in a hydrogen fuel cell?

Answer: The role of hydrogen in a hydrogen fuel cell is to act as the fuel that gets oxidised. Hydrogen gas enters the anode side of the fuel cell, where it splits into protons and electrons. The electrons move through an external circuit, producing electricity, while the protons pass through the electrolyte to the cathode. Hydrogen is the key reactant that drives the electrochemical reaction.

Q152. What is the role of oxygen in a hydrogen fuel cell?

Answer: The role of oxygen in a hydrogen fuel cell is to act as the oxidising agent. Oxygen enters the fuel cell at the cathode and combines with the electrons (that travelled through the external circuit) and protons (that passed through the electrolyte) to form water. This reaction completes the circuit and ensures that electricity continues to flow. Oxygen is essential for completing the redox reaction.

Q153. How does a hydrogen fuel cell generate electricity?

Answer: A hydrogen fuel cell generates electricity through a redox reaction. At the anode, hydrogen is oxidised into protons and electrons. The electrons flow through an external circuit, creating a current (electricity). The protons move through an electrolyte to the cathode, where they combine with oxygen and the returning electrons to form water. This process generates a continuous flow of electricity as long as fuel is supplied.

Q154. What is the overall chemical reaction in a hydrogen fuel cell?

Answer: The overall chemical reaction in a hydrogen fuel cell is:

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$.

This equation shows that hydrogen reacts with oxygen to form water. The hydrogen is oxidised, and the oxygen is reduced, producing water as the only byproduct. This reaction also generates a potential difference, which is used to produce electricity.

Q155. How is water formed in a hydrogen fuel cell?

Answer: Water is formed in a hydrogen fuel cell at the cathode. Protons (from the anode) pass through the electrolyte, and electrons (that travelled through the external circuit) arrive at the cathode. These combine with oxygen gas supplied to the cathode. The overall reaction is: $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$. This is the reduction half-equation where water is produced as the only product.

Q156. Why is hydrogen described as being oxidised in the fuel cell?

Answer: Hydrogen is described as being oxidised in the fuel cell because it loses electrons. At the anode, each hydrogen molecule splits into two hydrogen atoms, and each atom loses one electron, forming H^+ ions. The loss of electrons is called oxidation. These electrons then flow through the external circuit, generating electricity, while the protons travel to the cathode.

Q157. What happens to the electrons from hydrogen during the reaction?
Answer: The electrons from hydrogen are released during oxidation at the anode. These electrons cannot pass through the electrolyte and instead flow through an external circuit, creating an electric current. After flowing through the circuit, they arrive at the cathode, where they help reduce oxygen by combining with it and protons to form water.

Q158. How is the potential difference created in a hydrogen fuel cell?
Answer: The potential difference in a hydrogen fuel cell is created by the movement of electrons through the external circuit from the anode to the cathode. This happens because hydrogen is oxidised at the anode (releasing electrons) and oxygen is reduced at the cathode (gaining electrons). The difference in electrical potential between these two electrodes drives the electrons, producing a voltage.

Q159. How are fuel cells different from rechargeable batteries?
Answer: Fuel cells are different from rechargeable batteries because they produce electricity continuously as long as they are supplied with fuel and oxygen. In contrast, rechargeable batteries store a fixed amount of energy and need to be recharged when depleted. Fuel cells do not run down or require recharging; instead, they keep working if reactants are supplied.

Q160. Why do hydrogen fuel cells not need recharging like batteries?
Answer: Hydrogen fuel cells do not need recharging because they continuously produce electricity through an ongoing chemical reaction between hydrogen and oxygen. Unlike batteries that store and release electrical energy, fuel cells rely on an external supply of fuel. As long as hydrogen and oxygen are available, the cell can keep generating electricity without being "recharged."

Q161. What are the environmental advantages of using hydrogen fuel cells?
Answer: The environmental advantages of using hydrogen fuel cells include producing only water as a byproduct, which means no carbon dioxide or other harmful gases are emitted. They do not rely on fossil fuels during operation and are much cleaner than traditional engines. If the hydrogen is produced using renewable energy, the entire process can be almost carbon-neutral.

Q162. What are the environmental disadvantages of using hydrogen fuel cells?
Answer: One disadvantage is that producing hydrogen often requires energy, which may come from fossil fuels, releasing carbon emissions. Also, hydrogen production through electrolysis is energy-intensive and may not always be efficient. In addition, storing and transporting hydrogen can be risky due to its flammability and the energy required to keep it pressurised or cooled.

Q163. Why is it important to evaluate the source of hydrogen used in fuel cells?
Answer: It is important to evaluate the source of hydrogen because the environmental benefits of fuel cells depend on how the hydrogen is produced. If it is made from fossil fuels, the process may release greenhouse gases, reducing the overall sustainability of the system. Using hydrogen from renewable sources makes the technology greener and more environmentally friendly.

Q164. What problems could arise from storing and transporting hydrogen fuel?
Answer: Hydrogen is a highly flammable gas and has a low ignition energy, making it dangerous if

leaked. It also needs to be stored under high pressure or at very low temperatures, which requires special, expensive containers. These factors make storage and transport challenging and can increase the cost and risk associated with using hydrogen as a fuel.

Q165. How do hydrogen fuel cells perform in vehicles compared to traditional petrol engines?
Answer: Hydrogen fuel cells are more efficient than petrol engines and produce no harmful emissions—only water. They are quieter and can offer smoother operation. However, fuel cell vehicles are currently more expensive, and hydrogen refuelling stations are limited. Despite these challenges, fuel cell vehicles offer a cleaner and more sustainable alternative to petrol cars.

Q166. Why are fuel cells used in some spacecraft and submarines?
Answer: Fuel cells are used in spacecraft and submarines because they can provide a clean and continuous supply of electricity and produce water as a useful byproduct. This is especially important in closed environments like space or underwater, where emissions must be minimal, and resources like water are valuable. They are also quiet and reliable in extreme conditions.

Q167. How is hydrogen gas usually produced for fuel cells?
Answer: Hydrogen gas is commonly produced by steam reforming of natural gas, which involves reacting methane with steam at high temperatures. Another method is electrolysis, where water is split into hydrogen and oxygen using electricity. Steam reforming is cheaper but releases CO_2, while electrolysis is cleaner if powered by renewable energy sources.

Q168. What are the limitations of using electrolysis to produce hydrogen for fuel cells?
Answer: Electrolysis requires a lot of electricity, making it expensive and sometimes inefficient, especially if the electricity comes from non-renewable sources. The overall energy efficiency of producing, storing, and transporting hydrogen can be low. Additionally, setting up large-scale electrolysis facilities requires investment and infrastructure that may not yet be widely available.

Q169. What role do catalysts play in hydrogen fuel cells?
Answer: Catalysts speed up the reactions at both electrodes in a hydrogen fuel cell. At the anode, the catalyst helps split hydrogen into protons and electrons. At the cathode, it aids the reaction between oxygen, protons, and electrons to form water. Common catalysts include platinum, which is effective but expensive. Catalysts are essential for making the reactions fast and efficient.

Q170. Why must a hydrogen fuel cell have a membrane?
Answer: A membrane in a hydrogen fuel cell allows only protons to pass through from the anode to the cathode while blocking electrons. This separation forces the electrons to travel through the external circuit, generating electricity. The membrane also helps prevent mixing of hydrogen and oxygen gases, which is important for safety and proper cell function.

Q171. What is the purpose of the electrolyte in a hydrogen fuel cell?
Answer: The electrolyte in a hydrogen fuel cell conducts ions—specifically, it allows protons (H^+ ions) to move from the anode to the cathode. It ensures that the electrochemical circuit is complete while keeping the hydrogen and oxygen gases separated. The electrolyte is essential for maintaining charge balance in the cell and allowing the redox reactions to proceed.

Q172. Why are hydrogen fuel cells considered more efficient than combustion engines?
Answer: Hydrogen fuel cells are considered more efficient because they convert chemical energy directly into electrical energy without combustion. In contrast, combustion engines lose much energy as heat. Fuel cells can reach efficiencies of 40–60%, whereas combustion engines are typically only about 25–30% efficient. This means fuel cells can deliver more usable energy from the same amount of fuel.

Q173. How does temperature affect the efficiency of hydrogen fuel cells?
Answer: Temperature affects how well the reactions occur in a hydrogen fuel cell. At low temperatures, reaction rates may slow down, reducing efficiency. Higher temperatures can improve performance but may also degrade materials and reduce the lifespan of components like membranes and catalysts. Therefore, most fuel cells operate at an optimal temperature range to balance performance and durability.

Q174. How does the size of the electrodes affect the performance of a fuel cell?
Answer: Larger electrodes provide more surface area for the reactions to occur, which can improve the rate of electron and ion transfer. This can enhance the overall efficiency and power output of the fuel cell. However, they must be carefully designed to allow good gas diffusion and maintain durability. Small electrodes may limit performance due to slower reaction rates.

Q175. What safety precautions are needed when using hydrogen as a fuel?
Answer: Hydrogen is highly flammable and explosive when mixed with air, so strict safety measures are necessary. These include using leak-proof containers, proper ventilation, flame arrestors, and sensors to detect hydrogen leaks. Storage tanks must be able to handle high pressures or low temperatures. Additionally, the entire system must be regularly inspected and maintained to prevent accidents.

Q176. In what ways are rechargeable cells more practical than hydrogen fuel cells?
Answer: Rechargeable cells are more practical than hydrogen fuel cells because they can be easily charged using electricity from the grid and do not require special fuel or infrastructure. They are also cheaper to use, more compact, and safer to handle. Their recharging process is simple and can be done at home, unlike hydrogen fuel cells that need special hydrogen refilling stations, which are not widely available.

Q177. In what ways are hydrogen fuel cells more practical than rechargeable batteries?
Answer: Hydrogen fuel cells are more practical for long-term and continuous use because they do not need to be recharged like batteries. Instead, they keep working as long as fuel is supplied. They also produce only water as waste, which makes them environmentally friendly. Hydrogen fuel cells are lighter than large battery systems and can be refuelled quickly compared to the time it takes to recharge a battery.

Q178. What factors affect the lifetime of a hydrogen fuel cell?
Answer: The lifetime of a hydrogen fuel cell depends on several factors, including the purity of hydrogen used, the operating temperature, the quality of the materials in the electrodes and

membranes, and how often the cell is used. Contaminants in hydrogen can damage the electrodes, and high or fluctuating temperatures can reduce the efficiency and durability of the cell components.

Q179. How can the cost of using hydrogen fuel cells be reduced?

Answer: The cost of hydrogen fuel cells can be reduced by improving the methods for hydrogen production, using cheaper and more efficient materials for the electrodes and membranes, and increasing the scale of production. Building better infrastructure for hydrogen storage and distribution will also lower overall costs by making fuel more accessible and the system more efficient.

Q180. Why is the infrastructure for hydrogen refuelling limited?

Answer: The infrastructure for hydrogen refuelling is limited because building and maintaining hydrogen stations is expensive and complex. Hydrogen is difficult to store and transport due to its flammable nature and low energy density. There is also less demand compared to petrol or electric vehicles, so companies are not yet investing heavily in hydrogen stations.

Q181. What are the half-equations at the electrodes in a hydrogen fuel cell?

Answer: The half-equations in a hydrogen fuel cell are as follows:

At the negative electrode (anode): $2H_2 \rightarrow 4H^+ + 4e^-$

At the positive electrode (cathode): $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$

These reactions show the oxidation of hydrogen and the reduction of oxygen to form water.

Q182. How do you balance the half-equation for hydrogen oxidation in a fuel cell?

Answer: To balance the half-equation for hydrogen oxidation, start with hydrogen molecules on the left: $H_2 \rightarrow H^+ + e^-$. Each H_2 molecule forms $2H^+$ and $2e^-$. If using $2H_2$ molecules, you get:

$2H_2 \rightarrow 4H^+ + 4e^-$.

This is the balanced half-equation, with equal numbers of atoms and charges on both sides.

Q183. What happens at the positive electrode in a hydrogen fuel cell?

Answer: At the positive electrode (cathode) in a hydrogen fuel cell, oxygen from the air reacts with hydrogen ions (H^+) and electrons (e^-) to form water. This is a reduction reaction. The equation is:

$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$.

This is the final step in the electrochemical reaction that produces electricity and water.

Q184. What happens at the negative electrode in a hydrogen fuel cell?

Answer: At the negative electrode (anode) in a hydrogen fuel cell, hydrogen gas is oxidised. It loses electrons and forms hydrogen ions. The reaction is:

$2H_2 \rightarrow 4H^+ + 4e^-$.

The electrons flow through an external circuit to generate electricity, while the hydrogen ions move through the electrolyte to the positive electrode.

Q185. What ions move through the electrolyte in a hydrogen fuel cell?

Answer: In a hydrogen fuel cell, hydrogen ions (H^+) move through the electrolyte from the anode (negative electrode) to the cathode (positive electrode). This movement is necessary for the reaction at the cathode to occur and to complete the circuit. The electrolyte must allow only positive ions to pass to keep the system working properly.

Q186. Why are fuel cells described as redox reactions?
Answer: Fuel cells are described as redox reactions because they involve both oxidation and reduction processes. At the anode, hydrogen is oxidised (loses electrons), and at the cathode, oxygen is reduced (gains electrons). These simultaneous reactions generate electricity and are typical characteristics of redox reactions.

Q187. What is the difference between the anode and cathode in a hydrogen fuel cell?
Answer: In a hydrogen fuel cell, the anode is the negative electrode where hydrogen gas is oxidised to produce hydrogen ions and electrons. The cathode is the positive electrode where oxygen reacts with the hydrogen ions and electrons to form water. The anode is the site of electron release, while the cathode is the site of electron acceptance.

Q188. Why is a constant fuel supply needed for a hydrogen fuel cell to keep working?
Answer: A constant fuel supply is needed because the cell relies on ongoing chemical reactions to produce electricity. If either hydrogen or oxygen stops being supplied, the reactions cannot continue, and the cell will stop generating power. Unlike batteries, fuel cells do not store energy but generate it continuously from fuel.

Q189. Why can hydrogen fuel cells be used in remote or off-grid locations?
Answer: Hydrogen fuel cells can be used in remote or off-grid locations because they do not need to be connected to the electrical grid. As long as there is a supply of hydrogen and oxygen, they can produce electricity on-site. This makes them useful for powering equipment in areas where power lines are unavailable or unreliable.

Q190. What happens to the energy in the chemical bonds of hydrogen in a fuel cell?
Answer: In a hydrogen fuel cell, the energy stored in the chemical bonds of hydrogen is released when the bonds are broken during oxidation. This energy is used to move electrons through a circuit, generating electrical power. The process converts chemical energy directly into electrical energy with high efficiency.

Q191. Why is the use of hydrogen fuel cells in cars still limited?
Answer: The use of hydrogen fuel cells in cars is still limited due to the high cost of production, the lack of refuelling infrastructure, and challenges in hydrogen storage and safety. Additionally, electric vehicles with rechargeable batteries are currently more common and have better support in terms of charging networks.

Q192. How can the purity of hydrogen affect the operation of a fuel cell?
Answer: The purity of hydrogen affects fuel cell operation because impurities can damage the catalyst at the electrodes, reducing efficiency and shortening the cell's life. For example, carbon monoxide can poison the catalyst and prevent hydrogen from reacting properly. Therefore, high-purity hydrogen is essential for optimal performance.

Q193. Why is it important that hydrogen fuel cells produce no carbon dioxide?
Answer: It is important because carbon dioxide is a greenhouse gas that contributes to global warming. By producing only water as a waste product, hydrogen fuel cells offer a cleaner alternative

to petrol and diesel engines, which emit CO_2 and other pollutants. This makes them more environmentally friendly.

Q194. What is one reason hydrogen fuel cells are considered sustainable?
Answer: Hydrogen fuel cells are considered sustainable because they can be powered by hydrogen produced from renewable sources like water electrolysis using solar or wind energy. This means the energy cycle can be maintained without depleting natural resources or emitting harmful gases, supporting long-term environmental goals.

Q195. How does the design of the electrodes affect the efficiency of a hydrogen fuel cell?
Answer: The efficiency of a hydrogen fuel cell is influenced by the surface area and material of the electrodes. A higher surface area allows more reaction to occur, and using good catalysts like platinum improves reaction rates. Poor design can increase resistance or reduce gas flow, lowering the overall efficiency.

Q196. What kind of emissions are produced by hydrogen fuel cells?
Answer: Hydrogen fuel cells produce only water vapour as emissions when pure hydrogen is used. There are no greenhouse gases like carbon dioxide or harmful pollutants such as nitrogen oxides, making them very clean compared to combustion engines. This is a major environmental benefit of using fuel cells.

Q197. Why is the production of hydrogen from fossil fuels less environmentally friendly?
Answer: Producing hydrogen from fossil fuels, such as natural gas, releases carbon dioxide as a by-product, which contributes to climate change. Although the fuel cell itself is clean, the overall process is not if the hydrogen comes from non-renewable sources. This reduces the environmental benefit unless renewable methods are used.

Q198. How do hydrogen fuel cells compare with lithium-ion batteries in terms of weight?
Answer: Hydrogen fuel cells can be lighter than lithium-ion batteries for the same energy output, especially in large systems. This makes them useful in transport applications like buses and trucks where weight matters. However, hydrogen tanks and safety systems can add extra weight, depending on the design.

Q199. Why might cold temperatures affect hydrogen fuel cell vehicles?
Answer: Cold temperatures can affect the performance of fuel cell vehicles by slowing down the chemical reactions, reducing efficiency, and making it harder for the cell to start. Water produced during operation may also freeze, blocking parts of the system. Special heating systems are often needed in cold climates.

Q200. What challenges must be overcome before hydrogen fuel cells can replace petrol engines?
Answer: Key challenges include building enough hydrogen refuelling stations, producing hydrogen in an environmentally friendly way, reducing the cost of fuel cells, improving storage and transport methods, and ensuring safety. Public awareness and government support are also needed to encourage the use of hydrogen vehicles over traditional engines.