AQA (GCSE Notes)

Chapter 4: Bioenergetics

Q1. What is the word equation for photosynthesis?
Answer: The word equation for photosynthesis is: carbon dioxide + water → glucose + oxygen. This means that green plants use carbon dioxide from the air and water from the soil to make glucose (a type of sugar), and oxygen is released as a by-product. Light energy from the Sun is needed for this process to happen.

Q2. What is the balanced chemical equation for photosynthesis?
Answer: The balanced chemical equation for photosynthesis is: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$. This shows that six molecules of carbon dioxide react with six molecules of water to form one molecule of glucose and six molecules of oxygen. The reaction needs light energy, which is absorbed by chlorophyll in the plant's leaves.

Q3. What does it mean when we say photosynthesis is an endothermic reaction?
Answer: Photosynthesis is called an endothermic reaction because it takes in energy from the surroundings. In this case, the energy is light from the Sun. This light energy is absorbed by chlorophyll in the plant's cells and is used to convert carbon dioxide and water into glucose. Since energy is taken in during the process, it is endothermic.

Q4. What are the main raw materials needed for photosynthesis to take place?
Answer: The main raw materials needed for photosynthesis are carbon dioxide and water. Carbon dioxide enters the plant through tiny holes in the leaves called stomata, and water is taken up by the roots from the soil. Light energy is also needed but is not a raw material. These components allow the plant to produce glucose and oxygen.

Q5. Where in a plant cell does photosynthesis happen?
Answer: Photosynthesis takes place in the chloroplasts of plant cells. Chloroplasts are small structures found mainly in the cells of leaves. They contain a green pigment called chlorophyll, which absorbs light energy from the Sun. This energy is then used to carry out the chemical reactions of photosynthesis.

Q6. What is the role of chlorophyll in photosynthesis?
Answer: Chlorophyll is the green pigment found in the chloroplasts of plant cells. Its main role is to absorb light energy, especially from the red and blue parts of the light spectrum. This energy is then used to drive the chemical reactions in photosynthesis, which turn carbon dioxide and water into glucose and oxygen.

Q7. How does light energy affect the process of photosynthesis?
Answer: Light energy is essential for photosynthesis because it powers the chemical reactions that convert carbon dioxide and water into glucose and oxygen. Without enough light, the plant cannot make enough energy, and the rate of photosynthesis slows down. More light increases the rate of photosynthesis, up to a certain point.

Q8. Why is carbon dioxide necessary for photosynthesis?
Answer: Carbon dioxide is one of the key raw materials in photosynthesis. It enters the leaves through the stomata and is used along with water to make glucose. Each carbon atom in glucose comes from carbon dioxide. Without enough carbon dioxide, the plant cannot produce enough glucose for energy and growth.

Q9. How does temperature affect the rate of photosynthesis?
Answer: Temperature affects the enzymes that control the chemical reactions in photosynthesis. As the temperature increases, the rate of photosynthesis increases because the enzymes work faster. But if the temperature gets too high, the enzymes become damaged or denatured, and the rate of photosynthesis decreases sharply.

Q10. What is a limiting factor in photosynthesis?
Answer: A limiting factor is something that slows down the rate of photosynthesis when it is in short supply. The main limiting factors are light intensity, carbon dioxide concentration, temperature, and the amount of chlorophyll. If any of these factors are not at their optimum levels, photosynthesis cannot happen at its fastest rate.

Q11. Explain why the rate of photosynthesis increases with light intensity up to a certain point.
Answer: As light intensity increases, more light energy is available for the plant to carry out photosynthesis, so the rate increases. However, after a certain point, increasing the light further does not increase the rate because another factor, like carbon dioxide or temperature, becomes limiting. This causes the graph to level off.

Q12. What happens to the rate of photosynthesis if a plant has low levels of chlorophyll?
Answer: If a plant has low levels of chlorophyll, it cannot absorb as much light energy. Since light energy is needed to drive the reactions in photosynthesis, the process slows down. This means the plant will produce less glucose and oxygen, affecting its growth and energy supply.

Q13. Describe how the concentration of carbon dioxide can affect photosynthesis.
Answer: Carbon dioxide is needed to make glucose during photosynthesis. If the concentration of carbon dioxide increases, the rate of photosynthesis will also increase because more raw material is available. However, beyond a certain level, the rate stops increasing because another factor, like light or temperature, becomes limiting.

Q14. What are the products of photosynthesis and how are they used by the plant?
Answer: The products of photosynthesis are glucose and oxygen. The glucose is used by the plant for respiration to release energy, stored as starch, or used to make cellulose for the cell wall, fats, or amino acids. The oxygen is released into the air or used by the plant for respiration.

Q15. How would you design an experiment to test the effect of light intensity on the rate of photosynthesis?
Answer: To test the effect of light intensity, you can place pondweed in water and shine a lamp at different distances. Measure the number of bubbles produced or collect the oxygen to measure the rate of

photosynthesis. Keep other variables constant, like temperature, carbon dioxide, and water level, to ensure valid results.

Q16. What is the role of water in the photosynthesis reaction?
Answer: Water provides the hydrogen needed to make glucose. It is also a source of electrons for the reactions. Water is absorbed by the roots and transported to the leaves. During photosynthesis, water molecules are split using light energy in a process called photolysis, and oxygen is released as a by-product.

Q17. What is meant by the term "rate of photosynthesis"?
Answer: The rate of photosynthesis refers to how fast a plant can carry out the process of making glucose and oxygen from carbon dioxide and water using light. It can be measured by the amount of oxygen produced, the uptake of carbon dioxide, or the increase in biomass over a period of time.

Q18. Why does photosynthesis slow down at very high temperatures?
Answer: Photosynthesis slows down at very high temperatures because the enzymes that control the reaction become damaged or denatured. Enzymes work best at a certain temperature range, and beyond that, their shape changes, stopping them from working properly. This means the chemical reactions cannot take place efficiently.

Q19. How can you measure the rate of photosynthesis in a lab experiment?
Answer: One way to measure the rate is to count the number of oxygen bubbles produced by a plant like pondweed over a certain time. You could also collect the oxygen gas and measure its volume with a gas syringe. This gives a good estimate of how fast photosynthesis is taking place.

Q20. How would you identify the limiting factor in a given photosynthesis graph?
Answer: To identify the limiting factor, look at where the graph levels off. If the rate of photosynthesis increases and then stays constant despite further increases in one factor, another factor must be limiting. For example, if the rate levels off when light is increased, then temperature or carbon dioxide may be the limiting factor.

Q21. Describe how a plant uses the glucose produced in photosynthesis.
Answer: The glucose made in photosynthesis is used in respiration to release energy for growth and repair. It can be turned into starch for storage, used to make cellulose for cell walls, or combined with nitrate ions to make amino acids for proteins. It can also be used to make fats and oils for storage.

Q22. Why is it important for farmers to understand limiting factors of photosynthesis?
Answer: Understanding limiting factors helps farmers control conditions like light, temperature, and carbon dioxide in greenhouses to increase crop growth. By adjusting these conditions, they can make plants photosynthesise faster, which leads to better yields. This helps them grow more food and make their farming more efficient.

Q23. What is the inverse square law and how does it apply to photosynthesis?
Answer: The inverse square law states that light intensity is inversely proportional to the square of the distance from the light source. In photosynthesis, if the distance between the lamp and the plant doubles, the

light intensity falls to one-quarter. This helps explain why the rate of photosynthesis decreases as the light gets further away.

Q24. How can graphs be used to interpret the effect of light intensity on photosynthesis?
Answer: Graphs show how the rate of photosynthesis changes with light intensity. As light increases, the graph rises, showing a higher rate. When it levels off, it shows that another factor is now limiting. By studying the graph's shape, we can understand how light affects the plant and when it stops having an effect.

Q25. Why might a greenhouse be heated artificially during cold weather?
Answer: In cold weather, the temperature inside a greenhouse can drop below the optimum for photosynthesis. Heating keeps the temperature in the best range for enzyme activity. This allows the plants to keep photosynthesising quickly, even in winter, which leads to better growth and higher crop yields.

Q26. What is the economic benefit of controlling light, temperature, and carbon dioxide in a greenhouse?
Answer: Controlling light, temperature, and carbon dioxide in a greenhouse allows farmers to increase the rate of photosynthesis, which leads to faster and better plant growth. This results in higher crop yields in a shorter time. Although it costs money to control these factors, the improved growth and larger harvests can increase profits, making the investment worthwhile.

Q27. Why might the rate of photosynthesis not increase even if light intensity is increased further?
Answer: The rate of photosynthesis may not increase with more light if another factor, like carbon dioxide concentration or temperature, is limiting. This means light is no longer the limiting factor, and even if you add more light, the plant can't photosynthesise faster unless the other limiting factor is also increased.

Q28. How do you know when a factor is limiting the rate of photosynthesis?
Answer: You can identify a limiting factor when increasing that factor causes an increase in the rate of photosynthesis, while other factors are kept constant. If the rate does not increase after a certain point, another factor has become limiting. Graphs showing plateaus in the rate of photosynthesis help identify when one factor is no longer limiting.

Q29. Why is oxygen released during photosynthesis?
Answer: Oxygen is released during photosynthesis as a by-product of the splitting of water molecules in a reaction powered by light energy. This process, called photolysis, occurs in the chloroplasts. The hydrogen from water is used to help make glucose, and the oxygen is released into the air through the stomata.

Q30. What is the role of chloroplasts in the process of photosynthesis?
Answer: Chloroplasts are the parts of a plant cell where photosynthesis takes place. They contain chlorophyll, which absorbs light energy. This energy is then used to convert carbon dioxide and water into glucose and oxygen. Without chloroplasts, the plant would not be able to capture light and carry out photosynthesis.

Q31. Why is photosynthesis important for life on Earth?
Answer: Photosynthesis is essential because it produces oxygen, which animals and humans need to

breathe, and glucose, which plants use for energy and growth. It also forms the base of food chains, as plants are producers. Photosynthesis helps remove carbon dioxide from the air and contributes to maintaining the balance of gases in the atmosphere.

Q32. How can a plant compensate for low light conditions?
Answer: In low light, plants may produce more chlorophyll to absorb as much light as possible. They may also grow larger or thinner leaves to catch more light. Some plants can adapt their growth patterns or turn their leaves toward the light source. These adjustments help them photosynthesise more effectively despite less light.

Q33. What type of energy transformation takes place during photosynthesis?
Answer: During photosynthesis, light energy from the Sun is converted into chemical energy stored in glucose molecules. This transformation allows the plant to store energy in a usable form. The chemical energy in glucose can later be used in respiration to provide energy for the plant's activities like growth and repair.

Q34. How does the structure of a leaf help it carry out photosynthesis?
Answer: The leaf is wide and flat to capture more sunlight. It has many chloroplasts, especially in the palisade layer, where most photosynthesis happens. The leaf has tiny holes called stomata that allow carbon dioxide to enter. The veins in the leaf transport water and carry glucose away. All these features help it photosynthesise efficiently.

Q35. Explain how stomata are involved in photosynthesis.
Answer: Stomata are tiny openings on the underside of leaves that allow gases to move in and out. Carbon dioxide enters the leaf through the stomata for use in photosynthesis. At the same time, oxygen produced as a by-product exits through the stomata. The stomata also help control water loss through transpiration.

Q36. What happens to the rate of photosynthesis when carbon dioxide levels are high but light is low?
Answer: If carbon dioxide levels are high but light intensity is low, the rate of photosynthesis will still be limited. This is because light is needed to power the chemical reactions. Even though carbon dioxide is available, the plant cannot photosynthesise faster without enough light energy, so the overall rate stays low.

Q37. Why does photosynthesis require enzymes?
Answer: Enzymes are needed in photosynthesis because they control and speed up the chemical reactions. The reactions involved in making glucose from carbon dioxide and water are complex and slow on their own. Enzymes make these reactions happen more efficiently and at a speed that supports plant growth and survival.

Q38. How could a scientist test the effect of carbon dioxide on photosynthesis?
Answer: A scientist can place pondweed in water and supply different amounts of carbon dioxide by adding sodium hydrogen carbonate to the water. They can then measure the rate of photosynthesis by counting oxygen bubbles or collecting oxygen gas. By changing only the carbon dioxide level and keeping other factors constant, they can test its effect.

Q39. Why might a plant grown in the shade have larger leaves?
Answer: A plant in the shade receives less light, so it may grow larger leaves to capture more light for photosynthesis. Bigger leaves increase the surface area for light absorption. This adaptation helps the plant make enough glucose to survive and grow even in low-light environments.

Q40. Describe a method to calculate the rate of photosynthesis using pondweed.
Answer: Place a piece of pondweed in a beaker of water and shine a lamp on it. Count the number of oxygen bubbles produced in a set time or measure the volume of oxygen with a gas syringe. Repeat the experiment at different distances to change the light intensity. Keep other factors like temperature and CO_2 constant.

Q41. How can artificial lighting be used to increase crop yield in greenhouses?
Answer: Artificial lighting can be used in greenhouses to extend the hours of light or provide extra light on cloudy days. This ensures that plants get enough light for photosynthesis even when natural light is low. More photosynthesis means faster growth and higher yields, especially during winter or in low-light areas.

Q42. What safety precautions should be taken when using lamps to investigate photosynthesis?
Answer: Ensure the lamp does not overheat or come too close to the water to avoid burns or breaking glass. Use heat shields or water baths to control temperature. Do not touch hot lamps. Make sure electrical equipment is kept dry, and wires are secure to avoid trips or electrical hazards.

Q43. How does increasing chlorophyll concentration affect photosynthesis?
Answer: More chlorophyll allows the plant to absorb more light energy, which increases the rate of photosynthesis. Chlorophyll is the pigment that captures sunlight, so a higher concentration means the plant can produce more glucose. This supports faster growth and higher energy production, especially in good light conditions.

Q44. How can temperature be controlled in an experimental setup for photosynthesis?
Answer: Use a water bath to keep the temperature of the pondweed steady during the experiment. A thermometer should be used to monitor temperature, and adjustments made to maintain it. The room should be free from drafts or direct sunlight to prevent sudden temperature changes that could affect the results.

Q45. Why is it necessary to control variables when testing photosynthesis rates?
Answer: Controlling variables ensures that only the factor being tested affects the outcome. For example, if testing light intensity, temperature, carbon dioxide, and water should stay the same. This makes the experiment fair and the results reliable, allowing clear conclusions about the effect of the chosen variable.

Q46. What conclusions can be drawn from a photosynthesis graph with a plateau?
Answer: A plateau in a photosynthesis graph shows that increasing one factor no longer increases the rate because another factor has become limiting. For example, if light is increased but the graph levels off, it means something like carbon dioxide or temperature is now preventing further increase in photosynthesis rate.

Q47. How do scientists use mathematical models to describe photosynthesis rates?
Answer: Scientists use equations and graphs to model how different factors affect the rate of photosynthesis. They might use the inverse square law to relate light intensity and distance, or graphs showing curves where rates level off due to limiting factors. These models help predict plant responses and guide farming techniques.

Q48. Why do plants need to photosynthesise during the daytime?
Answer: Plants need light energy to carry out photosynthesis, and sunlight is only available during the day. Without light, chlorophyll cannot absorb energy, and the chemical reactions to make glucose and oxygen cannot take place. At night, plants stop photosynthesising and may switch to using stored energy for respiration.

Q49. What is meant by the term "optimum temperature" in relation to photosynthesis?
Answer: Optimum temperature is the best temperature at which the enzymes involved in photosynthesis work most efficiently. If the temperature is too low, the enzymes work slowly. If it's too high, they can become damaged. The optimum is the range where the plant can photosynthesise at the fastest possible rate.

Q50. How can photosynthesis graphs help in deciding how to increase plant growth in different seasons?
Answer: Photosynthesis graphs show how light, temperature, and carbon dioxide affect the rate of glucose production. In different seasons, light and temperature vary. Farmers can use graphs to decide when to add artificial light, heat, or CO_2 to maintain good growth conditions, ensuring steady crop production all year round.

Q51. How can you investigate the effect of light intensity on the rate of photosynthesis using pondweed?
Answer: To investigate the effect of light intensity on the rate of photosynthesis, place a piece of pondweed such as Elodea in a beaker of water. Set up a lamp at varying distances from the beaker to change the light intensity. At each distance, count the number of oxygen bubbles released in a fixed time (e.g., one minute). Repeat the experiment for each distance and take an average. The more bubbles produced, the higher the rate of photosynthesis, showing how light intensity affects the process.

Q52. What is the role of a lamp in the pondweed experiment on photosynthesis?
Answer: The lamp acts as an artificial source of light to provide energy for photosynthesis. By adjusting the distance of the lamp from the pondweed, you can change the light intensity received by the plant. This allows you to observe how different light levels affect the rate of photosynthesis, measured by counting oxygen bubbles. Without the lamp, it would be difficult to control and measure light intensity during the experiment.

Q53. How can you make sure the temperature stays constant during the photosynthesis practical?
Answer: To keep the temperature constant, perform the experiment in a room with stable temperature. You can also place the beaker in a water bath at a fixed temperature or use a heat shield between the lamp and the beaker to stop the lamp from heating the water. Using the same type of bulb and avoiding any movement

of equipment also helps to maintain consistent conditions, ensuring light intensity is the only variable affecting the results.

Q54. Why is it important to count the number of oxygen bubbles released in the pondweed experiment?
Answer: Counting oxygen bubbles gives an estimate of the rate of photosynthesis. As plants photosynthesise, they produce oxygen, which appears as bubbles in water. The more bubbles seen per minute, the faster the plant is photosynthesising. Although it may not be very precise, it is a simple, visible way to measure how conditions like light intensity affect the photosynthesis process in pondweed.

Q55. What is one way to make the measurement of oxygen more accurate in the light intensity experiment?
Answer: Instead of counting oxygen bubbles, you can collect the oxygen gas in an inverted measuring cylinder or a gas syringe and record the volume produced. This gives a more accurate result because bubbles can vary in size, which can lead to unreliable counts. Measuring the volume removes this problem and gives a clearer idea of how much oxygen the plant is producing at each light intensity level.

Q56. What does AT 1 refer to in the context of the photosynthesis practical?
Answer: AT 1 stands for Apparatus and Techniques 1, which is a part of the science practical skills required in exams. In the context of the photosynthesis experiment, it means students should be able to use equipment like beakers, lamps, rulers, timers, and measuring cylinders accurately, and record data carefully. It also includes making observations, taking readings, and repeating tests to get valid and reliable results.

Q57. What variable should be changed to investigate light intensity in the required practical?
Answer: The variable that should be changed is the distance between the lamp and the pondweed. This changes the light intensity the plant receives. As the lamp is moved closer, the light intensity increases, and as it moves away, the intensity decreases. This is the independent variable, the one you deliberately change, to see how it affects the rate of photosynthesis, which is measured by the oxygen bubbles produced.

Q58. What are the controlled variables in the light intensity experiment using pondweed?
Answer: Controlled variables are the factors that must be kept the same to make the test fair. In this experiment, they include the volume of water, the temperature of the water, the type and length of pondweed, the time for which oxygen bubbles are counted, and the concentration of carbon dioxide. Keeping these constant ensures that only the change in light intensity affects the rate of photosynthesis.

Q59. What would be the effect of increasing the distance between the lamp and the pondweed?
Answer: Increasing the distance between the lamp and the pondweed reduces the light intensity reaching the plant. As a result, the rate of photosynthesis usually decreases. This happens because less light energy is available for the plant to carry out photosynthesis. Therefore, the number of oxygen bubbles released goes down as the lamp moves further away from the pondweed.

Q60. Why is it important to repeat the pondweed experiment and take an average?
Answer: Repeating the experiment helps to reduce the effect of any random errors and increases the reliability of the results. Taking an average of multiple results gives a more accurate and trustworthy answer

than relying on a single trial. It also helps to spot any outliers or unusual results that may have occurred due to mistakes or unexpected changes during the experiment.

Q61. How can the rate of photosynthesis be calculated from the experiment with pondweed?
Answer: The rate of photosynthesis can be calculated by counting the number of oxygen bubbles produced in a certain time, like one minute. For a more accurate method, collect the oxygen gas in a measuring cylinder or syringe and measure its volume over time. Then divide the total oxygen volume by the time to get the rate in units like cm^3 per minute. This gives a clear idea of how fast the plant is photosynthesising.

Q62. What is meant by a qualitative reagent?
Answer: A qualitative reagent is a chemical used to show if a substance is present in a sample, but it does not give an exact amount. It causes a colour change or other visible effect when the target substance is present. For example, iodine solution is a qualitative reagent used to test for starch in leaves; if starch is present, the iodine turns blue-black.

Q63. How can you test a leaf for the presence of starch?
Answer: First, place the leaf in boiling water for a minute to stop chemical reactions. Then boil the leaf in ethanol using a water bath to remove chlorophyll. Rinse the leaf in warm water to soften it. Finally, add iodine solution. If starch is present, the leaf will turn blue-black. This shows the leaf has been photosynthesising and has stored glucose as starch.

Q64. Why is the leaf boiled in ethanol during the starch test?
Answer: The leaf is boiled in ethanol to remove the green chlorophyll, which makes it easier to see any colour change during the iodine test. This step helps ensure the blue-black colour caused by the presence of starch is clearly visible. Since ethanol is flammable, this should be done using a hot water bath and not over a naked flame.

Q65. What reagent is used to test for glucose in plants?
Answer: Benedict's solution is used to test for glucose. A small sample is mixed with Benedict's reagent and heated in a water bath. If glucose is present, the solution changes colour from blue to green, yellow, or brick-red, depending on how much glucose is there. This is a qualitative test used to check for simple sugars in plants.

Q66. What colour change would you expect when testing for protein using biuret reagent?
Answer: When using the biuret reagent to test for protein, the solution changes from blue to purple if protein is present. This colour change shows that peptide bonds, which link amino acids in proteins, are in the sample. If there is no protein, the solution stays blue. This is a simple test to detect protein in plant or animal material.

Q67. What is the chemical formula for glucose?
Answer: The chemical formula for glucose is $C_6H_{12}O_6$. It is a simple sugar, or monosaccharide, and contains six carbon atoms, twelve hydrogen atoms, and six oxygen atoms. Glucose is made by plants during photosynthesis and is used as a source of energy in respiration or converted into other useful substances like starch, fats, and cellulose.

Q68. How is glucose used for respiration in plants?
Answer: In plants, glucose is broken down during cellular respiration to release energy. This energy is used for various functions such as active transport, cell division, and building new cells. The glucose is mainly used in mitochondria, where it reacts with oxygen in aerobic respiration to produce carbon dioxide, water, and energy in the form of ATP.

Q69. Why do plants convert glucose into starch?
Answer: Plants convert glucose into starch so they can store it for later use. Glucose is soluble and can affect the plant's water balance if stored directly. Starch is insoluble and does not affect the water potential of cells, making it a better storage form. The plant can break it down later when it needs glucose for energy or growth.

Q70. Why is starch stored in an insoluble form in plants?
Answer: Starch is stored in an insoluble form so it doesn't dissolve in water and affect the plant cell's water balance. If glucose were stored directly, it would attract water into cells by osmosis, which could damage them. Insoluble starch prevents this and allows plants to store large amounts of energy in a compact and safe way.

Q71. How is glucose used to produce fat or oil in plants?
Answer: Plants can use glucose, along with other substances, to make fatty acids and glycerol, which combine to form fats or oils. These are stored in seeds and other parts of the plant as an energy source. The fats are especially useful in seeds because they store more energy than carbohydrates and help the seed grow when it starts to germinate.

Q72. What is the importance of cellulose made from glucose?
Answer: Cellulose is made from many glucose molecules linked together. It is used to build strong cell walls in plants, giving them structure and support. Cellulose helps the plant stay upright, protects the inner parts of the cell, and controls the movement of water in and out of the cell. It is a key structural material in all plant cells.

Q73. What extra nutrient do plants need to make amino acids?
Answer: Plants need nitrate ions from the soil to make amino acids. Nitrates provide the nitrogen needed to combine with glucose to form amino acids, which are the building blocks of proteins. Without nitrates, plants cannot make proteins and will show poor growth and yellow leaves.

Q74. How do plants get nitrate ions from the soil?
Answer: Plants absorb nitrate ions from the soil through their root hair cells using active transport. This process uses energy because the nitrate concentration in the soil is usually lower than inside the plant. The nitrate ions are then used to make amino acids and proteins needed for growth and development.

Q75. What is the word equation for aerobic respiration?
Answer: The word equation for aerobic respiration is:
glucose + oxygen → carbon dioxide + water + energy

This reaction takes place in the mitochondria of cells and releases energy that the plant uses for various activities like growth, transport, and repair. It is the main way plants release the energy stored in glucose.

Q76. Write the balanced chemical equation for aerobic respiration.
Answer: The balanced chemical equation for aerobic respiration is: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$. This shows that one molecule of glucose reacts with six molecules of oxygen to produce six molecules of carbon dioxide, six molecules of water, and energy in the form of ATP, which is used by cells for various activities like movement, growth, and repair.

Q77. Why is aerobic respiration described as an exothermic reaction?
Answer: Aerobic respiration is described as an exothermic reaction because it releases energy to the surroundings. When glucose reacts with oxygen in cells, it produces carbon dioxide, water, and energy. The energy released is used by cells for different processes, and since energy is given out, the reaction is called exothermic.

Q78. In what part of the cell does aerobic respiration mostly take place?
Answer: Aerobic respiration mostly takes place in the mitochondria of the cell. Mitochondria are known as the "powerhouses" of the cell because they release most of the energy by breaking down glucose with oxygen. This energy is used for essential processes like movement, active transport, and synthesis of large molecules.

Q79. How is the energy from respiration used in movement?
Answer: The energy released during respiration is used by muscles to contract. Muscle cells use ATP, the energy carrier made during respiration, to slide protein filaments over each other and cause movement. This energy is vital for walking, running, breathing, and even moving food through the digestive system using muscles.

Q80. Why is respiration important for keeping animals warm?
Answer: Respiration helps animals maintain a constant body temperature because it releases energy as heat. This is especially important for warm-blooded animals like mammals and birds. The heat from respiration helps keep their body temperature stable even when the environment is cold, allowing enzymes and other processes to work properly.

Q81. What is the word equation for anaerobic respiration in human muscles?
Answer: The word equation for anaerobic respiration in human muscles is: glucose → lactic acid + energy. This happens when there is not enough oxygen for aerobic respiration, such as during intense exercise. It provides a small amount of energy quickly but produces lactic acid as a waste product.

Q82. Why is less energy released in anaerobic respiration compared to aerobic respiration?
Answer: Less energy is released in anaerobic respiration because glucose is only partially broken down. Without oxygen, the energy stored in glucose cannot be fully extracted. As a result, anaerobic respiration produces only a small amount of ATP, while aerobic respiration produces much more because it completely breaks down glucose using oxygen.

Q83. What is the main product of anaerobic respiration in muscles?
Answer: The main product of anaerobic respiration in muscles is lactic acid. It forms when glucose is broken down without oxygen during vigorous activity. Lactic acid builds up in muscles and can lead to pain or fatigue. The body later removes it by converting it back to glucose in the liver.

Q84. Why does lactic acid cause fatigue in muscles?
Answer: Lactic acid causes fatigue because it lowers the pH in muscles, making the environment more acidic. This can interfere with the function of enzymes and slow down muscle contraction. As more lactic acid builds up, muscles become sore and tired, reducing their ability to continue working efficiently during exercise.

Q85. What process breaks down lactic acid after exercise?
Answer: Lactic acid is broken down by aerobic respiration in the liver. After exercise, the body continues to breathe deeply and the heart pumps more oxygen-rich blood to the muscles and liver. The lactic acid is transported to the liver, where it is converted back into glucose or used in respiration to release energy.

Q86. What is the word equation for anaerobic respiration in yeast?
Answer: The word equation for anaerobic respiration in yeast is: glucose → ethanol + carbon dioxide + energy. This process is also known as fermentation. It allows yeast to produce energy without oxygen and is used in the baking and alcohol industries.

Q87. What are the products of anaerobic respiration in yeast?
Answer: The products of anaerobic respiration in yeast are ethanol, carbon dioxide, and a small amount of energy. This process happens in the absence of oxygen and is used in making alcoholic drinks and bread. The carbon dioxide makes bread rise, and the ethanol is used in beer and wine production.

Q88. What is fermentation?
Answer: Fermentation is the process where microorganisms like yeast break down sugars without oxygen to produce energy. In yeast, fermentation produces ethanol and carbon dioxide. It is a type of anaerobic respiration and is useful in food and drink industries, such as in baking, brewing, and making dairy products like yogurt.

Q89. How is fermentation used in bread making?
Answer: In bread making, yeast ferments the sugars in the dough and produces carbon dioxide and ethanol. The carbon dioxide forms bubbles, which make the dough rise and give bread its light texture. During baking, the heat kills the yeast, and the alcohol evaporates, leaving soft and airy bread.

Q90. How is fermentation used in the production of alcoholic drinks?
Answer: Fermentation is used in alcoholic drink production by adding yeast to sugary liquids like grape juice or grain mash. The yeast ferments the sugars, producing ethanol and carbon dioxide. The ethanol becomes the alcohol in drinks like beer and wine, while the carbon dioxide may be removed or used for fizz.

Q91. What gas is produced during fermentation that helps dough rise?
Answer: The gas produced during fermentation that helps dough rise is carbon dioxide. Yeast in the dough

breaks down sugars and releases carbon dioxide bubbles, which get trapped in the dough and make it expand. This gives the bread its soft, airy texture once baked.

Q92. Why do yeast cells switch to anaerobic respiration when oxygen is not available?
Answer: Yeast cells switch to anaerobic respiration when there is no oxygen because they still need to produce energy. Without oxygen, they cannot do aerobic respiration, so they break down glucose through fermentation. Although it produces less energy, it allows the yeast to survive and continue functioning in low-oxygen environments.

Q93. Compare the products of aerobic respiration and anaerobic respiration in humans.
Answer: In aerobic respiration, the products are carbon dioxide, water, and a large amount of energy. In anaerobic respiration in humans, the product is lactic acid and a small amount of energy. Aerobic respiration needs oxygen and is more efficient, while anaerobic happens when oxygen is low and produces less energy with a waste product.

Q94. Compare the amount of energy released in aerobic and anaerobic respiration.
Answer: Aerobic respiration releases a large amount of energy because glucose is fully broken down using oxygen. Anaerobic respiration releases much less energy since the glucose is only partially broken down. Aerobic respiration produces about 36 ATP molecules per glucose, while anaerobic respiration produces only 2 ATP per glucose.

Q95. How does the body respond to increased energy demands during vigorous exercise?
Answer: During vigorous exercise, the body increases breathing rate and heart rate to deliver more oxygen and glucose to muscles. Blood vessels widen to improve blood flow. If oxygen can't be delivered fast enough, muscles switch to anaerobic respiration, producing lactic acid. The body also increases depth of breathing and starts to break down stored glycogen for energy.

Q96. Why does heart rate increase during aerobic respiration?
Answer: Heart rate increases during aerobic respiration to pump more oxygen and glucose to the working muscles. These materials are needed for respiration to release energy. The faster heart rate ensures that waste products like carbon dioxide are removed quickly and that energy production continues to meet the demand of the body.

Q97. How does anaerobic respiration differ between muscle cells and yeast cells?
Answer: In muscle cells, anaerobic respiration produces lactic acid and a small amount of energy. In yeast cells, it produces ethanol, carbon dioxide, and energy. Muscle cells do this during intense exercise, while yeast does it during fermentation. The end products are different, but both release energy without using oxygen.

Q98. What are the similarities between aerobic and anaerobic respiration?
Answer: Both types of respiration release energy from glucose, involve chemical reactions in cells, and are essential for life. They both begin with the breakdown of glucose. However, aerobic needs oxygen and releases more energy, while anaerobic does not require oxygen and produces different waste products depending on the organism.

Q99. What happens to the oxygen supply to muscles during very intense exercise?
Answer: During very intense exercise, the oxygen supply to muscles may not meet the high demand. As a result, the muscles start using anaerobic respiration to release energy. This leads to the build-up of lactic acid, which can cause pain and fatigue. After the exercise, the body needs extra oxygen to remove the lactic acid.

Q100. Why is respiration considered a continuous process in all living cells?
Answer: Respiration is considered a continuous process because cells always need energy to function. Even at rest, cells require energy for basic tasks like maintaining temperature, cell repair, and movement of substances. Since respiration provides this energy, it must keep happening all the time in every living cell to keep the organism alive.

Q101. What changes happen in the body during exercise to meet increased energy demands?
Answer: During exercise, the body responds by increasing the breathing rate and depth to take in more oxygen. The heart rate also increases to pump more blood, carrying oxygen and glucose to the muscles. Blood vessels widen to improve blood flow to active muscles. These changes help meet the higher energy demand. If oxygen is still not enough, muscles use anaerobic respiration, which produces lactic acid and less energy.

Q102. Why does the heart rate increase during physical activity?
Answer: The heart rate increases during exercise to deliver more oxygen and glucose to the muscles. These are needed for aerobic respiration, which releases energy for muscle contraction. The faster the heart beats, the more blood flows to the muscles, ensuring they get the materials needed for energy production and removing carbon dioxide more quickly.

Q103. How does an increase in breathing rate help the body during exercise?
Answer: An increased breathing rate allows the body to take in more oxygen and get rid of more carbon dioxide. During exercise, muscles need more oxygen for respiration and produce more carbon dioxide as a waste product. Breathing faster helps meet this increased demand and keeps the blood oxygenated, supporting continuous energy release.

Q104. What is meant by an increase in breath volume during exercise?
Answer: An increase in breath volume means that with each breath, more air is taken into the lungs. This brings more oxygen into the body and allows more carbon dioxide to be removed. During exercise, both breathing rate and breath volume increase to meet the higher oxygen needs of the muscles and help maintain energy supply.

Q105. Why do muscles need more oxygen during exercise?
Answer: Muscles need more oxygen during exercise because they are contracting more and require more energy. Oxygen is needed for aerobic respiration, which releases energy from glucose. The more a muscle works, the more oxygen it needs to keep up the energy supply. Without enough oxygen, muscles may switch to anaerobic respiration, which is less efficient.

Q106. What happens when the body cannot supply enough oxygen to the muscles during exercise?
Answer: When oxygen supply is too low, muscles switch from aerobic to anaerobic respiration. This allows

them to continue producing energy without oxygen, but it also produces lactic acid as a waste product. Lactic acid builds up in the muscles, causing fatigue and sometimes cramps. After exercise, the body needs to remove the lactic acid and restore oxygen levels.

Q107. What causes a build-up of lactic acid in the muscles?
Answer: A build-up of lactic acid occurs when muscles carry out anaerobic respiration. This happens during intense exercise when there is not enough oxygen for aerobic respiration. Glucose is only partially broken down, and lactic acid is produced as a by-product. If exercise continues, lactic acid accumulates and leads to tiredness and discomfort in the muscles.

Q108. What is meant by the term "oxygen debt"?
Answer: Oxygen debt is the amount of extra oxygen the body needs after exercise to remove lactic acid from the muscles. During anaerobic respiration, oxygen is not used, and lactic acid builds up. After exercise, the body breathes faster and deeper to repay the oxygen debt by breaking down lactic acid and restoring normal conditions in the cells.

Q109. How is oxygen debt paid back after exercise ends?
Answer: After exercise, breathing and heart rates remain high so that more oxygen is delivered to the muscles and liver. This oxygen is used to break down the lactic acid that built up during anaerobic respiration. The lactic acid is transported to the liver, where it is either converted back to glucose or broken down, helping the body recover.

Q110. What effect does lactic acid have on muscle function?
Answer: Lactic acid lowers the pH in muscle cells, making them more acidic. This can interfere with enzymes that help muscles contract, leading to a decrease in muscle performance. As more lactic acid builds up, muscles become fatigued, causing pain or cramps and making it harder to continue exercising.

Q111. What does it mean when muscles become fatigued?
Answer: Muscle fatigue means the muscles are no longer able to contract efficiently. It often happens after prolonged or intense exercise when energy stores are low and waste products like lactic acid have built up. This leads to a feeling of weakness, reduced strength, and sometimes soreness in the muscles.

Q112. How does the liver help the body recover after anaerobic respiration?
Answer: After anaerobic respiration, the liver helps by converting lactic acid into glucose, which can be used for energy or stored for later use. The liver also helps clear lactic acid from the bloodstream. This process requires oxygen, so the body continues to breathe deeply after exercise to help the liver carry out this recovery process.

Q113. How is lactic acid removed from muscle cells after exercise?
Answer: Lactic acid is transported from the muscles to the liver through the blood. In the liver, it is broken down using oxygen in a process that helps reduce acidity and restore energy balance. The breakdown of lactic acid either releases more energy or turns it back into glucose that can be reused by the body.

Q114. Why do athletes need to warm up before vigorous exercise?
Answer: Warming up increases the body temperature and blood flow to the muscles. It helps muscles become more flexible and prepares the cardiovascular and respiratory systems for the increased demands of exercise. Warming up also helps prevent injury and allows the athlete to perform better by gradually preparing the body for activity.

Q115. What is the importance of cooling down after exercise?
Answer: Cooling down helps the body return to normal after exercise. It keeps the blood flowing, which helps remove lactic acid and other waste products from the muscles. Cooling down also reduces the chance of dizziness or fainting by allowing the heart rate and breathing rate to gradually return to normal, and helps prevent stiffness and soreness.

Q116. What types of data could be collected during an investigation on the effects of exercise?
Answer: Data could include heart rate, breathing rate, breath volume, time taken for recovery, or the number of steps taken. Other data might include how long exercise is performed or how quickly the heart returns to normal. These data help show how the body responds to exercise and can be used to analyse fitness levels or recovery time.

Q117. How can heart rate be measured accurately before and after exercise?
Answer: Heart rate can be measured by counting the number of beats per minute using your fingers on your wrist or neck. For more accuracy, a digital heart rate monitor or smartwatch can be used. Measurements should be taken at rest, immediately after exercise, and during recovery to compare changes and assess the body's response to physical activity.

Q118. What is one method to investigate the effect of exercise on breathing rate?
Answer: One method is to count how many breaths a person takes in one minute before, during, and after exercise. You can observe the rise and fall of the chest or use a breath sensor. Comparing the breathing rate before and after exercise shows how the body responds to the increased energy demand during activity.

Q119. Why should results be repeated when measuring the effects of exercise?
Answer: Repeating results helps make the data more reliable and reduces the chance of errors. It also allows you to calculate an average, which gives a more accurate picture of the body's response. Repeated tests help spot patterns and make sure the results are not affected by random mistakes or unusual events during the experiment.

Q120. What is metabolism?
Answer: Metabolism is the sum of all the chemical reactions in the body's cells. These reactions include breaking down molecules to release energy and building new molecules for growth and repair. Metabolism includes respiration, digestion, and synthesis of proteins, carbohydrates, and lipids. It is essential for keeping the body alive and functioning properly.

Q121. What are the main components involved in the synthesis of carbohydrates, proteins, and lipids?
Answer: Carbohydrates are made from simple sugars like glucose. Proteins are made from amino acids,

which contain nitrogen. Lipids are made from glycerol and fatty acids. These components are built into larger molecules through chemical reactions in cells. These processes require energy and are part of the body's metabolism.

Q122. What is formed when glucose is converted to starch?
Answer: When many glucose molecules join together in a chain, they form starch. This is a storage form of carbohydrate in plants. Starch is insoluble and can be stored in cells without affecting water balance. When needed, it can be broken down back into glucose to release energy.

Q123. How are glycogen and cellulose related to glucose?
Answer: Glycogen and cellulose are both made from glucose. Glycogen is the storage form of glucose in animals and is found in liver and muscle cells. Cellulose is made by plants and forms strong fibres in cell walls. Both are made by joining many glucose molecules together in different arrangements for storage or structure.

Q124. What are lipids made from?
Answer: Lipids are made from glycerol and three fatty acids. These components join together in a reaction that stores energy. Lipids are important for making cell membranes, storing energy, and insulating the body. They are also used to make hormones and other important molecules in the body.

Q125. Describe the basic structure of a lipid molecule.
Answer: A lipid molecule has one glycerol molecule joined to three fatty acid chains. This structure is often called a triglyceride. The fatty acids can vary in length and type, but all lipids store a lot of energy. This basic structure is used in fats and oils, which are found in both plants and animals.

Q126. What molecules are needed to make amino acids in plants?
Answer: To make amino acids, plants need glucose and nitrate ions. Glucose is produced during photosynthesis and provides the carbon skeleton. Nitrate ions are absorbed from the soil and supply nitrogen. Together, these form amino acids, which are the building blocks of proteins used for growth and repair in the plant.

Q127. How are proteins built from amino acids?
Answer: Proteins are made when amino acids join together in a specific sequence through a process called protein synthesis. This happens in the ribosomes of cells. Each protein has a unique shape and function depending on the order of amino acids. The formation of proteins from amino acids is an example of an anabolic reaction.

Q128. Why is respiration included in the definition of metabolism?
Answer: Respiration is included in metabolism because it is one of the main processes that releases energy from glucose. This energy is needed to power all other metabolic reactions in the body, such as making proteins, breaking down waste, and maintaining body temperature. Without respiration, these reactions could not happen.

Q129. What type of reaction is the breakdown of excess proteins into urea?
Answer: The breakdown of excess proteins into urea is a catabolic reaction. In this process, amino acids are broken down in the liver, and the nitrogen part is converted into urea. Urea is then transported to the kidneys for removal from the body through urine. This reaction helps prevent the build-up of harmful substances.

Q130. What is the role of the liver in protein breakdown?
Answer: The liver breaks down excess amino acids that are not needed to make proteins. It removes the nitrogen part of the amino acid in a process called deamination, producing ammonia, which is then converted into urea. Urea is transported to the kidneys and excreted in urine. This process helps the body safely get rid of extra protein.

Q131. How is urea removed from the body?
Answer: Urea is removed from the body through the kidneys. After the liver converts ammonia into urea, it is carried by the blood to the kidneys. The kidneys filter the urea out of the blood and pass it into the bladder as part of urine. It is then removed from the body when a person urinates.

Q132. What role do enzymes play in metabolic reactions?
Answer: Enzymes speed up metabolic reactions in the body by lowering the energy needed for the reactions to happen. Each enzyme is specific to a particular reaction. Without enzymes, most metabolic processes would be too slow to support life. They help build large molecules like proteins and break down substances like carbohydrates and fats.

Q133. Why is energy needed for metabolic processes?
Answer: Energy is needed to drive the chemical reactions that make and break molecules in the body. This includes building proteins, making cell structures, repairing tissues, and removing waste. Energy from respiration fuels all these processes, allowing cells to carry out their functions and the body to grow, stay healthy, and stay alive.

Q134. How does metabolism support growth in organisms?
Answer: Metabolism supports growth by building the large molecules needed to make new cells and tissues. It includes the synthesis of proteins, nucleic acids, and cell membranes. These substances help the body grow, repair damage, and maintain healthy functions. Energy from respiration powers these reactions and keeps the process going.

Q135. What is the relationship between respiration and metabolism?
Answer: Respiration is a part of metabolism. It provides the energy required for all other metabolic reactions. Without respiration, the body would not have enough energy to build or break down molecules. Therefore, metabolism depends on respiration to supply the energy needed for processes like growth, repair, and maintaining body temperature.

Q136. What is the difference between anabolic and catabolic reactions?
Answer: Anabolic reactions build larger molecules from smaller ones, such as making proteins from amino acids. These reactions usually require energy. Catabolic reactions break down larger molecules into smaller

ones, such as breaking down glucose in respiration. These reactions often release energy. Both types are part of metabolism.

Q137. How are glucose molecules used in metabolism?
Answer: Glucose is used in respiration to release energy. It is also used to make larger molecules like starch in plants, glycogen in animals, and cellulose for plant cell walls. Glucose can also combine with nitrates to form amino acids and proteins. These uses make glucose essential for growth and energy in metabolism.

Q138. What is the importance of metabolic reactions in everyday life?
Answer: Metabolic reactions allow the body to grow, repair itself, make energy, and remove waste. They support breathing, digestion, movement, and even thinking. Without these chemical reactions, the body would not function. Metabolism keeps all systems working and is essential for survival, health, and daily activities.

Q139. How does the body store glucose when it is not immediately needed?
Answer: When the body has more glucose than it needs, it stores the extra glucose as glycogen. Glycogen is stored mainly in the liver and muscles. When blood sugar levels fall or more energy is needed, the glycogen is broken down back into glucose to be used by the body. This helps keep blood glucose levels stable.

Q140. What happens to glucose during cellular respiration?
Answer: During cellular respiration, glucose is broken down in cells to release energy. In aerobic respiration, glucose reacts with oxygen to form carbon dioxide, water, and energy in the form of ATP. This energy powers many functions in the cell, such as making new molecules, muscle contraction, and active transport.

Q141. How is excess glucose stored in the liver and muscles?
Answer: Excess glucose is stored as glycogen in the liver and muscles. When there is more glucose than the body needs, insulin from the pancreas signals the liver and muscles to store it. When the body needs energy later, glycogen is converted back into glucose and used in respiration to release energy.

Q142. How are fatty acids important in metabolism?
Answer: Fatty acids are used to make lipids, which store energy and form parts of cell membranes. They can also be broken down in respiration to release energy when glucose is low. Fatty acids are part of many hormones and help the body absorb some vitamins, making them important for many metabolic processes.

Q143. How do metabolic processes affect body temperature?
Answer: Metabolic processes release heat, especially during respiration. This heat helps keep the body's temperature steady. If metabolism increases, more heat is produced. This is why exercise makes you feel warm. Keeping a stable temperature is important because enzymes that control metabolism work best at a certain temperature.

Q144. What are examples of molecules broken down during metabolism?
Answer: During metabolism, molecules like glucose, amino acids, and fatty acids are broken down. Glucose is broken down in respiration. Excess amino acids are broken down into urea. Fatty acids can be used for energy. These breakdowns release energy or help remove waste from the body.

Q145. How can a poor diet affect metabolic processes in the body?
Answer: A poor diet may lack the nutrients needed for metabolic reactions. Without enough proteins, vitamins, or minerals, the body cannot build or repair tissues properly. This can slow metabolism, weaken the immune system, reduce energy levels, and lead to health problems like tiredness, poor growth, and weakened bones or muscles.

Q146. How does exercise influence the rate of metabolism?
Answer: Exercise increases the rate of metabolism by raising the body's energy demand. Muscles need more energy during activity, so respiration speeds up. Regular exercise also builds muscle, and muscle cells use more energy even at rest. This means people who exercise often have a higher resting metabolic rate.

Q147. How can hormones affect metabolism?
Answer: Hormones like thyroxine and insulin control the speed of metabolism. Thyroxine, made by the thyroid gland, increases the rate of reactions like respiration. Insulin helps control how glucose is used or stored. Hormone imbalances can lead to problems such as weight gain, fatigue, or poor growth.

Q148. Why is the balance of metabolic reactions important for health?
Answer: A balance between building up and breaking down substances is needed to stay healthy. If this balance is lost, it can lead to weight problems, illness, or damage to cells. The body needs to make enough energy and new materials, while also removing waste. Balanced metabolism keeps all systems working properly.

Q149. Why must the body remove excess amino acids?
Answer: The body cannot store amino acids, so extra ones must be removed. Too many amino acids can be harmful. The liver breaks them down, removing the nitrogen part and forming urea. Urea is then excreted in urine. This process keeps the body safe and prevents the build-up of toxic substances.

Q150. What is one way to investigate the effect of physical activity on metabolism in a classroom setting?
Answer: One way is to measure students' breathing or heart rates before and after light exercise, like jogging in place. The increase shows how the body responds to the need for more energy. You can also time how long it takes for their heart or breathing rate to return to normal. This gives an idea of their metabolic response to activity.