GCSE / IGCSE Biology – Bioenergetics

GCSE/IGCSE (Edexcel/Cambridge style, Higher tier) · Total marks: 43 · Answers on the last page

This worksheet covers photosynthesis, the limiting factors of photosynthesis, and aerobic and anaerobic respiration. A calculator is allowed. Allow about 40 minutes.

Section A – Photosynthesis

1. (a) Write the balanced word equation for photosynthesis.
(b) State the type of reaction photosynthesis is (in terms of energy transfer) and name the organelle in which it takes place.
(c) Name the green pigment that absorbs light energy for photosynthesis, and state where it is located within the organelle. [4]

2. A student uses pondweed (Elodea) to investigate the rate of photosynthesis by counting the number of oxygen bubbles produced per minute at different light intensities.
(a) Suggest why counting bubbles is not a very accurate way of measuring the rate of photosynthesis.
(b) Describe one improvement the student could make to obtain more accurate data. [3]

3. Glucose produced during photosynthesis can be used by a plant in several ways.
(a) State two substances, other than glucose used directly, that a plant can make from the glucose produced in photosynthesis.
(b) Explain why plants need a supply of nitrate ions from the soil in addition to the products of photosynthesis. [3]

4. Explain, in terms of gas exchange, why a green plant kept in bright light might show no net uptake of carbon dioxide even though photosynthesis is occurring, but does show a net uptake of carbon dioxide as light intensity is increased further. [3]

Section B – Limiting factors of photosynthesis

5. (a) Name three factors that can limit the rate of photosynthesis.
(b) Explain what is meant by a 'limiting factor'. [4]

6. A greenhouse grower increases the light intensity on a crop but finds the rate of photosynthesis does not increase further, even though light levels are still rising.
(a) Suggest an explanation for this observation, referring to limiting factors.
(b) Suggest two changes the grower could make to increase the rate of photosynthesis further. [4]

7. Explain why the rate of photosynthesis decreases at very high temperatures (e.g. above about 45 °C), even though light intensity and carbon dioxide concentration are kept constant. [3]

8. An investigation measures the rate of photosynthesis in pondweed at increasing CO_2 concentrations, first at a low light intensity and then repeated at a high light intensity, with temperature controlled throughout.
(a) Sketch-by-description how the rate of photosynthesis would change with increasing CO_2 concentration in each case.
(b) Explain why the curve for high light intensity continues to rise for longer (to a higher CO_2 concentration) before leveling off, compared with the low light intensity curve. [4]

Section C – Respiration (Exam-style)

9. (a) Write the word equation for aerobic respiration.
   (b) State whether aerobic respiration is exothermic or endothermic, and explain what happens to the energy released. [3]

10. During vigorous exercise, muscle cells may not receive oxygen fast enough and switch to anaerobic respiration.
    (a) Write the word equation for anaerobic respiration in muscle cells.
    (b) State one way in which anaerobic respiration differs from aerobic respiration in terms of the amount of energy released per glucose molecule.
    (c) Explain what is meant by 'oxygen debt' and how it is repaid after exercise. [5]

11. Yeast cells can respire anaerobically in the absence of oxygen, a process used in bread-making and brewing.
    (a) Write the word equation for anaerobic respiration in yeast, naming this process.
    (b) Explain why this process is useful in bread-making, referring to one of the products. [3]

12. State and explain two changes that occur in the human body during exercise, other than the switch to anaerobic respiration, that help to supply muscle cells with more oxygen and glucose and remove carbon dioxide more quickly. [4]

Answers

Check your working against these. If an answer does not match, try the question again before looking for the method.

1. (a) carbon dioxide + water → glucose + oxygen (in the presence of light)
   (b) Photosynthesis is an endothermic reaction (it takes in energy from the environment, in the form of light); it takes place in the chloroplast.
   (c) Chlorophyll; it is located in the thylakoid membranes inside the chloroplast.

2. (a) Bubbles vary in size, so counting the number of bubbles does not accurately reflect the volume of oxygen produced.
   (b) Collect the gas produced in a syringe or capillary tube over a fixed time and measure its volume directly, instead of counting bubbles (or repeat and calculate a mean).

3. (a) Any two of: starch (for storage), cellulose (for cell walls), lipids/fats (for storage), amino acids/proteins (when combined with nitrate).
   (b) Nitrate ions provide nitrogen, which is needed (combined with sugars from photosynthesis) to make amino acids, which are then built into proteins for growth; glucose alone does not contain nitrogen.

4. The plant is simultaneously respiring, which releases carbon dioxide, and photosynthesising, which absorbs carbon dioxide. At the compensation point, the rate of photosynthesis equals the rate of respiration, so the carbon dioxide produced by respiration is exactly used up by photosynthesis, giving no net gas exchange. As light intensity increases further, the rate of photosynthesis exceeds the rate of respiration, so there is a net uptake of carbon dioxide from the surroundings.

5. (a) Light intensity, carbon dioxide concentration, and temperature.
   (b) A limiting factor is the factor that is in shortest supply relative to the others, and so is the one restricting the rate of a process at a given time; increasing that factor increases the rate, until another factor becomes limiting.

6. (a) Light intensity is no longer the limiting factor; some other factor, such as carbon dioxide concentration or temperature, has become limiting, so further increases in light intensity have no effect on the rate until that other factor is increased.
   (b) Any two of: increase the carbon dioxide concentration in the greenhouse (e.g. using a carbon dioxide generator/burner), increase the temperature (e.g. with heaters, up to an optimum before enzymes denature).

7. At very high temperatures, the enzymes involved in photosynthesis (e.g. those catalysing the reactions that fix carbon dioxide) become denatured: their active site changes shape so substrate can no longer bind, so the rate of the enzyme-controlled reactions, and hence the rate of photosynthesis, decreases.

8. (a) In both cases, the rate of photosynthesis increases roughly proportionally as CO_2 concentration rises from zero, then levels off to a plateau at high CO_2 concentration; the high light intensity curve rises more steeply and levels off at a higher rate than the low light intensity curve.
   (b) At low light intensity, light becomes the limiting factor at a lower CO_2 concentration, so the curve plateaus sooner. At high light intensity, more light energy is available, so CO_2 concentration can keep increasing the rate for longer before it, rather than light, becomes limiting and the curve plateaus at a higher rate.

9. (a) glucose + oxygen → carbon dioxide + water
   (b) Aerobic respiration is exothermic; the energy released is transferred to make ATP, which the cell then uses for processes such as muscle contraction, active transport, and the synthesis of larger molecules (e.g. proteins), with some energy also released as heat.

10. (a) glucose → lactic acid
(b) Anaerobic respiration releases much less energy per glucose molecule than aerobic respiration, because glucose is only partially broken down (it is not fully oxidised to carbon dioxide and water).
(c) Oxygen debt is the extra oxygen the body needs after exercise to break down the lactic acid that has built up in the muscles during anaerobic respiration. It is repaid by continuing to breathe deeply and quickly after exercise, so that the extra oxygen taken in can react with lactic acid (largely in the liver), oxidising it to carbon dioxide and water (or converting it back to glucose).

11. (a) glucose → ethanol + carbon dioxide; this process is called fermentation.
(b) The carbon dioxide gas produced forms bubbles in the bread dough, which cause it to rise, giving bread its light, aerated texture once baked.

12. Any two of, with explanation: (1) Heart rate increases, so blood (carrying oxygen and glucose) is pumped around the body faster, delivering more oxygen and glucose to muscles and removing carbon dioxide more quickly. (2) Breathing rate and depth increase, so more air is exchanged in the lungs per minute, increasing the rate of oxygen uptake and carbon dioxide removal by diffusion. (3) Blood vessels supplying the muscles vasodilate (widen), increasing blood flow to the muscles and so increasing the delivery of oxygen and glucose.

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