4.2 Respiration and metabolism

Name: _____ Class: _____ Date: _____ **Total: 19 marks**

KEY WORDS anaerobic respiration • fermentation • lactic acid • oxygen debt • metabolism

Objective

Give the uses of glucose, compare aerobic and anaerobic respiration, explain the response to exercise with (HT) oxygen debt, and define metabolism. Original questions for spec statements 4.4.1.3, 4.4.2.1–4.4.2.3.

1 Key knowledge and worked examples

Uses of glucose (five): **respiration**; converted to **insoluble starch** for storage; used for **cellulose** to make cell walls; used to make **amino acids** for proteins (nitrate ions absorbed from soil needed); **lipids** (oils/fats) for storage in seeds.

Respiration is exothermic and occurs **continuously in living cells**, including plants in darkness. It transfers energy for movement, keeping warm and building larger molecules; it does not create energy.

Human muscle comparison:

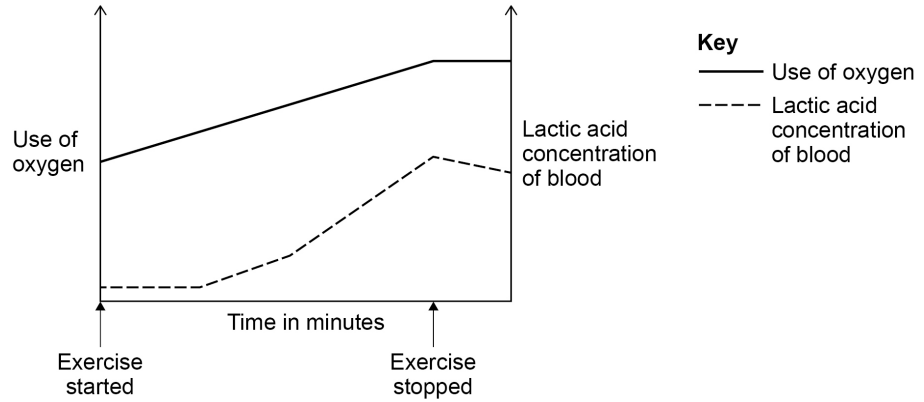
Feature	Aerobic	Anaerobic
Oxygen	Required	Not required
Location	Cytoplasm + mitochondria	Cytoplasm
Products	CO_2 + water	Lactic acid
Energy per glucose	Much more transferred	Much less transferred

Equations: aerobic: glucose + oxygen → carbon dioxide + water. Muscle anaerobic: glucose → lactic acid. Plant/yeast anaerobic: glucose → ethanol + carbon dioxide. Incomplete oxidation of glucose explains the lower energy transfer in anaerobic respiration.

Fermentation: yeast respires anaerobically with little oxygen in dough. Carbon dioxide bubbles are trapped, making bread rise; ethanol is important in alcoholic drinks. Yeast can also respire aerobically when oxygen is available.

Exercise: heart rate, breathing rate and breath volume increase, supplying more oxygenated blood to muscles. If supply cannot meet demand, anaerobic respiration contributes alongside aerobic respiration. Lactic acid accumulates, causing fatigue / less efficient contractions in the GCSE model. (HT) Blood transports lactic acid to the liver, which converts it back into glucose. **Oxygen debt** is the extra oxygen needed after exercise to react with and remove accumulated lactic acid; do not describe that oxygen as a reactant in conversion back to glucose.

Worked recovery example [2], adapted from 2025 Q05.7: why does oxygen use stay high after exercise stops?



Lactic acid has accumulated / oxygen debt exists (1); extra oxygen is needed to react with and remove accumulated lactic acid (1). Compare changes within each curve, not absolute heights across different axes.

Metabolism = the sum of all reactions in a cell or body. It includes glucose → starch/glycogen/cellulose; **one glycerol + three fatty acids → lipid**; amino acids → proteins (plants need glucose and nitrate to make amino acids); respiration; and **breakdown of excess proteins to form urea for excretion**. Urea is not a protein building block. Energy transferred by respiration supports continual enzyme-controlled synthesis.

Worked investigation plan, 2023 Q04.2 [6]: the same suitable athletes complete at least two exercise types for the same duration. Let heart rate return to resting before each trial and measure that baseline. Measure immediately after exercise with the same method and delay; control prior activity and other relevant conditions. Calculate each increase = after-exercise − resting heart rate, then compare mean increases. A mean = sum of increases ÷ number of athletes. The method must be logical and give a valid comparison; six isolated facts do not guarantee six marks.

Pondweed and snail, 2021 Q04.6–.8: in light, pondweed takes in CO_2 for photosynthesis while both organisms respire and release it. Balanced uptake/release gives constant concentration. Black paper stops photosynthesis, but respiration continues and CO_2 rises. After the snail dies, living decomposers break it down and release CO_2 through respiration.

2 Practice

2.1 State three uses of glucose in plants. [3]

2.2 Write the word equation for anaerobic respiration in yeast cells. [1]

2.3 Define metabolism. [1]

3 Exam-style questions

3.1 Compare aerobic and anaerobic respiration in human muscle cells: location, products and energy transferred. [5]

3.2 Explain why muscles may become fatigued during intense exercise, and (HT) how the body removes the substance that builds up. [5]

3.3 A baker adds yeast and sugar to dough and leaves it in a warm place. Explain why the dough rises. [4]