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ANSWER BOOK

# Cofactors, coenzymes and where enzymes work

Enzymes and metabolic control · Unit B03

OCR A 2.1.4 · Edexcel A 2.10, 3.3 · Edexcel B 1.5 vii · CAIE 3.1, 3.2

15 questions · 45 marks

NAVY EDITION

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## SECTION A · Short, 1 to 2 marks

**A1** CCW-Q6

**B1** a coenzyme is an organic cofactor: a small non-protein organic molecule that binds to an enzyme, carries hydrogen or chemical groups between reactions and is released again. **B1** NAD is made from nicotinamide, which is vitamin B3. [2]

**A2** CCW-Q14

**B1** a prosthetic group is a cofactor that is tightly bound to a protein, and may be organic or inorganic. **B1** haem in catalase, or the zinc ion of carbonic anhydrase. [2]

**A3** CCW-Q15

**B1** the peroxisome, inside the cell. **B1** intracellular, acting in the same cell. [2]

## SECTION B · Standard, 3 to 5 marks

**B1** CCW-Q1

**B1** vitamin B3 (nicotinamide) is the raw material from which cells make the coenzyme NAD. **B1** NAD carries hydrogen from the oxidation reactions of respiration to the electron transport chain. **B1** with too little NAD those reactions slow, so less ATP is made by respiration. **B1** tissues with a high demand for ATP are affected first, because active transport, synthesis and impulse transmission all depend on it. [4]

**B2** CCW-Q7

**B1** an intracellular enzyme catalyses reactions inside the cell that made it, such as catalase acting in peroxisomes, whereas an extracellular enzyme is secreted from the cell that made it and acts outside it, such as trypsin acting in the small intestine. **B1** an intracellular enzyme need only tolerate the conditions inside its own cell, whereas an extracellular enzyme must remain active in conditions the secreting cell never itself experiences, such as the strongly acidic stomach. **B1** intracellular enzymes are not released by exocytosis, whereas extracellular enzymes are. **B1** both classes are made by ribosomes inside a cell; what differs is only where each subsequently acts. [4]

**B3** CCW-Q8

**B1** vitamin B5 is the raw material from which cells make coenzyme A, so a deficiency would limit the supply of coenzyme A available. **B1** coenzyme A carries the two-carbon acetate group from the link reaction into the Krebs cycle, so with too little of it fewer acetate groups could be delivered and the Krebs cycle would slow. **B1** a slower Krebs cycle would reduce the ATP a cell can make by aerobic respiration. **B1** because every respiring cell in the body needs coenzyme A for this step, a wide range of tissues, not just one, would be affected, especially those with the highest demand for ATP. [4]

**B4** CCW-Q2 **B1** both are non-protein partners that an enzyme needs in order to function. **B1** a coenzyme binds and is released and recycled, whereas a prosthetic group is tightly bound to the protein and may be organic or inorganic. **B1** NAD or coenzyme A as the coenzyme, against the haem group of catalase or the zinc ion of carbonic anhydrase as the prosthetic group. [3]

**B5** CCW-Q3 **B1** the chloride ion is a cofactor that amylase requires in order to function. **B1** without the ion the active site does not take, or hold, the shape complementary to starch, so few enzyme-substrate complexes form. **B1** the ion is not the substrate and is not used up: it binds near the active site and allows the reaction to be catalysed. [3]

**B6** CCW-Q4 **B1** food molecules such as starch and proteins are too large to cross the cell surface membrane, so they cannot be digested inside a cell. **B1** the enzymes are therefore secreted, by exocytosis, and hydrolyse the food outside the cells, so only the small soluble products are absorbed. **B1** salivary amylase and trypsin, or another correct pair of secreted digestive enzymes. [3]

**B7** CCW-Q5 **B1** enzyme P has the higher affinity, because affinity runs opposite to Km. **B1** a low Km means the enzyme reaches half of its maximum rate while the substrate is still scarce, which is only possible if it binds the substrate readily. **B1** at low substrate concentration P works at a far higher fraction of Vmax than Q, so with similar Vmax values P converts more substrate. [3]

**B8** CCW-Q9 **B1** pantothenic acid, vitamin B5. **B1** coenzyme A, the coenzyme formed. **B1** the Krebs cycle, which it feeds acetate into. [3]

**B9** CCW-Q10 **B1** the distinction between a visiting cofactor and a prosthetic group is about how tightly and permanently it is bound, not about whether it is organic or inorganic. **B1** the zinc ion in carbonic anhydrase never leaves the active site once the enzyme has folded around it, unlike a coenzyme, which binds and is released repeatedly. **B1** because it remains permanently bound, it is classed as a prosthetic group, in the same category as the organic haem group of catalase, despite being an inorganic ion. [3]

**B10** CCW-Q11 **B1** NAD collects hydrogen released during the oxidation reactions of glycolysis and the Krebs cycle. **B1** it delivers that hydrogen to the electron transport chain, where the energy carried is used to make ATP. **B1** having released its hydrogen, NAD is free to collect more from a further oxidation reaction, which is why only a small quantity is needed despite being used repeatedly. [3]

**B11** CCW-Q12

**B1** a cofactor is not a substrate: it is not chemically changed into a product by the reaction it enables. **B1** it may be required simply to be present, as the chloride ion is for amylase, or it may bind, leave carrying what the reaction removed, and be restored to its original form at another enzyme, as a coenzyme does. **B1** because it is regenerated or unaffected rather than consumed, only a small quantity of a cofactor is needed relative to the amount of substrate the enzyme processes. [3]

**B12** CCW-Q13

**B1** a Km far below the normal blood glucose concentration means the enzyme is already working close to its maximum rate under normal conditions, since Km is the concentration needed to reach only half of Vmax. **B1** because glucose concentration is already well above the level needed to saturate hexokinase, only a small proportion of active sites are ever free at any moment. **B1** raising glucose concentration further after a meal makes little difference, because there is little room for the rate to rise: hexokinase is already close to its ceiling. [3]

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