HL Paper 3
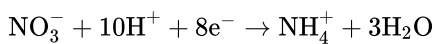
In an acidic soil, nitrate ions may undergo reduction to form ammonium ions. Deduce a half-equation for the reaction.

Markscheme

$$NO_3^- + 10H^+ + 8e^- \rightarrow NH_4^+ + 3H_2O$$

correct reactants;

correct products;

correct balancing;

*M3 can only be scored if M1 and M2 correct*.

Examiners report

The equation caused some difficulty for many students; electrons were omitted on the left-hand side, incorrect products were given and equations were left unbalanced.

Enzymes are catalysts that increase the rate of all biochemical reactions, including those involved in respiration.

Cytochrome oxidase is a complex enzyme that catalyses the reduction of oxygen in the final stage of aerobic respiration. This enzyme is inhibited both by nitrogen(II) oxide, NO, and separately by cyanide ions, CN^-. It has been suggested that NO acts competitively while CN^- acts non-competitively in inhibiting the enzyme. Experiments were carried out to test this hypothesis.

b.ii.The graph below shows the effect of substrate concentration on the rate of the reaction in the absence of an inhibitor. Draw and label the results [2] of the **two** experiments showing how the rate of the reaction changes in the presence of NO and in the presence of CN^-, if the hypothesis is correct.
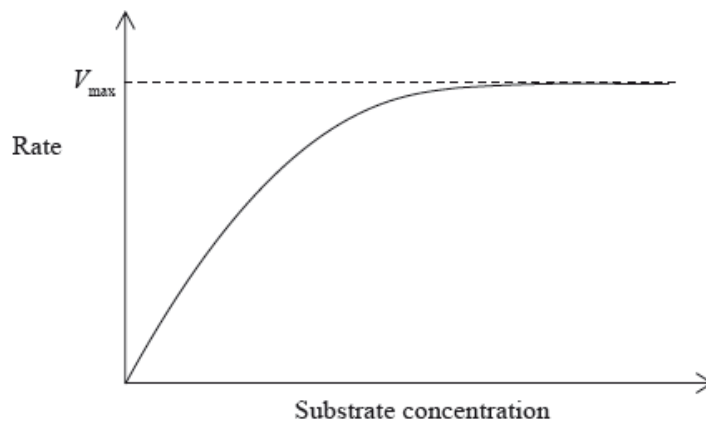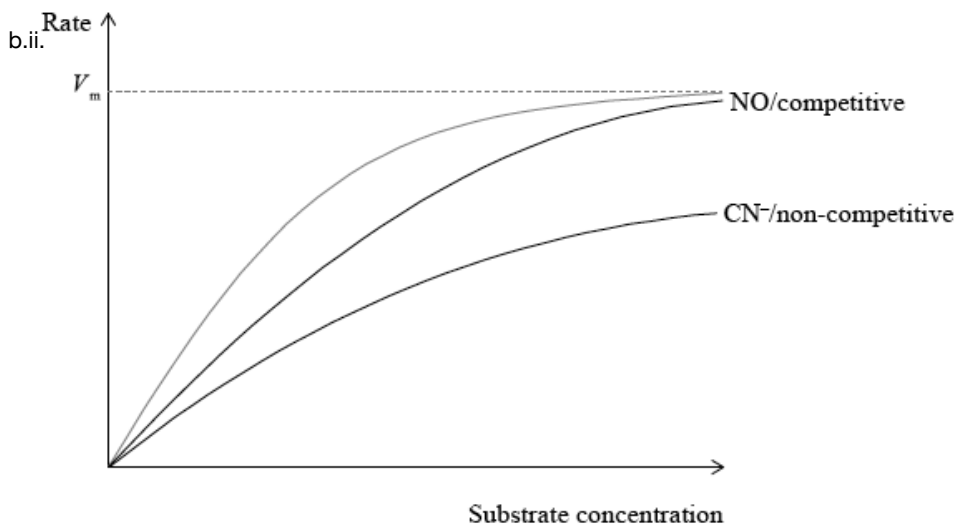
b.iii Suggest a reason why it is more likely that NO, rather than CN^-, acts competitively. [1]

b.iv The reducing agent in the cytochrome oxidase reaction is a species that can be denoted as XH_2 in the reduced form. Using this notation, [2]

deduce an equation for the reaction of XH_2 and O_2, and outline, using oxidation numbers, why it is a redox reaction.

Markscheme

b.ii.

line labelled NO/competitive reaching V_m but with lower gradient;

line labelled CN^-/non-competitive not reaching V_m;

b.iii NO more likely to fit into active site / NO (structure) similar to O_2 / CN^- structure different to O_2 / *OWTTE*;

b.iv $2XH_2 + O_2 \rightarrow 2X + 2H_2O$ / $XH_2 + O_2 \rightarrow X(OH)_2$ / $XH_2 + O_2 \rightarrow XO + H_2O$;

oxygen changes from 0 to –2;

Allow X_2 instead of 2X.

Do not allow 2– notation.

Accept "X changes from –2 to 0 in X or X_2" or "X changes from –2 to +2 in $X(OH)_2$/XO".

Examiners report

b.ii. Option B was a very popular, and question 6 was well answered with the exception of not listing alkenyl when identifying two functional groups

common to three vitamins (A, C and D). Some students did not read the question on formula of zwitterion carefully and instead have the formula of

the amino acid itself without any charges. In the separation of alanine and cysteine, the first mark was well scored by many while the second mark

proved to be more demanding and often candidates lost this mark as no reference was made to charges or charges inversely stated. Although the disulfide bridge was correctly identified by even weaker candidates a much few were able to identify this as a covalent bond. Structure of the triglyceride was better answered than in past sessions but drawing the ester linkage correctly was still challenging for many candidates. Although the identification of the other reactant (water) was identified by many, the one essential condition (enzyme/lipase) was done poorly. Identification of the polyunsaturated fatty acid was done well by most but the second mark on its ability to lower LDL cholesterol was missed by most. The question on enzymes and inorganic catalysts was done poorly since comparison was often missing. While some candidates were able to suggest a pair of ions in cytochrome oxidase, only stronger candidates provided both pairs. Competitive and non-competitive inhibition was generally well done; however, the reason why it is more likely that NO, rather than the cyanide ion, acts competitively was not done as well. The redox reaction of the reducing agent XH_2 with O_2 produced a range of possible equations but rarely did candidates scored full marks.

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