A level Biology A

H420/03 Unified biology

Question Set 4

1 Nitrogen cycling within ecosystems is controlled by various bacterial species. The table below lists four groups of bacterium that are involved in the nitrogen cycle.

(a) Complete the table to show the locations of each type of bacterium in the cycle and the reactions they perform.

Type of bacteria	Location	Reactant(s)	Product	Oxidation or reduction of nitrogen?
Rhizobium	root nodules / leguminous roots	N_2 and H^+ ions	NH_3	reduction
Nitrosomonas	soil	NH_4^+ ions	nitrites	oxidation
Nitrobacter	soil	nitrites	NO_3^-	oxidation
Denitrifiying bacteria	soil	NO_3^-	N_2 gas	reduction

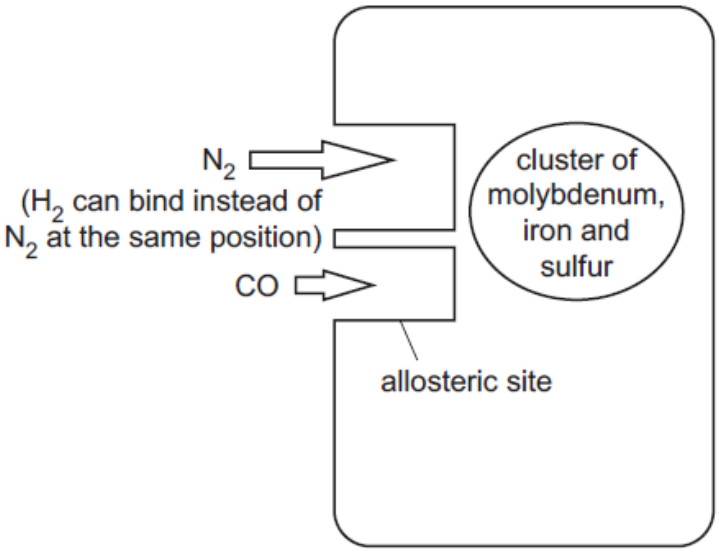
[4]

(b) Nitrogen fixation is an important part of the nitrogen cycle.

The rate of nitrogen fixation is reduced by the presence of oxygen.

Rhizobium uses the enzyme nitrogenase to fix atmospheric nitrogen.

Fig. 4 shows a simplified representation of the structure of nitrogenase and the reaction that it catalyses.



- cluster is prosthetic groups / cofactors
- H_2 is a competitive inhibitor
- CO is a non-competitive inhibitor
- CO binds to allosteric site causing change in shape of active site
- energy required from ATP
- acidic conditions are tolerated

Overall reaction: $N_2 + 8H^+ + 8e^- + 16ATP \rightarrow 2NH_3 + H_2 + 16ADP + 16P_i$

Fig. 4

(i) What can you conclude from Fig. 4 about the molecules or ions that affect the functioning of the nitrogenase enzyme? **[4]**

(ii) Leghaemoglobin is a molecule that improves the performance of nitrogenase. It has very similar properties to mammalian haemoglobin.

Suggest **two** ways in which leghaemoglobin improves the performance of the nitrogenase enzyme. **[2]**

- transports oxygen for respiration
- removes excess oxygen so less inhibition of reaction & CO to prevent inhibition

(c) Many species of bacteria act as decomposers within ecosystems by breaking down organic material.

Scientists analysed the energy flow within a grassland ecosystem.

They estimated that the energy in the decomposers' trophic level was 950 000 J m^{-2} yr^{-1}.

The energy within the producers' trophic level was 800% greater than that of the decomposers.

(i) Calculate the energy in the producers' trophic level in **kJ m^{-2} yr^{-1}**.

$\frac{x - 950\,000}{950\,000} \times 100 = 800$

$x = 8\,550\,000$ J m^{-2} yr^{-1}

Answer: 8550 kJ m^{-2} yr^{-1} **[2]**

(ii) Calculate the percentage efficiency of the energy transfer from producers to decomposers.

Give your answer to **two** significant figures.

$\frac{950\,000}{8\,550\,000} \times 100 = 11.1\%$

Answer: 11 % **[1]**

Total Mark for Questions Set 4: 13