

University of Canterbury

# Mid Year Examination and Test Period 2009

Prescription Number(s):	BCHM 201
Paper Title:	Biochemistry 1

Time Allowed: 2.5 HOURS

Number of pages: SEVEN

Answer **FIVE** questions out of six

All questions are of equal value

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**Question 1**

The reciprocal of the Michaelis-Menten equation is:

$$\frac{1}{v} = \left( \frac{K_m}{V_{\max}} \right) \left( \frac{1}{[S]} \right) + \frac{1}{V_{\max}}$$

- (a) Explain how the above form of the equation, in conjunction with data from an experiment in which an enzyme is incubated with its substrate, S, and [S] is measured at timed intervals, can be used to determine  $K_m$  and  $V_{\max}$ . (8 marks)
- (b) Outline the importance of  $K_m$  and  $V_{\max}$ . (4 marks)
- (c) What is  $k_{\text{cat}}$  and why is it useful? (4 marks)
- (d) Show how the catalytic efficiency of an enzyme can be calculated from  $k_{\text{cat}}$  and  $K_m$  and outline its importance. (4 marks)

**Question 2**

- (a) Discuss the differences in inhibitor binding to an enzyme in competitive, non-competitive and uncompetitive inhibition. (8 marks)
- (b) Using the Lineweaver-Burke plot show how it is possible to distinguish between the three types of enzyme inhibition experimentally. (8 marks)
- (c) Outline an important commercial use of an enzyme inhibitor. (4 marks)

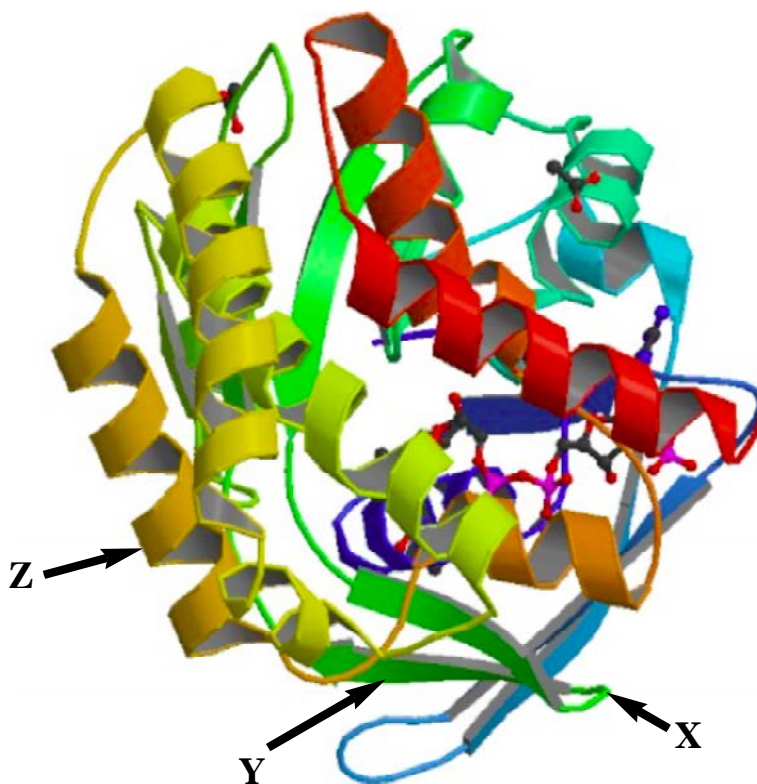
**Question 3**

- (a) Explain why the conformational arrangement of amino acid residues in the active site of an enzyme is crucial to the mechanism of catalysis. (8 marks)
- (b) Outline the mechanism of catalysis of a named enzyme example. (8 marks)
- (c) Why is the stability of  $EX^\ddagger$  (transition state complex) important in catalysis? (4 marks)

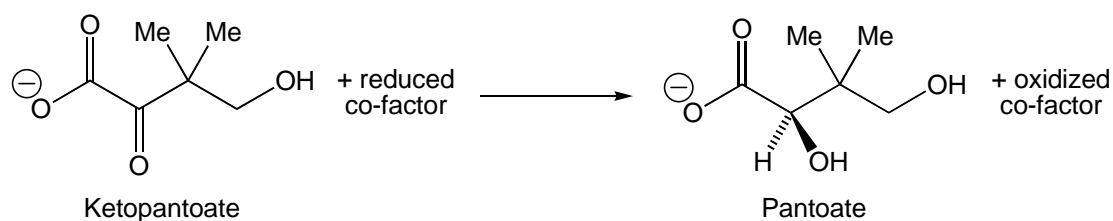
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### Question 4

The diagram below shows the X-ray crystal structure of the enzyme ketopantoate reductase with its co-factor NADP<sup>+</sup> bound.



- (a) Identify the secondary structural elements **X**, **Y** and **Z**. For each of these elements describe the key structural features. Draw diagrams to illustrate the molecular details of these secondary structures. (9 marks)
- (b) Give an example of an amino acid that is not found in **Z**, but is commonly found in **X**. Explain your choice with the aid of a diagram of the amino acid residue. (4 marks)
- (c) Ketopantoate reductase catalyses the reduction of ketopantoate to pantoate, as shown below. The enzyme uses NADP<sup>+</sup>/NADPH as the co-factor to catalyse this reaction. Identify which form of the co-factor is required to carry out the reduction of ketopantoate and briefly explain your reasoning. (3 marks)



*Question 4 continued on following page*

*Question 4 continued*

- (d) Look at the diagram below which shows the details of the active site of the enzyme ketopantoate reductase with its cofactor  $\text{NADP}^+$  bound. Panel A is where the protein is open conformation, and B is what happens when the enzyme has closed up slightly. It is in the latter form that the reaction can be catalysed.

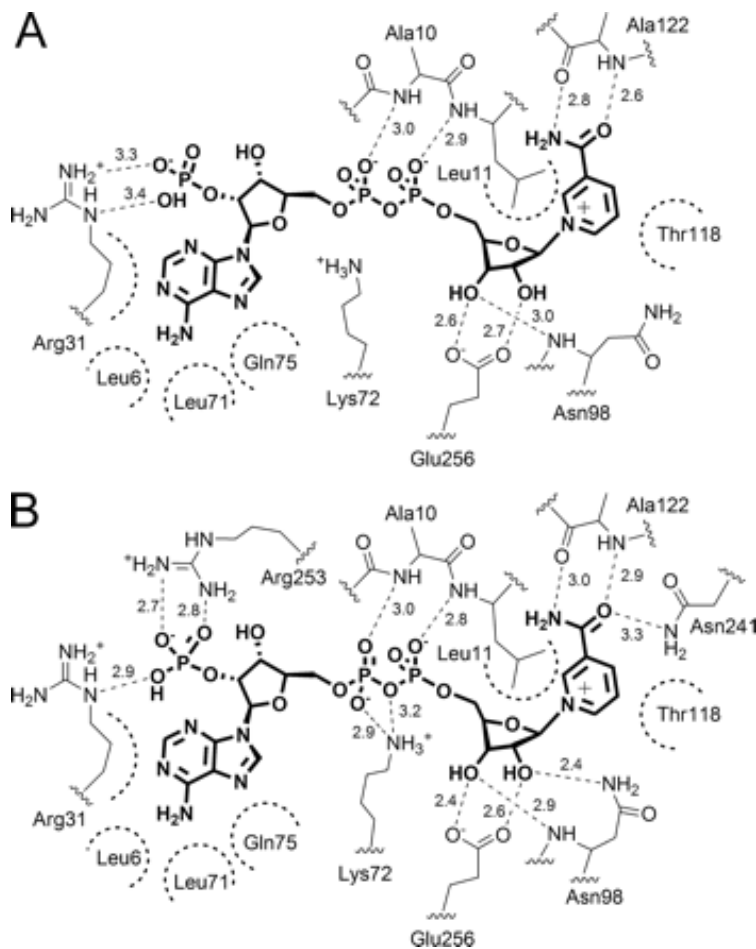


Figure 1

Schematic diagram showing non-covalent interactions between  $\text{NADP}^+$  and the binding site residues in ketopantoate reductase. Binding interactions of  $\text{NADP}^+$  (in bold) with the open (A) and closed (B) form of the enzyme. Hydrogen bonds are indicated with dashed lines, and their distances are indicated in Å. Residues involved in hydrophobic contacts are surrounded by dashed lines.

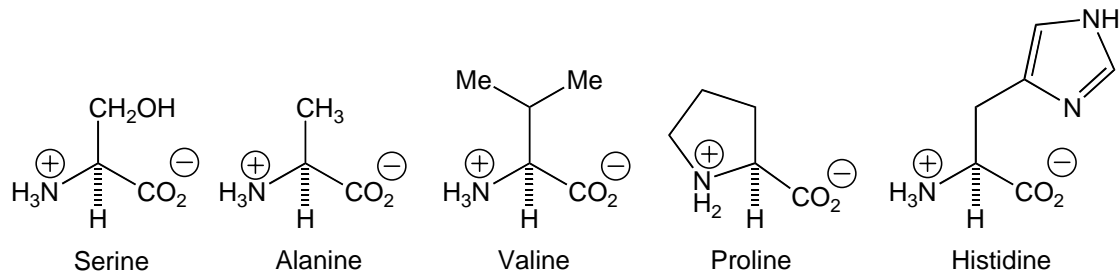
What is the difference between  $\text{NADP}^+/\text{NADPH}$  and  $\text{NAD}^+/\text{NADH}$ ? This enzyme does not use  $\text{NAD}^+/\text{NADH}$  as co-factor very effectively. Based on the interactions shown above, can you explain why? What is the advantage to the cell to be able to have two co-factors, such as  $\text{NADP}^+$  and  $\text{NAD}^+$ , which are so similar, and yet cannot substitute for one another in the same enzyme?

(4 marks)

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**Question 5**

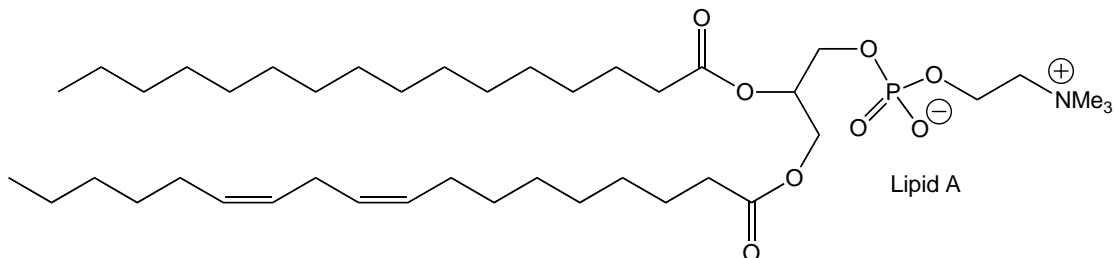
The diagram below shows the structures of five amino acids.



- (a) Identify the amino acid that is most likely to be found in the interior of proteins. Explain your reasoning. (3 marks)
- (b) Identify the amino acid in the group that is most useful for mediating acid-base catalysis by enzymes. Explain your reasoning with the use of molecular diagrams. (5 marks)
- (c) Identify the amino acid in this group that is sometimes incorporated into lipids as well as into proteins. Where would you expect to find this amino acid residue when it is present in proteins? Explain your reasoning. (5 marks)
- (d) Identify the protein that is likely to be commonly found in proteins both on the surface and in the interior. Explain your reasoning. (3 marks)
- (e) Draw out the structure of the peptide that would result if the five amino acids were joined together in the order shown. If this peptide was subject to an Edman degradation reaction, what would be the amino acid derivatised in the first cycle. Explain your reasoning. (4 marks)

**Question 6**

The diagram below shows the structure of a lipid molecule, lipid A, which is built from two fatty acids.



- (a) What type of lipid is this? Explain the structural features that underpin the role of this molecule as an important component of cellular membranes. (6 marks)
- (b) Identify and draw the structure of the fatty acid building block for lipid A that is dietary essential for humans. Explain your reasoning. (5 marks)
- (c) Triglycerides prepared from these fatty acid building blocks can have very different melting points. Explain this observation including drawing the structures of two such triglycerides one of which would be liquid at room temperature and one of which would be a solid. (5 marks)
- (d) Draw the structure of a wax molecule that could be formed from these two fatty acid building blocks. Explain your reasoning. (4 marks)

**END OF PAPER**

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