Enzyme Practice - SL and HL [66 marks]

1. *[1 mark]*

What is denaturation?

A. A structural change of a protein that results in the loss of its biological properties
B. A change in the genetic code of an organism
C. A change in the amino acid sequence of a protein causing a disruption of its 3D shape
D. The process by which amino acids are broken down and ammonia is released

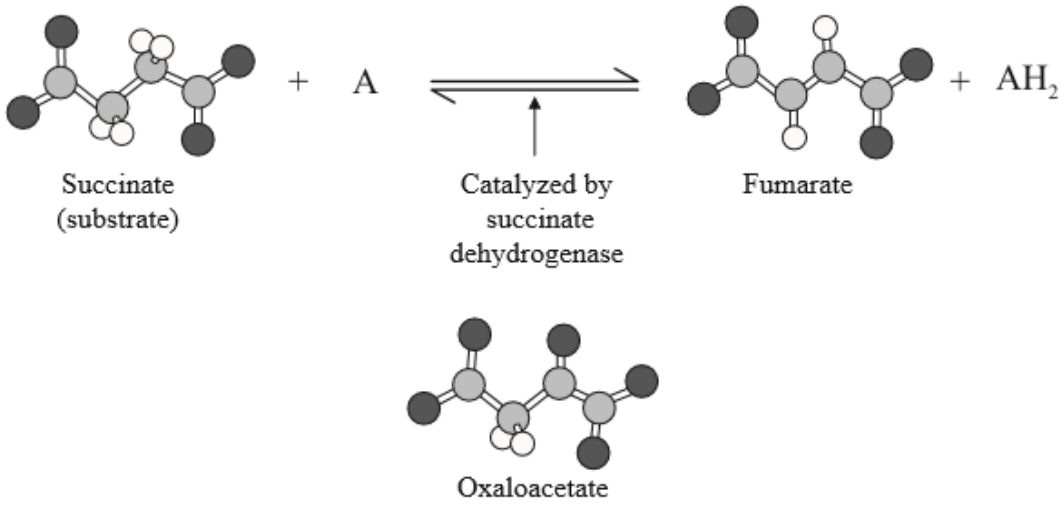
2. *[1 mark]*

Which is correct for the non-competitive inhibition of enzymes?

	Inhibitor resembles substrate	Inhibitor binds to active site
A.	+	+
B.	+	–
C.	–	+
D.	–	–

3. *[1 mark]*

Why is oxaloacetate a competitive inhibitor?



[Source: image from WK Purves, *et al*., (2003) *Life: The Science of Biology*, **4**, Sinauer Associates (www.sinauer.com) and WH Freeman (www.whfreeman.com)]

A. It causes a conformational change to the active site.
B. It binds to the enzyme away from the active site.
C. It is structurally similar to succinate.
D. It is structurally similar to succinate dehydrogenase.

4. *[1 mark]*

What happens as an enzyme becomes denatured?

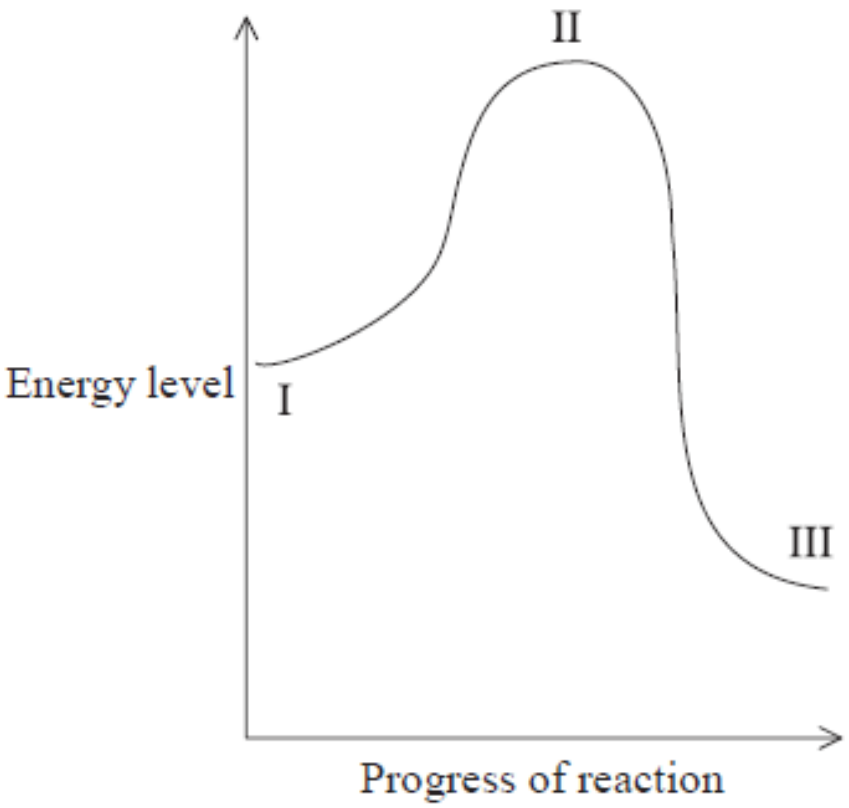
A. The enzyme works faster.
B. The enzyme works slower.
C. The enzyme can perform a new role.
D. The enzyme can make the reverse reaction proceed faster.

5. *[3 marks]*

Explain the control of metabolic pathways by end-product inhibition.

6. *[1 mark]*

The graph below shows energy changes during a chemical reaction that occurs without a catalyst. What would change if the reaction was catalysed by an enzyme?



A. The initial energy level (I) would be higher, speeding up the reaction.
B. The maximum energy level (II) would be higher, speeding up the reaction.
C. The maximum energy level (II) would be lower, speeding up the reaction.
D. The final energy level (III) would be lower, speeding up the reaction.

7. *[1 mark]*

Which of the following statements is **true** about enzymes?

A. They are used up in the reactions they catalyse.
B. Allosteric inhibitors bind to the active site.
C. They lower the energy of activation for a reaction.
D. They supply the energy of activation for a reaction.

8a. *[4 marks]*

Outline the effect of temperature and substrate concentration on the activity of enzymes.

8b. *[5 marks]*

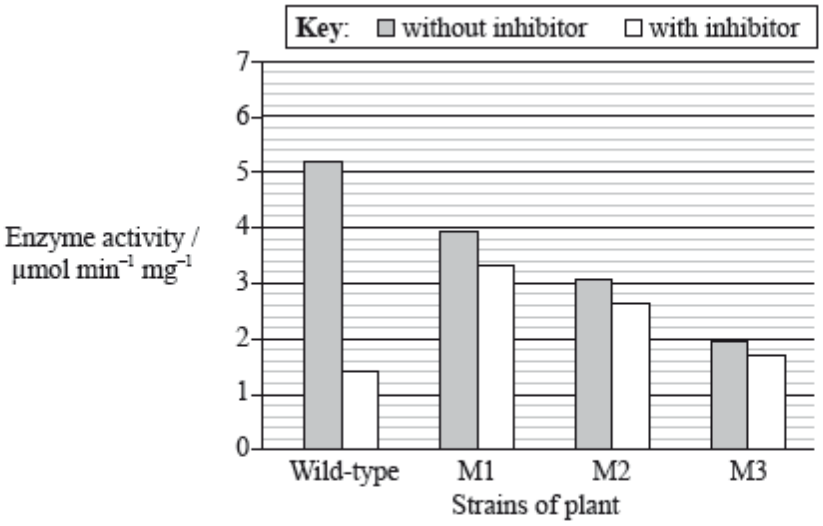
Distinguish between competitive and non-competitive enzyme inhibition of chemical reactions, giving an example of each.

9a. *[1 mark]*

Metabolic pathways can be controlled by end-product inhibition of the enzyme-catalysed reactions.

KAS III is the initial enzyme of fatty acid production in plants and bacteria. The substrates for this reaction are acetyl CoA and malonyl-ACP.

Three different strains of plant were generated, each with a different mutated KAS III gene: M1, M2 and M3. The enzyme activity of the normal (wild-type) and the three mutant strains was tested without and with the addition of the inhibitor, dodecanoyl-ACP. Dodecanoyl-ACP has a similar structure to malonyl-ACP. The graph shows the mean activity of the enzymes.



[Abbadi et al., 2010, "Knockout of the regulatory site of 3-ketoacyl-ACP synthase III enhances short- and medium-chain acyl-ACP synthesis", The Plant Journal, 24 (1) pp. 1-9, Figure 4 (adapted). Reprinted with permission of John Wiley & Sons Inc.]

State the activity of the wild-type enzyme without the inhibitor and with the inhibitor.

Without inhibitor:

With inhibitor:

9b. *[1 mark]*

Distinguish between the enzyme activity without the inhibitor in the wild-type and the mutant strains.

9c. *[3 marks]*

Explain why the activity of the enzyme from wild-type plants changes when the inhibitor is added.

9d. *[3 marks]*

The scientists concluded that the enzymes of the mutant plants had a reduced activity, but were insensitive to the inhibition by dodecanoyl-ACP. Evaluate these conclusions.

10a. *[4 marks]*

Outline the role of hydrolysis in the relationships between monosaccharides, disaccharides and polysaccharides.

10b. *[6 marks]*

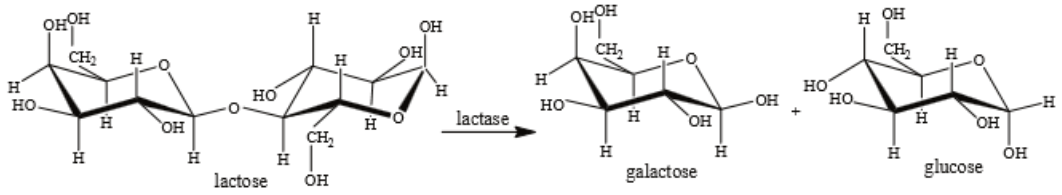
Describe the use of biotechnology in the production of lactose-free milk.

11a. *[1 mark]*

Glucose and galactose are examples of monosaccharides. State **one** other example of a monosaccharide.

11b. *[1 mark]*

The equation below shows the production of glucose and galactose from lactose.



There are several different types of carbohydrate. State which type of carbohydrate lactose is.

11c. *[1 mark]*

State the type of chemical reaction that occurs when lactose is digested into glucose and galactose.

11d. *[2 marks]*

Simple laboratory experiments show that when the enzyme lactase is mixed with lactose, the initial rate of reaction is highest at 48°C. In food processing, lactase is used at a much lower temperature, often at 5°C. Suggest reasons for using lactase at relatively low temperatures.

12. *[3 marks]*

Explain the control of metabolic pathways.

13a. *[3 marks]*

Distinguish between the secondary structure and tertiary structure of proteins.

13b. *[3 marks]*

Explain what is meant by allosteric inhibition.

14a. *[1 mark]*

Define *active site*.

14b. *[3 marks]*

Explain enzyme-substrate specificity.

15a. *[2 marks]*

Explain how materials are moved across membranes of cells by active transport.

15b. *[3 marks]*

Explain the effects of pH on enzyme catalysed reactions.

16. *[7 marks]*

Outline how enzymes catalyse reactions.

Enzyme Practice - SL and HL [66 marks]

1. *[1 mark]*

A

2. *[1 mark]*

D

3. *[1 mark]*

C

4. *[1 mark]*

B

5. *[3 marks]*

metabolic pathway is a series of enzyme-catalysed reactions;
end-product acts as inhibitor of enzyme at beginning of pathway;
allosteric site for inhibitor to bind / allosteric enzyme with two different binding sites;
more inhibition if end-product concentration rises;
prevents an excess of production/build-up of intermediate products;

6. *[1 mark]*

C

7. *[1 mark]*

C

8a. *[4 marks]*

enzymes most active at one temperature/optimum temperature;
any deviation from that temperature lowers the enzyme activity;
denaturing/change in active site/no activity at higher temperatures / inactivated at (very) low temperatures;
increasing the substrate concentration increases the enzyme activity/more enzyme-substrate complex formed/more collisions between enzyme and substrate;
eventually no increase in enzyme activity with increased substrate concentration / plateau when enzymes are working to the maximum/when all active sites occupied/saturated;
Accept answers shown graphically.

8b. *[5 marks]*

example of competitive; *(e.g. malonate competes with succinate dehydrogenase)*
example of non-competitive; *(e.g. opioids inhibit nitric oxide synthase)*

Competitive	Non-competitive
attaches to active site	attaches at place other than active site;
similar in structure to substrate	not similar to substrate;
does not change shape of enzyme	changes shape of enzyme;
increase in substrate concentration increases rate of reaction	increase in substrate concentration does not affect rate of reaction;

*Award **[2 max]** for examples and **[1]** for each correct paired statements up to **[3 max]**. Answers do not need to be shown in a table format.*

9a. *[1 mark]*

without inhibitor: 5.2 μmol min^{-1} mg^{-1} *(units required)*

with inhibitor: 1.4 μmol min^{-1} mg^{-1} *(units required)*

Both needed to award the mark.

9b. *[1 mark]*

wild-type enzyme has greater activity than the mutant enzymes

9c. *[3 marks]*

a. inhibitor is similar in shape/structure to malonyl-ACP which is a substrate of the reaction;

b. inhibitor is competing for the active site / competitive inhibition;

c. attaches to active site and does not let reaction occur;

d. if more substrate is added then the inhibition will be less;

9d. *[3 marks]*

a. activity of mutant enzymes without the inhibitor is always lower than wild-type;

b. activity of mutant enzymes with the inhibitor is always less than without;

c. but the differences are not as great as in the wild-type enzyme / the mutant enzymes were less sensitive to the inhibitor;

d. the activity of the mutant enzymes with the inhibitor are always higher than the activity of the wild-type enzyme with the inhibitor;

e. the data does not indicate whether these differences are significant or not / difference between wild-type enzyme and M1 enzyme not great;

10a. *[4 marks]*

monosaccharides are single sugars and disaccharides are two sugars and polysaccharides are multiple sugars;
hydrolysis is the addition of water to split a molecule into smaller fragments;
–OH and –H are added to the fragments;
disaccharides are split/digested into two single sugars;
polysaccharides are broken/digested into smaller fragments (*e.g.* diasaccharides);
process depends on enzyme control (in organisms);

10b. *[6 marks]*

a particular yeast (growing in natural milk) contains lactase;
biotechnology companies can grow/culture the yeast;
lactase (an enzyme) is extracted from the yeast;
natural milk contains lactose/milk sugar;
when added directly to milk, lactase converts lactose into simpler forms;
same effect when milk is passed past immobilized (on surface or beads) lactase;
simpler forms of sugar (glucose and galactose) are easily absorbed (in the small intestine);
a commercial market exists for lactose-free milk / lactose-free milk is example of biotechnology's economic impact;
some people are lactose intolerant/cannot digest lactose in milk/have lost lactase activity in intestinal cells;
consuming lactose-free milk allows lactose intolerant people to be nourished by milk without discomfort (abdominal cramps and diarrhoea);
many Asians are lactose intolerant whereas less common among other groups (northern Europeans and some Africans);
biotechnology produced in one part of world is more useful in another;

11a. *[1 mark]*

fructose/ribose/ribulose/deoxyribose other monosaccharides apart from glucose and galactose

11b. *[1 mark]*

disaccharide

11c. *[1 mark]*

hydrolysis

11d. *[2 marks]*

less denaturation / enzymes last longer at lower temperatures;
lower energy costs / less energy to achieve 5°C compared to 48°C;

reduces bacterial growth / reduces (milk) spoilage;
to form products more slowly / to control the rate of reaction;

12. *[3 marks]*

metabolic pathway is a series of reactions carried out in a particular sequence;
products of one reaction become substrates for the next;
each reaction is enzyme-catalyzed (and thus represents point of control);
some enzymes are allosteric;
allosteric control / end-product inhibition/negative feedback;
end-product acts as inhibitor of enzyme at beginning of pathway;
product binding changes the conformation of the active site so substrate of the pathway can no longer bind;

13a. *[3 marks]*

secondary structure refers to regular repeating regions within the overall protein structure	while tertiary structure refers to the protein overall / 3-D;
secondary structure α helix/β sheets	while tertiary is globular/fibrous;
forces between amino and carboxyl groups/atoms within backbone in secondary structure	while intramolecular forces between R-groups for tertiary structure;
H-bonds	H-bonds / disulfide bonds / ionic bonds / hydrophobic interactions;

To award a mark responses must refer to both secondary and tertiary structures.

13b. *[3 marks]*

form of non-competitive inhibition;

(inhibitor) binds to a site that is not the active site;

causing conformational change;

changes the active site;

so substrate can no longer bind to active site;

14a. *[1 mark]*

site on surface/portion of the enzyme/protein to which the substrate binds

14b. *[3 marks]*

enzymes fit together with substrates similar to a lock and key;
active site has shape that gives specificity;
enzymes catalyze a reaction with a specific substrate;
example of named enzyme and its substrate;
substrate held precisely in (optimum) position to make/break bonds/carry out reaction / chemical interaction occurs between enzyme and substrate;
Accept these points shown in an annotated drawing.

15a. *[2 marks]*

transport against a concentration gradient / from low to high concentration;
through protein pumps;
uses energy/ATP;

15b. *[3 marks]*

enzymes have a pH optimum;
active site works best at this pH;
activity decreases above and below the optimum;
by interfering with H-bonding/active site structure;
denaturing by extremes of pH so enzyme activity/reaction stops;

16. *[7 marks]*

they increase rate of (chemical) reaction;
remains unused/unchanged at the end of the reaction;
lower activation energy;
activation energy is energy needed to overcome energy barrier that prevents reaction;
annotated graph showing reaction with and without enzyme;
substrate joins with enzyme at active site;
to form enzyme-substrate complex;
active site/enzyme (usually) specific for a particular substrate;
enzyme binding with substrate brings reactants closer together to facilitate chemical reactions (such as electron transfer);

induced fit model / change in enzyme conformation (when enzyme-substrate/ES complex forms);
making the substrate more reactive;