



A-Level Biology

Proteins and Enzymes

Mark Scheme

Time available: 78 minutes

Marks available: 60 marks

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Mark schemes

1.

- (a) 1. Substrate binds to the active site/enzyme

OR

Enzyme-substrate complex forms;

Accept for 'binds', fits

2. Active site changes shape (slightly) so it is complementary to substrate

OR

Active site changes shape (slightly) so distorting/breaking/forming bonds in the substrate;

3. Reduces activation energy;

3

- (b) 1. Adenosine diphosphate;

1

- (c) Mark in pairs, 1 **and** 2 OR 3 **and** 4 OR 5 **and** 6

1. Boil

OR

Add (strong) acid/alkali;

Accept heat at > 50°C OR at very high temperatures

2. Denatures the enzyme/ATP synthase;

OR

Accept for 'denatures', a description of denaturation

3. Put in ice/fridge/freezer;

4. Lower kinetic energy so no enzyme-substrate complexes form;

OR

Accept ES for enzyme substrate complex

5. Add high concentration of inhibitor;

6. Enzyme-substrate complexes do not form;

2

- (d) 1. (With) increasing Pi concentration, more enzyme-substrate complexes are formed;
2. At or above 40 (mmol dm⁻³) all active sites occupied

OR

At or above 40 (mmol dm⁻³) enzyme concentration is a limiting factor;

2

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2.

- (a) All three correct and no other substances = 1 mark Gluconic acid, water, green pigment;
Accept in any order

1

- (b) Correct answer for 3 marks = 544 **and** nm³;;;

Accept for 2 marks:

612 (cage volume occupied by enzymes)

OR

68 (volume of HRP)

OR

544 (correct answers with no unit)

Accept for 1 mark:

6800 (cage volume)

3

- (c) 1. (Trapping) increases enzyme/GOx/HRP activity;
2. Difference/increase is significant

OR

Difference is not (likely to be) due to chance;

3. (Because) SDs do not overlap;

Accept for 'standard deviations', error bars

3

(d) Denatured enzymes

OR

Inactivated enzymes

OR

Empty cages (in water);

Accept any valid method of denaturing/inactivation

1

[8]

3.

(a) 1. Starch (solution) in first column;

Ignore columns with replicates/ mean

Ignore lines

2. Headings for starch concentration/solution **and** time for (starch) hydrolysis/digestion with mg dm⁻³ **and** minutes/mins/min/m/seconds/s;

Accept brackets for solidus

Ignore reference to enzyme

Reject graph

2

(b) As starch concentration increases, time to hydrolyse/digest starch increases;

Accept converse

1

(c) 1. Inhibitor similar shape to substrate;

Reject same shape

Accept 'complementary to active site'

2. Fits/binds to active site;

3. Prevents/reduces enzyme-substrate complex forming;

3

(d) 1. Less hydrolysis of starch;

Accept no hydrolysis

2. (To) maltose;

3. (So) less absorption (of glucose)

OR

(So) more egested (starch/carbohydrate);

Accept description of egestion, eg lost in faeces

3

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4.

- (a) 1. Lowers activation energy;
2. Induced fit **causes** active site (of enzyme) to change shape;
3. (So) enzyme-substrate complex **causes** bonds to form/break;
Accept: description, of induced fit
Accept: enzyme-substrate complex causes stress/strain on bonds.

3

- (b) Size/dimensions /mass/variety of potato

OR

Temperature (of solution/flask)

OR

pH (of solution);

Accept : weight of potato

Ignore : amount of potato

Ignore concentration/ volume of catalase

1

- (c) 0.33, 0.60, 0.86, 1.0, 1.0 = 2 marks;;

$$\frac{6}{\text{time}}$$

2 significant figures

If answer incorrect accept for 1 mark,

Correct values but incorrect number of significant figures

OR

1.0 written on row for hydrogen peroxide 2.0/2.5 in the table

OR

Answers showing correct division, eg 0.3, 0.6, 0.9

OR

Answers showing correct significant figures using incorrect calculation ($\div 18$) 1.0, 0.56, 0.39, 0.33, 0.33

2

- (d) 1. Hydrogen peroxide concentration on x axis **and** rate of reaction on Y axis,
linear number sequence **and** appropriate scale;
*Graph should cover half or more of the grid; eg reject if Y axis covers only
three big squares*
2. Correct units /mol dm⁻³ **and** /arbitrary units/au;
Accept brackets instead of solidus
3. All co-ordinates plotted accurately **with** point-to-point or smooth curve;
Accept accurate plotting of co-ordinates given in part (c)
Reject : bar chart
Reject : if ruled straight line of best fit
Accept: if x axis starts at 0.5
Accept: if line is extended to (0,0)
- Plot coordinates must be processed data, hydrogen peroxide vs time = 0*

3

- (e) Cut up/use discs/homogenise/increase surface area (of potato chips)
OR
Use bigger chips
OR
Increase temperature
OR
Change pH;
Reject answer if the temperature is above 40°C
Ignore: more/increase heat

1

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5.

- (a) 1. Reduces activation energy;
Accept 'reduces E_a '
2. Due to bending bonds
OR
Without enzyme, very few substrates have sufficient energy for reaction;
*Accept 'Due to stress/pressure/tension on bonds' OR 'Due to
weakening bonds'.*
Ignore references to 'breaking bonds'.

2

(b) 1.93×10^{11} ;;

Allow 1 max for

$578/3.0 \times 10^{-9}$

1.93×10^x when $x \neq 11$

Correct answer with incorrect standard form e.g. 19.3×10^{10}

Accept any number of significant figures ≥ 2 , if rounding correct (1.926×10^{11}). Same principle applies to one max answers.

2

(c) 31.4;;

Allow 1 max for

0.44 **and** 1.4

32.8

33.1

30

29.3

Accept any number of significant figures ≥ 2 , if rounding correct (31.4284714).

Same principle applies to 1 max answers.

32.8 = Both readings at 2.5 mmol dm^{-3} (0.44/1.34)

33.1 = Both readings at 2.5 mmol dm^{-3} (0.44/1.33)

30 = Incorrect reading for C (0.42/1.4)

29.3 = Incorrect reading for C (0.41/1.4)

2

- (d) 1. (Binding) alters the tertiary structure of the enzyme ;
Max 1
if lyxose acting as an inhibitor
OR if answer linked to lower rate of reaction
OR if lyxose used an energy source/respiratory substrate
2. (This causes) active site to change (shape);
3. (So) More (successful) E-S complexes form (per minute)

OR

E-S complexes form more quickly

OR

Further lowers activation energy;

Accept 'acts as a co-enzyme'

Accept description for E-S complexes.

3

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6.

- (a) Any **two** of the following:
 Concentration of enzyme
 Volume of substrate solution
 pH.

Allow same concentration of substrate

1

- (b) Ratio between 5.18:1 and 5.2:1
 Initial rates incorrect but correctly used = 1 mark.

Allow 1 mark if rate at:

$$60^{\circ}\text{C} = 0.83\text{g dm}^{-3} \text{ s}^{-1} / 49.8\text{g dm}^{-3} \text{ minute}^{-1}$$

OR

$$37^{\circ}\text{C} = 0.16\text{g dm}^{-3} \text{ s}^{-1} / 9.6\text{g dm}^{-3} \text{ minute}^{-1}$$

2

- (c) At 60 °C:
 1. More kinetic energy;
 2. More E–S complexes formed.
Allow converse for 37 °C

2

- (d) Different times:
1. Higher temperature / 60 °C causes denaturation of all of enzyme;
Accept converse for 37 °C
 2. Reaction stops (sooner) because shape of active site changed;
Reject if active site on substrate

Different concentrations of product (at 60 °C)

3. Substrate still available (when enzyme denatured);
4. But not converted to product.

4

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7.

- (a) diagram showing molecule **A** fitting in inhibition site; distortion of active site;

2

- (b) molecules moving less / slower; reduces chance of collision (between enzyme and substrate) / of enzyme-substrate complexes being formed; (*reject converse*)

2

- (c) these bonds hold / maintain tertiary / globular structure (of enzyme); enzyme denatured / tertiary structures destroyed; (shape of) active site distorted / changes; substrate no longer fits / enzyme-substrate complex not formed;

3 max

[7]