Enzyme Answers

**M1.**          (a)     (i)      Increase to 30 °C/31 °C and then decreases / optimum or max  
rate at 30 °C/31 °C;

*Accept: peak at 30 °C/31 °C*

**1**

(ii)     1. Enzyme denatured / hydrogen bonds/bonds holding tertiary  
    structure broken / tertiary structure changed;

2. Change in shape of active site (of enzymes);

3. Substrate / protein no longer fits / binds (into active site) / few or no ES  
    complexes;

4. More enzyme (molecules) denatured as temperature increased;

*1. Reject: Peptide bonds broken*

*Denatures active site = 2 marks for mp 1 and 2*

*2. Q Only allow second point if active site is used correctly*

*Accept: active site no longer complementary*

*3. Accept: Substrate cannot bind to enzyme*

**3 max**

(b)     (i)      Use buffer / test pH (at end/ at intervals);

*Accept a method of measuring pH.*

*Reject litmus.*

**1**

(ii)     (30 °C/31 °C) Maximum rate / optimum temperature;

*Accept other valid answers e.g. temp below  
30 °C as enzyme not denatured.*

**1**

(iii)     Works best at pH 6 / at higher pH activity decreases;

*Accept converse*

*Insufficient: pH 6 had largest clear area*

**1**

**[7]**

**M2.**          (a)     specific 3D tertiary structure/shape;  
substrate complementary shape;

*(reject same shape)*

substrate (can bind) to active site/ can fit into each active site;

**3**

(b)     (bacterial) active site/enzymes/proteins denatured /  
tertiary 3D structure disrupted/changed;  
(ionic) bonds broken;

*(reject peptide bonds)  
(ignore other bonds)*

no enzyme substrate complex formed / substrate no longer fits;

**3**

**[6]**

**M3.**          (a)     (i)      (Grinding) breaks open cells / increases surface area (of liver);  
Releases catalase/enzyme/more catalase /  
allows more hydrogen peroxide into liver;

**2**

(ii)     Heating causes bonds (maintaining tertiary structure) to break;  
Denatures / changes tertiary structure;  
Active site changed;  
Substrate no longer fits / ES complex not formed;

**max 3**

(b)     (Control) to show that sand did not affect reaction (with ground liver);

**1**

(c)     (i)      Lower activation energy / less energy required to bring  
about reaction;

**1**

(ii)     Energy in products/water and oxygen less than energy in  
substrate/reactants/hydrogen peroxide;  
(Difference) given out as heat / exothermic;

**2**

**[9]**

**M4.**          (a)     Active site;  
(Complementary/specific) structure/shape;  
(Only) fits/binds to gangliosides;  
Forms enzyme-substrate complexes;

***OR***

Active site;  
(Complementary/specific) structure/shape;  
(Does not) fit/bind with other lipids;  
Does not form enzyme-substrate complexes;

*Note: ‘active site has a specific shape’ = 2 marks;  
Reject: same shape*

*Second mark for either route can refer to the enzyme or the substrate*

*Accept: converse of second mark point and (different) structure/shape if referring to other lipids*

**3 max**

(b)     (i)      No change/substrate remains high/horizontal line;

*Curve should be labelled  
If curve* ***H*** *correctly labelled then assume other is curve* ***T***

*Reject: obvious rise or fall/rise then plateau*

**1**

(ii)     Curve decreases rapidly at first then more slowly;

*Curve should be labelled*

*If curve* ***T*** *correctly labelled then assume other is curve* ***H***

*Reject: falling at a slower rate initially*

**1**

(c)     (Enzymes are) proteins;  
Digested/broken down/destroyed (by enzymes/acid);

**OR**

(Enzymes are) too large;  
To cross cell membranes/be absorbed/enter the bloodstream;

*Accept: denatured (by acid)*

*Neutral: digested by saliva*

*Reject: digested by amylase*

*Neutral: will not reach the bloodstream*

**2**

**[7]**

**M5.**          (a)     (i)      Glucose;

Fructose;

*Any order.*

**2**

(ii)     Lactose has a different shape/structure;

Does not fit/bind to active site of enzyme/sucrase;

*Only allow a second mark if reference is made to the active site.  
Max 1 mark if active site is described as being on the substrate.*

**OR**

Active site of enzyme/sucrase has a specific shape/structure;  
Does not fit/bind to lactose;

*Do not accept same shape.*

**2**

(b)     (i)      Rose and fell;

Peak at 45 (minutes) / concentration of 6.6 (mmol dm–3);

**2**

(ii)     Glucose (produced by digestion) is absorbed / enters blood;

Decrease as used up/stored;

**2**

(iii)     Curve roughly parallel to the x-axis or falling, starting  
from approximately the same point;

**1**

**[9]**

**M6.**          (a)     Enzyme/active site has a (specific) tertiary structure;

Only glucose has correct shape / is complementary / will bind/fit;

To active site;

(Forming) enzyme-substrate complex;

***Q*** *Allow second mark if candidate refers to correct shape or complementary in terms of the enzyme. Do not allow ‘same’ shape*

***Q*** *Do not allow third mark if active site is described as being on substrate.*

**3 max**

(b)     (Only detects glucose whereas) Benedict’s detects (all) reducing  
sugars/named examples;

Provides a reading / is quantitative / Benedict’s only provides a colour /  
doesn’t measure concentration / is qualitative/semiquantitative;

Is more sensitive / detects low concentration;

Red colour/colour of blood masks result;

Can monitor blood glucose concentration continuously;

***Q*** *Do not credit quicker/more accurate unless qualified.*

***Q*** *Allow Benedict’s detects monosaccharides for first mark point.*

**2 max**

(c)     (i)      Broken down by enzymes / digested / denatured (by pH) too  
large to be absorbed;

**1**

(ii)     Study not carried out on humans / only carried out on rats;  
Long-term/side effects not known;  
Scientists have vested interest;  
Study should be repeated / further studies / sample size not known;

**2 max**

**[8]**

**M7.**          (a)     (i)      Increases then plateaus/constant/steady/rate does not change;

*Neutral: ‘peaks’/‘reaches a maximum’/‘stops increasing’/‘no effect’ instead of ‘plateaus’  
Reject: rate decreases/reaction stops*

Correct reference. to 27/28 units;  
e.g. increases up to/plateaus at 27/28

**2**

(ii)     Substrate concentration/amount of substrate;

As substrate concentration increases, rate increases/positive  
correlation (between rate and substrate concentration);

**2**

(iii)     All active sites occupied/saturated/enzyme limiting (rate of  
reaction)/maximum number of E-S complexes;

*Reject: enzymes used up  
Reject: substrate limits rate of reaction  
Neutral: substrate no longer limits the reaction  
Neutral: reference to temperature*

**1**

(b)     Curve is lower and plateaus at a higher substrate concentration  
(it must also start at zero);

*Accept: curve lower and joins existing curve at final point (with no plateau)  
Reject: if curve plateaus before original  
Reject: if curve plateaus lower than original*

**1**

(c)     (i)      Methotrexate/drug is a similar shape/structure to substrate;

***Q*** *Reject: same structure/shape*

         Binds to/fits/is complementary to active site;

***Q*** *Reject: reacts with active site*

         Less substrate binds/less enzyme-substrate complexes formed;

*Accept: substrate cannot bind/enzyme-substrate complex not formed*

**2 max**

(ii)     Methotrexate/drug is only similar shape to specific substrate/  
only fits this active site;

*Assume that ‘it’ refers to the drug*

***OR***

Methotrexate/drug is a different shape to other substrates/will  
not fit other active sites;

**1**

**[9]**

**M8.**          (a)     (i)      150;

**1**

(ii)     27;

**1**

(b)     100;  
number of peptide bond hydrolysed = total number present / all peptide  
bonds have been hydrolysed;

*accept calculation showing same number top and bottom.*

**2**

(c)     curve rising to peak at pH 2 and falling to zero by pH 6;

**1**

(d)     (change in pH) leads to breaking of bonds holding tertiary structure  
/ changes charge on amino acids;  
enzyme/protein/active site loses shape/denatured;  
substrate will not bind with/fit active site;  
fewer/no ES complexes formed;

**3 max**

(e)     more resistant to changes in pH and washing conditions variable/  
works in alkaline pH and washing powders alkaline;  
*mark awarded for indicating aspect of effect of pH and advantage of this  
in terms of washing powder and conditions in wash.*

**1**

(f)      *maximum of three marks for specificity, points 1 - 4.*   
*Can only be given credit in context of specificity*

1       each enzyme/protein has specific primary structure / amino  
acid sequence;

2       folds in a particular way/ has particular tertiary structure;

3       active site with unique structure;

4       shape of active site complementary to/ will only fit that of substrate;  
*maximum of three marks for inhibition, points 5 – 8*

5       inhibitor fits at site on the enzyme other than active site;

6       determined by shape;

7       distorts active site;

8       so substrate will no longer fit / form enzyme-substrate complex;

**6 max**

**[15]**

**M9.**          (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]**

**M10.**          (a)     maximum rate at which enzyme can combine with substrate /  
form enzyme-substrate complexes / substrate no longer limiting /  
enzyme is a limiting factor;  
(active site of) enzyme saturated with substrate  
(*disqualify active sites/enzymes* ‘*used up*’);

**2**

(b)     inhibitor attaches to enzyme away from the active site;  
changes shape of active site;  
prevents formation of enzyme-substrate complex;

**2 max**

(c)      x 100;

= 26.32%; *(accept 26% or 26.3%)*

*(correct answer = 2 marks)*

*(principle –  × 100 = 1 mark)*

**2**

(d)     curve below top curve (without inhibitor) joining to top curve /  
continues to increase to end of *x*-axis  
(*must not exceed or level out below ‘without inhibitor curve’ and  
 must start from origin*);

**1**

**[7]**

**M11.**          (a)     (i)      Curve rising and levelling out;

**1**

(ii)     Substrate becomes limiting/falls/gets less;  
Fewer collisions/complexes formed;

**2**

(b)     To keep pH the same / optimum pH / so change  
in pH does not affect reaction;

**1**

(c)     (i)      For temperature up to 40 – 50 °C has no effect;  
Over temperature (of 40 – 50 °C) reduces rate of reaction;

*Note. Award one mark for general statement about the  
longer the incubation time, the slower the rate of reaction.*

**2**

(ii)     Bonds (holding tertiary structure) broken;  
More enzyme denatured / tertiary structure destroyed;  
Active sites lose shape/no longer fit;  
Fewer enzyme-substrate complexes formed;

*Note. Award marks if clearly in the context of more denaturation. Allow credit here for converse relating to exposure for 5 minutes.*

**max 3**

(d)     1 Statement about two types, competitive and non-competitive;

*Note. Award points 2 –5 only in context of competitive and non-competitive inhibition*

Competitive  
2 Similarity of shape of inhibitor and substrate;  
3 Inhibitor can enter/bind with active site (of enzyme);

Non-competitive  
4 Affect/bind to enzyme other than at active site;  
5 Distorts shape of active site;

Inhibitors  
6 Prevent entry of/binding of substrate to active site;  
7 Therefore fewer/no enzyme-substrate complexes formed;

**max 6**

**[15]**

**M12.**          (a)     (i)      absorbed by diffusion;  
no energy/ATP available / active transport requires energy/ATP;

**2 max**

*(disqualify energy made)*

*(allow energy reference in either (i) or (ii))*

(ii)     absorbed by active transport;

**1**

(b)     (absorption by) diffusion no longer occurs / diffusion/movement  
of ions equal in both directions;  
because no concentration/diffusion gradient / reached equilibrium;

**2**

(c)     malonate fits into/blocks active site of enzyme / complementary to active site;  
(prevents fitting neutral)  
competes with substrate / is a competitive inhibitor / prevents substrate  
forming enzyme-substrate complex;

**2**

**[7]**