

# Proteins and enzymes 3

Level: CIE AS 9700

Subject: Biology

Exam Board: Suitable for all boards

Topic: Proteins and enzymes 3

Type: Mark Scheme

To be used by all students preparing for CIE AS Biology 9700 foundation or higher tier but also suitable for students of other boards.

## Mark schemes

- 1** (a) Lilac / purple / mauve / violet;  
 Xanthine oxidase is a protein;  
*Reject pink or blue as the resulting colour with biuret.* 2
- (b) Substrate has specific shape;  
 Allows binding / fitting / forms ES complex with active site;  
 Or  
 Active site has specific shape;  
 Allows binding / fitting / forms ES complex with substrate;  
*Accept structure  $\equiv$  shape* 2
- (c) Xanthine similar shape to drug;  
 Drug fits active site / competes for active site / is a competitive inhibitor;  
 Less / no uric acid formed; 3
- [7]**
- 2** use of water;  
*must be above arrowhead*  
*OH drawn correctly in place of glycosidic bond on*  
*each monosaccharide;* 2
- [2]**
- 3** (a) Stimulates memory cells;  
 Secondary response, so antivenom / antibodies produced quicker; 2
- (b) Passive immunity; so no memory cells produced;  
 Antivenom breaks down / destroyed; 2
- (c) Could transfer disease / Allergy / Immune response to antibodies from animal; 1
- [5]**



4

(a)

	Glycolysis	Link reaction	Krebs cycle
Occurs in mitochondria		√	√
Carbon dioxide produced		√	√
NAD is reduced	√	√	√

Mark horizontally

3

- (b) (i) 1. Glucose is used / broken down during glycolysis / in cytoplasm;  
*1. Accept: glucose to pyruvate or glucose not converted to pyruvate for one mark*
2. Glucose cannot cross mitochondrial membrane(s) / pyruvate can cross mitochondrial membrane(s);
- (ii) 1. Is a competitive inhibitor / attaches to active site;  
*1 Accept: inhibitor / malonate attaches to active site to form an enzyme-substrate complex*
2. Reduces / prevents enzyme-substrate / E-S complex forming;  
*2 Accept: substrate / succinate cannot bind to enzyme*  
*2 Accept mark point 2, but not mp1 in context of non-competitive inhibition*
- (iii) 1. Krebs cycle inhibited as NAD / Coenzyme / FAD not / less reduced;
2. Hydrogens not passed to ETC therefore oxygen not used as (much as a) final / terminal (electron) acceptor;

2

2

2

[9]



5

(a) (i) Glucose and fructose;  
*Ignore reference to alpha and beta*  
*Either way around*

1

(ii) Glucose and galactose;  
*Ignore reference to alpha and beta*  
*Either way around*

1

(b) 1. (Amylase) pancreas, produces maltose;  
*Place and product = 1 mark*  
*(mark horizontally)*

2. (Maltase) in / on epithelium (of small intestine), produces glucose;  
*Ignore references to salivary glands or saliva*  
*Accept wall / lining of small intestine*  
*Ignore reference to cells alone*  
*Ignore reference to ribosomes / rER*

2

[4]



- 6 (a) 1. (Phosphate) changes shape of TK / changes shape of enzyme / changes the active site;  
*It = phosphate*  
*Accept 'alters' for changes*  
*Reject that phosphate is an inhibitor*  
*Accept adding energy / affecting charged / affects polar groups (on amino acids)*

2. Active site forms / becomes the right shape / can bind to substrate / complementary to substrate / E-S complex can form;  
*Reject similar / same shape as substrate*

2

- (b) 1. Faulty TK has functional active site without phosphate;  
*Accept 'works without phosphate'*

2. (So, faulty) TK functional all the time / TK not controlled (by phosphate);

2

- (c) 1. Non-competitive inhibitor / binds to site other than active site;  
*Accept allosteric site*  
*Do not accept 'changes shape' unqualified*

2. Causes TK to be in non-functional form / active site not formed / wrong shape / E-S complex not formed;

3. So, (uncontrolled) cell division stopped / slowed / controlled;

2 max

[6]

- 7 (a) 1. Cell wall not formed / production inhibited;  
*1. Q Accept: weakened cell wall, but do not accept 'cell wall is broken down'*

2. Lower water potential in bacterium;  
*2. Accept: converse*  
*2. Must be clear that the lower water potential is in the bacterium*

3. Water enters and causes lysis / expansion / pressure;

2 max

- (b) Human cells lack enzyme (**B**) / have a different enzyme / produce different fatty acids / use different substrates;

*Neutral: 'human cells do not have cell walls' as out of context*

1



- (c) 1. Change in base sequence (of DNA / gene) leading to change in amino acid sequence / primary structure (of enzyme);  
*1. Accept: different amino acids coded for*  
*1. Reject: different amino acids produced*
2. Change in hydrogen / ionic / disulphide bonds leading to change in the tertiary structure / active site (of enzyme);  
*2. Neutral: alters 3D structure / 3D shape*
3. Substrate not complementary / cannot bind (to enzyme / active site) / no enzyme-substrate complexes form;

3

[6]

8

- (a) (i) (Human cells) don't have a cell wall;  
*Accept "they" refers to human cells.*
- (ii) (Affects) protein synthesis;  
*Allow description e.g. 'amino acids not joined together / translation.*  
*Reject: affects transcription.*
- (b) 1. Mutation present / occurs;  
*Ignore antibiotic causes mutation.*
2. Resistance gene / allele;  
*1. or 2.*  
*Reference to immunity disqualifies first credited marking point.*
3. Resistant bacteria (survive and) reproduce;  
*Reference to mitosis negates marking point 3.*

1

1

2

[4]

9

- (a) (i) Hydrolysis;  
*Accept phonetic spelling.*  
*Ignore reaction.*
- (ii) (Alpha) glucose;  
*Accept  $\alpha$  glucose.*  
*Reject  $\beta$  glucose / beta glucose*

1

1



(b) (i) Add Benedict's (reagent) and heat / warm;

Red / orange / yellow / green (colour);

*Reject Add HCl*

*Accept brown, reject other colours*

2

(ii) 2 products / 2 sugars produced;

*Look for idea of **two***

*Accept named monosaccharides produced.*

*"More" insufficient for mark*

*Neutral if incorrect products named*

*Neutral "lactose is a polysaccharide"*

*Neutral "lactose is not a reducing sugar"*

*Neutral: Reference to surface area.*

1

(c) 1. Galactose is a similar shape / structure to lactose / both complementary;

*Q Reject: Same shape / structure*

2. (Inhibitor / Galactose) fits into / enters / binds with active site (of enzyme);

*Accept blocks active site*

3. Prevents / less substrate fitting into / binding with (active site) / fewer or no E-S complexes;

*Look for principles:*

*1. Shape*

*2. Binding to active site*

*3. Consequence*

2 max

[7]

10

(a) 2 marks for Chymosin / enzyme is a protein; ;

Protein / peptide bonds present;

2 max

(b) Water removed;

1

[3]

11

Similar structure / shape (to PABA) / both complementary;

Competes for / binds to active site / competitive inhibitor;

Less PABA binds / less E-S complexes;



OR

Specific reference to different structure / shape (to PABA) using the diagram;

Binds to position other than active site / binds to allosteric site / binds to inhibitor site / non-competitive inhibitor;

Changes the active site so substrate cannot bind / less PABA binds / less E-S complexes;

*Q Reject: same structure / shape*

*Note: competitive inhibitor binds to active site = 1 mark (same mark point)*

*Assume that 'it' refers to sulfanilamide*

*Accept: PABA / substrate cannot bind*

*Neutral: less product produced as in question stem*

*Neutral: different structure / shape to PABA*

*Reject: active site on substrate for second marking point only*

[3]

12

(a)

✓	✓	✓	
			✓
		✓	✓

*One mark for each correct column*

*Mark ticks only and ignore crosses*

4

- (b) 1. Two marks for box round two hydrogens and one of the oxygens from OH groups on carbons 1 and 4;;
2. One mark from incorrect answer involving any two hydrogens and an oxygen from carbons 1 and 4;

*Do not award marks if all atoms concerned are on same carbon atom or are on carbon atoms other than 1 and 4 or where the answer does not have two hydrogen and one oxygen*

2

- (c) (i) 1. Holds chains / cellulose molecules together / forms cross links between chains / cellulose molecules / forms microfibrils, providing strength / rigidity (to cellulose / cell wall);
2. Hydrogen bonds strong in large numbers;x  
*Principles here are first mark for where hydrogen bonds are formed and second for a consequence of this.*  
*Accept microfibrils*

2





- (ii) Compact / occupies small space / tightly packed;  
*Answer indicates depth required. Answers such as “good for storage”, “easily stored” or “small” are insufficient.*

1

[9]

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- (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]



14

(a) Ammonia / ammonium /  $\text{NH}_3$  /  $\text{NH}_4^+$ ;

1

(b) Will have similar shape / tertiary structure (as substrate) / complementary shape (to active site);

*Neutral: same shape as substrate*

Fit / bind with active site / forms enzyme-substrate complex;

*Reject: same shape as active site*

2

(c) (i) Provides ATP for the reaction / nitrogen fixation / reduction of nitrogen / formation of ammonia;

*Accept: ATP or energy*

Enzyme / nitrogenase produced quicker / more enzyme produced;

*Ignore references to temperature*

Uses / removes oxygen (so nitrogenase works);

*Use of oxygen must be in the correct context*

2 max

(ii) ATP used for / needed for nitrogen fixation / reduction of nitrogen / formation of ammonia / production of enzyme / nitrogenase;

*Accept: ATP or energy*

(So less ATP) available for growth / protein synthesis / production of new cells / production of biomass;

*Accept: converse for those without fertiliser*

2

[7]

15

(a) (i) Faster / greater / more effective response in children;

*Do not accept children have more haemoglobin*

1

(ii) Use line of best fit;

1

Extrapolate / extend line (and read from graph);

*Allow calculation using rate of increase per day = one mark.*

*However for both marks this must be linked to line of best fit.*

1

(iii) More than one polypeptide chain;

*Allow many polypeptide chains.*

*'Haemoglobin has four polypeptide chains' must be in correct context to gain mark.*

1



- (b) (i) Has same water potential;  
*Allow converse for effect of using distilled water or a concentrated solution.* 1
- No (net) water movement / osmosis; 1
- Cells will not swell / burst / change size;  
*No osmotic lysis = two marks* 1
- (ii) Pernicious anaemia (cells) greater range / spread / variation of diameters / widths;
- Some pernicious anaemia (cells) wider than 9 ( $\mu\text{m}$ ) / some less than 5.5 ( $\mu\text{m}$ ) / without pernicious anaemia none more than 9 ( $\mu\text{m}$ ) / none less than 5.5 ( $\mu\text{m}$ );
- Pernicious anaemia (cells) peak / most frequent at 8.5 ( $\mu\text{m}$ ) / peak / most frequent at higher diameter / / without pernicious anaemia peak / most frequent at 7 ( $\mu\text{m}$ ) / peaks at lower diameter;  
*There are several alternatives for marking points 2 and 3* 2 max

[9]

16

- (a) (i) (Lactose +) Water; → (Glucose +) Galactose;  
*Accept: H<sub>2</sub>O for water* 2
- (ii) Hydrolysis;  
*Accept: if phonetically correct* 1
- (b) (i) (Add Biuret reagent to both solutions) – no mark;  
*Neutral: positive / negative result*
- Lactase / enzyme will give purple / lilac / mauve;  
*Neutral: incorrect reference to the method*
- OR**
- Lactose / reducing sugar will not give purple / lilac / mauve / will remain blue; 1
- (ii) Lactase / enzyme is a protein;  
*Accept: lactase / enzyme contains peptide bonds* 1

[5]



- 17** (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
- (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
- 18** (a) (i) Deoxyribose;  
*pentose / 5C sugar = neutral*  
1
- (ii) Phosphate / Phosphoric acid;  
*phosphorus / P = neutral*  
1
- (b) Hydrogen (bonds);  
1
- (c) 381 / 384 / 387;  
1
- (d) (Gln) Met Met Arg Arg Arg Asn;  
1

[8]



(e) Change in (sequence of) amino acids / primary structure;

Change in hydrogen / ionic / disulfide bonds leads to change in tertiary structure / active site (of enzyme);

Substrate cannot bind / no enzyme-substrate complexes form;

*Q Reject = different amino acids are formed*

3

[8]

19

(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<sup>-3</sup>);

2

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

Decrease as used up / stored;

2

[8]



- 20**
- (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
- (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 - 3. 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 giving an active site with a unique structure;
  - 3 shape of active site complementary to / will only fit that of substrate;  
maximum of three marks for inhibition, points 5 – 8
  - 4 inhibitor fits at site on the enzyme other than active site;
  - 5 distorts active site;
  - 6 so substrate will no longer fit / form enzyme-substrate complex
- 6**

**[15]**



21

(a) Accept **three** suitable suggestions:

1. (Lactase / beads) can be reused / not washed away;
  1. *Accept lactase / beads not wasted*
  1. *Less lactase used is insufficient*
2. No need to remove from milk;
  2. *Accept lactase not present in milk.*
3. Allows continuous process;
4. The enzyme is more stable;
5. Avoid end-product inhibition.

*Ignore ref to SA*

3 max

- (b)
1. (Lactose hydrolysed to) galactose and glucose;
  2. (So) more sugar molecules;
    2. *Idea of **more** sugars essential*
  3. (So) more / different receptors stimulated / sugars produced are sweeter (than lactose).

2 max

[5]

22

(Maintaining constant pH to avoid)

1. Named protein / enzyme (in blood) sensitive to / affected by change in pH;

*Accept converse for MP2 and MP3.*

*Named example should be a protein that might be affected (by change in pH) eg haemoglobin, carrier protein in plasma membrane.*

*Accept 'change in H<sup>+</sup> concentration' for 'change in pH'.*

2. (Resultant) change of charge / shape / tertiary structure;

*The change in charge idea relates to the enzyme / protein and not the blood (plasma) or red blood cells.*

*'Denaturation' alone is insufficient.*

3. Described effect on named protein or enzyme.  
e.g. less oxygen binds with haemoglobin / less transport across membranes / fewer substrates can fit active site / fewer enzyme-substrate complexes.

*Idea of 'less' or 'fewer' required. Ignore suggestion of 'no' or 'none'.*

[3]



23

- (a) 1. (Enzyme has) active site;
1. *Reject active site is same shape as substrate*
  1. *Reject active site is on the substrate*
  1. *Accept active site forms during induced fit*
2. Only substrate fits (the active site);
2. *Accept converse statement*

2

(b) Assume "it" = allopurinol

1. (Allopurinol) is a similar shape to xanthine;
  1. *Reject same shape. Accept similar structure*
2. (Allopurinol) enters active site / is a competitive inhibitor;
  2. *Ignore e-s complexes in relation to inhibitor*
  2. *Reject non-competitive inhibitor in the context of binding to the active site*
  2. *Ignore complementary / fits*
3. Less xanthine binds / fewer e-s complexes / fewer uric acid crystals formed / less uric acid formed;
  3. *Reject no e-s complexes / xanthine cannot enter active site, no uric acid*
  3. *Can award in context of non-competitive inhibition*

3

[5]