CAMBRIDGE INTERNATIONAL AS & A LEVEL BIOLOGY · 9700

BIOLOGY



MARK SCHEME

3 ENZYMES

SCORE	PERCENTAGE
/	%

STEMUP

These questions belong to CIE, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by Cambridge International (CIE). They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with CIE and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. CIE has not endorsed, approved or been involved in the production of it. CIE and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

CIE publishes its past papers, mark schemes and examiner reports. Always check the current syllabus at cambridgeinternational.org before you revise.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Paper 1 Multiple Choice Answers: Enzymes

Question	Paper	Q. No.	Answer
461	9700_s20_qp_11	12	C
462	9700_s20_qp_12	13	B
463	9700_s20_qp_12	14	D
464	9700_w20_qp_11	13	A
465	9700_w20_qp_11	14	B
466	9700_w20_qp_12	12	A
467	9700_w20_qp_12	14	B
468	9700_w20_qp_13	13	C
469	9700_w20_qp_13	14	B
470	9700_m19_qp_12	15	C
471	9700_m19_qp_12	16	B
472	9700_s19_qp_12	10	D
473	9700_s19_qp_12	11	C
474	9700_w19_qp_11	14	D
475	9700_w19_qp_12	14	D
476	9700_m18_qp_12	13	C
477	9700_m18_qp_12	14	A
478	9700_m18_qp_12	15	A
479	9700_s18_qp_11	13	D
480	9700_s18_qp_13	14	C
481	9700_s18_qp_13	15	B
482	9700_w18_qp_13	15	B
483	9700_m17_qp_12	14	D
484	9700_s17_qp_12	10	B
485	9700_s17_qp_12	11	C
486	9700_s17_qp_13	10	B
487	9700_w17_qp_11	11	D
488	9700_w17_qp_11	12	C
489	9700_w17_qp_11	14	A
490	9700_w17_qp_12	14	D
491	9700_w17_qp_12	16	A
492	9700_w17_qp_13	14	A
493	9700_w17_qp_13	15	A
494	9700_m16_qp_12	11	A
495	9700_m16_qp_12	13	C
496	9700_s16_qp_11	12	D
497	9700_s16_qp_11	14	C
498	9700_s16_qp_12	10	C
499	9700_s16_qp_13	11	C
500	9700_s16_qp_13	12	D
501	9700_w16_qp_12	14	D
502	9700_w16_qp_13	11	D
503	9700_w16_qp_13	12	D
504	9700_s15_qp_11	13	D
505	9700_s15_qp_11	14	B
506	9700_w15_qp_11	12	B

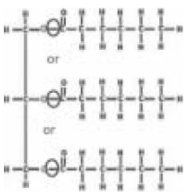
Paper 1 Multiple Choice Answers: Enzymes (continued)

Question	Paper	Q. No.	Answer
507	9700_w15_qp_11	14	D
508	9700_w15_qp_11	15	A
509	9700_w15_qp_12	12	A
510	9700_w15_qp_13	12	A
511	9700_w15_qp_13	13	C
512	9700_m20_qp_12	13	D
513	9700_m20_qp_12	14	B
514	9700_s20_qp_11	13	B
515	9700_s20_qp_13	12	A
516	9700_s20_qp_13	13	A
517	9700_w20_qp_11	15	D
518	9700_w20_qp_12	13	D
519	9700_s19_qp_11	14	D
520	9700_s19_qp_13	15	A
521	9700_s19_qp_13	16	B
522	9700_w19_qp_11	13	D
523	9700_w19_qp_12	15	B
524	9700_w19_qp_12	16	C
525	9700_w19_qp_13	12	D
526	9700_s18_qp_11	12	A
527	9700_s18_qp_12	12	A
528	9700_s18_qp_12	13	D
529	9700_s18_qp_12	14	C
530	9700_s18_qp_13	13	B
531	9700_w18_qp_11	14	B
532	9700_w18_qp_12	14	D
533	9700_w18_qp_12	15	C
534	9700_w18_qp_13	13	D
535	9700_m17_qp_12	15	C
536	9700_s17_qp_11	14	A
537	9700_s17_qp_11	15	C
538	9700_s17_qp_11	16	C
539	9700_s17_qp_12	12	B
540	9700_s17_qp_13	11	C
541	9700_s17_qp_13	12	C
542	9700_w17_qp_11	13	A
543	9700_w17_qp_12	15	D
544	9700_w17_qp_13	13	D
545	9700_w17_qp_13	16	C
546	9700_m16_qp_12	12	A
547	9700_s16_qp_11	13	D
548	9700_s16_qp_12	11	B
549	9700_s16_qp_13	10	D
550	9700_w16_qp_11	12	C
551	9700_w16_qp_11	13	A
552	9700_w16_qp_12	15	A

Paper 1 Multiple Choice Answers: Enzymes (continued)

Question	Paper	Q. No.	Answer
553	9700_w16_qp_13	13	C
554	9700_s15_qp_12	13	D
555	9700_s15_qp_13	13	D
556	9700_s15_qp_13	14	C
557	9700_w15_qp_11	13	A
558	9700_w15_qp_12	13	C
559	9700_w15_qp_12	14	A
560	9700_w15_qp_13	14	D

13. 9700_w20_ms_21 Q: 2

(a)(i)	circle around any one correct bond ; **R** if circle includes the double bond O  	**1**
(a)(ii)	condensation ; **A** dehydration (synthesis) **A** esterification three ;	**2**
(b)(i)	macromolecule and extracellular enzyme ;	**1**
(b)(ii)	4 (hours) ;	**1**
(b)(iii)	*any **four** from:* **1** triglyceride hydrolysis / action of lipase, produces fatty acids ; **2** decrease in pH / described, because of production of (fatty) acids ; **3** steepest rate of (pH) decrease at start because, substrate / triglyceride, concentration highest ; **4** rate of pH decrease / AW, slows because decrease in rate of formation of fatty acids ; **5** rate of pH decrease /AW, slows because enzymes, not at optimum / begin to denature ; **6** rate of pH decrease slows because, substrate / triglyceride, being used up **or** substrate concentration becomes a limiting factor / AW ; **7** *ref. to* plateau at 18 hours / at pH 6.1, enzymes are denatured ; **8** *ref. to* plateau at 18 hours / at pH 6.1, as all the, triglyceride / substrate, has been, hydrolysed / AW ; **9** optimum pH for lipase activity, is pH 8 / alkaline conditions / at the start ; **10** AVP ; e.g. *ref. to* tertiary structure of lipase	**4**
(b)(iv)	*any **two** from:* (initial) decrease in pH would be more rapid ; plateau would be reached earlier ; AW plateau would be at the same pH (as the previous experiment) ;	**2**

14. 9700_s18_ms_23 Q: 2

(a)	*too small to see* 35 μm is 0.035 mm (smaller than 0.05 mm) **or** 0.05 mm is 50 μm (larger than 35 μm) ;	**1**
(b)	*in context of light microscope* *two from:* 1 resolution / resolving power, poor / not high enough / AW ; 2 ability to distinguish between two points not high enough / AW ; 3 ref. to limit of resolution ; e.g. organelles smaller than, 0.2 μm / 200 nm, not visible **A** organelles smaller than 200 nm (accept range 100–300 nm) 4 organelle too small to interfere with light waves ; **A** wavelength of light too long **I** organelles are small	**2**
(c)(i)	ester ;	**1**
(c)(ii)	facilitated diffusion ; *plus two from:* (diffusion) through (membrane), transport / channel / carrier, protein ; **A** pore **I** transmembrane / integral, protein high to low concentration **or** down, concentration / diffusion, gradient ; passive ; **A** no, ATP / (metabolic) energy, required *if active transport incorrectly stated allow ecf* through (membrane), transport / carrier, protein ; **R** channel protein low to high concentration / against a concentration gradient / requires ATP / requires (metabolic) energy ;	**3**
(c)(iii)	*four from:* 1 ref. to hormones, released into / arrive at adipocyte in, blood stream ; **A** released by another, cell / tissue (elsewhere in the body) 2 hormone is, (chemical) signal / signalling molecule / messenger molecule ; 3 (adipocyte is) target cell ; **A** (adipose is) target tissue 4 (hormone) binds to / AW, receptor ; *in context of* on cell surface membrane of adipocyte 5 ref.to receptor (shape) complementary to hormone ; **A** specific receptor for hormone 6 (binding) triggers / stimulates, reactions within the cell ; **A** cascade of reactions **I** binding causes a reaction to occur 7 cell signalling results in a response, qualified ; e.g. triglyceride breakdown fatty acids (and glycerol) produced fatty acids leave, the cell / via transport protein	**4**
(d)	*any one valid suggestion:* *e.g.* do not have mitochondria / mitochondria required (to produce ATP) ; do not have nucleus (so no mRNA produced) ; no mRNA for enzyme synthesis ; (required) enzymes not present ; impermeable to fatty acids / AW ; have lost / do not have, the required organelles ;	**1**

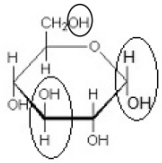
15. 9700_m20_ms_22 Q: 2

(a)	*any **two** from:* *PAP2, because* activity is shown at 0.0 mmol dm^{-3} / does not require Mg^{2+} for activity ; (at 0.0 mmol dm^{-3}) 30 arbitrary units activity ; no / very little, change at all concentrations of Mg^{2+} ;	**2**
(b)	**A** substrate for phosphatidate throughout **A** enzyme for PAP throughout *any **four** from:* 1 increasing concentration of phosphatidate increases PAP activity ; 2 at higher phosphatidate concentrations the increase in PAP activity is less steep ; 3 data to support marking point 1 or 2 ; 4 phosphatidate (concentration) is limiting factor / enzyme concentration begins to be limiting at higher concentrations (of phosphatidate) ; 5 at low phosphatidate concentrations, not all (enzyme) active sites are occupied / active sites are available or more active sites occupied at higher concentrations / AW ; **R** all active sites saturated (at higher concentrations)	**4**
(c)(i)	*any **two** from:* (fatty acid tails are long) hydrocarbon chains / many C-H bonds ; ref. to dense packing / large mass per unit volume ; AVP ; e.g. qualified ref. to role of hydrogens (in oxidative phosphorylation) bond energy released when bonds are broken ;	**2**
(c)(ii)	*any **two** from:* hydrophilic / polar, (phosphate) head and, hydrophobic / non-polar, (fatty acid) tails ; (so) heads face, watery environment / tissue fluid / cytoplasm / cytosol / aqueous environment ; (so) tails, form hydrophobic core / form area away from water / face each other ; **A** ref. to tails and hydrophobic interactions	**2**

16. 9700_s20_ms_21 Q: 3

(a)(i)	*one mark for units* *one mark per column* 		V_{max} µmol min^{-1}	K_m mmol dm^{-3} ;
J	60	0.2
K	50 ;	0.2 ;		**3**
(a)(ii)	*K compared with J* *max 3 from mp4–mp8* *any four from:* 1. rate of reaction is lower at all substrate concentrations ; 2. *ref. to* greater difference as substrate concentration increases ; 3. rate of reactions for **J** and **K** compared at two substrate concentrations to support mp1 or mp2 *or* manipulated data at two substrate concentrations to support mp2 ; 4. less efficient / acts more slowly / AW ; 5. active site is still binding substrate ; 6. *idea that* active site is less effective at catalysing reaction 7. *or* enzyme has lower affinity for substrate ; 8. (replaced / changed) amino acid is important in, shape / structure, of active site ; 9. AVP ; e.g. how the mutation may have changed interaction between substrate and, active / catalytic, site e.g. *ref. to* hydrogen bonding / transfer of electrons	**4**
(b)	each polypeptide shows primary, secondary and tertiary structure ; **A** description of levels of structure both (forms of G6PD / enzyme) composed of more than one polypeptide (so have quaternary structure) ;	**2**

17. 9700_s20_ms_23 Q: 4

(a)	converted the measured length (in mm) to μm (and dropped the, μm / units) *or* multiplied the measurement by 1000 ;	1
(b)	phosphate(-containing) heads are hydrophilic *or* triglycerides do not have a hydrophilic portion ; lipid droplet is stored in / phosphate heads can interact with, cytosol / aqueous environment / watery environment ;	2
(c)	to, digest / break down, worn out organelles / waste metabolic products / toxic substances / AW ; **A** invading pathogens	1
(d)(i)	correct orientation of H and OH on, C1 and on C3 ; OH added to carbon 6 ; 	2
(d)(ii)	positive result is coloured precipitate ; *only allow if hydrolysis noted* **A** green / yellow / orange / brown / red, *for colour* *any two from* *ref. to* (heat with) Benedict's (reagent / solution) and, negative test / no colour change / remains blue, and test again with Benedict's ; boil with (hydrochloric) acid ; **A** hydrolyse with, acid / enzyme AVP ; e.g. use a fresh sample to hydrolyse boil for 5-10 minutes with acid cool before neutralising neutralise (remaining acid) with alkali test with universal indicator paper (to check for pH7) compare with a control *allow one mark for heat with Benedict's and coloured precipitate*	3
(e)(i)	*any two from* *(higher K_m enzyme)* has a lower affinity for its substrate ; **A** binds substrate less easily needs a higher concentration of substrate to reach, V_{max} / maximum activity / ½ V_{max} ; less likely to be saturated with substrate ; variations in substrate have greater effect on rate of reaction ;	2
(e)(ii)	*any two from* *in the vacuole ; **A** in lysosome* qualified ; e.g. has, acidic / low pH, environment contains, acid hydrolases / enzymes that require low pH non-regulatory trehalase needs acidic conditions for optimum activity cytosol has neutral pH so likely to be location of regulatory trehalase (and enzymes are in different locations) if in cytosol then this would mean low pH and other enzymes, would (partially) denature / work below optimum as acid conditions required, will be in area protected from rest of cell and vacuole has the tonoplast as barrier **A** lysosomes are membrane bound	2
(e)(iii)	yes because they both work, within the cell / inside the cell ;	1
(f)	*any three from* *likely to be regulatory trehalase / unlikely to be non-regulatory trehalase* nearer to optimum of regulatory trehalase (of S. cerevisiae) ; ora pH 6.5 / 6.6 nearer to pH 7.0 (than to pH 5.0 of non-regulatory trehalase) ; no / (very) low, activity at pH 4.5 *or* greater activity at pH 7 than pH 4.5(–5.0) ; *alternative* suggestion that enzyme could be a different form of trehalase ; because has different optimum pH to both regulatory and non-regulatory ; pH 6.5 / 6.6, rather than pH 7.0 or pH 5.0 ; *general* (so) likely to act in the cytosol with, neutral pH / pH7 ; unlikely to be found in vacuole / lysosome, with low / acid, pH ;	3

STEMUP.CO.UK

18. 9700_w20_ms_22 Q: 5

(a)	fructose ; **I** α or β	**1**
(b)	*any **two** from:* formation of enzyme-substrate complex / substrate fits into active site ; **A** substrate binds to active site (so) reactants held close together (e.g. for bond formation) ; lowers, activation energy / energy of activation ; **A** Ea / Ae *can award annotated on a sketch* detail ; e.g. transfer of electrons strain on bonds alternative pathway holds substrate in a way that the bonds needed to be broken are exposed	**2**
(c)	**I** *ref. to* denaturation, either mp2 **or** mp10 can be awarded *any **four** from:* *immobilised* **1** higher optimum temperature ; AW e.g. peak / max activity / 100% activity ; **2** 74 / 75 / 76°C, v, 56 / 57 / 58 / 59°C ; **A** one correct value and calculation e.g. 17°C lower **3** *idea that* greater range of pH with, higher activity / greater stability ; AW *allow use of comparative data at one pH value to support if answer unclear* **4** *idea that* if pH changes, less effect on enzyme activity ; **A** resists changes in pH **5** *ref. to* more active at, higher temperatures / temperatures above 68°C ; **A** more thermostable / less effect on enzyme at higher temperatures **A** free enzyme not active above 70°C *allow use of comparative data at one temperature to support if answer unclear*	
(c)	**6** one advantage of immobilised ; **e.g.** reusable o less / no, contamination of product (by enzyme) o easier, downstream processing / separation of enzyme from product o longer shelf-life useful if enzyme, difficult to obtain **A** *ref. to* cost effective o can use in continuous processes so more productive o suggestion that (can carry out process at) lower pH (more acid conditions and) may be more effective against microorganisms *free enzyme* **7** higher activity, at lower temperatures / between 35°C to 68°C ; *in context of a range, quoting one temperature not enough* **8** two temperatures, comparative values for both enzymes to support mp7 ; **9** optimum temperature lower so cheaper maintaining that temperature ; AW **A** lower temperatures cost efficient to maintain and enzyme works well / AW **10** (values of optimum) 74 / 75 / 76°C, v, 56 / 57 / 58 / 59°C ; **A** calculation, e.g. 17°C lower **11** lower optimum temperature still high enough to kill microorganisms ;	

STEMUP.CO.UK

19. 9700_s19_ms_21 Q: 3

(a)(i)	*any two from:* (Neutrase® breaks down / hydrolyses) protein to, peptides / amino acids / smaller molecules ; **A** idea of increase in solubility during the reaction / AW, more light passes through / more light is transmitted / less light is absorbed ; *idea that* 100 s is long enough to see the progress of the reactions ; **I** 'the rate of reaction can be calculated' **I** 'allow time for reaction to complete'	**2**
(a)(ii)	*accept* ***ora*** *where appropriate* **1** copper sulfate, decreases / AW, the activity of Neutrase (*ref. to* **A** or **B**) ; **2** 0.01 (mol dm^{-3}) / low concentration, $CuSO_4$ has less of an effect than, 0.05 (mol dm^{-3}) / high concentration (*ref. to* **A** and **B**) ; **3** potassium sulfate has, little / no, effect on activity (*ref. to* **C**) ; **4** data quote to show absorbance for two different lines at the same time ; *one time and two absorbance readings from different lines on the graph with the unit for time used once anywhere in answer, allow 'at the end' for 100 s* **5** copper sulfate is an inhibitor of Neutrase ; **6** potassium sulfate is not an inhibitor ; **A** 'less of…' **7** copper sulfate binds to Neutrase ; **A** anywhere **8** substrate cannot enter active site / ESCs do not form (so protein not hydrolysed) ; **A** fewer ESCs	
(b)	*higher productivity / higher yield and fewer costs because* enzyme can be re-used ; enzyme can be easily recovered ; downstream processing is easier ; product, not / less, contaminated ; **A** less purification needed longer shelf-life of enzyme ; reduces product inhibition ; enzyme is, more stable / less likely to denature *or* described ; **A** thermostable / can work at high temperatures **A** in context of change in pH **I** 'can withstand changes in temperature'	**2**

20. 9700_s19_ms_22 Q: 6

(a)(i)	*any two from:* correct ref. to time ; correct ref. to volume of oxygen ; **A** gas for oxygen **A** volume of water displaced by oxygen **A** measuring height of water level (decreasing) **A** cm^3 instead of volume AVP ; subtract volume of gas displaced by H_2O_2 addition	**2**
(a)(ii)	*any two from:* greater surface area (over which catalase released) ; greater number of cells, damaged / cut open, to release catalase ; higher concentration of, catalase / enzyme ; **A** more, catalase / enzyme **A** more active sites available *must be linked to idea of more enzyme (i.e. must get mp 2 or 3)* so, higher rate of reaction / more enzyme-substrate complexes / more oxygen released ; AW	**2**
(b)	increase to optimum and steeper decrease ; **A** if curve does not touch one or both axes	**1**

21. 9700_m18_ms_22 Q: 3

(a)	*any **four** from:* 1 disaccharide to monosaccharides ; 2 **R** is water / water required ; 3 hydrolysis reaction ; 4 glycosidic bond broken ; 5 **S** is α-glucose ; 6 detail of enzyme action ; e.g. induced fit or lock and key hypothesis described 7 AVP ; e.g. (β-)1,4(-glycosidic) bond broken	**4**
(b)(i)	*intracellular advantage:* *idea of* control / maintaining balance / efficient metabolism ; e.g. if, (enough) glucose / galactose / monosaccharides, present then no need for, uptake / breakdown, of lactose avoids osmotic problems as no build-up of monosaccharides high quantities of product means no requirement for use in respiration by cell *disadvantage:* loss of product / reduced productivity / product required continuously / slows rate of reaction / ref. to enzyme needing to remain active ;	**2**
(b)(ii)	*any **one** from:* products and enzyme kept separated / AW ; product removed immediately ;	**1**
(b)(iii)	*any **one** from:* inert / unreactive / cannot be digested by lactase / AW ; non-toxic ; insoluble ; long shelf-life ; AVP ; e.g. can create small mesh size suggestion of enzyme attachment to fibres	**1**
(c)	*any **three** from:* 1 ref. to controlled variables ; e.g. constant, pH / temperature 2 take samples at timed intervals ; **A** regular intervals 3 determine, substrate concentration / product concentration ; 4 plot graph of, dependent variable (*y*-axis) against time (*x*-axis) ; 5 ref. to rate of disappearance of substrate **or** ref. to rate of appearance of product ; 6 determine initial rate ;	**3**

22. 9700_s18_ms_21 Q: 3

(a)	*four from:* activity increases and decreases / activity peaks, for both ; **A** both have maximum activity / optimum temperature, at 60 °C activity is 76% at 40 °C for both ; (overall) activity decreases more steeply for free enzyme after, optimum / maximum / 60 °C ; **A** ora at 80 °C free enzyme is inactive / (fully) denatured / 0%, but immobilised enzyme, is still active / is partially denatured / 27% ; for immobilised enzyme, activity is higher (than free enzyme) at all temperatures above 60 °C ;	**4**
(b)	*two from:* (alginate / immobilisation), is protective / has stabilising effect ; **A** enzyme, less / not, exposed (to solution) hydroxide ions do not penetrate the alginate beads ; shape of active site (of immobilised enzyme) is, less / not, disrupted / AW ; **A** active site is (more) complementary to substrate **A** few(er) active sites are, altered / changed few(er) bond(s) within (immobilised) enzyme break ; **A** hydrogen / ionic **R** peptide / disulfide at pH 8 immobilised enzyme is not fully denatured ; **A** pH 7 / 7.5	**2**
(c)	*explanation must match variable stated* *standardised variable* concentration / volume, of, enzyme / substrate, solution ; *explanation for standardised variable* *idea that:* concentration / volume, of, enzyme / substrate, influences the probability of collisions between enzyme and substrate molecules / formation of enzyme/substrate complexes ; **A** number of / frequency of, collisions between substrate and enzyme **or** *standardised variable* use the same method for determining enzyme activity ; e.g. time when samples are taken *explanation for standardised variable 3* ref. to how enzyme activity is measured by conversion of substrate to product ;	**2**
(d)	*two from:* 1 (may be able to) obtain more product (per unit time) ; 2 can use higher temperatures (to obtain more product) / still active at higher temperatures ; **A** thermostable 3 does not denature (as easily as free) if temperatures increase / AW ; 4 immobilised enzyme can be reused / immobilised enzyme can be recovered ; 5 enzyme does not contaminate product ; **A** no effect on quality of product, e.g. taste 6 less, purification (of product) / downstream processing, needed ; **A** idea that downstream processing less, complex / difficult 7 longer shelf-life of enzyme / AW ; **A** durability 8 AVP ; e.g. allows continuous production (rather than batch) some enzymes are difficult to extract **I** ref. to cost / cost effective unqualified **R** reduces effect of end product inhibition	**2**

23. 9700_s18_ms_23 Q: 5

(a)(i)	*three from:* 1 papain higher optimum temperature than ficin / ora **or** temperature is higher for papain for percentage of maximum activity of 100 **A** 100% activity / maximum activity / peak of activity **or** (100% of maximum activity) papain 60 °C v ficin 45 °C ; 2 papain (overall) less steep increase / AW, (to peak) / ora ; 3 papain steeper decline / AW (after peak) / ora ; *for mp 2 and 3 allow ecf for a ref. to time, e.g. rapidly / slowly* 4 papain lower activity at all temperatures between 20 °C and, 54 °C / 55 °C ; 5 papain higher activity at all temperatures above, 54 °C / 55 °C ; 6 ref. to ficin more active over a greater range of temperatures ; **A** ref. to activity at temperatures around 100% maximum 7 comparative, extracted / manipulated, data to support mp, 2–6 ;	**3**
(a)(ii)	ficin, as higher activity at 37 °C / body temperature ;	**1**
(b)	*one from:* (may be able to) obtain more product (per unit time) ; **A** can use in a continuous system (may be) more, thermostable / tolerant to pH changes / AW ; **A** idea that enzyme less likely to denature product, not / less, contaminated with enzyme ; **A** less downstream processing longer shelf-life / AW ; enzyme, easier to recover / can be reused ; AVP ; e.g. ficin may be, costly / difficult, to extract	**1**
(c)(i)	extracellular (enzyme) ;	**1**
(c)(ii)	*any one valid example:* e.g. collagen / elastin ;	**1**

24. 9700_w18_ms_21 Q: 2

(a)	glycosidic ; **I** any qualification of glycosidic, e.g. β,1–4	**1**
(b)(i)	hydrolysis ;	**1**
(b)(ii)	*any two from* (lactose) lowers the water potential (in the lumen of the intestine) / AW ; reduces the water potential gradient (between the intestine and the blood) ; osmosis occurs ; (must be in the correct context)	**2**
(c)(i)	*any two from* pack more beads into the column ; slows the passage of milk through the column ; more time for enzyme to be exposed to substrate ; (small beads have a) larger surface area to volume ratio ; rate of reaction will be faster / AW ; **A** faster reactions will take less time to collect results (at each temperature) ; fast(er), rate of diffusion of, substrate / product ;	**2**
(c)(ii)	*any three from* both have same activity between 0 and 20 °C ; **A** described with values from **Fig. 2.2** between 20 °C and 40 °C, the activity of **F** increases more steeply than **I** ; **F**, has a lower optimum temperature / peaks at a lower temperature / AW, than **I** ; **A** optimum temperature, **F** is 40 °C v **I** is 50 °C at 70 °C, no activity for **F** but there is activity for **I** ; **A** 4% for **I** and 0% for **F** **A** denatured for 0% above the optimum temperature **I** has a steeper decrease of activity ; **I** is active over a greater range of temperatures (than F) ;	**3**

25. 9700_s17_ms_21 Q: 2

(a)	half V_{max} / AW, = 7 (μmol dm^{-3} min^{-1}) / take half of V_{max} of 14 (μmol dm^{-3} min^{-1}) ; **A** description of using the graph to find ½ V_{max} without reference to figures read (substrate concentration) from *x*-axis / AW ; *alternative* plot 1 / [S] = x	**2**
(b)	***allow*** *phosphate group(s) / organic compound for substrate* *if affinity not used, accept idea of ability to form ESC* *check for* ***ora*** **I** *ref. to* competitive inhibition **1** enzyme **B** has a lower affinity for its substrate (than enzyme **A**) **or** the higher the K_m the lower the affinity of the enzyme for its substrate ; **R** if substrate has affinity for the enzyme **2** enzyme **B** needs a higher concentration of substrate to reach, V_{max} / ½V_{max} / K_m (than enzyme **A**) ; **3** AVP ; e.g. enzyme **B** forms fewer ESC in the same unit of time enzyme **B** active site is a less good fit for substrate *idea that* in normal cell enzyme **A** is saturated (with substrate) so works at a constant rate variations in substrate concentration will have less effect on the rate of formation of product by enzyme **A** **I** *ref. to* turnover number(s)	**max 2**
(c)	*marks can be taken from a sketch graph* **1** competitive inhibitor, occupies / competes with substrate for / AW, active site (of the enzyme) ; **2** reduces frequency of collisions (with substrate) / fewer ESCs form ; **R** no ESCs form **3** reduces reaction rate at low substrate concentrations ; ***4*** *idea that* curve with inhibitor is to the right of the curve without inhibitor ; **5** at high substrate concentration / with increasing substrate concentration, the inhibitor has, no / less, effect ; **A** *idea that* substrate outcompetes inhibitor at high substrate concentration **6** therefore V_{max} is the same as it is determined by the enzyme concentration / AW ; **A** explanation in terms of active sites, saturated / fully occupied ***7*** *idea of* intercept to curve gives a higher value for K_m ;	**max 4**

STEMUP.CO.UK

26. 9700_s17_ms_22 Q: 2

(a)	addition of water shown ; **A** H_2O fatty acid(s) and glycerol ;	**2**
(b)	*positive result* emulsion ; **I** on top / throughout **A** milky (layer) / cloudy (suspension) / opaque / white droplets **R** precipitate *ref. to* mixing with / dissolving in / adding / adding to, alcohol / ethanol ; **R** *if incorrect substance added to alcohol, e.g. fatty acids, then allow ecf* then, add / add to, water ; *max 1 for method if heated or added additional chemicals* *max 1 if wrong sequence or all contents into one test tube at once* *no marks if both of above (wrong sequence and heated)* *accept other valid methods*	**3**
(c)	**1** increase (pH2) to pH7, decrease from pH7 (to pH10.5) ; **A** trend described as increase then decrease **or** optimum / peak / maximum activity / 99% / 100% (relative) activity, at pH7 ; **2** steep(er) decrease from, pH7 / optimum, (to pH10.5) ; *in context of steepness of increase from pH2–7* **3** detail either side of optimum (pH2–7 **or** pH7–10.5) ; *pH2–7* less steep (increase) pH5–pH7 / little difference between pH5 and 6 / steepest increase between pH2–4 **or** *pH 7–10.5* steeper decrease between pH 7 and 7.5 / less steep decrease between pH 7.5 and 10.5 **4** activity, pH2–7 / below 7, higher than activity, after pH8 ; **A** in, alkaline / basic, pH / conditions **A** enzyme works better in acidic and neutral conditions ora **A** enzyme works better in acidic than, alkaline / basic, conditions ora **5** enzyme active throughout the pH range ; **6** data / manipulated data, (to support above mps) ; *needs comparison values, pH and, percentage activity / %* **7** *ref. to* partial denaturation at higher pH ; **A** starts to denature	**max 4**
(d)(i)	*suggestion of changed conditions for immobilised compared to free e.g.* (immobilised) support material / AW, affects enzyme action ; support material is charged ; *idea that* free has greater exposure to hydrogen ions **or** immobilised has protection from hydrogen ions ; *idea that* immobilised has changed ability to catalyse ; immobilised has (slightly) altered active site ; **R** *ref. to* denaturation **I** changes to tertiary structure support material causes change to, external / substrate, solution ;	**max 1**
(d)(ii)	can be re-used ; can be easily recovered ; easier downstream processing ; product, not / less, contaminated ; longer shelf life of enzyme ; more stable ; can use higher temperatures (owing to protective matrix) ; more productive ; less time-consuming ; *cost alone is not enough*	**max 1**
	Total:	**11**

STEMUP.CO.UK

27. 9700_s16_ms_22 Q: 1

(a) **A** activation energy / energy of activation ;

B induced fit ; **A** induced fit, model / hypothesis / theory / mechanism

C globular ;

D extracellular ;

E Michaelis-Menten constant ; **A** K_m **[5]**

[Total: 5]

---

28. 9700_s16_ms_23 Q: 2

(a) **(i)** 3.4 μM min^{-1} ; **A** 3.4 μM / min [1]

(ii) 0.15 mM ;; **A** ecf from **(a) (i)**
allow 1 mark if no units given

if answer incorrect allow one mark for evidence of ½ V_{max}
3.4 / 2 = 1.7 [2]

(b) *max 3 if no attempt at description (D) with explanation (E)*

at lower substrate concentrations
1 *(D)* rate of reaction proportional to substrate concentration ; AW
2 *(D)* up to 0.25 mM ; **A** range 0.25–0.30 mM
3 *(E)* not all active sites occupied ;
A few, enzyme-substrate complexes / ES complexes / ESC
A more active site occupied as substrate concentration increases
4 *(E)* substrate concentration is limiting ;

at higher substrate concentrations
5 *(D)* less steep increase in rate (from 0.25 mM) ;
6 *(D)* further increase in substrate concentration gives, no further increase / plateau / levelling out, in rate ; **A** rate remains at 3.4 μM min^{-1}
7 *(D)* greater than / at, 0.45 mM ; **A** 0.46 / 0.47, mM
8 *(E)* enzyme concentration is limiting ; **A** idea that some other factor is limiting
9 *(E)* all active sites occupied / AW ;
10 *(E)* **A** *for mp3 / mp6* description in terms of enzyme-substrate collisions in context ; [max 4]

(c) **(i)** folding / coiling, (of polypeptide chain) ;
tertiary structure ;
(held in position by) *ref. to* R group interactions ;
A two or more bond types in context
brings distant, amino acids / parts of the chain, close ; AW [max 3]

(ii) water ; **A** H_2O [1]

[Total: 11]

---

29. 9700_w16_ms_21 Q: 3

(a) (i) peptide and disulfide ; **R** sulfide [1]

(ii) sequence / arrangement / order, of amino acids ; **I** *ref. to* disulfide bonds [1]

(b) (i) breaking a (covalent) bond with addition of water ; [1]

(ii) peptidoglycan / murein ; **A** carbohydrate / polysaccharide / amino sugar [1]

(iii) *four from*
substrate shape not (exactly) complementary to active site shape / AW ;

active site (partially) flexible / changes shape slightly, when substrate, enters / binds ;
(so) active site and substrate, now complementary / better fit ;

(allows) formation of enzyme-substrate complex ; **A** ES complex / ESC

AVP ; e.g. role of R-groups in active site interacting with substrate lowers, activation energy / E_A, so products form [4]

(c) outside cells ; *can be in a general context or in context of enzymes* [1]

(d) (i) 2.9 mmol ; **A** 2.75–3.0 mmol [1]

(ii) 1 mmol ; [1]

(e) single graph line with lower gradient ;
reaches or approaches plateau ; [2]

[Total: 13]

---

30. 9700_s15_ms_22 Q: 4

(a) either diagram A or B below (or more detailed – e.g. all carbons and all bonds shown in diagram A) ;;
A CH_30 for CH_2OH
I incorrectly numbered carbons

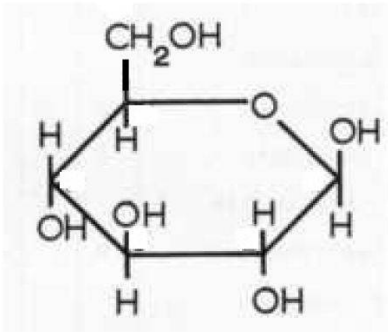


diagram A

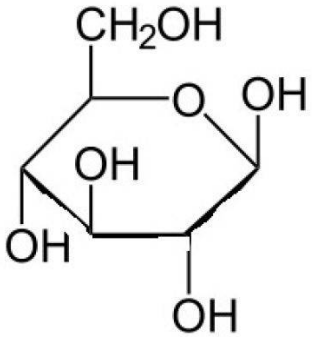


diagram B

if incorrect (e.g. If one or more H missing from the ring in diagram A ***or*** *if an H added to diagram B ring) allow one mark if*:

- hexose ring with oxygen shown in correct position and
- CH_2OH group in correct position and

OH groups of ring in correct position. **[2]**

STEMUP.CO.UK

(b) (i) accept *T. maritima* or **T** and *A.tumefaciens* or **A** throughout for the β-glucosidases
*accept **T** if stated as **B** (as long as **A** is clearly mentioned)*
*if only **A** or **T** stated, look for comparative phrase*
compare optimum temperatures

1 optimum temperature, **A** lower (than **T**) / **T** higher (than **A**) **;**
A maximum activity **A** is at a lower temperature

2 40 °C(**A**) v 85° C(**T**) / **A** lower by 45 °C **;**

3 one difference in shape of curve before or after optimum **;**
e.g. after optimum, **T** does not have the less steep decrease after the initial steep decrease (unlike **A**)
before optimum, steepest increase for **A** is at the lower temperatures, (unlike **T**)

compare activity below and above 55 °C

4 below 55 °C, **A** has a higher activity / above 55 °C **A** has a lower activity, (than **T**) **;**
ora
A has a higher activity at low(er) temperatures and a lower activity at high(er) temperatures ora

5 comparative data to support mp 4 **;**

compare temperature ranges of activity

6 temperature range for activity is greater for **A ;** ora

7 (**A**) spans 80 °C v (**T**) spans 65 °C **; A** (**A**) 10–90 °C v (**T**) 30–95 °C

*compare **L** for both*

8 **A** has a lower, **L** / lowest temperature for (detectable) activity **or** ora
L is 20 °C lower for **A ; A** 10 °C (**A**) v 30 °C (**T**) **;**

9 (at **L**), A (relative) activity = 35%, **T** = 10% **;**

*compare **H** for both*

10 **T** has a higher, **H** / highest temperature for detectable activity **or** ora
H is 5 °C higher for **T ; A** 95° (**T**) v 90 °C (**A**) **;**

11 (at **H**) (relative) activity = 4%, **T** = 60% **;**

if mp 10 data given to support mp 1, then CON = no marks for mp 1 or 10 **[max 4]**

(ii) **1** primary structure, dictates, folding of the polypeptide chain / tertiary structure **;**
A idea that differences in primary structure leads to differences in, secondary / tertiary, structure
A in terms of folding to give the active site

similarity

2 same / (very) similar, (shape of) active site **;**

3 active site (shape) is complementary to / AW, substrate / cellobiose **; R** matches
A ES complex forms

differences

4 differences in, side-chain / R-group, interactions / AW **;**

5 qualified **;** e.g. differences in, numbers / types, of bonds
differences in bonding to give different stabilities
R different bonds without further qualification
R peptide bond

6 suggestion for thermal stability of **T ;** e.g. more bonds / more of a named bond type

7 suggestion of how active site may work in different ways **;**
e.g. at lower temperatures, **T** induced fit mechanism may mean active site does not mould fully round substrate **[max 4]**

[Total: 10]

1.	C
2.	D
3.	C
4.	B
5.	A
6.	A
7.	A
8.	D
9.	D
10.	D
11.	B
12.	B
13.	B
14.	A
15.	D
16.	C
17.	C
18.	C
19.	A
20.	C
21.	D
22.	
23.	
24.	D
25.	B
26.	B
27.	B
28.	D
29.	A
30.	C
31.	C
32.	D
33.	A
34.	D
35.	A
36.	A
37.	B
38.	B
39.	D
40.	D
41.	D
42.	D
43.	B
44.	D
45.	D
46.	A
47.	D

	D

Q1.

Question				Expected Answers	Marks
4	(a)	(i)	A	transcription; (ignore mRNA synthesis)	
			B	translation;	
			C	exocytosis; **R** secretion	**[max 3]**
		(ii)	D	(sub unit of) ribosome	
			E	Golgi apparatus/body;	**[2]**
		(iii)	F	mRNA;	**[1]**
	(b)			active site;	
				(is) specific shape; **A** complementary/other amino acids are the wrong shape to fit, **R** same shape	
				only accepts R groups of these two amino acids; **R** accepts peptide bond	**[2]**
	(c)			correct bond broken (between C-N);	
				involvement of water molecule in breaking the peptide bond shown clearly;	
				two amino acids with free groups as follows	
				$-COOH/-COO^-$ and $-NH_2/-NH_3^+$;	
				A from diagram(s).	**[3]**
					[Total: 11]

Q2.

(b) **(i)** **6** ; **[1]**
(ii) **5** ; **[1]**
(iii) **3** ; **[1]**

(c) curve starting at 0;
but lower;
reaches same plateau but at higher concentration of urea; **[2]**

(d) inhibition is reversible;
enzyme is still active;
inhibitor fits into active site temporarily;
substrate is broken down (reaction does proceed);
same end point;
just takes longer / reaction is slower with inhibitor; **[max 2]**

Q3.

STEMUP.CO.UK

2 **(a)** catalyst ;
active site ;
complementary (to specific substrate) ;
lock and key/induced fit, correctly described ;
enzyme-substrate complex ; **A** E-S complex
lowers activation energy ; **A** Ea
further detail of active site ; e.g. role of **R** groups in active site/catalytic/
binding, site/mechanism to lower Ea [max. 4]

(b) **(i)** (idea of) presence of starch ; [1]

(ii) control ;
to show, enzyme involved/enzyme catalysed reaction/not spontaneous/**AW** ;
enzyme denatured by boiling ; [max. 2]

(c) **A** starch, broken down/converted to glucose (1-) phosphate/AW ; ora for **B**

A at pH 6.5/nearly neutral/AW, enzyme is active idea/AW ;
e.g. ref to optimum at or near 6.5

(B) at pH 2.0/acidic qualified, enzyme is inactive idea/AW ;
e.g. well away from optimum
further detail e.g. specific effects of pH / bonds affected by hydrogen ions;

C enzyme denatured, by boiling/high temperature ;
ref to bonds broken by high temperature ;

(D) glucose phosphate gives, no reaction with iodine/negative
result ; **A** no starch/no substrate added gives, no reaction with iodine/negative result
[max. 4]

(brackets) denote the letter not required for mark

[Total: 11]

Q4.

STEMUP.CO.UK

4 **(a)** **(i)** **A** transcription ;
B tRNA / transfer RNA ;
C ribosome ; **A** subunit of ribosome / ribosomal subunit
treat 70S / 80S or small / large as neutral
D anticodon ; [4]

(ii) *similarities*

made of amino acids / amino acid monomers / polymer of amino acids **A** protein / polypeptides
have quaternary structure / have more than one polypeptide chain ;
four, sub-units / polypeptides ;
haem / porphyrin / prosthetic group(s) ; [2 max]

difference

(four) sub-units / polypeptides, are identical ;
or
haemoglobin has, two different, sub-units / polypeptides ;
or
haemoglobin has alpha and beta polypeptides ;

(catalase) has active site(s) ; **A** Hb has (oxygen) binding site [1 max]

(iii) each, sub-unit / polypeptide, has an active site ;
catalase has four, active sites / haem groups ; [1 max]

(b) iodine in potassium iodide solution / iodine in KI solution / I in KI solution ; **A** iodine solution **R** iodine

Benedict's, solution / reagent ; **A** Benedict's
A Fehling's solution / NaOH and $CuSO_4$ [2]

treat refs to colour changes as neutral

[Total: 10]

Q5.

(c) **(i)** active site ; **ignore** binding / catalytic [1]

(ii) 1 (shape of) **U** / active site, gives specificity ; **A** *ecf* from **(i)**
2 substrate, fits into / binds with, active site / **U** ; **A** *ecf* from **(i)**
3 complementary (shape) / matching shape ;
A 'lock and key' / induced fit **R** 'same shape'
4 further detail of substrate binding to active site ;
5 forms, enzyme-substrate / E-S, complex ;
6 causes stress in substrate / AW ;
7 lowers activation energy / reactions occur at low(er) temperatures ;
8 not used up in reaction / remain unchanged / reusable ;
9 high turnover number / catalyse many reactions per unit time ; [4 max]

Q6.

STEMUP.CO.UK

(c) **(i)** to check that urea is not hydrolysed/broken down, without enzyme ; ora
A there is no reaction without enzyme [1]

(ii) hydrolysis reduces, substrate/urea, concentration ;
urea, hydrolysed/broken down, more quickly in Tube **A** than in Tube **B**;
A ref. to differences in reaction rates

*Tube **A*** enzyme can bind with substrate normally/ES complexes forming (at fast rate) ;
ora *Tube **B***
shape of active site complementary to (shape of) substrate/AW ;

*Tube **B*** (competitive) inhibitor, occupying/binding at/AW, active site ;
ref. substrate unable to enter active site/AW ;

correct data quote from either column to illustrate ; [4 max]

Q7.

4 **(a)** **(i)** hydrolysis / hydrolysing ; **I** catabolic / digestive **R** hydrolsis [1]

(ii) to stop the reaction ; **R** 'stop it working'
by denaturing, the enzyme / sucrase ; **R** incorrect context
A 'change shape of active site'
to make the Benedict's solution, react / AW ; [2]

(b) *description to max 2*

rate increases to a, maximum / plateau ; **A** 'levels off' / remains constant
idea that increase in rate slows ;
11.5 (arbitrary units / au) at 80 - 90, g dm^{-3} ; **A** range 11.4 – 11.6

explanation to max 4 – accept ora where appropriate

substrate concentration is limiting (factor) ;

(at low concentration) *may be given in terms of increasing concentration*
few collisions between enzyme and substrate ;
few, enzyme-substrate / E-S, complexes formed ;
active sites unoccupied ;

(at high concentration / >80 g dm^{-3})
enzyme concentration is limiting (factor) ;
A 'not enough enzyme for substrate to bind to'
maximum number of enzyme-substrate complexes formed ;
active sites , saturated / always occupied ; **A** ref to V_{max} [max 5]

[Total: 8]

Q8.

STEMUP.CO.UK

(c) optimum pH *or* pH at which, lipase / enzyme, works best ; [1]

(d) (i) pH, decreases / AW, over time ;
steep decrease / high rate, in first 5 minutes ; **A** faster
less steep decrease / levels out, correct time ref ; **A** slower
correct, manipulation of data / comparative data quote (ref. to both axes) ;
e.g. pH 8 – 7.3 from 0 – 5 min
pH 7.3 – 6.45 from, 50 / 60, min [2]

(ii) triglyceride / oil, hydrolysed / broken down / digested, to produce (fatty) acids ;
increasing, acids / H^+ / hydrogen ions, decreases / AW, pH ;

accept, triglyceride / lipid, for substrate throughout

steep decrease
ref. enzyme has high initial turnover rate *or* high rate of, collision between enzyme and substrate / ES complex formation ;
(because initially) high concentration of, substrate / triglyceride ;

less steep / levelling / plateau,
substrate, being used up / used up / limiting ;
active sites available *or* fewer enzyme substrate collisions / fewer ES complexes formed;
ref. presence of hydrogen ions, partial denaturation (less steep) / denaturation (plateau);
A description of denaturation [4]

Q9.

4 (a) *this can be answered in the context of penicillinase*
1 complementary shape ;
2 substrate, fits into / enters / binds to / with, active site ;
A enzyme-substrate complex / ESC
3 ref. to specificity ;
4 lock and key / induced fit ; **A** description of induced fit
5 ref. to temporary bonds form with, active site / R groups (of amino acid residues) ;
[max 3]

(b) *shown to max 2*

secondary structure ;
α / alpha, helix ; **R** 'helix' / helical structure unqualified by alpha
β pleated sheet ;
tertiary structure / folding ; **ignore** 3D shape or structure
globular ;

not shown to max 2

amino acids / primary structure / sequence of amino acids ;
(types of) R groups ;
bonds / named bonds ; **A** peptide
quaternary structure ;
prosthetic group ; [max 3]

STEMUP.CO.UK

(c) (i) one lower peak inside line than uncatalysed ;
start and finish at, dotted lines / same energy levels as uncatalysed ; [2]

(ii) activation (energy) / (energy of) activation ; [1]

(d) **1** do not prescribe for viral diseases ;
2 only use when necessary / do not overprescribe ;
3 only available on prescription / not available 'over the counter' ;
4 people must, complete the course / take as instructed ;
R take a long course
5 test to find out which is most appropriate antibiotic to use ;
A use most, appropriate / effective, antibiotics
A use narrow-spectrum antibiotics
6 details of sensitivity test ;
7 rotate / AW, antibiotics / use in combination ; **R** use many antibiotics
8 do not use same antibiotics for humans and animals ; [max 2]

[Total: 11]

Q10.

(d) (i) **1** active site has, specific / particular, shape ;

2 complementary to substrate ; **A** substrate fits into active site

3 ref. to (some enzymes) induced fit mechanism ; **A** described

4 formation of enzyme-substrate complex ; AW

5 lowering, activation energy / Ea ; **A** detail of how activation energy lowered
e.g substrates held close together for bond formation
facilitates transfer of electrons
places strain on bond(s) to be broken [max 3]

(ii) **1** loss of tertiary structure / hydrogen bonds broken / ionic bonds broken ;
R if include disulfide or peptide bonds

2 changes shape / substrate unable to fit, active site; **A** enzyme changes shape so alters active site

3 loss of / AW, globular structure ;

4 hydrophobic groups to outside of molecule ;

5 hydrophilic groups no longer interact with water / AW ; [max 2]

STEMUP.CO.UK

(e) *penalise once for no units*

1 with no cryoprotectant, enzyme (remains), inactive / AW ;
A at 0 mmol of cryoprotectant, 0% (of maximum) activity

2 for both, increasing concentration increases % (enzyme) activity recovered ;
A comparative data quote with ref. to increase *need units*

3 trehalose, steeper curve / AW, up to 10 mmol (cryoprotectant) ; ora **R** rapid

4 at all concentrations (below 90 mmol), trehalose has higher percentage of (maximum enzyme) activity

5 comparative data quote to support either mps 3 or 4 ;
for mp 3 trehalose from 0 to 80% and glycerol from 0 to 10%

6 both cryoprotectants can produce,100% / maximum, (enzyme,activity / recovery) ;

7 trehalose produces, 100% (enzyme) activity / full (enzyme) recovery at,
lower concentrations than glycerol / 30 mmol
compared to, 90-100 (mmol) ; *this is also mp 6*

8 trehalose more effective than glycerol (up to 90 – 95 mmol cryoprotectant) ;
A trehalose is a better cryoprotectant (than glycerol) [max 4]

Q11.

4 **(a)** any one valid ;
e.g.(first) appearance of (brown) colour
use of, colour standards / colour charts
use of colorimeter
time-lapse photography / video [1]

(b) *allow catechol for substrate throughout*
rate of reaction 0 au, no substrate to act on / AW ;

at substrate concentrations lower than 5mM
substrate (concentration) is limiting (factor in rate of reaction) ;
presence of free active sites / enzyme is in excess ;
few collisions between enzyme and substrate ;
rate increases with substrate concentration as more, active sites can be occupied / E-S complexes can form ;
one data quote to support response
V_{max} reached / rate becomes maximum, at 4.5–5 mM substrate concentration;
rate constant / levels out / AW, from 4.5–5 mmol substrate concentration ;

at substrate concentrations greater than 5 mM
enzyme (concentration) becomes limiting (factor) ;
all active sites, saturated / occupied ;
(so) further increase in substrate concentation does not increase rate ; [max 5]

STEMUP.CO.UK

(c) **(i)** curve always lower than that with no inhibitor ; *must be similar shape*
curve reaches the maximum ; **A** curve heading to maximum [2]

(ii) PHBA / inhibitor, similar shape to, substrate / catechol ;
(so) binds to active site ;
blocks access to substrate / fewer (successful) enzyme-substrate collisions ;
reduces rate of, reaction / conversion of substrate to product ;
AVP ;
e.g. inhibitor has a greater effect on rate at lower substrate concentrations
V_{max} reached at higher substrate concentrations
inhibitor forms same interactions with R-groups in active site [max 2]

(d) enzymes work in a limited pH range / either side of optimum pH rate decreases ;
(acid so) presence of H^+ ions, partially denatures / denatures (some), enzymes ;
further detail ; e.g. ref. to breaking ionic or hydrogen bonds
change of active site shape means substrate can no longer fit ;
AVP ; e.g. ref. to antioxidant effect of, lemon juice / citric acid / vitamin C [max 2]

[Total: 12]

Q12.

4 (a) active site;
specific shape / configuration / conformation (in ref to active site);
complementary to substrate / exact / perfect fit (between substrate and active site);
combine to form enzyme-substrate / ES complex;
mould around substrate / substrate alters shape of active site (induced fit); R. induced fit unqualified
ref to temporary bonds / named bond; **3 max**

(b) **(i)** EcoR1; **1**

(ii) sticky ends; **1**

(c) plasmid DNA cut with same restriction enzyme / endonuclease;
DNA and plasmid mixed together / AW; R. inserted
ref complementary / base pairing / C and G on sticky ends pair up;
ref to hydrogen bonding;
ligase forms bonds between sugar and phosphate / phosphodiester bonds; **3 max**

[Total : 8]

Q13.

STEMUP.CO.UK

5 (a) *measure*

disappearance of substrate; **A** measure conc. of substrate

appearance of product; **A** measure conc. of products **2**

(b) active over a wide range of pH/AW e.g. whole range/pH 1-9;

increasing activity as pH increases to, optimum/pH 5;

decreasing activity as pH increases, above optimum/> pH 5;

optimum is, between pH 4 to 5.5/pH 5; **A** any figure between 4-5.5 **3**

(c) (idea of) some enzymes active/all enzymes partly active; **1**

low pH equivalent to high H^+ ion concentration;

(so) enzymes (partly) denatured;

reference to tertiary structure affected;

reference to hydrogen/ionic bonds, disrupted/broken;

(so) active sites changed e.g. no longer complementary to substrate;

(detail) affect on R groups of amino acids (in active site);

(therefore) (few) enzyme-substrate complexes formed; **3 max**

(c) curve same shape with same optimum (at pH 5 - between 2.0 and 3.0 units on y axis);

lower (starting at pH 1 and finishing at pH 9 without touching x axis); **2**

STEMUP.CO.UK

(e) similar/same shape to, substrate/organic phosphates;
R similar structure

occupies/binds/combines/fits into, active site; **R** inhibitor competes with substrate for active site

so blocking/preventing, entry of substrate; (therefore) decreased rate of product/ e-s complex/phosphate, formation (at low substrate concentrations);

inhibitor molecules, not permanently bound to active site/bind briefly;

reference effect of concentration of substrate e.g. inhibitor less effective at high concentrations of substrate

A from sketch graph if given **3 max**

[Total 14]

Q14.

(d) *Penalise once if minutes not used*
(i) 5 minutes. **[1]**

(ii) 10 - 11 minutes. **[1]**

(e) Fatty acids are released.; **[1]**

(f) Steeper decrease from 5 minutes;
Levels off at pH 7.0.; **[2]**

[Total: 11]

Q15.

3 **(a)** *max 2 if no reference to data*
up to substrate concentration of 24 / 25 g dm^{-3}, substrate concentration is limiting ;
24 / 25 to 30 g dm^{-3}, another factor is limiting ;
enzyme concentration / temperature / pH ;
active sites, not filled up to 24 / 25 g dm^{-3} / all filled above 24 / 25 g dm^{-3} ;
A enzyme working at maximum rate
ref to collisions between substrate molecules and enzyme ; [3 max]

(b) same shape starting at the origin and with plateau starting at 24 / 25 g dm^{-3} ;
lower ; **A** plateau that starts between 7–12 au [2]

STEMUP.CO.UK

(c) *either*
competitive inhibitor / effect described in terms of competition ;
same shape as protein / substrate / elastin ; **A** complementary shape to active site **R** same / similar, structure to active site
fits into active site ;
blocking entry of substrate / prevents formation of ES complex ;

or
non-competitive inhibitor / described in terms of not competing ;
fits into, a site other than active site / allosteric site ;
shape of enzyme changes / shape of active site changes ;
active site no longer complementary shape to substrate ;

or
combines permanently with, active site / other site on enzyme ;
e.g. by covalent bonding ;
blocks access to active site / causes tertiary structure to change ;
prevents formation of ES complex ; [3 max]

(d) set up different concentrations of substrate ;
same concentration of inhibitor ;
measure rate of reaction ;

if competitive
lower rate at low substrate concentrations, but at high substrate concentration will reach the same plateau ;
increasing substrate concentration reverses inhibition ;

if non-competitive / irreversible
lower rate / no activity / does not reach the same rate at high substrate concentrations ;
increase substrate concentration does not reverse inhibition ;

accept sketch graphs to show results [4 max]

(e) expands / stretches, during inhalation ;
recoils during exhalation ;
forces air out of alveoli ;
prevents bursting of alveoli ; [2 max]

(f) emphysema ; **A** chronic obstructive, pulmonary / lung disease
A COPD or COLD [1]

[Total: 15]

Q16.

3 **(a)** **(i)** tertiary (structure) ; **A** 3^o [1]

(ii) secondary (structure) ; **A** 2^o, alpha / α, helix [1]

(b) active site ; **A** catalytic site [1]

STEMUP.CO.UK

(d) (i) *reject references to time e.g. rapid, slowly*
as the concentration of, enzyme / lysozyme, increases the percentage of bacteria surviving decreases / AW ; **R** if only 1 named
steep, decline / decrease, 0 to 10 / first two concentrations, for *E. coli* ;
A large percentage difference in *E.coli* surviving at 0 to 10 / first two concentrations
less steep / more gradual, decline / decrease, from 10 to 150 for *E. coli* ;
decline / decrease, shallower / less steep from 0 – ,40 / 60 / 70 / 80, for *S. aureus* ;
A small percentage difference in *S. aureus* surviving from 0 – , 60 / 70 / 80
decline / decrease, more significant / steeper / more abrupt, from 60 / 70 / 80, up to 150 for *S. aureus* ; **A** large percentage difference *in S.aureus* surviving from 60 / 70 / 80, up to 150
always more *S. aureus* than *E. coli* ; ora
all bacteria survive with no lysozyme ;
lysozyme is more effective, at killing / against, *E. coli* / AW ; **A** ora
all *E. coli* killed, at 150 pmol dm^{-3} (of lysozyme) / at highest concentration ;
comparative data quote ; *both axes, both curves*
comparative data quote ; *penalise once for lack of units in both* [4 max]

(ii) different, polysaccharides / peptidoglycans, in cell walls ;

S. aureus, does not have / has less, polysaccharides / peptidoglycans, in cell wall ;
ref to shape of active site ;
ref to shape of, polysaccharide / peptidoglycan (to fit into active site) ;
S. aureus has a capsule / ora ; **A** protective lipids
AVP ; e.g. *S. aureus* produces inhibitor [2 max]

Q17.

2 (a) *marking points are independent*

iodine in potassium iodide solution / I in KI solution / iodine solution ;
R iodine / iodine test
A if 'solution' not used, but clear that it is a solution

positive result = (from yellow / red brown to) blue-black / blue / black ;
R blue-black precipitate [2]

(b) no activity at pH 2.0 **and** pH 9.0, some activity at pH 3.0 **and** 8.0 ;
optimum between pH 5.5 and 6.5 ; [2]

STEMUP.CO.UK

(c) *description*

1 optimum / peak / described, at pH 6.0 ; *allow ecf from graph*
A 'enzyme works best at' / 'most efficient at'
'rate of reaction / activity, is greatest at…'

2 low / no, hydrolysis / activity, with **at least one** correct pH ;

3 data quote (from table) using time ;
e.g. within 10 minutes / change within 2 minutes / 1/t

explanation to max 4 accept ora

4 at optimum pH, most successful collisions ; **A** alternative wording

greater or less than optimum

5 high / low, hydrogen ion concentration ;

6 enzyme denatured (fully) at / <pH2 *or* at / >pH9 ;

7 partial denaturation / AW, at other stated value(s) of pH ;

at any pH – optimum or sub-optimum

8 ref to, hydrogen bonds / ionic bonds ; **R** if other bonds named

9 ref to tertiary structure ; **A** ref to allosteric site

10 shape of active site ;

11 detail of active site ;
e.g. changes to charge on active site / no longer complementary to substrate forms, no / fewer, enzyme-substrate complexes [5 max]

[Total: 9]

Q18.

2 **(a)** denature, sucrase / enzyme ; **A** deactivate
stop the reaction (in each tube at the same time) ;

idea that Benedict's test requires a high temperature ;
ref to reducing sugars ; [2 max]

(b) starts at, the origin / 5 g dm^{-3}, increases to 45–55 g dm^{-3} ;
constant from 80 to 100 g dm^{-3} ; [2]

STEMUP.CO.UK

(c)

description	*conc*	*rate**
	5	0.0036
	10	0.0069
	15	0.0105
	20	0.0133
	50	0.0213
	100	0.0222

penalise lack of units once only

1 increase in rate of hydrolysis to approx 50 g dm^{-3} ;
A decrease in time taken to approx 50 g dm^{-3} / correct rate calculations* to show an increase
2 remains constant / plateaus / levels out / AW, from approx 50 g dm^{-3} to 100 g dm^{-3} ;

explanation to max 4
3 (sucrase / enzyme) hydrolyses / breaks , glycosidic bonds ;
4 forming, reducing sugars / glucose / fructose ;

5 *idea that* concentration is the limiting factor, at low concentration of, sucrose / substrate ;

6 (at low concentrations) active sites, unoccupied / available ;
A as concentration increases, more active sites are occupied / more enzyme-substrate complexes formed / AW

7 at higher concentrations all active sites, occupied / saturated / AW ;
R enzymes for 'active sites'
8 substrate, in excess / AW ;
9 V_{max} reached / working at maximum rate ;

idea that
10 at higher concentrations, enzyme / sucrase, is the limiting factor ; [5 max]

[Total: 9]

Q19.

3 **(a)** spherical / ball-shaped / AW ; **A** round(ed) / circular
has tertiary structure ; **R** 3D
hydrophilic / polar, (R) group(s), on outside / face to watery exterior ;
hydrophobic / non-polar, (R) group(s), in centre ;
water soluble ; [max 3]

(b) **(i)** *idea that plant cell walls and fungal cell walls have different components*
fungal cell walls made of, glucans / chitins / fungal cellulose / different components to plant cell walls ; **A** peptidoglycan / murein
A plant cell walls contain cellulose, but fungi do not
idea of specificity in context of question
enzymes are specific ;
A specificity explained e.g. both substrates not complementary / shape of active site specific to one substrate [2]

STEMUP.CO.UK

(ii) **1** (at optimum pH) maximum / peak, activity ; **A** most efficient / works best
2 above / below, optimum, activity declines ;
A description / graph sketched with pH and rate / activity
3 changing pH changes hydrogen ion concentration ;
4 hydrogen / ionic, bonds (between amino acids), break / disrupted ;
5 hydrogen / ionic, bonds, important in maintaining shape of, tertiary structure / active site ;
R 4 and **5** if refer to disulfide, hydrophobic interactions, peptide
at sub-optimum pH
6 active site / tertiary, shape altered ; **A** enzyme denatured
7 charges at the active site may be affected ;
8 further detail ; e.g. transfer of electrons may not be possible
9 the substrate may be altered by pH changes ; **R** cell wall unqualified
10 (therefore) substrate no longer fits / ES complexes not formed ; [max 3]

Q20.

3 **(a)** **(i)** glucose and fructose ; *ignore monosaccharides* [1]

(ii) **1** active site, gives specificity ; **A** specific active site
ignore ref to specific substrate
2 substrate binds with active site or enzyme-substrate / E-S, complex forms ;
3 complementary (shape) / substrate fits into active site ; **A** 'lock and key'
A matching shape
R 'same shape'
4 induced fit / described ;
5 further detail of substrate and active site ; e.g. binding by hydrogen bonding, e.g. transfer of electrons
6 lowers activation energy / described e.g. causes strain in substrate / AW ; **A** Ea
7 breaks glycosidic bond ;
8 glucose and fructose / products, no longer fit / AW ; [max 4]

(iii) non-competitive (inhibition) ;
irreversible (inhibition) ; [max 1]

(b) **(i)** idea of, hydrolysis / product formation / further metabolism, lowering sucrose concentration (in, companion cells / sink cells) ;
maintains, concentration / diffusion, gradient (between phloem sieve tubes and, companion cells / sink cells) ;
to remove sucrose from the phloem (sieve tubes) ;
AVP ; e.g.ref. easier transport of, glucose / fructose, through membranes ; [max 2]

(ii) ref. facilitated diffusion out / may be lost from cells ;
products / glucose / fructose, are soluble / AW ;
(so) will lower the water potential / water potential becomes more negative ;
causes water to move into cells by osmosis ; **A** osmotic, problems / stress
reactive / easily metabolised, qualified ; e.g. so interferes with, other metabolic processes / cell chemistry **A** more reactive than starch [max 3]

[Total: 11]

STEMUP.CO.UK

Q21.

2 (a) (i) tangent drawn on the graph as close as possible to time 0 e.g. 1.6 / 6 ;
0.27 ;

accept

correct volume of gas	e.g.	2.5	4.3
stated time, up to and including 20 secs		10	20
or			
tangent drawn on the graph before 20 secs		5.8 / 20	

;

correct calculation ; e.g. 0.25 ($cm^3 s^{-1}$), 0.22 ($cm^3 s^{-1}$) **A** 0.215
e.g. 0.29

award one mark if the time is 21–40 s but the calculation is completed correctly [2]

(ii) *accept hydrogen peroxide or reactant for substrate*
initially high concentration of substrate so, rate of reaction high / enzyme activity at a maximum / AW ;
(rate slows as) concentration of substrate decreases ; **A** substrate being used up
no further change in volume / AW, reaction has stopped ;
correct data quote to support explanation(s) ;

correct ref. to number of (successful) collisions;
correct ref. to enzyme-substrate complexes / active sites occupied; [max 3]

(b) 1 (copper ions act as enzyme) inhibitor ; **R** competitive inhibitor
2 non-competitive (inhibition) ;
3 (non-competitive) inhibitor / Cu^{2+}, combines with enzyme at site other than active site ;
4 active site shape / tertiary structure / 3D shape, changes ;
5 active site no longer accepts substrate / enzyme-substrate complex not formed / AW ;
6 independent of substrate concentration / increase in substrate concentration has no effect / AW ;
7 comparative rates quoted from Fig. 2.2 ;
e.g. max, 3.25 $cm^3 s^{-1}$ v 0.22–0.25 $cm^3 s^{-1}$
8 AVP ; e.g. actual rate depends on the relative concentration of inhibitor / AW
V_{max} not reached
effect of ion presence on tertiary structure [max 4]

(c) enzymes are proteins ;
ref. transcription ; *accept description*
ref. to mRNA ; } *in correct context*
ref. translation ; *accept description*
ref. to further folding / glycosylation / modifying, in, RER / Golgi body ; [max 3]

[Total: 12]

Q22.

STEMUP.CO.UK

(e) 1 increasing concentration of ara-ATP decreases enzyme activity;
can be comparison between 0 and 5 / 20 or between 5 and 20
A ref. to rate of DNA synthesis for enzyme activity
2 ara-ATP acting as an inhibitor;
3 substrate unable to bind with active site / fewer enzyme-substrate complexes (formed);
4 further detail;
for either competitive
e.g. competes with substrate for (binding to) the active site / similar, structure / shape, as substrate *or* complementary shape to active site
or non-competitive inhibition
e.g. binds to site other than active site / changes shape of active site [max 3]

Q23.

(b) 1 nitrogen and hydrogen / substrates, bind to / AW, active site ;
2 enzyme-substrate complex (forms) ;

3 ref. lock and key / induced fit, mechanism ;

4 activation energy of reaction is lowered ;
5 example of how activation energy lowered ;
e.g. strain on (triple) bond of, N_2 / (di)nitrogen
A bond broken between nitrogen (atoms)
nitrogen and hydrogen ions held close together for bond formation
transfer of electrons
alternative pathway

6 product / NH_4^+, leaves active site ;

7 ATP, required / used / provided from respiration ;
8 ref. anaerobic conditions for enzyme action ;

9 suggestion as to use of, vanadium / molybdenum, in active site ;
e.g. act as cofactor / coenzyme
transfer of, electrons / protons [max 4]

Q24.

STEMUP.CO.UK

(b) (i) 47.5 °C ; [1]

(ii) *accept activity for relative activity throughout*
accept manipulated data quotes and penalise once for, incorrect / no, units

Fig. 2.2 (relative activity of enzyme at different temperatures)

1 as temperature increases, activity increases up to, optimum / 47.5 °C (*allow ecf from* **(i)**, then decreases ;
A peaks (*for increase then decrease)*

2 activity increases from 30 °C to 47.5 °C, then decreases to 70 °C ; *also mp 1*
or
increase or decrease, described with comparative data (*activity and temperature compared with another activity and temperature*)

3 at higher temperatures (compared to most others) enzyme still active ;

4 high optimum temperature (compared to most other enzymes) ;

Fig. 2.3 (stability over time for enzyme maintained at different temperatures)

5 enzyme becomes less stable over time ;
A activity decreases over time
A description if at least two temperatures described

6 data quote to support ; *activity at two times for any one temperature*
if time 0 or 'start', then assume 100% relative activity
if 100%, assume time 0

STEMUP.CO.UK

7 (over the time period) the lower the temperature, the more stable the enzyme ; ora
A enzyme has higher activity at the lower temperatures
A stated temperatures (at least two) to illustrate the point
e.g. 28 °C higher activity than 40 °C throughout
A 28 °C, highest activity / enzyme most stable (throughout)

8 data quote to support ; *temperatures and (relative) activity (with one time)*

discussion points

9 AVP ; ;

10 *e.g. Fig 2.2*
reason for increasing activity up to optimum / decrease after optimum
e.g. ref. collisions, kinetic energy increase e.g. denaturation at 60–70 °C
R denaturation at 50 °C (but **A** denaturation begins)
suggested reason for higher optimum temperature e.g. more bonds

Fig. 2.3
(suggests that) more molecules become, denatured / inactive, as time progresses
greater stability / higher activity, at 40 °C than 37 °C between 40–50 hours

Fig. 2.2 and 2.3
optimum temperature for activity not most stable temperature
steep decrease in stability at 60 °C in a short time as (nearly complete) denaturation occurs *allow once only*
commercial application e.g. if hydrolysis occurs over a longer time period, better to use a lower temperature than optimum [max 5]

Q25.

(c) *answers may be general or in the context of phloem transport*

active site (with shape) complementary to substrate ;
A description in terms of lock and key (either way round)
I structure
induced fit / described ;
substrate binds to active site / enzyme-substrate complex forms / ESC forms ;
ref. to specificity of enzymes ;
activation energy of reaction is lowered ;
example of how activation energy lowered ;
e.g. reactants held close together for bond formation
transfer of electrons
strain on bonds
alternative pathway
holding the substrate in such a way that the bonds needed to be broken are exposed
product released from, enzyme / active site ;
A enzyme can be used again / enzyme unchanged at end of reaction [max 3]

Q26.

STEMUP.CO.UK

(b) (i) *data quote may help to decide if mp2 is matched*
units must be used at least once in the answer to award mp3

1 as retention time increases percentage of cell wall material digested increases / positive correlation ;
A 'time for digestion' / reverse relationship
R directly proportional

2 results scattered / not all animals fit the pattern / varying percentages for the same retention time ; *not just a data quote*

3 data quote with units (% and h) using both axes ;
e.g. (highest percentage) 65% at 78 hours
(lowest percentage) 35.5 ± 0.5%, 35 hours

4 no retention time shorter than 35 hours and none longer than 88 hours ;
A lowest / shortest and highest / longest
A reverse relationship **A** 'time for digestion'

5 none of the (24) herbivores can digest the cell wall material completely ;
A no more than 65% is digested
not just a data quote [max 3]

STEMUP.CO.UK