

F212: Nodule 1: Enzymes
June 2009-January 2013
Mark schemes

- | |
|---|
| (a) state that enzymes are globular proteins, with a specific tertiary structure, which catalyse metabolic reactions in living organisms; |
| (b) state that enzyme action may be intracellular or extracellular; |
| (c) describe, with the aid of diagrams, the mechanism of action of enzyme molecules, with reference to specificity, active site, lock and key hypothesis, induced-fit hypothesis, enzyme-substrate complex, enzyme-product complex and lowering of activation energy; |
| (d) describe and explain the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity; |
| (e) describe how the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity can be investigated experimentally; |
| (f) explain the effects of competitive and noncompetitive inhibitors on the rate of enzyme-controlled reactions, with reference to both reversible and non-reversible inhibitors; |
| (g) explain the importance of cofactors and coenzymes in enzyme-controlled reactions; |
| (h) state that metabolic poisons may be enzyme inhibitors, and describe the action of one named poison; |
| (i) state that some medicinal drugs work by inhibiting the activity of enzymes |

F212

Mark Scheme

January 2013

Question	Answer	Marks	Guidance
3 (a)	globular ; catalysts ; intracellular ; extracellular / hydrolytic ; inhibitors ;	5	<p>Mark the first answer on each prompt line. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = 0 marks</p> <p>DO NOT CREDIT metabolic (as given in Q) DO NOT CREDIT digestive (as given in Q)</p>

F212

Mark Scheme

January 2013

Question	Answer	Marks	Guidance
3 (b)	1 carry out with and without, Ca ²⁺ / cofactor ; 2 <i>idea of using at least three concentrations (of Ca²⁺) (other than zero) ;</i> 3 keep , concentration / volume of , enzyme / rennin, constant ; 4 keep , concentration / volume of , caseinogen / substrate / milk, constant ; 5 keep , temperature / pH , constant ; 6 measure / AW , appearance of , product / casein or measure disappearance of , substrate / caseinogens or assess cloudiness (of solution) ; 7 over time intervals / after fixed time / end point time ; 8 replicates / repeats ;	5	1 ACCEPT 'use a control with no calcium' 1 ACCEPT calcium as AW for Ca ²⁺ as the question is testing AO3 1 IGNORE increase / decrease , concentration 2 ACCEPT implication of 3 or more concentrations, e.g. 'use several concentrations' 3 IGNORE amount 4 IGNORE amount 5 IGNORE 'use a water bath' unqualified 6 <i>This mp is for measurement of the dependent variable</i> 6 ACCEPT observe as AW for measure appearance disappearance 6 ACCEPT filter and weigh 6 ACCEPT 'assess degree of solubility / insolubility' 7 'measure how much substrate is left after 30 min' = 2 marks (mp 6 and 7) 8 IGNORE repeat / replicate on its own – must imply minimum of 3 in total, i.e. original plus two

Question	Answer	Marks	Guidance
3 (c)	<p>1 idea of cofactors / minerals , being , recycled / used again ;</p> <p>2 idea that in enzyme action total mass of , cofactor / coenzyme , very small compared to total mass of protein ;</p> <p>3 idea that proteins are used for purposes other than enzymes ;</p> <p>4 proteins are not stored in the body but vitamins and minerals are ;</p> <p>5 some enzymes don't need cofactors ;</p>	1	<p>2 AWARD only if the enzyme context is clearly stated</p> <p>3 CREDIT stated example, e.g. muscle / hormones / antibodies.</p> <p>3 IGNORE growth / repair / replace</p>
	Total	11	

Question		Answer	Marks	Guidance
1	(a)			
	(i)	A substrate ; B active site ;	2	Mark the first answer on each prompt line. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = 0 marks.
	(ii)	idea of simple representation of the , process / structure or idea of showing people how it works ;	1	Examples of acceptable responses 'to make the process easy to understand' 'it is a visual representation' IGNORE 'because you don't know exactly what is happening' IGNORE 'because that's the way it works' IGNORE 'because it is still unproven'
	(iii)	supported by , more evidence / new research / more work ; idea of fitting evidence more closely (than lock & key) ;	1 max	ACCEPT example, e.g. X-ray crystallography ACCEPT e.g. 'it has now been found that the enzyme shape changes during the reaction' IGNORE responses in terms of 'because that is how it happens'. Answers must refer to evidence. ACCEPT 'in the lock and key model the lock changes rather than the key'

Question		Answer	Marks	Guidance
(b)	(i)	<p>1 enzyme / LDH , concentration / volume ;</p> <p>2 substrate / lactate, concentration / volume ;</p> <p>3 time ;</p> <p>4 <i>idea that fish should be as closely related as possible ;</i></p> <p>5 pH ;</p>	3 max	<p>Mark the first answer on each prompt line. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = 0 marks.</p> <p>1 IGNORE 'amount / number'</p> <p>2 IGNORE 'amount / number'</p> <p>2 IGNORE 'reactants'</p> <p>1 or 2 CREDIT 'volume / concentration , of solution' once if no reference to enzyme or substrate</p> <p>4 ACCEPT e.g. 'same type of fish'</p> <p>4 IGNORE size / age / sex</p>
	(ii)	L ;	1	<p>Do not award mark if more than one letter given.</p> <p>ACCEPT lactate and water at all temperatures</p>

Question	Answer	Marks	Guidance
(iii)	<p>1 (1°C is) below the optimum temperature / optimum temperature is higher , for this enzyme ;</p> <p>2 (at 1°C) low kinetic energy / KE , of , enzyme / substrate ;</p> <p>3 less chance of substrate entering active site / less chance of ESC formation / fewer collisions between substrate and active site ;</p> <p>4 idea of activation energy harder to reach ;</p>	2 max	<p>1 ACCEPT 'optimum is 10°C' 1 IGNORE '1°C is not the optimum temperature' 1 ACCEPT '1°C is further away from the optimum (than 10°C)' 2 ACCEPT 'molecules' / 'particles' 3 ACCEPT 'fewer ESC formed' 3 ACCEPT 'slower ESC formation' 3 IGNORE denatured 4 ACCEPT 'activation energy is greater'</p>
(iv)	<p>easier for / increased chance of , substrate, entering active site ;</p> <p>more bonds can form / greater surface area for contact (between active site and substrate) ;</p> <p>easier for active site to change shape (as part of induced fit) ;</p> <p>the induced fit , will be easier / AW ;</p>	1	<p>Answers must imply 'easier' or 'quicker' ACCEPT 'fitting into' 'joining' 'binding' IGNORE refs to 'binding to a larger range of substrates' IGNORE refs to ESC ACCEPT 'different bonds can form' ACCEPT '(named) bonds form more easily' DO NOT CREDIT if a candidate thinks that flexibility increases kinetic energy</p>

Question	Answer	Marks	Guidance
(c)	(i) different, amino acids / amino acid sequence / primary structure ; different, (named feature of) secondary / (named feature of) tertiary / quaternary, structure ;	2	ACCEPT 'different R groups present' ACCEPT e.g. more α -helices / different or fewer (named) bonds / (different) prosthetic group / co-factor / ion / co-enzyme / R-groups in different orientation / polypeptide OR chain will fold differently IGNORE 3D IGNORE protein / enzyme , will fold differently
	(ii) different , base / nucleotide , sequence ; different , proportion / ratio , of bases / nucleotides ; different , allele / gene (would code for the polypeptide) ;	2	IGNORE 'different gene sequence' IGNORE mutation ACCEPT different triplet / codon ACCEPT 'number of bases / nucleotides' ACCEPT 'different numbers of A or T / C or G' ACCEPT 'more adenines' etc ACCEPT 'mRNA will be different' IGNORE chromosome
	(d) enzyme could have potential / future , application ; any example of potential application ;	1 max	IGNORE refs to enzyme being useful to the Antarctic fish IGNORE genetic resource or any ref to biodiversity ACCEPT 'could be of use to humans' eg medical use, low temperature washing powder, scientific research

Question	Answer	Marks	Guidance
(ii)	1 ban fishing (in this area / Antarctic) ;	2 max	1 Answers must refer to banning or legislating (and fishing) 1 IGNORE 'legislation' unqualified, 1 IGNORE less fishing unqualified 1 IGNORE 'ban hunting' unqualified
2	<i>idea of</i> quotas / limits on numbers caught ;		2 ACCEPT refs to net / mesh size 2 ACCEPT idea of patrolling / enforcing
3	<i>idea of</i> protecting (this) habitat (from drilling etc) ;		3 CREDIT in terms of maintaining fish's food source 3 IGNORE 'feeding fish' 3 IGNORE refs to 'in National Parks' unqualified 3 e.g. 'protect habitat by banning fishing' = 2 marks (mp1 and mp 3)
4	<i>ex situ</i> (conservation) / captive breeding ;		4 ACCEPT 'in captivity' / AW 4 ACCEPT 'fish farming' 4 ACCEPT ref to sperm / egg, banks
5	<i>idea of</i> promoting other species (for eating) ;		
6	educating people in the fishing industry ;		6 IGNORE education unqualified
	Total	18	

Question	Expected Answers	Mark	Additional Guidance
2	(a) (enzymes are) proteins / used in metabolism / used in named metabolic pathway ; alter rate of (chemical) reaction / lowers activation energy / provides alternative route for reaction / is not changed / is not used up ;	2	ACCEPT 'used in reactions , in organisms / in the body' IGNORE 'biological / enzyme / in nature' ACCEPT does not take part in reaction Note 'speed up metabolic reactions' = 2 marks Mark the first answer. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = 0 marks
2	(b) (i) time ;	1	IGNORE 'how long' IGNORE correct units The M mark can be awarded without a correct P mark
2	(b) (ii) P1 idea of different samples have different concentrations of, catalase / enzyme ;	2	P1 Look for the idea of variation within the sample (e.g. different amounts) CREDIT examples of lack of uniformity such as: breakage of cells / surface area / mixing / disruption of lysosomes / changes to enzyme shape (caused by blending process) / presence of other substances interfering with reaction IGNORE refs to celery being a poor source of catalase M1 ACCEPT 'from same plant'
	M1 source the extract for the whole experiment from a single source ; M2 thorough , mixing , required before use ; M3 filter / purify , extract ; M4 idea of using , known / standard , concentration of enzyme ; M5 commercial source of catalase ;		

Question	Expected Answers	Mark	Additional Guidance
2 (b)	(iii) repeat / replicate ; compare replicate values / identify anomalous results ; mean / range / standard deviation / error bars / % error ; compare results with , others / book / internet , values / results ;	2 max	e.g compare replicates with Table 2.1 IGNORE average Must contain the idea of other investigators ACCEPT 'look up normal values on the internet'
2 (c)	(i) 1 rate , rises / increases , initially ; 2 peak at / maximum at / highest at / decrease after, <u>40</u> (°C) ; 3 (overall) fall more rapid than rise ; 4 idea that before peak / after peak , temperature increase has increasing effect on rate ; 5 comparative figures to support any point ; 6 no , reaction / oxygen produced , at 60(°C) ;	4 max	IGNORE explanations 1 DO NOT CREDIT if 'rate' not stated for this mp only 2 ACCEPT optimum 3 Look for a comparative statement 4 ACCEPT , e.g., line is steeper between 30 and 40 than between 10 and 20. 5 Two temperatures and two rates, with units . Or calculated difference with appropriate units, e.g. rate doubles between 10 and 20°C or $Q_{10} = 2$ 6 ACCEPT rate is 0 at 60 IGNORE units
2 (c)	(ii) 2 ;	1	IGNORE units
2 (c)	(iii) temperature ; maximum / peak / V_{max} ; denatured ; active ;	4	Mark the first answer for each letter . If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = 0 marks ACCEPT kinetic energy / KE ACCEPT optimum / optimum temperature IGNORE descriptions
Total		[16]	

F212

Mark Scheme

January 2011

Question	Expected Answer	Mark	Additional Guidance
2 (a) (i)	blue-black / black / dark blue ;	1	ACCEPT dark purple / purplish-blue DO NOT CREDIT blue or purple unqualified by darkness ACCEPT acceptable colour change
2 (a) (ii)	1 between oxygen and hydrogen (atoms) ; 2 (between) electronegative / δ^- , and electropositive / δ^+ ;	2	CREDIT marking points from clearly labelled diagram max 1 if incorrect charges are on atoms 1 DO NOT CREDIT molecules / ions 2 DO NOT CREDIT ions / + and - 2 ACCEPT slight / partial (negative / positive), charge
2 (a) (iii)	1 hydrogen / H, bonds break ; 2 helix, lost / unravels / AW ; 3 iodine, released / no longer in complex / AW ;	2 max	IGNORE refs to denaturation 2 ACCEPT spiral / coil 3 ACCEPT no longer contained in helix

F212

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January 2011

Question	Expected Answer	Mark	Additional Guidance
2 (b)	<p>1 take samples at a range of times / AW ;</p> <p>B2 same volumes (of solutions) added / removed (each time) ;</p> <p>B3 heat with, Benedict's (solution) / CuSO_4 and NaOH ;</p> <p>B4 (use of) excess Benedict's ;</p> <p>B5 changes to, green / yellow / orange / brown / (brick) red ;</p> <p>C6 remove precipitate / obtain filtrate ;</p> <p>C7 colorimeter ;</p> <p>8 calibrate / zero, using, a blank / water / (unreacted) Benedict's ;</p> <p>9 use (red / orange) filter ;</p> <p>T10 reading of, transmission / absorbance OR mass of precipitate ;</p> <p>11 more transmission / less absorbance, of filtrate, OR greater mass ppt, = more maltose present ;</p> <p>12 using, standard / known, concentrations (of maltose) ;</p> <p>13 (obtain) <u>calibration curve</u> ;</p> <p>14 plot, transmission / absorbance / mass of ppt, against (reducing sugar) concentration ;</p> <p>15 use <u>graph</u> to read off concentration of maltose / AW ;</p> <p>QWC – correct sequence ;</p>	<p>1</p> <p>6 max</p>	<p>B2 must be in context of Benedict's test rather than reaction mixture B3 DO NOT CREDIT boil / warm B3 DO NOT CREDIT if Benedict's added to the mixture at the beginning</p> <p>C6 CREDIT description of method e.g. filtering / centrifuging / decanting</p> <p>8 IGNORE 'control'</p> <p>9 DO NOT CREDIT if colour of filter is incorrect</p> <p>T10 ACCEPT 'measure how much light, does / does not, pass through'</p> <p>11 if unfiltered Benedict's / precipitate is clearly indicated as being present in sample, ACCEPT 'less transmission / more absorbance, = more maltose present'</p> <p>11 DO NOT CREDIT if precipitate is added to colorimeter</p> <p>12 CREDIT 'serial dilutions'</p>
		1	1 of mps B2 to B5, then mp C6 or C7, then mp T10

Question	Expected Answer	Mark	Additional Guidance																														
2	(c) (i)	2 max	<p>1 ACCEPT any time between 3.45 and 3.55 min.</p> <p>3 two maltose concentrations (+ or – chloride) for a given time or two times (+ or – chloride) for given maltose concentration.</p> <p>3 ACCEPT calculated difference</p> <p>3 DO NOT CREDIT if ‘%’ and ‘min.’ not given</p> <p>3 ACCEPT any concentration within $\pm 1\%$ and time within ± 0.05 min.</p>																														
				<p>1 increases / greater / faster ;</p> <p>2 reaction completed in / plateaus after / concentration is 100% after, 3.5 minutes ;</p> <p>3 figures with units to support mp 1 ;</p>																													
2	(c) (ii)	2 max	<p>1 IGNORE ‘coenzyme’</p> <p>2 ACCEPT binds to, active site</p> <p>3 ACCEPT description</p>																														
				<p>1 (acts as a) cofactor ;</p> <p>2 (Cl⁻) binds to, enzyme / amylase / amylose / substrate ;</p> <p>3 enzyme substrate complex / ESC, forms more, easily / quickly ;</p>																													
<p>Allow a + / - 1% for any concentration of maltose and a +/- 2% for the difference in maltose concentrations or absent</p>																																	
<p>The percentage concentration of maltose (%) present every half a minute</p>																																	
<p>Presence or absence of chloride ions</p>																																	
<table border="1"> <thead> <tr> <th></th> <th>0.0 min</th> <th>0.5 min</th> <th>1.0 min</th> <th>1.5 min</th> <th>2.0 min</th> <th>2.5 min</th> <th>3.0 min</th> <th>3.5 min</th> <th>4.0 min</th> </tr> </thead> <tbody> <tr> <td>Chloride ions present</td> <td>0</td> <td>24</td> <td>54</td> <td>70</td> <td>80</td> <td>88</td> <td>95</td> <td>100</td> <td>100</td> </tr> <tr> <td>Chloride ions absent</td> <td>0</td> <td>12</td> <td>20</td> <td>29</td> <td>36</td> <td>40</td> <td>45</td> <td>48</td> <td>50</td> </tr> </tbody> </table>					0.0 min	0.5 min	1.0 min	1.5 min	2.0 min	2.5 min	3.0 min	3.5 min	4.0 min	Chloride ions present	0	24	54	70	80	88	95	100	100	Chloride ions absent	0	12	20	29	36	40	45	48	50
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F212

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January 2011

Question	Expected Answer	Mark	Additional Guidance
2 (c) (iii)	1 temperature ; 2 pH ; 3 enzyme / amylase / chloride, <u>concentration</u> ; 4 substrate / starch / amylose, <u>concentration</u> ; 5 constant / regular, stirring ; 6 (fixed) <u>volume</u> of solution (removed each time for sampling) ;	3 max	Mark the first three answers only regardless of which line they are on DO NOT CREDIT refs to, time 3 IGNORE 'amount' or 'volume' 3 DO NOT CREDIT 'concentration' unqualified 4 IGNORE 'amount' or 'volume' 4 DO NOT CREDIT 'concentration' unqualified
Total		19	

Question	Expected Answer	Mark	Additional Guidance
4 (b)	<p>1 non-competitive (inhibitor) ; (α-amanitin / inhibitor / toxin) fits into, allosteric site / a place other than active site ;</p> <p>2 <u>active site</u> changes, shape / configuration / conformation / structure ;</p> <p>3 substrate no longer, fits / complementary to, <u>active site</u> ;</p>	2 max	<p>3 ACCEPT 'distortion of active site'</p> <p>4 Mark to be awarded in context of active site (although need not be repeated if stated in mp 3) IGNORE ESC</p>
4 (b)	<p>(ii)</p> <p>1 inhibits production of mRNA / mRNA not produced ;</p> <p>2 prevents protein synthesis / AW ;</p> <p>3 e.g. of, specific named protein / (vital) process, that may be affected ;</p>	2 max	<p>1 CREDIT prevents transcription</p> <p>2 CREDIT translation</p> <p>3 e.g. respiration / photosynthesis (as question refers to 'an organism') / haemoglobin / cytochrome C oxidase</p>
4 (c)	(i)	1	IGNORE number / organisation
(c)	<p>sequence / order, of amino acids ;</p> <p>A = ionic ;</p> <p>B = hydrogen ;</p> <p>C = <u>disulfide</u> (bond / bridge) ;</p>	3	<p>ALLOW phonetic spelling</p> <p>DO NOT CREDIT <u>disulfate</u></p>
4 (d)	<p>1 increased <u>kinetic energy</u> ;</p> <p>2 (any part of protein molecule) vibrates ;</p> <p>3 hydrophilic / hydrophobic / hydrogen / ionic, bonds / interactions, break ;</p> <p>4 change in, <u>3D</u> shape / conformation (of protein) ;</p> <p>5 <u>denatures</u> ;</p>	3 max	<p>1 must contain the idea of <u>more</u> than normal</p> <p>3 IGNORE Van der Waals DO NOT CREDIT if disulfide / covalent / peptide bonds are included</p> <p>4 IGNORE tertiary / structure (as in question) IGNORE refs to, active site / enzymes</p>
Total		17	

Question	Expected Answers	Marks	Additional Guidance
3 (a) (i)	X ;	1	
3 (a) (ii)	<p>1 substrate / PABA, and, inhibitor / sulfonamide, similar shape;</p> <p>2 able to, bind / fit into / block, <u>active site</u> ;</p> <p>3 (shape) <u>complementary to active site</u> ;</p> <p>4 both have, hex / benzene / 6-C, (ring) ;</p> <p>5 both have, NH₂ / amine ;</p> <p>6 correct ref to a difference between sulfonamide and PABA ;</p>	3 max	<p>1 ACCEPT similar structure DO NOT CREDIT same shape</p> <p>3 DO NOT CREDIT refs to PABA and sulfonamide being complementary to each other or to the enzyme (alone)</p> <p>6 e.g. only sulfonamide contains S sulfonamide has 1 more NH₂ group sulfonamide has SONH₂ but PABA has N₂ only PABA has COOH group</p>
3 (b) (i)	<p><i>without inhibitor</i></p> <p>1 more, PABA / substrate, molecules enter <u>active site</u> ;</p> <p>2 more, enzyme substrate complexes / ESCs, formed ;</p> <p>3 at low concentration not all active sites occupied / at high concentration all active sites occupied ;</p> <p>4 achieves / reaches, max (turnover) rate / V_{max} ;</p> <p>5 (at high substrate concentration) enzyme <u>concentration</u> limiting ;</p>	3 max	<p>1 ACCEPT more successful collisions between substrate and active site</p> <p>3 ACCEPT active sites filled / no free active sites DO NOT CREDIT active sites run out</p> <p>4 ACCEPT 'cannot work any quicker' DO NOT CREDIT 'optimum rate' or 'rate levels off'</p>

F212

Mark Scheme

January 2010

Question	Expected Answers	Marks	Additional Guidance
3 (b) (ii)	<p><i>with inhibitor</i></p> <p>1 inhibitor / sulfonamide, can, fit / block / bind to / compete for, <u>active site</u> ;</p> <p>2 (occupies it) for a short time / temporary / reversibly ;</p> <p>3 fewer active sites available (for substrate) / AW ;</p> <p>4 (idea of) more substrate reduces chance of inhibitor getting in;</p>	2 max	<p>3 ACCEPT substrate can't access active site</p> <p>4 ACCEPT more ESC formed in context of overcoming inhibition / substrate can out-compete inhibitor</p>
3 (c)	<p>1 mutation ;</p> <p>2 sulfonamide is <u>selective</u>, agent / pressure ;</p> <p>3 resistant survive / non resistant die ;</p> <p>4 (resistance) allele / gene / mutation, passed to, offspring / next generation ;</p> <p>5 (happens) over many generations ;</p> <p>6 AVP ;</p>	4 max	<p>DO NOT CREDIT immune for any mark point</p> <p>3 IGNORE refs to (survivors) breed / reproduce ;</p> <p>5 IGNORE refs to time. Look for generations</p> <p>6 e.g. mutation is, random / spontaneous allele / gene, passed on by, plasmids / horizontal transmission</p>
3 (d) (i)	<p><u>bacteria</u>, killed / destroyed / cannot grow / lyse, in presence of antibiotic ;</p>	1	<p>DO NOT CREDIT 'antibiotic works better' or 'there are no bacteria there' or 'bacteria are broken down'</p>
3 (d) (ii)	streptomycin ;	1	<p>IGNORE '4' as it is the number rather than the name</p>