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.

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.

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.

(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.

(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]

(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]

(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]

(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.

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**

(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]

(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]

(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]

(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]

(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]

(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]

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.

(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.

(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

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.

(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]