AQA A-LEVEL · 7402

BIOLOGY



MARK SCHEME

3.1.4 PROTEINS AND ENZYMES

SCORE	PERCENTAGE
/995	%

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Q1.

(a) 1. Condensation (reaction) / loss of water;
Accept each marking point if shown clearly in diagram.

2. Between amine / NH_2 and carboxyl / COOH;
Accept between amino (group) and carboxylic / acid (group)

2

(b) 1. Hydrogen bonds;
Accept as a diagram
Reject N - - - C / ionic / disulfide bridge / peptide bond

2. Between NH (group of one amino acid) and C=O (group);
OR
Forming β pleated sheets / α helix;

2

(c) 1. Different sequence of amino acids
OR
Different primary structure;
If candidate assumes proteins are the same, accept effect of different pH/ temperature

2. Forms ionic / hydrogen / disulfide bonds in different places;

2

[6]

Q2.

(a) 1. Hydrolysis (of);

2. (Large / insoluble substances) to small(er) / soluble substances;
Ignored named examples
Accept polymer to monomer

2

(b) 1. Active sites are different shapes;

2. So different enzyme-substrate complexes (are formed);
OR
So complementary to different parts of cellulose / substrate;

2

(c) 2×10^{-3} / 2.0×10^{-3} / 2.01×10^{-3};;
If the answer includes additional decimal places, award the marks if it would round to a correct answer
Accept for 1 mark, correct answer not in standard form 0.002 / 0.00201 / 0.002014;
OR
Correct calculation using incorrect figure from table (9.2) 0.003 / 0.0031 / 0.00319 / 3×10^{-3} / 3.0×10^{-3} / 3.19×10^{-3} /

3.2×10^{-3}

OR

Correct calculation with answer expressed as g hr^{-1}, 0.12 / 0.121 / $1.2x10^{-1}$

2

(d) 1. Endocellulase create more ends / increases surface area;

2. For exocellulase to act on / hydrolyse / digest;

2

(e) $\frac{\text{Initial Mass} - \text{Final Mass}}{\text{Initial Mass}} \times 100$

Accept

((final mass – initial mass) ÷ initial mass) × 100

OR

((change in mass) ÷ initial mass) × 100

OR

$100 - (\frac{final\ mass}{initial\ mass} \times 100)$

OR

(1 – (F/I)) × 100

OR

((I – F) ÷ I) × 100 / ((F – I) ÷ I) × 100

OR

((15 – final mass) ÷ 15) × 100 / ((final mass - 15) ÷ 15) × 100

1

[9]

Q3.

(a) 1. Reduces activation energy;

Accept 'reduces E_a'.

2. Due to bending bonds

OR

Without enzyme, very few substrates have sufficient energy for reaction;

Accept 'Due to stress/pressure/tension on bonds' OR 'Due to weakening bonds'.

Ignore references to 'breaking bonds'.

2

(b) 1.93×10^{11};;

Allow 1 max for

$578/3.0 \times 10^{-9}$

1.93×10^{x} when $x \neq 11$

Correct answer with incorrect standard form e.g. 19.3×10^{10}

Accept any number of significant figures ≥2, if rounding

correct (1.926˙ × 10^{11}). Same principle applies to one max answers.

2

(c) 31.4;;

Allow 1 max for

0.44 **and** 1.4

32.8

33.1

30

29.3

Accept any number of significant figures ≥2, if rounding correct (31.4284714).
Same principle applies to 1 max answers.
32.8 = Both readings at 2.5 mmol dm^{-3} (0.44/1.34)
33.1 = Both readings at 2.5 mmol dm^{-3} (0.44/1.33)
30 = Incorrect reading for C (0.42/1.4)
29.3 = Incorrect reading for C (0.41/1.4)

2

(d) 1. (Binding) alters the tertiary structure of the enzyme ;

Max 1
if lyxose acting as an inhibitor
OR if answer linked to lower rate of reaction
OR if lyxose used an energy source/respiratory substrate

2. (This causes) active site to change (shape);

3. (So) More (successful) E-S complexes form (per minute)

OR

E-S complexes form more quickly

OR

Further lowers activation energy;

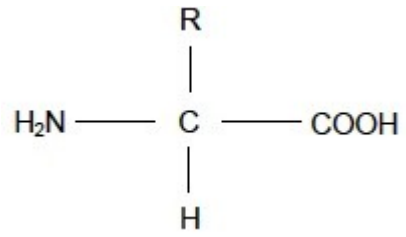
Accept 'acts as a co-enzyme'
Accept description for E-S complexes.

3

[9]

Q4.

(a)



Accept other correct representations.

1

(b) 1. More than one codon codes for a single amino acid;

Accept 'triplet' or 'sequence of 3 bases/nucleotides' for 'codon'.

Reject 'production/produces' for 'codes for'.

Do not infer mp1 from mp2.

2. Suitable example selected from Table 1;

2

(c) 1395;

Accept 1398 and 1401 (for those that include start and/or stop codons)

Allow 2796 or 2802 or 2790

Ignore 'bases/base pairs/bp/bps' written after the numerical answer.

1

(d) ✔CAA → CGA

1

(e) 1. (Both) negatively charged to positively charged change in amino acid;

2. Change at amino acid 300 does not change the shape of the <u>active site</u>
OR
Change at amino acid 300 does not change the tertiary structure OR Change at amino acid 300 results in a similar tertiary structure;

Reference to 'shape' of active site only needed once.

3. Amino acid 279 may have been involved in a (ionic, disulfide or hydrogen) bond **and** so the shape of the active site changes
OR
Amino acid 279 may have been involved in a (ionic, disulfide or hydrogen) bond **and** so the tertiary structure changed;
OR
Amino acid 279 may be in the active site **and** be required for binding the substrate;

Reference to 'shape' of active site only needed once.

Both parts are required for each mark option.

For 'a bond' reject peptide bond.

3

[8]

Q5.

(a) (Insulin stimulates release of osteocalcin – no mark)

1. Osteocalcin causes **more** (release of) insulin;

2. (**More**) insulin causes **more** (inactive) osteocalcin (release);

1. and 2. Idea of more required but other words can be used

1. and 2. Ignore ref. to further

1. and 2. Ignore ref. to more B cells / osteoblasts stimulated

2

(b) 1. (Change in pH) changes / breaks ionic / hydrogen bonds;

Ignore ref. to peptide or sulfur-sulfur bonds

Accept polar bonds

2. Changes tertiary structure;

Ignore changes to primary structure

Reject ref. to active site / enzyme

Accept forms binding site

Ignore 3D

Accept 3°

2

(c) 1. (Insulin) leads to more transport proteins / channel (proteins) / carrier (proteins) for glucose;

Ignore references to opening channels

Accept co-transport / GLUT 1 or 4 protein

2. More glucose (for respiration / glycolysis) enters cell;

*Idea of more required **once** to cover both mark points*

Ignore references to glycogen formation / fat metabolism / enzyme activation

2

[6]

Q6.

(a) Correlation coefficient **and** because looking for correlation / relationship / association between two variables / between B cells destroyed and CD20;

Accept Pearson and Spearman

Accept factor for variable

Wrong test or wrong reason = 0 marks

1

(b) 1. The more CD20 (on B cells), higher the percentage of / more B cells destroyed / more effective it is;

Ignore ref. to 'positive correlation' unqualified

Ignore ref. to correlation vs. causation

Ignore ref. to effects on the immune system

2. (At best) only destroys (about) 80% of B cells

OR

In no cases are all B cells killed;

3. Don't know % / proportion of cancer cells killed;

4. Won't cure CLL / cancer / slows but doesn't stop CLL / cancer;

5. Little effect below (about) 5 CD20 on cells;

Ignore ref. to little effect where little CD20

3 max

(c) 1.8×10^{8};;

If correct difference but expressed in non-standard form, award 1 mark;

Award 1 mark if answer given as 1.8×10^{-8}

2

(d) 1. Mutation changes the tertiary structure / amino acid sequence of transcription factor;

Do not accept unqualified statements about non-functional transcription factor – this is in stem of question

Answers must be in context of transcription factor, not CD20, or generic statements

2. Transcription factor not complementary to / cannot bind to CD20 gene / CD20 DNA;

Do not accept unqualified statements about non-functional transcription factor – this is in stem of question

Answers must be in context of transcription factor, not CD20, or generic statements

Accept TF cannot bind to promoter (on DNA)

3. Little / less / not enough / no mRNA for CD20 produced
OR
Little / less / not enough / no (mRNA for) CD20 translated / produced;

4. (Not enough CD20 so) nothing / little for Rituximab to bind to, so few / no B cells destroyed;

Accept converse for cells with a lot of CD20

Accept lower median percentage for fewer cells destroyed

3 max

[9]

Q7.

(a) Biuret;

Ignore any other detail

Accept

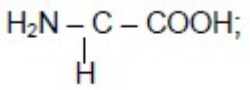
- *Copper sulfate and sodium hydroxide*
- *$CuSO_4$ + NaOH*
- *Alkaline copper sulfate*
- *Copper sulphate and sodium hydroxide*
- *Alkaline copper sulphate*
- *Biurette*
- *Buiret*
- *Biruet*

- *Bieuret*

Reject burette or Beirut

1

(b) Draw around



1

(c) Nitrogen;

Ignore N

1

(d) Choice: (Student's) *t*-test;
Reason for choice: Looking for differences between two means;

Reason: Allow comparing contrasting two means

Explanation: Difference is significant / not due to chance because the P value is 0.04 / is less than 0.05;

Explanation: Assume 'it' means difference

Explanation: Reject result / data is significant / not due to chance

Explanation: do not accept P value is less than 0.04

3

[6]

Q8.

(a) 1. Low starch, fewer copies;
2. Ranges overlap almost completely;
OR
Ranges overlap from 2 − 13 copies;
3. (surprisingly) very few / 2 or 3% have only 2 copies / are diploid;
4. the mode / highest percentage for low starch is 4 copies and for high starch is 6;
5. the range / spread is greater with high starch;

4. "most people" is not equivalent to mode

3 max

(b) 1. More mRNA / more transcription;
2. More translation / enzyme;
3. So reaction faster;

The idea of "more" must be stated at least once.

2. Accept 'amylase' for enzyme

3. "More starch digested" is insufficient

3

(c) 1. Mutation(s) produce extra copies of (*AMY1*) gene;
2. Those with more copies / this adaptation/mutation reproduce / survive better on high starch diet;
2. And pass on multiple copies / this adaptation/mutation (to offspring);

Ignore ref. to single allele/gene

3

[9]

Q9.

(a) 6 (g dm^{-3});

1

(b) Correct answer of (−)0.14;
1 mark for correct difference in concentration (5) divided by 35 / (69 − 64) ÷ 35 / 1 ÷ 7

Ignore +/- sign

Ignore additional d.p.

Accept 0.31(4) for 1 mark if female data used

2

(c) 1. Protein content decreases with age and decreases more in females;
2. Difference (between sexes) only significant at 95 years because SDs do not overlap;
OR
Differences not significant because 2 × SD would overlap;

2

(d) 1. Produce known concentrations of protein;
2. Measure absorbance of each concentration
OR
Measure each concentration with colorimeter;
3. Plot a graph of absorbance on y-axis against concentration (on x-axis) and draw curve;
4. Use absorbance of sample to find protein concentration from curve;

1. Idea of known concentrations required.

Accept % transmission / absorption for absorbance

3 max

(e) 1. (Lower plasma protein concentration suggests) fewer antibodies;

Ignore ref. to other proteins.

Reject answers which refer to white blood cells as proteins.

1

[9]

Q10.

(a) 1. Binary fission;
2. Replication of (circular) DNA;
3. Division of cytoplasm to produce 2 daughter cells;
4. Each with single copy of (circular) DNA;

1. Ignore reference to 'chromosome'

2. Ignore 'copy'.

4. Ignore references to number of plasmids.

2 max

(b) 1. Both denatured (by high temperature);
2. Denaturation faster at 60 °C due to more (kinetic) energy;
3. Breaks hydrogen / ionic bonds (between amino acids / R groups);
4. Change in shape of the active site / active site no longer complementary **so** fewer enzyme-substrate complexes formed / substrate does not fit;

3. Ignore references to disulphide bonds

*3. Accept (at 60 °C) Change in shape of the active site / active site no longer complementary **so** no enzyme-*

substrate complexes formed / substrate does not fit;

4

(c) 1. To digest protein;
2. (So) they can absorb amino acids for growth / reproduction / protein synthesis / synthesis of named cell component;
OR
(So) they can destroy a toxic substance / protein;

1. For 'digest' accept 'break down' here.

2. Accept '(so) they can destroy antibodies / antibiotics / viral antigens / bacterial antigens'

2

(d) 1. Hydrolyse (peptide bonds) to release amino acids;
2. Amino acids can cross (cell) membrane;
OR
Dipeptides cannot cross (cell) membrane;
OR
Maintain concentration gradient of amino acids for absorption;
OR
Ensure (nearly) maximum yield from protein breakdown;

2. Ignore references to crossing gut membranes.

2. Accept 'there are carrier proteins for amino acids'

2. Accept 'no carrier proteins for dipeptides'

2

[10]

Q11.

(a) 1. (DNA) helicase;
2. (DNA) polymerase;

List Rule Applies

Accept (DNA) ligase / Primase / telomerase / Topoisomerase / DNA gyrase

Reject RNA

Accept phonetic spellings

2

(b) 1. Changes tertiary structure of the enzyme;
2. (Enzyme) active site formed / able to be formed / active site becomes complementary;

1. Accept tertiary symbol 3°

1. Ignore 3D

2. Reject refs to inhibition / inhibitors

2. Ignore refs to E-S complexes form

2. Ignore refs to substrate phosphorylation

2

(c) (Phosphorylation / phosphate) makes substrates more reactive / raises their energy level(s) / lowers activation energy for the reaction;

Ignore provides energy unqualified

Ignore refs to kinetic energy unqualified

1

(d) 1. ATM will not bind to (broken) DNA;
2. DNA not repaired / cell still has broken DNA;
3. Cell division continues / tumour forms;
4. Tumour suppressor (gene) not effective / not activated;
5. May have no effect in diploid / heterozygous (organism);
6. (Which) still has a functional ATM / ATM gene;

3 max

[8]

Q12.

(a) 1. Sodium ions actively transported from ileum cell to blood;

2. Maintains / forms diffusion gradient for sodium to enter cells from gut (and with it, glucose);

3. Glucose enters by facilitated diffusion with sodium ions;

3

(b)

Biochemical test	Liquid from beaker	Liquid inside Visking tubing
Biuret reagent		✔
I_2/KI		✔ or blank
Benedict's	✔	✔

1 mark for each correct row

3

(c) 1. Biuret: protein molecules too large to pass through tubing;
Neutral: enzyme molecules

2. Iodine in potassium iodide solution: starch molecules too large to pass through tubing;
If no tick in 04.2, allow no starch hydrolysed

3. Benedict's: starch hydrolysed to maltose, which is able to pass through tubing.
Reject: glucose

3

[9]

Q13.

(a) 1. IV on x axis and DV on y axis **and** both axes on linear scales;

2. Axes labelled clearly and with correct units separated from variable by solidus or in brackets;

3. All rates calculated correctly;

4. Points plotted correctly **and** joined by ruled lines and no extrapolation;

4

(b) Yes:

1. Expect optimum temperature of enzyme to be same

OR

Similar to temperature where bacterium lives;

2. Optimum temperature for enzyme (appears to be around) 15 °C;

No:

3. Need data from more temperatures (between 10 °C and 20 °C);

4. Data for only isolated enzyme

OR

Isolation may affect activity;

4

(c) 1. Initial / starting substrate concentration

2. Enzyme concentration

3. pH.

*Any **2** for **1** mark*

1 max

[9]

Q14.

(a) Lactase hydrolyses lactose in to glucose (and galactose);

1

(b) No lactase in the milk
OR
Enzyme can be reused.

1

(c) 100 cm^3 $minute^{-1}$ is too fast to bind to active site / converse for 50 cm^3 $minute^{-1}$;

1

(d) 14.1(4);

1

(e) 1. Galactose is a competitive inhibitor / attaches to the active site (of lactase);

2. Fewer enzyme substrate complexes formed.

2

[6]

Q15.

(a) Student was measuring change in pH
OR
Buffer would maintain a constant pH.

1 max

(b) 1. Volume of suspension of lipids;

2. Concentration of suspension of lipids;

3. Volume of lipase solution;

4. Temperature;

2 max

(c) Boiled lipase solution;

1

(d) –0.34 = 2 marks

0.34 = 1 mark

2

(e) 1. Fatty acids produced;

2. Curve levels off as all substrate used up.
accept the lower pH inactivates / denatures the enzyme

2

(f) 1. Faster fall in pH **and** levels off at same point;

2. More enzyme = substrate complexes formed;

3. Same amount of fatty acids produced / product

3

[11]

Q16.

(a) 1. A = β glucose;

B = Adenosine triphosphate;
do not accept ATP

2

(b) 1. Saturated;

1

2. Fatty acid;

1

(c) 1. Peptide bond shown correctly;

2. Rest of dipeptide structure shown correctly;

2

(d) Water;

1

[7]

Q17.

(a) 1. Increases because more enzyme-substrate complexes formed;
Neutral; more collisions

2. Levels off because all enzyme molecules involved in enzyme-substrate

complexes (at a given time)

1. and 2. Accept ES

2. Reject enzymes are used up

OR

Levels off because no free active sites (at a given time)

OR

Levels off because enzyme (concentration) is limiting factor.

2

(b) 1. Competitive inhibitor binds to active sites of enzyme but non-competitive inhibitor binds at allosteric site / away from active site;

2. (Binding of) competitive inhibitor does not cause change in shape of active site but (binding of) non-competitive does (cause change in size of active site);

3. So with competitive inhibitor, at high substrate concentrations (active) enzyme still available but with non-competitive inhibitor (active) enzymes no longer available;

4. At higher substrate concentrations likelihood of enzyme-substrate collisions increases with competitive inhibitor but this is not possible with non-competitive inhibitor;

4

(c) Reaction with non-competitive inhibitor has the same value of K_m as with no inhibitor / value is 5 (g dm^{-3}) / reaction with competitive inhibitor has higher K_m value than with no inhibitor / value is 7 (g dm^{-3}).

1

[7]

Q18.

(a) 2 to 11;

1

(b) ± 2.0;

Data show great variation (around mean)

OR

4.4 ± 2 × SD includes most of the values measured.

2

(c) 1. Shows a positive correlation;

2. Their probability of getting this correlation by chance is less than 0.0001;

Allow less than 0.01%

3. Correlation is highly significant.

Reject 'results' are significant / not due to chance

3

(d) 1. Little digestion of starch by salivary amylase

OR

starch in mouth for a short period

OR

salivary amylase inactivated by stomach acid;

2. Amylase also secreted by pancreas;

3. So (most) starch digestion occurs in small intestine.

3

[9]

Q19.

(a) 1. Replacement of a base by a different base (in DNA);

1

(b) 1. (Depends on) size / mass (of protein);

2. (Depends on) charge (of protein);

Accept for 2 marks 'Smaller / more highly charged move further'

2 max

(c) 1. Each protein has a different tertiary structure;

2. (Each) antibody has a specific antigen / binding / variable region / site;

3. So, (each antibody) forms different antigen-antibody complex
OR
(each antibody) only binds to complementary (protein);

3

(d) 1. Less NL3;

2. More NR2A **and** NR2B;

2

(e) 1. Higher ratio NR2B to NR2A with mutation;

Accept 'more' as equivalent to 'ratio'

2. (Perhaps) better memory in mice with mutation;

2

[10]

Q20.

(a) 1. (ESCs) can replace any type of (heart) cell;

Accept named type of cell, e.g. heart muscle cell

1

(b) 1. Might divide out of control;

2. Leading to tumour / cancer;

2

(c) 1. Shows the effects of surgery;

2. Allows effects of transplants / treatment to be seen;

Allow in either order

2

(d) 1. Other cell types cause some increase but most of increase due to cardiomyocytes;

2. Large SD, so some not much increase / no better than control;

3. Overlap of SDs indicates / suggests no significant difference;

3

(e) 1. Greater blood supply (to damaged areas);

2. Bringing more oxygen / glucose for respiration;

3. Brings more amino acids for protein synthesis;

4. For cell repair / mitosis / division;

3 max

(f) 1. Measure diameter of field of view and calculate area;

2. Using micrometer slide and eyepiece graticule;
Accept descriptions

3. Count number of capillaries in large number of fields of view and calculate mean;

4. Select fields of view randomly

4

[15]

Q21.

(a) Concentration of substrate solution / of enzyme solution / pH.

1

(b) 1. 2.5 / 0.04;
1 mark for correct value

2. g dm^{-3} $minute^{-1}$ / g dm^{-3} s^{-1};
1 mark for related unit

2

(c) 1. Initial rate of reaction faster at 37 °C;
2. Because more kinetic energy;
3. So more E–S collisions / more E–S complexes formed;
4. Graph reaches plateau at 37 °C;
5. Because all substrate used up.
Allow converse for correct descriptions and explanations for curve at 25 °C

5

[8]

Q22.

(a) Deoxyribose.

1

(b) 1. Thymine 18 (%);
2. Guanine 32 (%).

2

(c) DNA polymerase.

1

(d) 1. (**Figure 1** shows) DNA has antiparallel strands / described;
2. (**Figure 1** shows) shape of the nucleotides is different / nucleotides aligned differently;
3. Enzymes have active sites with specific shape;
4. Only substrates with complementary shape / only the 3' end can bind with active site of enzyme / active site of DNA polymerase.

4

[8]

Q23.

(a) Translation.

1

(b) Transfer RNA / tRNA.

1

(c) TAC;

UAC.

2

(d) Have different R group.

Accept in diagram

1

(e) 1. Substitution would result in CCA / CCC / CCU;
2. (All) code for same amino acid / proline;
3. Deletion would cause frame shift / change in all following codons / change next codon from UAC to ACC.

3

[8]

Q24.

(a) **Two** suitable suggestions;
E.g.
1. (Are mammals so) likely to have same physiology / reactions as humans;
2. Small enough to keep in laboratory / produce enough milk to extract;
3. (Can use a) large number.

Ignore references to ethical issues

2 max

(b) 1. Hydrolysis of lipids produces fatty acids;
2. Which lower pH of mixture.

2

(c) 1. (Bile-activated lipase / it) increases growth rate (of kittens);
2. Results for formula with lipase not (significantly) different from breast milk / are (significantly) different from formula milk alone;
3. Showing addition of (bile-activated) lipase is the likely cause (of increased growth);
4. Lipase increases rate of digestion of lipids / absorption of fatty acids.

3 max

[7]

Q25.

(a) Any **two** of the following:
Concentration of enzyme
Volume of substrate solution
pH.

Allow same concentration of substrate

1

(b) Ratio between 5.18:1 and 5.2:1
Initial rates incorrect but correctly used = 1 mark.

Allow 1 mark if rate at:

60°C = 0.83g dm^{-3} s^{-1} /49.8g dm^{-3} $minute^{-1}$

OR

37°C = 0.16g dm^{-3} s^{-1} /9.6g dm^{-3} $minute^{-1}$

2

(c) At 60 °C:
1. More kinetic energy;
2. More E–S complexes formed.

Allow converse for 37 °C

2

(d) Different times:
1. Higher temperature / 60 °C causes denaturation of all of enzyme;

Accept converse for 37 °C

2. Reaction stops (sooner) because shape of active site changed;

Reject if active site on substrate

Different concentrations of product (at 60 °C)
3. Substrate still available (when enzyme denatured);
4. But not converted to product.

4

[9]

Q26.

(a) Box around single nucleotide.

1

(b)

DNA strand	**Percentage of each base**			
	A	**C**	**G**	**T**
Strand **1**	(16)	**34**	**21**	**29**
Strand **2**	**29**	(21)	(34)	**16**

2 rows correct = 2 marks;
1 row correct = 1 mark.

2

(c) 1. Reference to DNA polymerase;

2. (Which is) specific;
3. Only complementary with / binds to 5' end (of strand);

Reject hydrogen bonds / base pairing

4. Shapes of 5' end and 3' end are different / description of how different.

4

[7]

Q27.

(a) 1. Helicase;
2. Breaks hydrogen bonds;
3. Only one DNA strand acts as template;
4. RNA nucleotides attracted to exposed bases;
5. (Attraction) according to base pairing rule;
6. RNA polymerase joins (RNA) nucleotides together;
7. Pre-mRNA spliced to remove introns.

6 max

(b) 1. Polymer of amino acids;
2. Joined by peptide bonds;
3. Formed by condensation;
4. Primary structure is order of amino acids;
5. Secondary structure is folding of polypeptide chain due to hydrogen bonding;

Accept alpha helix / pleated sheet

6. Tertiary structure is 3-D folding due to hydrogen bonding and ionic / disulfide bonds;
7. Quaternary structure is two or more polypeptide chains.

5 max

(c) 1. Hydrolysis of peptide bonds;
2. Endopeptidases break polypeptides into smaller peptide chains;
3. Exopeptidases remove terminal amino acids;
4. Dipeptidases hydrolyse / break down dipeptides into amino acids.

4

[15]

Q28.

(a) 1. Maltose;
2. Salivary amylase breaks down starch.

2

(b) Maltase.

1

(c) (Mimics / reproduces) effect of stomach.

1

(d) 1. Add boiled saliva;
2. Everything same as experiment but salivary amylase denatured.

2

(e) 1. Some starch already digested when chewing / in mouth;
2. Faster digestion of chewed starch;
3. Same amount of digestion without chewing at end.

Accept use of values from graph

3

[9]

Q29.

(a) 1. In phospholipid, one fatty acid replaced by a phosphate;

Ignore references to saturated and unsaturated

Accept Pi/PO_4^{3-} / (P)

Reject P/Phosphorus

Accept annotated diagrams

1

(b) 1. Add ethanol, then add water;

Reject ethanal/ethonal

Accept 'Alcohol/named alcohol'

2. White (emulsion shows lipid);

Accept milky – Ignore 'cloudy'

Sequence must be correct

If heated then DQ point 1

Reject precipitate

2

(c) Saturated single/no double bonds (between carbons)
OR
Unsaturated has (at least one) double bond (between carbons);

Accept hydrocarbon chain/R group for 'between carbons' for either

Accept Sat = max number of H atoms bound

'It' refers to saturated

1

(d) 1. (Fat substitute) is a different/wrong shape/not complementary;
OR
Bond between glycerol/fatty acid and propylene glycol different (to that between glycerol and fatty acid)/no ester bond;

2. Unable to fit/bind to (active site of) lipase/no ES complex formed;

If wrong bond name given (e.g. peptide/glycosidic), then penalise once

2

(e) It is hydrophilic/is polar/is too large/is too big;

Ignore 'Is not lipid soluble'

1

[7]

Q30.

(a) 1. (before reaction) active site not complementary to/does not fit substrate;

2. Shape of active site changes as substrate binds/as enzyme-substrate complex forms;

Note. Points 1 and 2 may be made in one statement and 'complementary' introduced at any point.

Points 1&2 – active site mentioned once applies for both points

Point 2 – Ignore references to how shape change is caused

3. Stressing/distorting/bending bonds (in substrate leading to reaction);

2 max

(b) 1. Tangent to curve drawn;

Tangent drawn at about 10 minutes

2. Value in range of 8 to 11;

1 mark only for correct answer

2

(c) 1. (Rate of) increase in concentration of maltose slows as substrate/starch is used up
OR
High initial rate as plenty of starch/substrate/more E-S complexes;

Reject ref. to amylase being used up

2. No increase after 25 minutes/at end/levels off because no substrate/starch left;

Accept 'little'

Ignore references to substrate a limiting factor

2

(d) 1. Make/use maltose solutions of known/different concentrations (and carry out quantitative Benedict's test on each);

2. (Use colorimeter to) measure colour/colorimeter value of each solution and plot calibration curve/graph described;

Axes must be correct if axes mentioned, concentration on x-axis and colorimeter reading on y-axis

3. Find concentration of sample from calibration curve;

3

[9]

Q31.

(a) 1. Different parts/areas/amino acid sequences (of amyloid-precursor) protein;

Accept APP

2. Each enzyme is specific/fits/binds/complementary to a different part of the APP;

Point 2 subsumes point 1 and is worth 2 marks total.

2

(b) 1. Peptide bond broken;

2. Using water;

Hydrolysis in stem

2

(c) 1. Mutations prevent production of enzyme(s)/functional enzyme;

2. (Increase in β-secretase) leads to faster/more β-amyloid production
OR
(Decrease in α-secretase) leads to more substrate for β-secretase;

'This' must refer to α-secretase

3. (Leads to) more/greater plaque formation;

3

(d) 1. (Inhibitor) binds to/blocks active site of β-secretase/enzyme;
2. Stops/reduces production of β-amyloid/plaque;

2

(e) 1. Some β-amyloid required/needed (to prevent side effects)
OR
(Some) β-secretase needed;
Accept 'Both enzymes needed'
2. Leads to build-up of amyloid-precursor protein (that causes harm)
OR
Too much product of α-secretase (causes harm);
Accept build-up of substrate (leads to harm)

1 max

[10]

Q32.

(a) 1. Change in DNA base/nucleotide (sequence);
Accept: mutation in DNA base (sequence).
Accept: deletion/substitution/addition of a DNA base/nucleotide.
2. Change in amino acid (sequence)/primary structure;
Reject: different amino acid formed.
Ignore: change in code for amino acid.
3. Alters (position of) hydrogen/ionic/disulfide bonds;
4. Change in tertiary structure (of receptor);
Reject: any reference to active site.
Ignore: 3°.

4

(b) 1. (Receptor) is not complementary
OR
(HIV) cannot bind/attach and enter/infect (helper) T cell;
Accept: 'complimentary'.
Accept: invade as alternative to infect.
2. No replication (of virus)
OR
No destruction of (helper) T cell;
Accept: reproduction (of virus).

2

(c) 1. Low/lower exposure to HIV (in Europe)
OR
Low/lower number of HIV/AIDS (infections/cases);
Accept: converse.
2. (HIV) has only been present for a short time period
OR
(HIV relatively) recently evolved;
3. Mutation/CCR5 has been around for many years;
Accept: frequency of mutation has always been high.
4. Mutation/CCR5 is advantageous (for something else);

2 max

[8]

Q33.

(a) Any **one** from:

1. Numerical readings / not subjective / colour change subjective / gives quantitative data / not qualitative / gives continuous data;
2. Greater accuracy;

Accept greater precision

1 max

(b) Fatty acids produced;

1

(c) 1. No more (fatty) acids produced;
2. All triglycerides/fat//lipids/substrate used up / enzyme denatured;

2

(d) 1. Line starting at same point and falling above original line;
2. Levels off at same pH, but later;

Accept the line still falling at 4 minutes

Do not credit if levels off at higher pH

2

[6]

Q34.

(a) Ribosome/rough endoplasmic reticulum;

Ignore RER or endoplasmic reticulum unqualified

1

(b) 1. Does not digest protein inside cells;

Accept named examples

2. So (pancreatic) cell/tissue/function not destroyed/damaged;

2

(c) (i) Peptide (bond);

1

(ii) 1. Inhibitor is a similar shape to the substrate;
2. (Inhibitor) blocks active site/is complementary to the active site/binds to the active site (of trypsin);
3. Substrate can't bind to active site / no/fewer ES complexes formed;

3

[7]

Q35.

(a) Quaternary (structure);

Accept phonetic spelling eg quarternary/quarternery /4°

Award no mark for quaternary as part of a list

1

(b) 423;

1

(c) 1. Oxyhaemoglobin formed/ haemoglobin is loaded/ uptakes/associates/binds with oxygen in area of higher ppO_2 / in gas exchange surface/lungs/gills;

Reference to "react with" = max 1

Accept: reversible interaction with oxygen

Ignore: haemoglobin is carried / contained in red blood cells

2. (oxygen) unloaded/dissociates from/released (in area of lower ppO_2 / in capillaries/to cells/tissues);

2

(d) (i) 56(%);

Accept responses in the range 54-58(%)

1

(ii) 1. (Anaemia curve shifted to right) haemoglobin has lower affinity for oxygen / binds less tightly;

Assume reference is to haemoglobin of anaemia unless stated

2. releases more oxygen / oxygen is released quicker / oxygen dissociates/ unloads more readily to muscles/tissues/cells;

3. (For) respiration;

Accept: even with a lower haemoglobin concentration / meet demand for ATP/energy;

3

[8]

Q36.

(a) C.

Ignore name of organ

1

(b) E.

Ignore name of organ

1

(c) 1. Active site (of enzyme) has (specific) shape / tertiary structure / active site complementary to substrate / maltose;

Reject active site on substrate.
Must have idea of shape

Assume "it" = maltase

Accept (specific) 3D active site

Reject has same shape

2. (Only) maltose can bind / fit;

Accept "substrate" for "maltose"

3. To form enzyme substrate complex.

Accept E−S complex

3

[5]

Q37.

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

1. (Lactase / beads) can be reused / not washed away;
   1. Accept lactase / beads not wasted
   1. Less lactase used is insufficient

2. No need to remove from milk;
   2. Accept lactase not present in milk.

3. Allows continuous process;
4. The enzyme is more stable;
5. Avoid end-product inhibition.
   Ignore ref to SA

3 max

(b) 1. (Lactose hydrolysed to) galactose and glucose;
2. (So) more sugar molecules;
   *2. Idea of **more** sugars essential*

3. (So) more / different receptors stimulated / sugars produced are sweeter (than lactose).

2 max

[5]

Q38.

(a) 1. Large / dense / heavy cells;
2. Form pellet / move to bottom of tube (when centrifuged);
3. Liquid / supernatant can be removed.
   Must refer to whole cells.

3

(b) Break down cells / cell parts / toxins.
   Idea of 'break down / digestion' needed, not just damage

1

(c) 1. To stop / reduce them being damaged / destroyed / killed;
   Reject (to stop) bacteria being denatured.

2. By stomach acid.
   Must be in context of stomach.

2

(d) 1. More cell damage when both present / A;

2. Some cell damage when either there on their own / some cell damage in B <u>and</u> C;
   MP1 and MP2 − figures given from the graph are insufficient.

3. Standard deviation does not overlap for A with B <u>and</u> C <u>so</u> difference is real;
   *MP3 and MP4 **both** aspects needed to gain mark.*

4. Standard deviations do overlap between B and C <u>so</u> no real difference.

MP3 and MP4 accept reference to significance / chance for 'real difference'

3 max

(e) 1. Enzyme (a protein) is broken down (so no enzyme activity);

Accept hydrolyse / digested for 'broken down'.

2. No toxin (as a result of protein-digesting enzyme activity);

Must be in the correct context.

3. (So) toxin is protein.

This must be stated, not inferred from use of 'protein−digesting enzyme'.

3

[12]

Q39.

(Maintaining constant pH to avoid)

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

Accept converse for MP2 and MP3.

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

Accept 'change in H^+ concentration' for 'change in pH'.

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

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

'Denaturation' alone is insufficient.

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

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

[3]

Q40.

(a) 1. Inhibition;

Accept either competitive or non-competitive inhibition or a description of either.

2. Changes tertiary structure (of enzyme);
3. Changes shape of / blocks <u>active site</u> (of enzyme);

The active site must be in the context of the enzyme / cytochrome oxidase.

4. Enzyme cannot bind to its substrate / no enzyme-substrate complex formed.

Accept 'ES'. Accept 'substrate cannot attach to enzyme'.

3 max

(b) (Antidote reacts with / binds to cyanide) *so* cyanide cannot bind to enzyme / cytochrome oxidase
OR
(Antidote reacts with / binds to cyanide) *so* causing cyanide to be released from the enzyme / cytochrome oxidase.

Key idea is how the antidote affects the cyanide.

1

(c) (i) 1. **A** + **C** + **E** / all liver (trials)
2. **B** + **D** + **F** / all kidney (trials)
3. **D** + **E** / all rat (trials);;

Accept a description of any trial letter.

All 3 groups correct = 2 marks.

Any 2 groups correct = 1 mark.

1 group / no groups correct = 0 mark.

2 max

(ii) 1. Cyanide reduces oxygen use / rate of respiration in **A** and **B** / in both
OR
as concentration of cyanide increases, the use of oxygen decreases in both;

*Accept use of letters or description of the animal **and** organ*

Reference to 'both', in some way, is required.

2. Greater effect of cyanide (on oxygen use) on sheep kidney / **B** than on sheep liver / **A**;

Comparison required in the statement. The statement should not be inferred from MP3.

3. Appropriate calculations of mean oxygen use from the data
E.g. 1 liver falls by 74% whereas kidney falls by 87%
OR
liver falls to 0.26 / to 26% whereas kidney falls to 0.13 / to 13%
E.g. 2 liver falls by 2.0(au) whereas kidney falls by 12.2(au);

Check correct calculations using the data but a comparison must be shown. Accept other calculations using the data.

3

(iii) 81(%);

Correct answer = 2 marks.

Allow 1 mark for either:

Showing 8.1 divided by 10 or answer of 19(%).

Ignore '+' or '−' in showing the difference.

2

[11]

Q41.

(a) 1. Tertiary structure / 3D shape of enzyme (means);

Accept references to active site

2. Active site complementary to maltose / substrate / maltose fits into active

site / active site and substrate fit like a lock and key;

Idea of shapes fitting together

3. Description of induced fit;

4. Enzyme is a catalyst / lowers activation energy / energy required for reaction;

Accept "provides alternative pathway for the reaction at a lower energy level"

5. By forming enzyme-substrate complex;

Accept idea that binding stresses the bonds so more easily broken

Do not award point 5 simply for any reference to E-S complex

5

(b) 1. Inhibitors reduce binding of enzyme to substrate / prevent formation of ES complex;

Max 3 if only one type of inhibition dealt with. Accept maltase and maltose as examples of enzyme and substrate (and others)

Only once, for either inhibitor

(Competitive inhibition),

2. Inhibitor similar shape (idea) to substrate;

3. (Binds) in to active site (of enzyme);

Accept allows max rate of reaction to be reached / max product will eventually be formed

Accept complementary to active site

4. (Inhibition) can be overcome by more substrate;

(Non-competitive inhibition),

5. Inhibitor binds to site on enzyme other than active site;

6. Prevents formation of active site / changes (shape of) active site;

Accept does not allow max rate of reaction to be reached / max product will not be formed

7. Cannot be overcome by adding more substrate;

5 max

[10]

Q42.

(a) 1. (Enzyme has) <u>active site</u>;

1. Reject active site is same shape as substrate

1. Reject active site is on the substrate

1. Accept active site forms during induced fit

2. Only substrate fits (the active site);

2. Accept converse statement

2

(b) Assume "it" = allopurinol

1. (Allopurinol) is a similar shape to xanthine;

1. Reject <u>same</u> shape. Accept similar structure

2. (Allopurinol) enters active site / is a competitive inhibitor;

2. Ignore e-s complexes in relation to inhibitor

2. Reject non-competitive inhibitor in the context of binding to the active site

2. Ignore complementary / fits

3. Less xanthine binds / fewer e-s complexes / fewer uric acid crystals formed / less uric acid formed;

3. Reject <u>no</u> e-s complexes / xanthine <u>cannot</u> enter active site, <u>no</u> uric acid

3. Can award in context of non-competitive inhibition

3

[5]

Q43.

(a)

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

Mark horizontally

3

(b) (i) 1. Glucose is used / broken down during glycolysis / in cytoplasm;

1. Accept: glucose to pyruvate or glucose not converted to pyruvate for one mark

2. Glucose cannot cross mitochondrial <u>membrane(s)</u> / pyruvate can cross mitochondrial <u>membrane(s)</u>;

2

(ii) 1. Is a competitive inhibitor / attaches to active site;

1 Accept: inhibitor / malonate attaches to active site to form an enzyme-substrate complex

2. Reduces / prevents enzyme-substrate / E-S complex forming;

2 Accept: substrate / succinate cannot bind to enzyme

2 Accept mark point 2, but not mp1 in context of non-competitive inhibition

2

(iii) 1. Krebs cycle inhibited as NAD / Coenzyme / FAD not / less reduced;

2. Hydrogens not passed to ETC therefore oxygen not used as (much as a) final / terminal (electron) acceptor;

2

[9]

Q44.

(a) 1. No effect at 25°C

The question only refers to plants <u>with</u> GB

1. Reject same mass

2. Keeps growing at 30°C and 35°C / up to 35°C (more than without GB);

3. Above 35°C, falls but grows more than plant without GB;

3. Accept at all temperatures above 25°C more growth than without GB

2 max

(b) (i) <u>Significantly</u> different / SEs do not overlap ;

Accept converse without GB

1

(ii) (As temperature increases,)

1. Enzyme activity reduced / (some) enzymes denatured;

2. Less photosynthesis, so fewer sugars formed;

3. Less respiration / less energy / ATP for growth;

4. Less energy for named function associated with growth

4. Eg mitosis, uptake of mineral ions

4

(c) 1. (Rubisco activase attaches to thylakoid and) this changes shape / tertiary structure (of enzyme) / blocks active site / changes active site;

Note - question states enzyme stops working when it attaches to thylakoid, not before

1. Accept rubisco in this context

2. (This) prevents substrate / RuBP entering active site / binding;

2. Accept prevents ES complex forming

2. Accept no longer complementary to substrate / RuBP

2

(d) 1. GB prevents / reduces binding of rubiscoactivase to (thylakoid membrane);

1. Accept enzyme instead of rubiscoactivase. Accept rubisco

2. (Prevents it) up to 35°C;

3. (So) rubiscoactivase / enzyme remains active;

4. (So) photosynthesis / light-independent stage still happens;

4. Accept descriptions of light-independent stage

5. Above 35°C, some binding still occurs but less than without GB, so less reduction in growth;

4 max

(e) 1. Looked for information / journals, on crop plants that grow at high temperatures;

1. "other research" is minimum accepted

1. Accept previous experiments research with temperature resistant crops

Ignore simple references to looking at previous studies / other plants - need to relate to this context

2. (Crop plants cited in this research) contain / make GB;

3. So assumed making plants produce GB makes them resistant to high temperatures;

2 max

[15]

Q45.

(a) 1. Enzyme hydrolyses / breaks down protein to amino acids;

2. Products are soluble / can be washed away;

2

(b) **Arguments for biological washing powder:**

3 max if only arguments against biological washing powder are referred to

1. More effective with all stains;

Accept different ways of expressing 'effective' e.g. higher % of stain removed

2. Greater improvement with salad dressing / chocolate milkshake / chocolate pudding;

Arguments against biological washing powder:

3. Little / less improvement with raspberry sorbet / raspberry smoothie;

4. Only tested 5 / a small number of stains;

5. Only chose stains that would work / didn't select stains that wouldn't work;

6. Only included results that did work / didn't show results that didn't work;

7. Only one set of results / not repeated;

8. Only compared against one washing powder / may not be true for other washing powders;

Ignore references to unknown masses of powder, temperature of washes or other aspects of technique or different fabrics

4 max

(c) 1. Enzyme **S** effective across a wider range of temperatures;

2. Enzyme **S** *more* active above 50 °C / active up to 80 °C / active above 60 °C;

3. Enzyme **S** more active below (about) 37 °C temperature;

4. (Although) Enzyme **P** has higher rate of reaction at optimum / 40 – 50 °C;

5. Enzyme **P** denatured above 50 °C;

*Answers should be in the context of choosing enzyme **S** but, if **P** is chosen, points 4 and 5 may still be awarded, if described*

In points 2 and 3, a temperature must be stated. Allow ± 5 degrees of values shown

3 max

(d) 1. Stains caused by different substances;

2. Enzymes are specific;

3. Active site specific to substrate / other substrates cannot fit active site;

This could be expressed in other ways e.g. 'other substrates are not complementary to the active site'

3

[12]

Q46.

(a) (i) Glucose and fructose;

Ignore reference to alpha and beta

Either way around

1

(ii) Glucose and galactose;

Ignore reference to alpha and beta

Either way around

1

(b) 1. (Amylase) pancreas, produces maltose;

Place and product = 1 mark

(mark horizontally)

2. (Maltase) in / on epithelium (of small intestine), produces glucose;

Ignore references to salivary glands or saliva

Accept wall / lining of small intestine

Ignore reference to cells alone

Ignore reference to ribosomes / rER

2

[4]

Q47.

(a) 1. (Phosphate) changes shape of TK / changes shape of enzyme / changes the active site;

It = phosphate

Accept 'alters' for changes

Reject that phosphate is an inhibitor

Accept adding energy / affecting charged / affects polar groups (on amino acids)

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

Reject similar / same shape as substrate

2

(b) 1. Faulty TK has functional active site <u>without phosphate</u>;

Accept 'works without phosphate'

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

2

(c) 1. Non-competitive inhibitor / binds to site other than active site;

Accept allosteric site

Do not accept 'changes shape' unqualified

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

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

2 max

[6]

Q48.

(a) 1. Cell wall not formed / production inhibited;

*1. **Q** Accept: weakened cell wall, but do not accept 'cell wall is broken down'*

2. Lower <u>water potential</u> in bacterium;

2. Accept: converse

2. Must be clear that the lower water potential is in the bacterium

3. <u>Water enters</u> and causes lysis / expansion / pressure;

2 max

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

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

1

(c) 1. Change in base sequence (of DNA / gene) leading to change in amino acid sequence / primary structure (of enzyme);

1. Accept: different amino acids coded for

1. Reject: different amino acids produced

2. Change in hydrogen / ionic / disulphide bonds leading to change in the tertiary structure / active site (of enzyme);

2. Neutral: alters 3D structure / 3D shape

3. Substrate not complementary / cannot bind (to enzyme / active site) / no enzyme-substrate complexes form;

3

[6]

Q49.

(a) 1. Add Benedict's;

Hydrolyse with acid negates mp1

2. Heat;

Accept warm, but not an unqualified reference to water bath

3. Red / orange / yellow / green (shows reducing sugar present);

Accept brown

3

(b) (i) 1. Starch hydrolysed / broken down / glucose / maltose produced;

Neutral: Sugar produced

2. Lower water potential;

3. Water enters by osmosis;

3

(ii) Only 2 pHs studied / more pHs need to be tested;

Accept: different amylase may have a different optimum pH

1

[7]

Q50.

(a) Hydrolysis (reaction);

Accept phonetic spelling

1

(b) 1. Too big / wrong shape;

Wrong charge - neutral

Accept insoluble

2. To fit / bind / pass through (membrane / into cell / through carrier / channel protein);

3. Carrier / channel protein;

Accept carrier / channel protein not present

3

(c) Foreign / (act as) antigen / non-self;
Reject foreign cells

1

(d) 1. Dose to be given;
Accept: interaction with other drugs

2. No (serious) side effects;

3. How effective;

4. Cost of drug;

2 max

[7]

Q51.

(a) ***EITHER***

Answer either based on

1. Molecules move at slower speeds;
2 diffusion or

2. Decreases rate of diffusion;
4 enzymes.

OR

3. Molecules move at slower speed;

4. Fewer collisions between enzymes and substrates / fewer enzyme-substrate complexes formed;
Accept converse answers if clearly in context of "If it stayed at 30 C".

2 max

(b) (i) 1. Allows comparison;
2. Different amounts of fungus added / fungus is different size at start;

2

(ii) Two marks for correct answer in range 1.7 : 1 to 1.3 : 1;;
Answer must be expressed this way round and must give the diameter of the fungus as 1.

One mark for unsimplified answer in range 29 : 19 to 27 : 21;
Calculations are based on tolerance limits for measurements of ± 1 mm. If the actual measurements are other than 28 and 20, marking guidelines should be adjusted accordingly.

2

(c) 1. Colourless zone around fungus / colourless zone outside fungus;

2. No fungus growing here / must be enzyme here;
Accept any alternative wording clearly relating to colourless zone.

2

[8]

Q52.

(a) (i) 1. Water potential same (inside and outside) / no water potential gradient;
Accept symbol Ψ or abbreviation WP as alternatives to water potential.

2. Water does not enter / leave spores;

3. By osmosis / prevents osmotic damage;
Answer must refer to osmosis.

2 max

(ii) Prevents growth (before ready) / stops growth of (other) microorganisms / slows enzyme action / prevents enzymes being denatured;

1

(b) 1. Nitrogen / N / sulfur / S;

2. Catalase is a protein / catalase is made up of amino acids / enzymes are proteins / enzymes are made up of amino acids;
Specific reference needed to proteins or amino acids.

2

(c) 1. Prevents contamination by (other) microorganisms;
Accept alternatives such as microbes, bacteria, other fungi.

2. Which also produce the enzyme / catalase / which would produce substances that affect catalase;

2

(d) (i) 90 hours;
Hours must be specified in answer to (c)

1

(ii) 70 – 80 (hours);
Allow with no reference to units.
Incorrect units negates answer.

1

(e) 1. Extra steps (with intracellular enzymes);

2. Cells have to be broken open;

3. Cell walls / bits of cells have to be removed / separated from enzyme;

4. Needs to be separated from all the other enzymes in the cell;

2 max

[11]

Q53.

(a) Amino acid / amino acids ;

If anything else is given as well do not award mark.

1

(b) (i) 1. Affects one monomer / amino acid;

i.e. What is affected

2. Not found in all active sites;

i.e. Where it is found.

2. Must relate to active site. Enzyme is insufficient.

2

(ii) 1. **X**;

2. Enzyme in both pathways;

2. Award independently

2

(c) 1. Occupies / blocks / binds to active site;

i.e. What it does in terms of the active site.

2. Substrate will not fit / does not bind / no longer complementary to / enzyme-substrate complex not formed;

1. Ignore references to change in shape and shape of aspirin molecule.

Ignore reference to competitive inhibitor i.e. Consequence required

2

[7]

Q54.

(a) (i) (Human cells) don't have a cell wall;

Accept "they" refers to human cells.

1

(ii) (Affects) protein synthesis;

Allow description e.g. 'amino acids not joined together / translation.

Reject: affects transcription.

1

(b) 1. Mutation present / occurs;

Ignore antibiotic causes mutation.

2. Resistance gene / allele;

1. or 2.

Reference to immunity disqualifies first credited marking point.

3. Resistant bacteria (survive and) reproduce;

Reference to mitosis negates marking point 3.

2

[4]

Q55.

(a) (i) Hydrolysis;

Accept phonetic spelling.

Ignore reaction.

1

(ii) (Alpha) glucose;

Accept α glucose.

Reject β glucose / beta glucose

1

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

Red / orange / yellow / green (colour);

Reject Add HCl

Accept brown, reject other colours

2

(ii) 2 products / 2 sugars produced;

*Look for idea of **two***

Accept named monosaccharides produced.

"More" insufficient for mark

Neutral if incorrect products named

Neutral "lactose is a polysaccharide"

Neutral "lactose is not a reducing sugar"

Neutral: Reference to surface area.

1

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

Q Reject: Same shape / structure

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

Accept blocks active site

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

Look for principles:

1. Shape

2. Binding to active site

3. Consequence

2 max

[7]

Q56.

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

Accept: peak at 30 °C / 31 °C

1

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

2. Change in shape of <u>active site</u> (of enzymes);

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

1. Reject: Peptide bonds broken

Denatures active site = 2 marks for mp 1 and 2

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

Accept: active site no longer complementary

3. Accept: Substrate cannot bind to enzyme

3

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

Accept a method of measuring pH.

Reject litmus.

1

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

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

1

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

Accept converse

Insufficient: pH 6 had largest clear area

1

[7]

Q57.

(a) (i) Antibiotics kill other bacteria / *Clostridium* is resistant;

Less / no competition so (*Clostridium*) reproduces / replicates / multiplies / increases in number;

Reference to bacteria being 'immune' negates first marking point.

Reference to mitosis negates second marking point.

2

(ii) Immune system less effective / more likely to have other infections / been in hospital;

Accept: 'Weak / lower' immune system'.

1

(b) Attaches to <u>active</u> <u>site</u> (of enzyme);
(Methicillin) is a competitive inhibitor / prevents monomers / substrate attaching (to enzyme);

'Competes for active site' = 2 marks.

Neutral: 'Prevents monomers joining / attaching to each other'.

Allow one mark max for answers relating to non-competitive inhibitor changing active site / preventing substrate attaching.

Do not penalise Methicillin forms an enzyme / substrate complex.

2

(c) (i) Have other illness / medical condition / 'weak' immune system / disease / infection;

Reject: Due to 'other factors', 'are smokers', 'are obese' unless related to disease or illness.

1

(ii) Increase up to 2006 / 20 (per 100 000) then decreases;

1

(iii) Correct answer in range of 52 – 59.1% = two marks;

Incorrect answer but shows change as between 4.8 – 5.2 / shows correct subtraction giving this change e.g. 14 – 9 = one mark.

2

[9]

Q58.

(a) 1. Hydrolysis breaks proteins / hydrolyses proteins / produces amino acids (from proteins);

2. Protein synthesis involves condensation;

2

(b) Amino acids (from calliphorin) can be joined in different sequences / rearranged;

1

(c) 1. Fall, rise and fall;

2. Rise after 40 and fall after 80;

Ignore concentration values.

2

(d) (i) Fall / increase then fall;

Lysosomes associated with tissue breakdown;

2

(ii) 1. Tissues / cells are being broken down;

2. RNA is digested / hydrolysed / broken down;

3. By enzymes from lysosomes;

4. New proteins not made / no new RNA made;

2 max

(e) 1. (RNA) associated with making protein;

2. New / adult tissues are forming;

2

(f) 1. In the first 6 days no / little oxygen supplied / with breakdown of tracheae, no / little oxygen supplied;

2. (Without tracheae) respire anaerobically;

3. Anaerobic respiration involves reactions catalysed by enzyme **B** / conversion of pyruvate to lactate / involves lactate production;

4. Enzyme **A** / Krebs cycle is part of aerobic respiration;

Or, with emphasis on aerobic respiration:

1. Tracheae supply oxygen / after 6 days oxygen supplied;

2. (With tracheae) tissues can respire aerobically.

4

[15]

Q59.

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

Protein / peptide bonds present;

2 max

(b) Water removed;

1

[3]

Q60.

(a) (Rennet) has less / variable amount of chymosin;

Limited supply (of rennet) available;

Pepsin may digest curd / protein / has another

protein- digesting enzyme;

(Animal) rennet unacceptable by vegetarians / vegans / against religious beliefs / harms animals;

Accept use of figures e.g. 80-90% for first mark point.

2 max

(b) Both contain chymosin / both derived from animal gene;

1

(c) (i) (Coagulation time) is reduced / is more active;

1

(ii) 2 marks for correct answer of 27% / 27.3%;;

1 mark for incorrect answer in which candidate has shown fall in coagulation time as 3 (minutes) or 11 -8;

2 max

(d) 1. (Enzyme) denatured / loss of tertiary structure / hydrogen bonds broken;

2. Shape of active site changes / no longer complementary;

3. Less / no substrate binds / fewer / no enzyme-substrate complexes formed;

3

[9]

Q61.

(a) Shows mass of wheat seedlings when grown on their own;

Allows percentage to be calculated / allows comparison / allows effect of competition to be seen;

2

(b) 1. Interspecific competition / ryegrass reduces growth of wheat;

2. Justification by using values;
100% with wheat but less when grown with ryegrass

3. Competition between shoots had a greater effect than competition between roots;

4. Justification by use of values;
*46% when shoots complete / in **Y** / 76% when roots compete / **X***
When marking please number marking points
E.g. 4✓ *means a mark awarded for point 4.*

4

(c) Growth involves enzymes / enzyme-controlled reactions;

Lower temperature means less kinetic energy / fewer collisions / fewer E–S complexes formed;

Wheat and ryegrass affected to a different extent;
Accept other valid physiological processes such as growth involves diffusion / lower temperature means less kinetic energy / molecules move slower.

2 max

[8]

Q62.

(a) (i) To show whether immune response occured / because cats are (genetically) related to cheetahs;
Ignore reference to control.

1

(ii) To show that rejection did not normally occur / skin could (successfully) be grafted;

1

(b) (i) Rapid rejection between unrelated (domestic) cats / cats are **not** genetically similar;
Rapid rejection between (domestic) cat and cheetah / cats and cheetahs are not genetically similar;
Slow / no rejection in cheetahs / cheetahs are genetically similar;

3

(ii) Sample size small;
Time observed was short;

1 max

(iii) Similar (antigens on all cheetahs);

Accept same / not very different

1

(iv) Protein / antigen production determined by alleles / genes / base sequence on DNA;
The more similar the proteins the more similar their alleles / genes / base sequence on DNA / the more they are genetically similar;

2

[9]

Q63.

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

Competes for / binds to active site / competitive inhibitor;

Less PABA binds / less E-S complexes;

OR

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

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

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

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

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

Assume that 'it' refers to sulfanilamide

Accept: PABA / substrate cannot bind

Neutral: less product produced as in question stem

Neutral: different structure / shape to PABA

Reject: active site on substrate for second marking point only

[3]

Q64.

(a)

✓	✓	✓	
			✓
		✓	✓

One mark for each correct column

Mark ticks only and ignore crosses

4

(b) 1. Two marks for box round two hydrogens and one of the oxygens from OH groups on carbons 1 and 4;;

2. One mark from incorrect answer involving any two hydrogens and an oxygen from carbons 1 and 4;

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

2

(c) (i) 1. Holds chains / cellulose molecules together / forms cross links between chains / cellulose molecules / forms microfibrils, providing strength / rigidity (to cellulose / cell wall);

2. Hydrogen bonds strong in large numbers;x

Principles here are first mark for where hydrogen bonds are formed and second for a consequence of this.

Accept microfibres

2

(ii) Compact / occupies small space / tightly packed;

Answer indicates depth required. Answers such as "good for storage", "easily stored" or "small" are insufficient.

1

[9]

Q65.

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

OR

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

Note: 'active site has a specific shape' = 2 marks;
Reject: same shape

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

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

3 max

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

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

Reject: obvious rise or fall / rise then plateau

1

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

Curve should be labelled

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

Reject: falling at a slower rate initially

1

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

OR

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

Accept: denatured (by acid)

Neutral: digested by saliva

Reject: digested by amylase

Neutral: will not reach the bloodstream

2

[7]

Q66.

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

Do not accept children have more haemoglobin

1

(ii) Use line of best fit;

1

Extrapolate / extend line (and read from graph);

Allow calculation using rate of increase per day = one mark. However for both marks this must be linked to line of best fit.

1

(iii) More than one polypeptide chain;

Allow many polypeptide chains.

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

1

(b) (i) Has same <u>water potential</u>;

Allow converse for effect of using distilled water or a concentrated solution.

1

No (net) water movement / osmosis;

1

Cells will not swell / burst / change size;

No osmotic lysis = two marks

1

(ii) Pernicious anaemia (cells) greater range / spread / variation of diameters / widths;

Some pernicious anaemia (cells) wider than 9 (μm) / some less than 5.5 (μm) / without pernicious anaemia none more than 9 (μm) / none less than 5.5 (μm);

Pernicious anaemia (cells) peak / most frequent at 8.5 (μm) / peak / most frequent at higher diameter / / without pernicious anaemia peak / most frequent at 7 (μm) / peaks at lower diameter;

There are several alternatives for marking points 2 and 3

2 max

[9]

Q67.

(a) Ammonia / ammonium / NH_3 / NH_4^+;

1

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

Neutral: same shape as substrate

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

Reject: same shape as active site

2

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

Accept: ATP or energy

Enzyme / nitrogenase produced quicker / <u>more</u> enzyme produced;

Ignore references to temperature

Uses / removes oxygen (so nitrogenase works);

Use of oxygen must be in the correct context

2 max

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

Accept: ATP or energy

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

Accept: converse for those without fertiliser

2

[7]

Q68.

(a) Increased <u>soaking</u> temperature decreases germination in seeds (germinated) at 35°C / soaking and germinating at 35°C results in failure (to germinate);

Soaking at 20°C and 25°C has no effect on seeds germinated at 20°C;

(Soaking above 30°C) may denature enzymes / proteins;

In 3rd marking point:
Accept description of denaturation
Reject breakage of <u>peptide</u> bonds

3 max

(b) So that they could compare different numbers of seedlings;

1

[4]

Q69.

(a) (i) 14 / 15 – 58 / 59 or 43 – 45 (mg per $100cm^3$);

Wrong calculation does not disqualify

1

(ii) The larger the person the more blood they would have so have a lower concentration of blood glucose;

as same amount of glucose absorbed / all / 50g absorbed;

2

(b) 1. Any reference to overlap between all 3 groups;

2. One lactase deficient subject had high blood glucose / similar to control;

3. Some control / Group A subjects had the similar blood glucose to LD / Group B subjects / some IBS subjects had similar results to lactase deficient subjects;

3

[6]

Q70.

(a) Increase in the first 3 – 4 hours and then decrease;

1

(b) Little / no difference (at 8 hours);

Between all groups;

2

(c) Respiration (produce CO_2);

By cells / tissues;

2

(d) Clear differences between the lactose deficient and IBS / control group;

No overlap in SD;

Accept between all groups

2

[7]

Q71.

(a) High sucrose / starch diet leads to increase in lactase activity;

1

(b) Not valid / cannot be certain because overlap in SD between high sucrose and high starch;

Study based on rats (not human) so may not apply to human;

2

[3]

Q72.

(a) Measure with eyepiece graticule / scale;
Calibrate with stage micrometer / scale on slide / object of known size;
Repeats and calculate the mean;
OR
Use a ruler to estimate the field diameter under microscope;
How many droplets go across the field;

Repeats and calculate mean;

Accept references to radius

3

(b) (i) Two mark for correct answer of 4 : 1;;
One mark for incorrect answer but working shows that candidate has clearly attempted to compare values of r^2 / 6^2 and 3^2 / 36 and 9;

Idea of comparing ratios
A ratio of 1 : 4 should gain 1 mark

2

(ii) Small droplets have a larger surface area to volume ratio;
More surface for lipase (to act), leading to faster digestion of triglycerides;
Fatty acids are produced more quickly so pH will drop more quickly in curve Y / with bile salts / less fatty acids in curve Z / without bile salts so pH drop more slowly;

3

[8]

Q73.

(a) (i) (Lactose +) Water; → (Glucose +) Galactose;

Accept: H_2O for water

2

(ii) Hydrolysis;

Accept: if phonetically correct

1

(b) (i) (Add Biuret reagent to both solutions) – no mark;

Neutral: positive / negative result

Lactase / enzyme will give purple / lilac / mauve;

Neutral: incorrect reference to the method

OR

Lactose / reducing sugar will not give purple / lilac / mauve / will remain blue;

1

(ii) Lactase / enzyme is a protein;

Accept: lactase / enzyme contains peptide bonds

1

[5]

Q74.

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

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

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

2

(ii) Substrate concentration / amount of substrate;

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

2

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

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

1

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

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

1

(c) (i) Methotrexate / drug is a similar shape / structure to substrate so binds to / fits / is complementary to active site;

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

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

Less substrate binds / less enzyme-substrate complexes formed;

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

2

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

Assume that 'it' refers to the drug

OR

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

1

[9]

Q75.

(a) (i) Deoxyribose;

pentose / 5C sugar = neutral

1

(ii) Phosphate / Phosphoric acid;

phosphorus / P = neutral

1

(b) Hydrogen (bonds);

1

(c) 381 / 384 / 387;

1

(d) (Gln) Met Met Arg Arg Arg Asn;

1

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

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

Substrate cannot bind / no enzyme-substrate complexes form;

***Q** Reject = different amino acids are formed*

3

[8]

Q76.

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

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

(Forming) enzyme-substrate complex;

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

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

3

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

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

Is more sensitive / detects low concentration;

Red colour / colour of blood masks result;

Can monitor blood glucose concentration continuously;

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

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

2 max

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

1

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

2 max

[8]

Q77.

(a) Amylase;

(Starch) to maltose:

Maltase;

Maltose to glucose;

Hydrolysis;

(Of) glycosidic bond;

Q *Do not penalise incorrect site for digestion or incorrect site of enzyme production.*

5 max

(b) Glucose moves in with sodium (into epithelial cell);

Via (carrier / channel) protein / symport;

Sodium removed (from epithelial cell) by active transport / sodium- potassium pump;

Into blood;

Maintaining low concentration of sodium (in epithelial cell) / maintaining sodium concentration gradient (between lumen and epithelial cell);

Glucose moves into blood;

By (facilitated) diffusion;

Q *Only allow diffusion mark in context of movement of glucose into the blood.*

5 max

[10]

Q78.

(a) (Most of) bromelain is digested / not absorbed / broken down in blood;

1

(b) Total volume of blood;

1

[2]

Q79.

(a) (i) Glucose;

Fructose;

Any order.

2

(ii) Lactose has a different shape / structure;

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

Only allow a second mark if reference is made to the active

site.
Max 1 mark if active site is described as being on the substrate.

OR

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

Do not accept same shape.

2

(b) (i) Rose and fell;

Peak at 45 (minutes) / concentration of 6.6 (mmol dm^{-3});

2

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

Decrease as used up / stored;

2

[8]

Q80.

(a) (i) 150;

1

(ii) 27;

1

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

accept calculation showing same number top and bottom.

2

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

1

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

3

(e) more resistant to changes in pH and washing conditions variable / works in alkaline pH and washing powders alkaline;

mark awarded for indicating aspect of effect of pH and advantage of this in terms of washing powder and conditions in wash.

1

(f) maximum of three marks for specificity, points 1 - 3. Can only be given credit in context of specificity

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

sequence;

2 folds in a particular way / has particular tertiary structure giving an active site with a unique structure;

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

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

5 distorts active site;

6 so substrate will no longer fit / form enzyme-substrate complex

6

[15]

Q81.

use of water;

must be above arrowhead
OH drawn correctly in place of glycosidic bond on each monosaccharide;

[2]

Q82.

(a) Lilac / purple / mauve / violet;

Xanthine oxidase is a protein;

Reject pink or blue as the resulting colour with biuret.

2

(b) Substrate has specific shape;

Allows binding / fitting / forms ES complex with active site;

Or

Active site has specific shape;

Allows binding / fitting / forms ES complex with substrate;

Accept structure ≡ shape

2

(c) Xanthine <u>similar</u> shape to drug;

Drug fits active site / competes for active site / is a competitive inhibitor;

Less / no uric acid formed;

3

[7]

Q83.

(a) Several / more than one polypeptide chain in molecule;

Evidence must only relate to 4º structure

1

(b) Chemical bonds formed between sulphur-containing groups / R-groups / form stronger disulphide bonds;
Bind chain(s) to each other;

2

(c) Different <u>number</u> / sequences of amino acids;
Bonds in different places which gives different shape;

2

(d) Outer layer of skin cells are dead / do not respire
Do not contain mitochondria / do not produce ATP / release energy;
Cells do not have required proteins / carriers;

3

(e) Advantages:

1 Small objects can be seen;

2 TEM has high resolution as wavelength of electrons shorter;
Accept better

Limitations:

3 Cannot look at living cells as cells must be in a vacuum;

4 must cut section / thin specimen;

5 Preparation may create artefact

6 Does not produce colour image;

6

[14]

Q84.

(a) Stimulates memory cells;

Secondary response, so antivenom / antibodies produced quicker;

2

(b) Passive immunity; so no memory cells produced;

Antivenom breaks down / destroyed;

2

(c) Could transfer disease / Allergy / Immune response to antibodies from animal;

1

[5]

Q85.

(a) diagram showing molecule **A** fitting in inhibition site; distortion of active site;

2

(b) molecules moving less / slower; reduces chance of collision (between enzyme and substrate) / of enzyme-substrate complexes being formed; *(reject converse)*

2

(c) these bonds hold / maintain tertiary / globular structure (of enzyme);
enzyme denatured / tertiary structures destroyed; (shape of) active site distorted / changes;
substrate no longer fits / enzyme-substrate complex not formed;

3 max

[7]

Q86.

(a) add antibodies / enzyme;
wash to remove unbound antibodies;
add (colourless) solution;

(mark correct responses sequentially)

3

(b) antibodies specific / shape only fits one antigen;
other antigens different shape and would not bind to antibodies;

2

[5]

Q87.

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

2

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

3

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

1

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

1

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

2

[9]

Q88.

(a) (i) (Molecule) made up of many identical / similar molecules / monomers / subunits;

Not necessary to refer to similarity with monomers.

1

(ii) Cellulose / glycogen / nucleic acid / DNA / RNA;

1

(b) (i) To keep pH constant;
A change in pH will slow the rate of the reaction / denature the amylase / optimum for reaction;

2

(ii) Purple / lilac / mauve / violet;
Do not allow blue or pink.

1

(iii) Protein present / the enzyme / amylase is a protein;
Not used up in the reaction / still present at the end of the reaction;

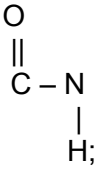
2

[7]

Q89.

(a) Rate of movement / diffusion proportional to concentration gradient / difference in concentration;
High concentration of potassium ions inside cell compared to outside;
Must mention high concentration. Ignore reference to other factors if reasoning is appropriate.

2

(b) (i)

1

(ii) 10;

1

(c) Action of vanilomycin depends on fluidity of membrane;
Fluidity reduced / not fluid at low temperatures;
Pore formed by gramicidin A remains in place / permanent;

3

(d) Pore between sterol molecules lined with polyene antibiotic;
Hydrophobic region next to sterol;

2

[9]

Q90.

(a) (i) Biuret / alkali + copper sulphate;
Lilac / purple / mauve / violet;
Do not give credit for blue or pink. Ignore references to heating.

2

(b) R group of phenylalanine copied accurately;

1

(c) (i) Bond shown linking carbon and nitrogen;
OH and H removed, =O and –H remaining;

2

(ii) Peptide bond;

1

(d) Addition of hydroxyl / OH group;

Candidate must distinguish clearly between hydroxylation and hydrolysis

1

[7]

Q91.

(a) (i) Hydrolysis;

1

(ii) Water enters fungus (by osmosis) which increases pressure inside fungus;
Cell wall no longer strong enough / present so cannot withstand this;

2

(iii) Cell wall (of plant) not made of chitin / made of cellulose;
Enzyme is specific to chitin / will not break down cellulose;

1

(b) Way in which the whole protein / polypeptide is folded / shape adopted by whole protein molecule / further folding of 2° structure;

Do not credit unqualified reference to three-dimensional shape.
Reject third level / third sort.

1

(c) (i) More (kinetic) energy;
Bonds / specified bonds (holding tertiary structure) break;

2

(ii) Change amino acids;
Allowing formation of more hydrogen bonds / disulphide bridges;

2

(d) 1. Sequence of amino acids gives shape;
2. This is tertiary structure;
3. Has similar shape to substrate;
4. Fits / competes for active site;
5. Fits at site other than active site;
6. Distorting active site;
7. Therefore substrate will not fit (active site);

max 6

[15]

Q92.

(a) Structure resulting from aggregation of several polypeptide chanins / tertiary structures / eq:

1

(b) Low pH / (more)H^+ ; due to (increased) CO_2 (increased) respiration;
(ignore refs to buffering action of haemoglobin)
(increased) dissociation of haemoglobin;
Oxygen diffuses from r.b.c. to tissues;

3

(c) Deaminated for use in respiration / used in protein synthesis / suitable e.g.;

1

[5]

Q93.

Quality of Communication

The answers to all sections of this question require the use of continuous prose. Quality of language should be considered in crediting points in the scheme. In order to gain credit, answers should be expressed logically and unambiguously, using scientific terminology where appropriate.

(a)
1. Deviation of a value from norm initiates corrective mechanisms;
2. fluctuations in plasma glucose concentration detected by hypothalmus / islet cells in pancreas;
3. initial decrease, no food given (in plasma glucose) stimulates (increased) secretion of glucagon;
4. increases (in plasma glucose) stimulate (increased) secretion of insulin from β cells as secretors;
5. correct ref. to interconversion of glycogen / glucose / increased / decreased uptake of glucose by cells (as appropriate) / correct ref to change in membrane permeability;

5

(b)
1. Body temp. / 37 °C is optimum temp for enzymes;
2. excess heat denatures enzymes / alters tertiary structure / alters shape of active site / enzyme so substrate cannot bind / eq;
3. reactions cease / slowed;
4. too little reduces kinetic energy of molecules / moleculesmove more slowly;
5. fewer collisions / fewer ES complexes formed'

5

[10]

Q94.

(a) Digestion / hydrolysis / breakdown of a disaccharide into monosaccharides;
OR
(glucose and galactose form lactose) glucose is a monosaccharide;

max 1

(b) (i) Dipeptidase / disaccharidase / named disaccharidase;

1

(ii) Enzymes not lost (with gut contents) / more effective absorption of products formed by these enzymes;

1

(c) No ATP formed / no energy released by respiration;
[reject "making" energy]

Link ATP to active transport (of galactose) into cells;

2

[5]

Q95.

(a) (i) Curve rising and levelling out;

1

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

2

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

1

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

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

2

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

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

3

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

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

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

6

[15]

Q96.

(a) any two named polymers [subsets = 1 max. (e.g. protein / haemoglobin)]

2

(b) (i) hydrostatic pressure / description of pressure;
causes ultrafiltration at Bowman's capsule / glomeruli / renal capsule;
through basement membrane;
enabled by small size of urea molecule;

max 2

(ii) reabsorption of water; [water out]
by osmosis;
at the PCT / descending LoH;
at the DCT / CD;
active transport of ions / glucose creates gradient (in context);

max 4

(c) (i) by (simple) diffusion;
[reject facilitated]

1

(ii) to maintain concentration gradients / stop reaching equilibrium;
[idea of maintaining concentration gradients]

1

(iii) ions, glucose and amino acids would diffuse into the dialysate;
because of their concentration gradients;
Causing deficiency in these substances;

OR

the WP of the dialysate would be higher / less negative than the WP of the surrounding tissues;
therefore osmosis would take place into the cells surrounding the abdominal cavity;
causing these cells to burst / damaging these cells / cannot be excreted;

max 2

[12]

Q97.

(a) Tapes / string / axes laid out at right angles / grid area;
Method of obtaining random co-ordinates;
Do not allow "Use random number generator"

2

(b) (i) Decrease then remain constant;
From 200 cm / over 150 cm;

2

(ii) Oxygen decreasing because soil becomes more compacted / not replaced;
Decrease in oxygen leads to fewer aerobes surviving;

2

(c) Anaerobic bacteria replace aerobic as oxygen decreased by aerobic bacteria;
Remove competition;
Aerobic bacteria no longer able to survive in these conditions;

3

(d) (i) Near the surface / in top 50 cm;
Table shows decrease with time at greater depths;

2

(ii) Decrease;
Fewer aerobic bacteria with depth;
Oxygen concentration decreases / less oxygen at depth;

3

(e) Probability greater than 95% / 0.95;
Results are not due to chance / results are significant;
Because bars do not overlap;

3

(f) Plot as graph;
Draw line of best fit;

Read off appropriate value;

3

[20]

Q98.

(a) **A** <u>and</u> structure(of **A**) is complementary to that of the active site;

1

(b) idea that non-competitive inhibitor(**C**) binds at a site not the active site; binding causes a change in the shape of the active site; substrate is no longer able to bind to the active site;

3

(c) (i) peptide;

1

(ii) idea that amino acid chain folds / tertiary structure;
named bond holding tertiary structure e.g. ionic disulphide hydrogen;
{reject peptide)

2

[7]

Q99.

(a) (i) **D** plasmid / ribosome(s) / cytoplasm / storage granules;
(accept any sensible structure)

E (slime / mucous) capsule

OR

slime / mucous layer;

2

(ii) protection / maintain shape / prevent lysis / strength / support;

1

(b) two of the following:
nucleus;

OR

nuclear envelope / mitochondria / chloroplasts / sER / rER / golgi apparatus / 80s ribosomes

linear <u>DNA</u> / chromosomes / lysosomes / vacuole / vescicles / <u>cellulose</u> cell wall;

2 max

(c) (i) <u>starch</u> digested / broken down;
by amylase / carbohydrase;

2

(ii) any sensible suggestion e.g. no secretion of amylase / functional amylase /
piece of fungus might have died;
(accept carbohydrase / enzyme for amylase)

(reject "no digestion" without qualification)

1

[8]

Q100.

(i) active sites contain substrate / ethylene glycol;
all active sites occupied / enzyme is limiting;

(reject idea of active sites used up)

2

(ii) Ethanol is a similar <u>shape</u> to the substrate (ethylene glycol) / complementary to active site;

(reject "same shape")

ethanol is a <u>competitive</u> inhibitor / reduces enzyme-substrate complexes / prevents <u>substrate</u> (ethylene glycol) entering the active site;

(reject "decreases rate of reaction")

2

[4]

Q101.

(a) lower enzyme activity;

decrease in rate of photosynthesis so less carbohydrate formed / named carbohydrate / lower translocation of sucrose / to growing point;
lower respiration;
lower rate of nutrient uptake / protein synthesis / cell division;

4

(b) (i) differ in height when plants from different altitudes grown in same environment;

1

(ii) plants from 1500 / 3000m differ in height when grown at different altitudes;

1

[6]

Q102.

(a) (i) box drawn around R group (i.e. CH_2OH group)

(allow circle if labelled R);

1

(ii) circle drawn around either of the Hs on NH_2 group and circle drawn around the OH;

1

(b) (i) (di)peptide and water;

1

(ii) peptide;

1

(c) sequence of amino acids changes;

tertiary structure changes / folds in a different way;
bonds form in different places;
(*Reject peptide bonds*)

3

[7]

Q103.

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

2 max

(disqualify energy made)

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

(ii) absorbed by active transport;

1

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

2

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

2

[7]

Q104.

(a) colour results from starch-iodine reaction;
decrease due to breakdown of starch by carbohydrase / enzyme;

2

(b) (i) curve drawn below curve on graph and starting at same point;

1

(ii) curve drawn above curve on graph and starting at same point but finishing above;

(allow curve or horizontal line)

(allow alternative curve for pH if explanation in (ii) is consistent)

1

(c) (i) 1. increase in temperature increases kinetic energy;
2. increases collisions (between enzyme / active site and substrate) / increases formation of enzyme / substrate complexes;
3. increases rate of breakdown of starch / rate of reaction / carbohydrase activity;

(ii) 4. (decrease in pH) increases H^+ ions / protons which attach / attracted to amino acids;
5. hydrogen / ionic bonds disrupted / broken which denatures enzyme / changes tertiary structure;
6. changes shape / charge of active site so active site / enzyme unable to combine / fit with starch / enzyme-substrate complex no longer able

to form;
7. decreases rate of breakdown of starch / rate of reaction / carbohydrase activity;

(allow alternative explanation for pH if consistent with line drawn in (ii))

7

[11]

Q105.

(a) (i) ammonia / ammonium ions / compound;

1

(ii) glucose;

1

(b) final acceptor for hydrogen:
to form water;

2

(c) glycolysis can continue;
NAD can accept more hydrogen;

2

(d) secondary / tertiary structure;
produces particular shape of active site;
or
(shape of) active site;
complementary to shape of substrate;

2

(e) sodium ions / non-competitive inhibitor binds to enzyme at a site other than active site;
resulting in change of shape of active site / no longer complementary;
substrate can no longer bind with the enzyme / enzyme-substrate complexes no longer formed;

3

[11]

Q106.

(a) urea diffused into / entered the tubing and was hydrolysed / broken down (inside tubing);
ammonia increases pH / makes (solution) more alkaline and indicator turns blue as pH above 8 / due to alkalinity / due to ammonia;
idea that outside stays yellow because urease does not pass out;

3

(b) (i) add biuret solution / add sodium hydroxide + copper sulphate (solution);

(disqualify heat / boil, but accept warm)

violet / lilac / purple colour;

2

(ii) inside: protein present, as enzyme is protein;
outside: no protein, as urease / enzyme / protein unable to pass through membrane / out;

(accept correct result of biuret test as indicator of protein)

2

(c) method to maintain range of temperatures, e.g. water baths;
method to measure rate of activity - e.g. time taken to turn indicator blue;

(principle - measure rate of activity over range of temperatures = 1 mark, if neither point)

other conditions kept constant / named examples,
e.g. volumes of solutions,
starting pH, sample time;
method of refining optimum, e.g. repeats at narrower range;

3 max

[10]

Q107.

(a) (i) fructose;

1

(ii) correctly drawn (OH group at bottom left);

1

(b) hydrolysis;

1

(c) (i) heat with Benedict's solution (*disqualify if HCl added*);
orange / brown / brick red / green / yellow colour or precipitate;

2

(ii) biuret test / NaOH + $CuSO_4$;
purple / violet / lilac / mauve;

2

[7]

Q108.

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

2

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

2

(c) $\frac{7.6 - 5.6}{7.6}$ × 100;
= 26.32%; *(accept 26% or 26.3%)*
(correct answer = 2 marks)

(principle – $\frac{\text{decrease in rate}}{\text{max rate}}$ *× 100 = 1 mark)*

2

(d) curve below top curve (without inhibitor) joining to top curve / continues to

increase to end of *x*-axis
(*must not exceed or level out below 'without inhibitor curve' and must start from origin*);

1

[7]

Q109.

(a) (i) fall in deaths due to rise in number of people with immunity / better care / targeting vaccination at vulnerable;

1

(ii) mutation of virus / new strain;
mutant form not recognised by memory cells (*allow antibodies*);

2 max

(b) (i) T lymphocyte receptors recognise shape of haemagglutinin / neuraminidase / viral antigen;
clone (*once only*);
destroy virus;

2 max

(ii) clone (*once only*);
produce antibodies;
effect of antibody e.g. stimulation of phagocytosis / precipitation of toxins;

2

(c) alter shape of active site of neuraminidase / block active site;
virus unable to leave host cells;

2

[9]

Q110.

21 – 25	Extended abstract Generalised beyond specific context	Response shows holistic approach to the question with a fully integrated answer which makes clear links between several different topics and the theme of the question. Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained. No significant errors or irrelevant material. For top marks in the band, the answer shows evidence of reading beyond specification requirements.
16 – 20	Relational Integrated into a whole	Response links several topics to the main theme of the question, to form a series of interrelated points which are clearly explained. Biology is fundamentally correct A-level content and contains some points which are detailed, though there may be some which are less well developed, with

		appropriate use of terminology. Perhaps one significant error and, or, one irrelevant topic which detracts from the overall quality of the answer.
11 – 15	Multistructural Several aspects covered but they are unrelated	Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question. Biology is usually correct A-level content, though it lacks detail. It is usually clearly explained and generally uses appropriate terminology. Some significant errors and, or, more than one irrelevant topic.
6 – 10	Unistructural Only one or few aspects covered	Response predominantly deals with only one or two topics that relate to the question. Biology presented shows some superficial A-level content that may be poorly explained, lacking in detail, or show limited use of appropriate terminology. May contain a number of significant errors and, or, irrelevant topics.
1 – 5	Unfocused	Response only indirectly addresses the theme of the question and merely presents a series of biological facts which are usually descriptive in nature or poorly explained and at times may be factually incorrect. Content and terminology is generally below A-level. May contain a large number of errors and, or, irrelevant topics.
0		Nothing of relevance or no response.

Commentary on terms and statements in the levels mark scheme

The levels mark scheme for the essay contains a number of words and statements that are open to different interpretations. This commentary defines the meanings of these words and statements in the context of marking the essay. Many words and statements are used in the descriptions of more than one level of response. The definitions of these remain the same throughout.

Levels mark scheme word/statement	**Definition**
Holistic	Synoptic, drawing from different topics (usually sections of the specification)
A fully integrated answer which makes clear links between several different topics and the theme of the question	All topics relate to the title and theme of the essay; for example, explaining the biological importance of a process.

	When considering, for example, the importance of a process, the explanation must be at A-level standard. 'Several' here is defined as at least four topic areas from the specification covered. This means some sentences, not just a word or two. It does not mean using many examples from one topic area.
Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained.	Detailed and comprehensive A-level content is the specification content. Terminology is that used in the specification. Well written and clearly explained refers mainly to biological content and use of terminology. Prose, handwriting and spelling are secondary considerations. Phonetic spelling is accepted, unless examiners are instructed not to do so for particular words; for example, glucagon, glucose and glycogen.
No significant errors or irrelevant material.	A significant error is one which significantly detracts from the biological accuracy or correctness of a described example. This will usually involve more than one word. Irrelevant material is several lines (or more) that clearly fails to address the title, or the theme of the title.
For top marks in the band, the answer shows evidence of reading beyond specification requirements.	An example that is relevant to the title and is not required in the specification content. The example must be used at A-level standard.
Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question.	Not addressing the biological theme of the essay (e.g. importance) at A-level standard.

Please note that to obtain full credit, students must use information to show **the importance of enzymes in plants and animals**.

Topics

1	principles of enzyme action (A) e.g. catalysis, protein structure, active site, activation energy, enzyme-substrate complex, specificity.

	good candidates relate protein structure to specificity / active site, catalysis to activation energy.
2	factors affecting enzyme action (F) e.g. temperature, pH, enzyme / substrate concentration, inhibition. good candidates – relate changes in activity to denaturing / tertiary structure; effects of concentration to active site availability, distinguish competitive / non-competitive inhibition.
3	enzyme synthesis (S) reference to protein synthesis; link to genes, gene expression, effects of mutation. good candidates – appreciation of connection between genes and enzyme production, e.g. 'one gene, one enzyme'. roles and functions of enzymes in different processes. In each case good candidates should specify enzyme and its function.
4	digestion (D) enzymes involved in mammalian digestive system, breakdown of polymers in other circumstances, e.g. saprophytic digestion / mobilisation of storage compounds. good candidates – range of enzymes giving source and action in sequence in mammalian digestion; reference to other breakdown.
5	metabolic pathways - photosynthesis (Ps) and respiration (R) e.g. light independent reaction, Krebs cycle, ATP formation. good candidates - reference to specific roles e.g. in l.i.r., distribution in mitochondria / chloroplasts.
6	other specific examples e.g. in nervous system (N), such as role of acetylcholinesterase in synapses, in homeostasis (H), such as in glycogenesis, in muscle action (M), such as role of ATPase, in fertilisation (Sp), such as enzymes in acrosome, in transcription / translation (T), such as role of polymerases. other specific examples e.g. in nervous system (N), such as role of acetylcholinesterase in synapses, in homeostasis (H), such as in glycogenesis, in muscle action (M), such as role of ATPase, in fertilisation (Sp), such as enzymes in acrosome, in transcription / translation (T), such as role of polymerases.

In order to fully address the question and reach the highest mark bands students must also include at least four topics in their answer, to demonstrate a synoptic approach to the essay.

Students may be able to show the relevance of other topics from the specification.

Note, other topics from beyond the specification can be used, providing they relate to the title and contain factually correct material of at least an A-level standard. Credit should not be given for topics beyond the specification which are below A-level standard.

[25]

Q111.

(a) (i) condensation;

1

(b) (i) **D**;

1

(ii) **C**;

1

(iii) **A**;

1

(c) absence of a double bond;
in the (hydrocarbon) chain;
unable to accept more hydrogen / saturated with hydrogen;

2 max

[6]

Q112.

(a) specific 3D tertiary structure / shape;
substrate complementary shape;
(reject same shape)

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

3

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

no enzyme substrate complex formed / substrate no longer fits;

3

[6]

Q113.

(a) (i) number of bases = 4440
allow 4446 if they refer to start / stop

each amino acid coded for by triplet / three bases
(so three times more bases than amino acids);

2

(ii) deletion;

(deletion) of three bases;
because substitution / addition would change amino acid(s);

2 max

(b) codon on mRNA;
specific / complementary base pairing with;
anti-codon on tRNA;
specific tRNA for each amino acid;
protein formed by condensation reactions /
peptide bonds formed;

4 max

[8]

Q114.

(a) pioneers / suitable example colonise land;
example of change in environment;
enables change in species;
conditions change further / example to favour trees;

4

(b) stable community / no further succession / final community;

1

(c) roots unable to respire (aerobically);
active transport of minerals / other metabolic effect stops;

2

(d) action of bacteria / decomposers inhibited / fewer bacteria / decomposers;
acid conditions inhibits enzymes / enzymes denatured / changes active site;
H^+ ions affect active site;
anaerobic conditions;

3 max

[10]

Q115.

(a) C_{12} ; $H_{22}O_{11}$;

2

(b) (i) heat with Benedict's;
yellow / brown / orange / red;

2

(ii) (yes)
(may appear on second line)

more precipitate in sample **B**;
both sugars are reducing sugars / give a positive test;

2

[6]

Q116.

(a) mutation changes the amino acid sequence / primary structure of Factor VIII protein;
changes the tertiary structure / 3D shape;

2

(b) (mutant) Factor VIII protein is non-functional / does not work with Factor IX;
so no conversion of Factor X to active form and pathway blocked;

2

(c) boy's blood contains (active) Factor VIII;
Factor VIII haemophiliac's blood contains (active) Factor IX;
the mixture has both Factors and so the pathway can complete / blood clots;

2 max

[6]

Q117.

(a) membrane relatively impermeable / less permeable to sodium ions / gated channels are closed / fewer channels;
sodium ions pumped / actively transported <u>out</u>;
by sodium ion carrier / intrinsic proteins;
inside negative compared to outside / 3 sodium ions out for two potassium ions in;

(if sodium mentioned but not in context of ions, negate 1 mark)

4

(b) (i) 1.6;

1

(ii) 18 ÷ 1.6 = 11.25;
multiply by 1000 to convert from ms to s / 11 250;

(correct method = 1 mark, i.e. $\frac{distance}{time}$ *or × 1000)*
(correct answer based on (b)(i) = 2 marks)

2

(iii) time for transmission / diffusion across the neuromuscular junction / synapse;
time for muscle (fibrils) to contract;

1 max

(c) movement by diffusion;
binding to receptors on (post-synaptic) membrane;
causing sodium channels to open / sodium ions to move in to muscle (cell);

3

(d) (i) toxin binds to / competes for / blocks the acetylcholine receptors;
acetylcholine can not depolarise the membrane / the toxin does not cause depolarisation;

(allow references to generating action potentials instead of depolarisation, do not allow references to impulses in muscles)

2

(ii) acetylcholinesterase is unable to breakdown acetylcholine;
acetylcholine still available to depolarise the membrane / generate action potentials in the membrane;

2

[15]

Q118.

21 – 25	Extended abstract Generalised beyond specific context	Response shows holistic approach to the question with a fully integrated answer which makes clear links between several different topics and the theme of the question. Biology is detailed and comprehensive A-level content, uses appropriate terminology, and is very well written and always clearly explained. No significant errors or irrelevant material. For top marks in the band, the answer shows evidence of reading beyond specification requirements.
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Response mostly deals with suitable topics but they are not interrelated and links are not made to the theme of the question.	Not addressing the biological theme of the essay (e.g. importance) at A-level standard.

Please note that to obtain full credit, students must use information to show **how the structure of proteins is related to their functions.**.

Topics

1	Structure (S) primary structure – peptide bond secondary structure tertiary structure. Globular - bonds between R groups give spherical shape – shape determines function – active sites and receptor sites (*allow quaternary structure – haemoglobin incorporates ions for oxygen transport*)
2	Structural proteins (ST) fibrous – regular pattern of hydrogen bonds – coiling, (*e.g. keratin coils twist together to form rope-like structures – flexible and strong*) (*e.g. collagen – coils more tightly bound – more rigid*)
3	Transport (T) channel – complementary shape – charges – gated carrier – complementary shape – can change shape active transport – phosphate group attached by energy from ATP – can change shape
4	Enzymes (E) active site, enzyme-substrate complex activation energy reduction - explanation e.g. brings molecules closer
5	Receptors (R)

	synapse insulin / glucagon ADH rhodopsin
6	Muscle (M) actin thin – binding site myosin thick - cross bridges tropomyosin – block binding sites

In order to fully address the question and reach the highest mark bands students must also include at least four topics in their answer, to demonstrate a synoptic approach to the essay.

Students may be able to show the relevance of other topics from the specification.

Note, other topics from beyond the specification can be used, providing they relate to the title and contain factually correct material of at least an A-level standard. Credit should not be given for topics beyond the specification which are below A-level standard.

[25]

Q1.

Generally, students demonstrated their good knowledge of protein structure in (a). Most students achieved a mark for naming condensation and many went further to describe the groups involved in joining together amino acids. Diagrams used to support descriptions were almost invariably accurate and labelled fully. Those who scored no marks (17%) named the reaction as hydrolysis, gave lengthy accounts of translation, referred to a reaction between H and OH, or confused the amine group with nitrate/nitrile.

In (b), 35.4% of students gained two marks, usually by referring to the involvement of hydrogen bonds in forming an alpha helix or beta-pleated sheet. The first alternative in mark point 2 was less often seen and students were often muddled about what bonded to what. Precise and well explained descriptions of hydrogen bonding were present in a few answers. Some students confused protein structure with nucleic acid structure. It was not unusual for students to have no idea about how secondary structure is produced.

In many answers to (c), students applied their understanding well and gave clear and often succinct explanations of why tertiary structures differed, using appropriate AS biology knowledge. Those who scored one mark often did not name the bonds or mention the ‘different location’ of bonds, and they could not explain the idea of ‘different sequences’. Some answers missed the point of the question by describing how tertiary structures formed, or confused DNA structure with protein structure. Some students incorrectly used the degenerate nature of the DNA code as the reason why primary structure varied. The alternative interpretation relating to changes being caused by variation in pH or temperature was seen a number of times and gained a mark.

Q2.

In (a), many of the definitions given for digestion were general statements well below the standard expected at AS level. They were often incorrect, such as “food is broken down ready for absorption”, or “it is a process taking food between mouth and rectum”, or “when food is eaten”. Also, many students seem to think that absorption is part of digestion. Irrelevant, but correct, details about enzyme action were given in more than a few answers and it suggested that students’ knowledge of section 3.1.4.2 of the specification is more detailed than it is of section 3.3.3.

Many students regarded question (b) as a test of why digestion is faster with two enzymes, and so duplicated the answer to (d), rather than suggest why they acted at different places. Many described the specific nature of an active site or stated active sites are different, without a precise focus on the idea of different shapes. The complementary relationship between enzymes and the location on cellulose where complexes form is well understood. Some students had the misconception that cellulose was a protein or acted as an enzyme.

Question (c) discriminated well. Almost every permutation of the numbers shown in Table 4 was used in calculations, so many students (33.1%) achieved no marks and a fair proportion (30%) scored only one mark. Many did not extract the correct information from the results table, and performed a calculation on the quantity of cellulose remaining, not on the amount digested. An equal proportion of students expressed rate as digestion per hour, not noticing the question required it to be per minute. The majority of students who derived a figure with decimals converted this correctly into standard form, although some failed to gain marks because they used 103 rather than 10^{-3}. Many answers were supported with clear working and demonstrated logical progression in mathematical steps.

A reasonable number of students (22%) achieved both marks in question (d), although some made it more difficult to convey their understanding by beginning the answer with the action of exocellulase rather than from how the 'ends' were created. A large number of students correctly described the role of each enzyme, but then failed to explain how this would give the greatest rate of reaction, or they gave a general account without identifying the enzymes. Many added together the quantity of enzymes in the mixture and suggested incorrectly that 'double the enzyme' or 'twice as many active sites' was the reason for the increased rate of digestion.

In (e), the correct formula for calculating percentage loss was presented in a variety of ways and demonstrated that many students are aware of this mathematics skill. Their use of terms such as 'total' for 'original', or 'new/old' for 'final/initial' occasionally made it difficult for examiners to determine precisely what students meant. Omitting to multiply by 100, and subtracting mass lost from the original mass, instead of subtracting final mass, were common errors. Many students failed to gain the mark by calculating the percentage of cellulose remaining. Surprisingly, 10.7% of students made no attempt at this question.

Q3.

This question was based on section 3.1.4.2 of the specification and specifically on the induced-fit model of enzyme action and the research that led to the proposal of this model of enzyme action.

In question (a), although many students could describe that the enzyme lowers the activation energy, only 18% could explain that this was due to the enzyme bending the bonds in the substrate. Some students gave lengthy descriptions of how the E-S complex forms, losing focus on the question of how this results in an increase in the rate of reaction.

Questions (b) and (c) assessed mathematical skills MS 0.2, MS 0.3 and MS 3.1. It was pleasing to see standard form being used successfully, with 71.9% of students achieving both marks for (b). Students found part (c) more challenging. Many thought they needed to calculate a rate, not appreciating that the y-axis already gave the rate of reaction. Many did not read the correct parts of the graph – at 2.5 mmol dm-3 for curve C and at the highest point for curve L. Credit of a single mark was given if a correct calculation was completed with readings from incorrect parts of the graph, but all readings had to be accurate and this was often not the case.

The key to answering question (d) successfully was to use the information provided – that the lyxose binds to the enzyme and that the graph shows that lyxose increases the rate of reaction. Many students started their answer with the idea of lyxose being an inhibitor and reducing the rate of reaction – this limited them to one mark out of three. A significant number of students inferred that lyxose is a respiratory substrate (rather than using the information that it binds to the enzyme), so there would be an increase in ATP levels, so more substrate and hence a faster rate. It was a shame that some students who worked out what was going on did not achieve full marks due to imprecise use of language, for example referring to changing the 3-D shape of the enzyme rather than changing the tertiary structure of its active site. Fewer than half the students scored any marks on this question.

Q4.

64.5% of students could answer question (a), a test of recall from section 3.1.4.1 of the specification.

For question (b), 67.5% of students achieved both marks. Those who could not define 'degenerate' in the context of the genetic code often failed to gain credit through not using

appropriate terminology, for example referring to ‘bases’ rather than ‘base triplets/codons’ or stating that base triplets ‘produce’ amino acids rather than ‘code for’ amino acids.

Question (c) was an interesting question as it could be interpreted as a straightforward 465 amino acids multiplied by three to give the 1395 bases of the gene. Students could also add three or six bases to this, for a start and/or stop codon. Some students appreciated that a gene would be made up of double-stranded DNA so would comprise double this number of bases – this was also awarded credit. 67% of students could complete this calculation.

Question (d) showed that multiple-choice questions are not always simplistic or based on recall. This question required students to interpret **Table 1**, convert the mRNA codon to a DNA base triplet, and also notice in the question that this was a single base substitution. Only 9.6% successfully achieved all of this. The majority of students ticked box 2 that did show a Val to Ala change, but with a mutation in the mRNA (not DNA) and of 2 bases.

The answers to question (e) revealed much misunderstanding of the principles of the link between DNA, polypeptides and proteins, as many students discussed the changes in amino acid in terms of silent mutations or frameshift mutations. The instruction to use all the information required the students to look back at **Table 1** and use the key showing the properties of the R group of the amino acid. Very few students could apply this information and link the reduction in rate of reaction with the R group of amino acid 279 changing from being negatively-charged to being positively-charged. Imprecise biological language was also often seen, for example omitting to reference the ‘shape’ of the active site and discussing the 3-D structure of the protein rather than its tertiary structure. Just over half of the students (54.2%) managed to score at least one mark here; only 3.2% gained maximum credit.

Q5.

It was hoped that part (a) would be a relatively accessible start to the paper but this did not prove to be the case. However, it discriminated quite well. To address this question, students required understanding that positive feedback is something producing a **greater** deviation from the normal state. They were told that positive feedback was involved and then needed to apply knowledge of the principle to this context. Good answers were seen from a minority (13%) of students who gained both marks by stating that osteocalcin causes **more** insulin and this leads to **more** osteocalcin. About 30% gained one mark by giving half the story; for example, insulin leads to more osteocalcin. Many wrote about insulin or osteocalcin stimulating the production of the other but that re-states what is in the diagram, with no idea of ‘more’. Many also wrote about one leading to ‘further’ production but that could be at the same rate. Others rather over-complicated the situation and wrote about β cells, osteoblasts or osteoclasts being stimulated to divide. A few gave rote-learnt answers consisting of definitions of positive feedback but with no reference to the diagram, or to osteocalcin and insulin. These answers were not credited. In all, 55% of students failed to score.

In question (b), 28% of students gained both marks by stating that the acidic pH would change ionic or hydrogen bonds in osteocalcin and this would change its tertiary structure. Nearly 40% obtained one mark for noting only the change to the tertiary structure. Many of the 32% who failed to score used terminology below A-level standard and only made vague statements about the acid changing the shape of the protein. Many wrote about changes to the ‘active site’ of the protein and did not score. Many students appear to think that all proteins are enzymes and all have active sites. They were told in the stem of the question that osteocalcin is a hormone. As such, it acts as a chemical messenger that binds specifically onto receptors of target cells; in this case β cells. Osteocalcin has a **binding** site (or even sites), not an active site, it is not a catalyst and it doesn’t have a substrate. The same misconception was evident in some later questions. The question

discriminated well.

Question (c) was based upon the specification content that requires understanding of “The action of insulin by controlling the uptake of glucose by regulating the inclusion of channel proteins in the surface membranes of target cells”. The specification does not give specific examples of target cells. In Fig. 1, students were shown that osteoblasts are target cells for insulin. In the event, 19% of students obtained both marks by stating that more glucose (for respiration) enters osteoblasts because more channel proteins join the surface membrane. About 20% obtained one mark, for suggesting there would be an increase in the uptake of glucose. These students did not mention more channel proteins joining the membrane. Many thought that insulin opens (existing) channels and others made no reference to channels at all. The nearly 60% who failed to score often gave accounts of control of blood glucose concentration. Others wrote about the conversion of glucose into glycogen, which would reduce glucose for respiration. The question discriminated well.

Q6.

Question (a) related to the figure, a scatter graph. 41% of students correctly suggested some form of correlation coefficient and the reason that some form of correlation between two variables was being considered. The question discriminated well.

Question (b) started with an instruction to consider the data in the figure. This question tested AO3, the ability to draw conclusions from information and data provided. The data concern the use of Rituximab to treat CLL, a ‘real life’ context. Many students (57%) obtained onemark, usually for noting that the more CD20 on B cells, the more B cells Rituximab destroys. A further 28% obtained two marks, usually for either noting that in no case are all B cells killed, or that the data do not show the proportion of cancerous and normal B cells killed. Only 5% of students made both points to score three marks. Very few students noted that Rituximab cannot cure CLL. There was a mark available for noting that Rituximab has little effect below 5 arbitrary units of CD20, but few students accurately noted this point in the trend of the data. Many students who failed to score simply described the data, quite often point to point. Others drifted away from these data and speculated on the possible lethal effects of damage to the immune system by Rituximab, meaning that it should not be used. This question was based on a treatment that is used, for a real cancer. Students should assume that doctors and scientists follow proper, ethical scientific and medical procedures and do not set out to kill patients.

In question (c), 54% of students calculated the correct difference and expressed it in standard form. One mark was obtained by 6% of students who calculated the correct difference but did not put it into standard form. The question discriminated well.

Question (d) discriminated very well. One mark was obtained by 20% of students, usually for either deducing that less CD20 would be produced in people with the *NOTCH1* mutation, or that there would be little for Rituximab to bind to and so few B cells destroyed. 24% of students obtained two marks, usually by making both linked points. Some obtained two marks by noting that the mutation would lead to a change in the tertiary structure of the transcription factor, leading to it not binding to the gene for CD20. Some 14% of students gave the whole story and obtained all three marks. This left 20% who failed to score. Many appeared not to know what a transcription factor is and often wrongly suggested that the mutation would affect the gene for CD20, or the structure of CD20, making it the wrong shape to bind to Rituximab.

Q7.

Other than with spelling, there were no issues with question (a); 76% of students answered correctly.

Question (b) proved to be harder than expected; again, this tested simple understanding but only 55% of students answered correctly.

68% of students scored the mark on question (c), which was fewer than expected for simple recall.

Question (d) showed that AS students lack an understanding of when to use each of the three statistical tests stated in the specification. Many thought that “a value for P of 0.04” meant that the difference between them was only 0.04. There was also a large number of students referring to the ‘sign test’; this is not in the AQA specification. 50% of students scored zero marks and only 4.6% scored three marks.

Q8.

Students clearly have difficulty in describing data with almost a quarter gaining no marks at all for question (a), and many of these confusing data for low-starch and high-starch diets. However, most could state that a low-starch diet was linked to fewer copies of the gene and many correctly identified the modal values. There were few references to the overlapping ranges and the higher range in populations with a high-starch diet. Students would benefit from learning to use terms such as mode and range in their answers to similar questions.

In answers to question (b), students seemed less confident in their knowledge of protein synthesis than in their knowledge of enzyme action. Consequently, very few students could explain that, with more copies of the gene, there would be more transcription or more mRNA formed. However, most realised that there would be more enzyme present and then went on to explain the advantage in terms of faster starch digestion.

Often students failed to use the information given to them in question (c) and wrote generic answers about natural selection which failed to gain any marks. Examiners were looking to award marks for points made in the context of multiple copies of the *AMY1* gene. Those students who did this often gave excellent answers referring to mutation resulting in extra copies; they then went on to explain that this mutation resulted in a higher chance of survival and reproduction in populations with a high-starch diet, with the beneficial mutation being passed on to their offspring.

Q9.

Two-thirds of the students gave the correct answer of 6 g dm^{-3} for question (a).

Approximately 40% of the students were able to gain 2 marks for question (b). A significant number did not read the key on the graph correctly and so gave figures for females instead of males. Some students left the calculation as a fraction, perhaps through not bringing a scientific calculator to the examination – these students scored 1 mark.

In question (c), many students realised that the protein concentration decreased more in females than males, but very few used the given information about the standard deviation to comment on the significance of this difference. Students should take more care in interpreting graphical information since, again, many confused the male and female data.

Question (d) was answered poorly, with 10% of students giving no response and over half scoring no marks. This was disappointing as the idea of preparing a dilution series to produce a calibration curve is in Required Practical 3. There were some good answers in which students wrote about measuring the absorbance of known concentrations of protein, but many suggested producing different concentrations of blood plasma rather than protein. These students were still able to gain some marks. Very few went on to

describe how to draw the calibration curve in sufficient detail to gain a mark. Many students suggested plotting age as part of their calibration curve, and few were able to give both axes. Those who did were usually able to continue their answer to gain one mark for the use of the curve to find the protein concentration from the absorbance value.

In question (e), almost 40% of students gained 1 mark for suggesting a decrease in protein content could be linked to fewer antibodies. Examiners were surprised by how many students thought that cells were proteins.

Q10.

(a) There were many excellent answers to this question, with over 50% of students achieving both marks. The majority of students knew that bacteria divide by binary fission, but often did not include sufficient, or specific enough, detail in their description of what happens during this process to score the second mark. There were several statements about mitosis and some descriptions of viral replication.

(b) This question required an **explanation** and so there were no marks for a description of the graph. Many students gave lengthy descriptions and, even if they went on to write creditworthy statements after this, they had wasted much time and energy. The first requirement was for students to realise that, since the 30 °C line stays at 100%, both lines at 50 °C and 60 °C show denaturation of the enzymes. Many students got this far, but their explanations of what happens to the protein during denaturation were often incomplete or imprecise. For example, some stated that 'bonds' would be broken or that 'hydrogen, ionic, disulfide and peptide bonds' would be broken, so not achieving mark point 3. The mark least often awarded was for the explanation that a temperature of 60 °C would denature the enzyme more quickly because of the increased (kinetic) energy at this temperature.

(c) / (d) Both of these questions required careful reading of the question stems to access the mark points; many students got half-way through their answers, but gave insufficient detail to score full marks. For question (c), many students appreciated that the extracellular proteases would digest protein and this might protect the bacteria in some way, but their answers were not specific enough to gain credit for this idea. Similarly, many appreciated that extracellular protein digestion would provide useful products for the bacteria but did not go on to state that these products would be amino acids that could be used for growth / protein synthesis within the bacteria. For question (d), it was pleasing to see how many students could state that the dipeptidases would hydrolyse bonds in dipeptides, but many were not confident what these bonds were, or what the products of this hydrolysis would be. Many did not continue their answer to state the importance of this hydrolysis with reference to the passage of amino acids across the cell-surface membrane into the cells for absorption.

Q11.

(a) It was pleasing to see that nearly all students could name two enzymes involved in DNA replication; 92% got both marks.

(b) This question discriminated well. 40% of students obtained one mark, usually by noting that phosphorylation of the enzyme caused the active site to be formed, or to become complementary to the substrate. About 38% of students obtained two marks, usually by also noting that phosphorylation changed the tertiary structure of the enzyme (which caused the change to the active site). Some students' terminology was poor and confused, and some referred, wrongly, to phosphate as a competitive, or non-competitive inhibitor. Some failed to mention the active site at

all, even though the question asks why enzymes become able to bind to their substrates.

(c) About 50% of students obtained the mark, by reference to the substrate becoming more reactive, or phosphorylation (of the substrate) lowering the activation energy for the reaction. Quite a few made vague references to kinetic energy changes that were not credited. Some wrongly continued to focus on phosphorylation of the enzyme.

(d) This was well done by many, with 47% obtaining 3 marks, but still discriminated quite well. Most students appeared to be able to follow the story in the stem of the question and apply some basic principles, such as the mutation leading to a form of ATM unable to bind to broken DNA. Only 3% of students failed to score.

Q29.

About two thirds obtained the mark in (a) for a correct description of the difference between a triglyceride and a phospholipid. Those who failed to score either did not know about the structure of these molecules or just described the structure of a phospholipid (or triglyceride).

In (b), about 40% of students could fully describe how to test for a lipid and obtained both marks. A minority described tests for other biological molecules. Many made errors in their descriptions of the emulsion test or of a positive result. These errors included: adding water before ethanol, heating the mixture, the presence of a precipitate and failing to note that the colour of the emulsion would be white.

Most students scored the mark in (c). Those who didn't got saturated and unsaturated the wrong way round in terms of carbon-carbon double bonds.

In (d), 28% obtained both marks for stating that the fat substitute would not bind to the active site of lipase because it has a different shape to a triglyceride. A similar percentage obtained one mark. Those who failed to score often ignored the question's reference to lipase and wrote about bile salts, micelles and methods of absorption.

Q30.

In (a), 29% obtained both marks. The idea of induced fit was generally known but often poorly expressed. Some students wrote about the substrate having the same shape as the active site, rather than a complementary shape. A minority had the active site on the substrate.

The rate **at** 10 minutes in (b) was correctly calculated by 22% of students. These students drew a tangent to the curve at 10 minutes and used it to calculate rate. 19% of students obtained one mark after drawing an incorrect tangent, or making a mistake in their calculation from a correct tangent. The remainder simply divided the y axis number by the x axis number at 10 days and failed to score.

In (c), many students simply described the curve, rather than explaining. Some attempting an explanation incorrectly wrote about the enzyme being used up, or all its active sites being occupied. 13% obtained both marks for writing about a rapid rate at the start because there is lots of starch and the rate levelling off/falling to zero after 25/30 minutes as all the starch is used up. Some 43% obtained one mark for making one or other of these points.

Question (d) was based around skills that students were expected to have developed in required practical 3; that is to say the production and use of a calibration curve. The

purpose of the required practicals is, generally, to allow students to practise and develop skills that can then be applied in many different settings. 21% of students obtained one mark, either for noting that the scientist would need solutions of maltose of known concentrations, or that a calibration curve would have concentration on the x axis and colorimeter reading on the y axis. About 12% obtained both of these marks. Only 5% then went on to (briefly) describe how the calibration curve would be used to determine the concentrations in the experiment.

Q31.

The questions here related to the passage and students who used information and ideas from the passage tended to do well. Many students appeared to attempt the questions without considering the contents of the passage. Students should be aware that great care is taken to reduce the length of the passage as far as possible, retaining only content that is useful and necessary.

In (a), the passage stated that amyloid-precursor protein is large, has a complex shape and is the substrate of two different enzymes. About 14% of students correctly suggested that each enzyme would have an active site that binds (specifically) to a different site on the amyloid-precursor protein. (This would be rather similar to endo and exopeptidases acting on a protein – see specification section 3.3.3.) Many students wrote about induced fit allowing an enzyme to adapt its active site to fit a/any substrate, so both enzymes would bind to the same place on the substrate. Others had active sites on the substrate that could adapt to the enzymes.

Question (b) produced more discrimination than expected. About 27% obtained both marks, for noting that a peptide bond is broken and water is used in the process. About 43% obtained one mark for one or other of these points, usually the use of water. The others either didn't know, or suggested water was given off in the reaction.

In (c), few students could string together all three points on the mark scheme. Many appeared to be unable to use information from the passage to come up with any sensible suggestion of how the mutations could lead to Alzheimer's disease, such as a faster/greater production of plaque.

In (d), about 46% obtained one mark for describing what a competitive inhibitor is and how it acts by binding to the enzyme's active site. About 30% were then able to go on and apply this knowledge to the context in the passage and suggest that the inhibitor would reduce or stop β-amyloid or plaque formation. Some students attempted to hedge their bets by saying that the inhibitor changes the enzyme's active site but not saying how. This approach was not given credit. Some students thought that active sites are on substrates and failed to obtain the first mark point. Students who could not remember what competitive inhibition of an enzyme entails were unable to access (d). 23% of students failed to score on (d).

Question (e) could only be answered using information from the passage. About 20% of students obtained this mark by noting that the brain normally has the enzymes, and produces the proteins, mentioned in the passage and they must, therefore, have some necessary function (that the drugs blocked).

Q32.

(a) It was disappointing that less than 50% of students obtained two or more marks out of the four available on this question. Although the context of the question was novel the knowledge and understanding required have been regularly assessed on previous AS Biology papers with students achieving better outcomes. The fact that a mutation involves a change in the DNA base/nucleotide sequence was only

appreciated by a minority of students, often the 5% of students who obtained maximum marks. Although most students appreciated that a different amino acid sequence would be coded for, a number of students incorrectly stated that different amino acids would be formed. Better answers did gain credit for references to changes in hydrogen, ionic or disulfide bonds. However, many students failed to gain a mark for a change in the tertiary structure as they incorrectly suggested that this changed 'the active site' of a receptor. 30% of students obtained no marks. These students often provided detailed accounts of translation or outlined the consequence of having a non-functional receptor which was required in the following question.

(b) Approximately half the students obtained at least one of the two marks available for this question. Usually this mark was awarded for appreciating that HIV would not be able to attach to the protein receptor and therefore could not enter the cell. Many other students omitted the latter part of this description. Again, many students referred to an active site on the receptor. Approximately 10% of students gained both marks by further explaining that HIV would not be replicated or that the T cells would not be destroyed.

(c) As expected, this question proved very difficult for the vast majority of students with less than 5% obtaining both marks. The most frequent correct response related to the low number of HIV infections in Europe compared with other parts of the world. A number of students did gain credit for outlining that HIV has only been present in humans for a relatively short time period. The other mark points were rarely awarded. A significant number of students appreciated that natural selection often occurs over a long time period but did not relate this information to the context of the question.

Q33.

(a) More than 80% of students correctly stated that the pH probe would give a more accurate or precise reading or that assessing a colour change would be subjective.

(b) It was disappointing that more than half the students did not recognise that the decrease in pH was due to fatty acid production. There were many answers that referred to the products of carbohydrate digestion or of protein digestion in their answer.

(c) Most students knew that the pH remains constant as all the triglycerides had been hydrolysed or that the low pH could have denatured the enzyme. Unfortunately there were many who disqualified their answer by suggesting that the enzyme would be used up or all the active sites would be full. Relatively few students went on to explain why this would result in a constant pH.

(d) It was pleasing to see that almost 70% of students were able express their answer correctly on the graph.

Q34.

(a) 62% correctly named the rough endoplasmic reticulum or the ribosome as the site of trypsin production. Those who did not score usually failed to specify the rough endoplasmic reticulum or simply gave the abbreviation RER. Students should be reminded that only those abbreviations given in the specification or in a question should be used in exam answers.

(b) This question discriminated well, with students writing about proteins within the cells not being digested and so the cell would not be damaged or its function would not

be impaired. The problem for many students was that they failed to recognise that the question was about the inactive enzyme within the cell. A common mistake was that it enabled the storage of large amounts of enzyme within the cell, or that it is a control mechanism over the rate of digestion.

(c) (i) 84% correctly named the peptide bond.

(ii) Students are clearly familiar with this type of question and many gave excellent answers. There were, however, the usual mistakes of referring to the active site on the wrong molecule and many thought that the inhibitor would be a similar shape to trypsin or its active site. Inevitably, there were a few students who confused competitive and non-competitive inhibition.

Q35.

(a) Most correctly identified ‘quaternary’ as the appropriate term to describe the protein’s structure with ‘tertiary’ being a common misconception.

(b) The triplet nature of the DNA nucleotide code for amino acids is well understood. Very few failed to achieve the mark, although some students divided by three instead of multiplying by three.

(b) Detailed accounts of haemoglobin’s allosteric properties, its structure, the Bohr shift or the number of oxygen molecules loaded per molecule were common, demonstrating where students had not read carefully enough the detail required in this question. Where students achieved only a single mark, they had usually not referred precisely to the location where haemoglobin associates with oxygen.

(d) (i) A vast majority of students successfully used the graph to find the correct difference in percentage saturation of haemoglobin with oxygen. A few failed to gain the mark despite having identified the correct values on the graph because they calculated a percentage change, rather than the difference.

(ii) This question discriminated well. Students who understand the transport of oxygen topic gave good responses that made clear a link to the context of anaemia with a sense that the shortage of haemoglobin molecules would, to some extent, be compensated for by the reduced oxygen affinity. Some did not make a direct reference to ‘reduced affinity’ although they demonstrated a good understanding of the principle. Occasionally students went off at a tangent by referring to the effects of altitude differences and some erroneously described the curve’s shift to the right as representing an ‘increase’ in affinity.

Q36.

(a) More than 80% of students correctly named organ C.

(b) More than 62% of students correctly named organ E.

(c) There was considerable evidence of a good understanding of the importance of the (specific) active site of the enzyme. This was expressed in a variety of ways. Students discussed the importance of the tertiary structure determining the active site. Many indicated that the active site of maltase was complementary to either the substrate or maltose. Unfortunately some students incorrectly stated that maltose possessed the specific active site. Nearly all students had a clear understanding of the resultant enzyme-substrate complex.

80% of students scored two marks, often because they failed to indicate that

maltose would bind / join / fit or attach to the maltase and so form the enzyme-substrate complex. The poor expression of some students resulted in them suggesting that the complementary shapes were matching. Unfortunately this conveyed the idea of the shapes being the same.

Q37.

(a) The question required students to apply their knowledge to an unfamiliar context and so learned responses about enzymes did not score well. Many students incorrectly suggested that the beads increased the surface area of the lactase - they did not think of the comparison in terms of adding a solution of the enzyme directly to the milk. However many students gained two marks, usually for stating that the enzyme remained on the beads and could be re-used and also that the enzyme did not have to be removed from the milk.

(b) This question discriminated well and over half the students scored both marks. Many students could name the two monosaccharides produced when lactose is hydrolysed but it was surprising how many thought that lactose was a polysaccharide. Some students failed to gain the second marking point as they went no further than repeating the question stem in their answer.

Q38.

(a) Most students tried to answer this question by writing all they knew about the use of the centrifuge in cell fractionation, rather than applying their knowledge of the use of the centrifuge to this example of obtaining a cell free liquid. Mark points 2 and 3 were still available if the cells were homogenised first. Mark point 3 was rarely awarded, as many students simply referred to removing the pellet (rather than the supernatant), or they suggested filtering which would break up the pellet and mix the contents once again.

(b) The vast majority of students could recall the function of lysosomes. Some only stated that lysosomes stored enzymes rather than identifying their active role.

(c) This question was generally well answered, with just a few students showing confusion by suggesting that ‘bacteria would be denatured’ or that ‘neutralising acid would lower the pH’.

(d) Mark points 1 and 2 were commonly awarded but few students could correctly describe the relevance of the standard deviation and the overlap with other strains. Some students tried to explain why the damage was caused to human cells, rather than explain how the data support the conclusion drawn.

(e) Students who fully understood Resource B and the principle of the cell-free liquid answered this question very well. Many students gave answers suggesting the *H. pylori* cells were still present. They were often unable to score mark point 2, as they were suggesting there was no toxin as a result of the cells being unable to produce it; the incorrect context for awarding this mark.

Q39.

Although this question tested familiar ground, many students could not gain more than two marks, as answers were either not of an A2 standard or appreciative that discussing digestive enzymes was not appropriate in the context of the blood. Besides ‘enzymes’, haemoglobin was the most commonly named protein. Students generally lost marks for weak descriptions of the effect of a change of pH on the (named) protein or the belief that a change in pH would mean that enzyme− substrate complexes would no longer be

formed or that haemoglobin could no longer carry oxygen. In this context, some felt that death would be the result, a rather drastic outcome for a fluctuation of blood pH.

Q40.

(a) Nearly all students scored 2 marks here with most achieving 3. Good answers incorporated all the mark points.

(b) Some students only repeated the information in the resource that 'antidote reacts with / binds to cyanide', some had the antidote destroying the cyanide and some referred to the cyanide as if it were an enzyme.

(c) (i) Many students only gave two trials in each group, rather than including all those that could be compared in each category as was required. The order in which the groups were given was not important.

(ii) This question required students to identify overall trends / patterns in the data rather than just restating the figures for mark point 1 and 2. Similarly some form of calculation was required for mark point 3; calculations equivalent to those shown (for example relating different concentrations of cyanide to those given in the examples) were acceptable.

(iii) Many students successfully calculated this percentage but a proportion of students made little or no attempt at this calculation.

Q41.

Both parts of this question discriminated well but for different reasons. Part (a) tested understanding of how enzymes work and (b) tested recall of how inhibitors of enzymes work.

(a) Many students obtained one or two marks by referring to the tertiary structure of the enzyme and/or the complementary fit; demonstrating understanding of why maltase only catalyses the reaction involving maltose. Only students with an understanding of how enzymes act as catalysts that lower activation energy obtained further marks. These students wrote about how the formation of the enzyme-substrate complex involved an induced fit. They went on to write about how this stressed bonds in the substrate molecule, making it more reactive and thus lowering the activation energy for the reaction. They also noted that the enzyme, as a catalyst, remains unchanged after the reaction. Many students appeared to be triggered by the word 'temperature' and wrote about why the enzyme would not work if the temperature was above or below normal body temperature; denaturing being frequently mentioned. These responses were not answering the question and did not receive any credit.

(b) About half of students obtained all five marks in this part, displaying good recall of how competitive and non-competitive inhibitors work. It was encouraging to see that quite a few wrote about the relative effects of increasing substrate concentration on the two types of inhibition. Some students got the two types of inhibitor mixed up and failed to score one or two of the marks. Poor expression also hindered quite a few, with statements such as, "The competitive inhibitor has the *same* shape as the substrate.", or "The non-competitive inhibitor binds to the other active site of the enzyme".

Q42.

(a) Most students were able to tackle this successfully, showing a good understanding of enzyme specificity. Where a mark was not awarded, it was usually because the

active site had not been specifically identified as the part of the enzyme where the substrate binds. Some incorrect responses referred to the active site of the substrate.

(b) The effect of a competitive inhibitor on the rate of a reaction was generally well known. Some students did not obtain mark point 3 because they stated that no uric acid crystals would be formed, rather than fewer crystals would be formed. A number of poor responses suggested a reaction between xanthine and allopurinol which would form a compound that could not enter the active site, or referred to the tertiary structure of allopurinol.

Q43.

(a) Over ninety percent of students obtained at least one mark, usually by identifying which reactions occur in mitochondria. The majority also knew the stages of respiration during which NAD is reduced. However, the stages of respiration during which carbon dioxide is produced were less well known.

(b) (i) Most students obtained a mark for stating that glucose is used in glycolysis or that it is broken down in the cytoplasm. Very few students gained the second mark, as they failed to explain that glucose could not pass through mitochondrial membranes.

(ii) The vast majority of students obtained a mark for suggesting that malonate attaches to the active site of an enzyme, or that it is a competitive inhibitor. Most of these students then gained credit for explaining that this would reduce the formation of enzyme-substrate complexes. However, weaker responses were very confused, with malonate, fumarate or succinate having an active site. Some students referred to non-competitive inhibition.

(iii) Almost forty percent of students gained both marks in this question, which produced some excellent answers. These students referred to the inhibition of the Krebs cycle, reduced production of reduced co-enzymes and the role of oxygen as the terminal electron acceptor. Students obtaining a single mark often referred to the Krebs cycle being inhibited. A common misconception in weaker responses was that oxygen is used directly in the Krebs cycle.

Q44.

As a whole, this question tested students' understanding of the relationship between photosynthesis and the growth of plants. The questions were marked on outcome; this is to say that the examiners expected answers of A-level standard.

(a) Many students failed to read the y axis carefully enough. All of the samples of plants increased in dry mass after 3 days, they all grew but some less than others. GB had no effect at 25°C, compared with plants without GB. Few students noted this and quite a number stated that GB produced more growth at all temperatures. Relatively few students made reference to the protection given to growth by GB up to 35°C. However, quite a few noted that growth was reduced less above 35°C with GB.

(b) (i) There was only one mark available for this question and, with this in mind, students were required to refer to the standard error bars not overlapping, or to state that there was a significant difference between plants producing GB and those that weren't.

(ii) Over a third of students obtained one mark, usually for linking a reduction in photosynthesis to a reduction in glucose (simple sugar) production. Some

were also given credit for suggesting that the reduction could be linked to reduced enzyme activity. This was as far as most students went. Indeed, quite a large number wrote about reduced photosynthesis producing 'less food for the plant'. This was disappointing at A-level. For most students, their statement about reduced glucose production was simply followed by 'therefore growth falls'. There were very good answers that linked reduced glucose production to less respiratory substrate and thus less ATP / energy for growth. Others displayed understanding that sugars from photosynthesis form the basis for production of other organic substances and that these add to dry mass.

(c) This was another question where some students failed to read the question carefully. A large majority correctly suggested that *when* the enzyme attaches to the thylakoid, this changes the shape of the enzyme, and / or its active site. They then went on to link this to a failure to bind to its substrate. Those who did not read carefully suggested that the enzyme was changed *before* binding to the thylakoid. This did not preclude them from scoring marks but made it less likely.

(d) It was pleasing to see that the chain of evidence and logic was seen by most students. The number of marks they obtained tended to be a question of how much of the story they gave.

(e) Many students ignored the statement in the stem that the hypothesis was developed on the basis of previous research. Instead, they reiterated the evidence from the study in the question. Good answers included the idea that research might have shown that crops in hot climates naturally produce GB.

Q45.

(a) There was some weakness with both the answers to this question and the assessment of what was written. As mentioned before, marking points show the minimum required answer and marking point 1 clearly identified that amino acids would be formed. It was disappointing that quite a few assessors felt that "smaller proteins are formed" or simply that "proteins are digested" was sufficient to award this marking point.

(b) In the main, students used the information provided well to answer this question. The majority referred to trusted ideas such as the limited number of stains used or that there was only a single set of results. Higher scoring students used the more sophisticated arguments, such as not including results where there was no change, and made specific reference to the actual stains.

(c) It was also the case that many students answered this question well, particularly where appropriate temperatures were identified to support the use of enzyme **S** or to explain why enzyme **P** was inappropriate for use. However, the general idea, that enzyme **S** was effective across a wider range of temperatures, was often not recognised.

(d) Many students finished with full credit in this question. In weaker answers, as was often the case with many questions, students failed to translate the idea in the question first. Thus, 'a wider range of stains' was not explained as caused by different substances being present but this did not prevent most being able to identify that the specific nature of enzymes was due to their active site.

Q46.

(a) It was pleasing to find that the vast majority of students are familiar with the

monosaccharides in sucrose and lactose.

(b) This proved to be one of the most challenging questions on the paper. Only about ten percent of students got both marks and sixty-five percent scored zero. The question clearly asks about digestion of starch in the small intestine. Despite this, many had the salivary glands as the site of production of the amylase active in the intestine (which was ignored by the examiners). Very few had any idea where maltase is produced and answers ranged from the thyroid gland to the pancreas.

Q47.

This was a question where many students failed to use the information given, or were let down by poor expression of ideas.

(a) Sixty percent of students obtained both marks and thirty percent obtained one mark. Those who obtained one mark frequently stated that phosphate was a non-competitive inhibitor and then went on to say that it made the enzyme active. Some students made more considered observations along the lines of, 'Like a non-competitive inhibitor, phosphate binds to a site other than the active site, changes the shape of the enzyme and causes the active site to form'. These answers were given full credit.

(b) This proved very difficult for the majority of students. Many failed to make any use of the information or diagrams in the question and resorted to vague statements about cancer and uncontrolled division. Some wrote about TK as though it was a cancerous cell, rather than an enzyme. Many got confused between faulty and non-functional forms of TK.

(c) This proved to be accessible, with marks awarded being very similar to those for (a). The context was obviously more familiar to students. Weaker answers often involved references to there being two active sites on the faulty TK. It has been noted in many papers that some students think any binding site, on any protein, is an active site.

Q48.

(a) This proved to be an excellent discriminator. Nearly half of students scored full marks. This was usually for stating that the cell wall does not form, leading to cell lysis due to entry of water. It was usually only the best responses that referred to a lower water potential in the bacterium. Weaker responses revealed a number of misconceptions. These often referred to the cell wall being broken down or that isoniazid *caused* the cell wall to become permeable to water.

(b) Half of students were aware that human cells may lack enzyme **B**, use different substrates, or produce different fatty acids. Weaker responses usually fell into one of two types. The first suggested the idea that isoniazid is an enzyme. This led to widespread references to enzyme inhibition and active sites on a variety of molecules. The second used the fact that human cells do not have cell walls. The question asked why isoniazid does not affect the production of *fatty acids* in human cells. Hence, reference to cell walls was out of context and was not credited.

(c) Two-thirds of students scored full marks and all marking points were regularly seen. Weaker responses were marked by the use of scientific terms in the wrong context, e.g. 'different amino acids produced', 'base sequence of the enzyme', 'amino acid base sequence', 'amino acids coding for' and 'different hydrogen bonds form between bases'.

Q49.

(a) The Benedict's test for reducing sugars was well known with most students gaining all three marks. The main problem here was that many students failed to heat the solution, either by not mentioning heating at all or simply saying 'put it in a water bath' without specifying a temperature - water baths can be at any set temperature. There was a significant number who confused the tests for reducing and non-reducing sugars and a small number who described other biochemical tests.

(b) (i) It was encouraging to see that the best students were able to apply their knowledge of several different parts of the unit and explain their answers well. These answers were often concise, explaining that more maltose would be produced, lowering the water potential so that water entered by osmosis.

There were many confused answers, however, and it was evident that some students were unsure as to whether pH 2 was acidic or alkaline. Most understood that amylase would hydrolyse the starch into maltose but then went on to write at length about the effect of pH on the rate of enzyme action.

(ii) Most students gained this mark, realising that you need to look at a range of pH values to be able to conclude what the optimum pH is, but some obviously thought that optimum simply meant the best of those considered. There was a surprising number of students who inexplicably referred to the optimum temperature.

Q50.

(a) Many students gave the correct answer, hydrolysis. Those who failed to score usually confused hydrolysis with condensation.

(b) Many students correctly identified that the peptide was too large or insoluble and therefore gained one mark. Only the more able students went on to explain that peptides would therefore not be able to pass through the carrier or channel protein. There was a significant number of students who wrote about active transport despite facilitated diffusion being referred to in the question.

(c) This question was generally answered well with most students recognising that the peptide would be considered "foreign" or "non-self". Those students who failed to score often referred to the peptides as cells.

(d) Some students failed to use the information in the passage, which stated that the drug had already been tested on patients with coeliac disease, and produced answers referring to trialling on animals or people without the disease. The majority correctly wrote about side effects, though some gave this answer twice with slightly different wording. Large numbers of answers gave generic responses here such as age or gender, without giving any thought to the context of the question.

Q51.

(a) Students were provided with "kinetic energy" as a starting point for their answers to this question and therefore should not have expected credit merely for stating that it decreased. They were expected to go beyond this and link the decrease in kinetic energy to the slower speed of molecular movement and, if they approached the question from an enzyme standpoint, fewer collisions between enzymes and substrates. In general, there was a clear understanding of principles but responses often lacked the necessary detail to secure full credit.

(b) (i) While it was widely appreciated that the use of ratios allowed comparisons to

be made, fewer students could explain why their use was important in the context of this investigation. The key feature was that it took into account differences in the initial amount of fungus, not just the amount of fungus.

(ii) The majority of students used the model provided and expressed the results of their calculations appropriately.

(c) It was again clear from the responses to this question that many of the less able students experienced difficulties with a question that required explanation. It was apparent to the moderating team that while most understood the relatively simple idea underpinning the question only the better students were able to explain this logically and unambiguously.

Q52.

(a) (i) The many students who understood the concept of water potential were able to gain maximum credit here.

(ii) Many students appeared of the opinion that this was another question centred on water potential. Others sought, more appropriately, to link this to enzyme action and growth. Not all of these students, however, appeared to understand that cooling an enzyme does not lead to its denaturation.

(b) Those students who could identify a chemical element as such and understood the protein nature of enzymes generally answered this question well. Some, who clearly appreciated the underlying principle, were handicapped by poor expression. Thus, it was not unusual to read such statements as “enzymes contain protein” or “proteins are turned into enzymes”.

(c) Most answers centred round the idea of contamination but relatively few students amplified this basic statement with a reference to other microorganisms.

(d) Most students gave appropriate values from the graph although there were occasional errors involving units. It was not unusual to find the time given in seconds rather than hours.

(e) One of the key ideas in answering questions in examinations is that of adding value. Students were provided with the information that “intracellular enzymes stay inside the cells that produce them” and “intracellular enzymes are more expensive to produce”. The many students who took four or more lines to write that because intracellular enzymes stay inside the cells that produce them they are more expensive to purify therefore gained no credit.

Q53.

There was much evidence from the answers to different parts of this question of the difficulties that many students experience with comprehension questions. It appeared that many of those of more limited ability took very little note of the information in the passage or of instructions embedded within the questions. They identified this question as relating to enzyme inhibition and sought refuge in set responses, many of which were largely irrelevant. Further evidence of the difficulties that the question presented was provided by the number of answers that were crossed through and rewritten on extra sheets.

(a) Most students correctly identified the monomers concerned as amino acids.

(b) Students, who read the question carefully and noted the information to which the lines referred, should have been able to point out in their answers to part (i) that

aspirin would bind to one of the amino acids making up the active site and that different enzymes would have different amino acid sequences. Responses along these lines were made by disappointingly few students. Better students produced economical answers to part (ii) in which they correctly identified enzyme **X** and explained that it was involved in the production of both prostaglandins and thromboxane. Others wrote at great length with tortuous logic and often included detailed quotes from the passage of marginal relevance.

(c) Many students appeared to be of the opinion that aspirin was a non-competitive inhibitor and described it binding at some site on the enzyme other than the active site. Most of these students, however, were able to gain some credit for correctly pointing out that the substrate itself could not bind and produce an enzyme-substrate complex.

Q54.

(a) (i) Over 90% of students correctly explained that vancomycin does not affect human cells as these cells do not contain a cell wall.

(ii) Approximately two thirds of students gained this mark by outlining the role of ribosomes in protein synthesis.

(b) This proved to be an effective discriminator. Most students obtained at least one mark often by referring to vertical gene transmission. Many students then referred to the reproduction of resistant bacteria to gain a second mark. Over a third of students gained maximum marks by explaining that a mutation leads to resistant strains or by stating that a resistant gene or allele is produced. Unfortunately, some weaker students incorrectly referred to bacteria becoming 'immune' or to bacteria reproduction by 'mitosis'.

Q55.

(a) (i) Most candidates correctly named the type of reaction as hydrolysis.

(ii) Most candidates correctly named glucose.

(b) (i) Most candidates gained full marks for describing the test for reducing sugars accurately. Some did not mention the need for heat, and a few could not recall the correct test – the biuret test being the most common error. A few candidates lost credit because they described the non-reducing sugar test and hydrolysed with hydrochloric acid first.

(ii) The majority of the candidates could explain the idea that one molecule of lactose was being hydrolysed to give two molecules of product, both of which were reducing sugars. The commonest reason for missing the mark was when students paraphrased the stem of the question, stating that the reason there was a higher concentration of reducing sugar was because there was more reducing sugar present. A surprising number of candidates gave answers relating to an increase in surface area.

(c) Although many candidates gained full marks on this question there was a significant number who were confused about the position of the active site, placing it on the sugar rather than the enzyme. A number of candidates thought that galactose would bind to lactose rather than lactase.

Q56.

(a) (i) Candidates answered this question well, often referring to the optimum temperature of 30/31 °C. Weaker candidates did not use the graph and those who did not do so failed to score. Some candidates explained the effect of temperature on the rate of reaction rather than describing it.

(ii) This part of the specification is well understood by candidates and many gained all three marks. A large number failed to answer the question asked and explained the shape of the curve between 20 and 30 °C. Although many of these candidates went on to score full marks, they wasted valuable time. It was pleasing to see that many candidates had understood the more difficult concept of more enzyme molecules being denatured as the temperature increased.

(b) (i) Most candidates correctly suggested using a buffer solution to maintain pH, but some answered in a different way by suggesting checking the pH at the end of the investigation using a pH meter or universal indicator. This also gained credit. Other indicators such as litmus would not give a precise enough measure of pH and so were not accepted. Surprisingly, common errors were to suggest keeping the temperature constant or sealing the plates.

(ii) Most students suggested a temperature near the optimum to give a fast rate of reaction or a temperature lower than 30 °C to avoid denaturation. Both of these answers gained credit. A small number of candidates suggested a temperature but failed to give a reason.

(iii) Most candidates gained credit here, but a minority were uncertain as to whether high or low pH was acidic. Weaker candidates did not make the link between the size of the cleared area and the activity of the enzyme.

Q57.

(a) (i) This caused little difficulty for most candidates with the vast majority gaining at least one mark for suggesting that *C. difficile* is resistant to antibiotics. Although many candidates realised that the other bacterial species would be killed, they failed to gain a second mark by not stating that there would be an increase in the number of *C. difficile*.

(ii) Most candidates gained this mark by suggesting that the immune system would be less effective. There were several answers linked to older people taking lots of antibiotics. These responses were not credited.

(b) Although the majority of candidates obtained at least one of the two marks available, there was still some confusion, particularly with weaker candidates, about the precise role of methicillin. Most candidates realised it was a competitive inhibitor but a significant number referred to it possessing an active site. Approximately forty percent of candidates provided a clear accurate explanation of competitive inhibition by methicillin.

(c) (i) The majority of candidates had little difficulty explaining that some of these patients were already ill and this illness could be the cause of death.

(ii) The vast majority of candidates gained this mark by describing the increase in the number of deaths up to 2006 followed by a decrease.

(iii) Less than a third of candidates could correctly calculate the percentage increase in the number of deaths caused by MRSA in Wales from 1996 to 2006. A small percentage of candidates obtained a single mark for reading

figures from the graph but almost sixty percent scored zero.

Q58.

This question was intended to be synoptic and as such required a basic understanding of principles established in other units. There were some outstanding answers but it was also disappointing to note that there were many candidates who clearly had little idea of the functions of cell organelles or of the role of ribosomes and RNA in protein synthesis.

(a) There were, perhaps inevitably, candidates who confused condensation and hydrolysis but most were able used the terms appropriately in the context of protein digestion and synthesis.

(b) Those who understood protein structure usually gained credit, but almost two-thirds of all candidates made no progress here. While the most frequent problems stemmed from confusing amino acids with bases, others appeared uncertain that proteins could be digested.

(c) Most, but by no means all, candidates identified the overall trend of decrease, increase, decrease but rather fewer supported this with data from the table relating to the age of the pupa. Where the age was quoted, it was not uncommon to see it given in days or years. A little common sense might have excluded the latter.

(d) Answers to part (i) might have been better had more candidates distinguished between the roles of lysosomes and ribosomes. There were many responses associating an increase in lysosomes with increased protein synthesis towards the end of the time spent as a pupa.

Others linked lysosomes with disease and answered in terms of increased exposure to bacterial infection. A major misconception in the answers to part (ii) was that protein synthesis would decrease RNA concentration as it was “used up” in the process.

(e) Although some of the candidates answering this part of the question were unable to identify the trend in the table, most recognised that tissue formation involved protein synthesis and hence the increase in RNA.

(f) This question discriminated very effectively over the range of available marks but, at all levels of ability, candidates appeared to find difficulty with spelling the words aerobic and anaerobic. Examiners try to avoid being unnecessarily pedantic over the spelling of technical terms but the onus is on candidates to make their intentions clear, particularly when the words concerned are closely similar. A considerable number of candidates failed to equate tracheae with insect gas exchange and wrote of breathing and the lungs.

Q59.

(a) Many candidates gained both marks by stating that ‘Chymosin is a protein’. However, a significant number of candidates stated that a purple colour in the biuret test indicated that no protein was present.

(b) Most candidates realised that removing water would increase the percentage of protein in mature cheese.

Q60.

(a) Most candidates gained a mark for realising that rennet has less chymosin. Many of

these candidates gained the second mark by mentioning the presence of another protein-digesting enzyme in the rennet. There were a few correct references to vegetarians but answers relating to ethical considerations often lacked focus and were too generalised.

(b) Many candidates failed to gain this mark as their answers suggested that the animal gene was present in chymosin.

(c) (i) Candidates had little difficulty gaining this mark, clearly recognising that vegetarian rennet reduces the coagulation time or has greater activity.

(ii) Approximately 60% of candidates obtained both marks for this calculation. Between 5 to 10% gained one mark for an incorrect answer which indicated that the fall in coagulation time was 3 minutes.

(d) Although a significant number of candidates gained three marks, this question still provided some discrimination. A large percentage of candidates did not specify which type of bond breaks during denaturation or incorrectly referred to peptide bonds being broken. Similarly, the idea of the shape of the active site being altered was not always evident. Nevertheless, the overall high quality of the answers demonstrated that enzyme activity is generally well understood by most candidates.

Q61.

(a) The general purpose of a control experiment was understood well and many expressed the idea that a control would allow comparison with wheat plants grown on their own.
Candidates were less inclined however to point out that a control was necessary in order to determine the dry mass as the relevant percentage.

(b) Most candidates were able to suggest that interspecific competition occurred and extract the relevant data to support this. They experienced considerably more difficulty, however, in explaining the effects of the plastic covers in terms of competition between the roots or the shoots.

(c) The marking guidelines allowed for full credit for less than comprehensive answers to this question. This was perhaps fortunate because few suggested that temperature might have affected wheat and ryegrass seedlings differently.

Q62.

(a) Candidates' knowledge of classification allowed many to make valid statements in their answers to part (a) about cats and cheetahs being from the same family or both being feline. Occasional candidates incorrectly referred to cats and cheetahs belonging to the same species. In part (b), some candidates were able to interpret the grafting of skin from one part of an animal to another as a test to see whether rejection would occur in these circumstances. The word 'reaction' was not considered to be synonymous with the specific biological meaning of rejection.

(b) Candidates could have taken one of two approaches in answering part (a). They could either have concentrated on the speed of rejection or on the closeness of the genetic relationship between relevant animals. Despite this, this part of the question was not answered well and responses tended to lack the necessary precision to gain credit. Most candidates responded to the word reliable in part (b) with a suitable comment about the size of sample, but there were a few responses that were correctly worded in terms of the duration of the observation. Although many of the answers to part (c) were correctly based on the inference that cheetahs must share

similar antigens as skin grafts were tolerated between animals, responses to part (d) were often poor. There were many confused accounts that failed to reflect the fundamental idea that proteins such as antigens are coded for by DNA and so any variation in the amino acid sequence of the protein implied a variation in the DNA coding. Candidates rarely answered in these simple terms.

Q63.

Over half of the candidates gained at least two marks for noting that sulfanilamide acts as a competitive inhibitor, which prevents PABA from binding. Many candidates were also aware of the importance of shape. However, this mark was sometimes disqualified for stating that sulfanilamide and PABA are the same shape. Weaker candidates were let down by poor expression. They referred to 'inhibiting bacteria' or placed the active site on PABA or sulfanilamide. A minority of candidates focused on folic acid and went on to describe enzyme denaturation by the acid. Few candidates took the non-competitive inhibitor route of the mark scheme. However, those who did often scored two marks.

Q64.

(a) Although this question produced an even spread of marks across the entire ability range, the overall marks were disappointing for a question largely targeted at Grade E candidates. Many appeared uncertain as to the distribution of starch and glycogen, the identity of deoxyribose as a carbohydrate or of DNA helicase as an enzyme.

(b) Most candidates were able to gain some credit for recognising that condensation involved the elimination of a molecule of water, although there were some who apparently failed to appreciate that water molecules contained two hydrogen atoms and an oxygen atom, or that condensation involved linking the molecules shown. The better candidates selected the appropriate atoms and gained both of the available marks.

(c) In part (i), candidates were usually able to make an appropriate reference to the role of hydrogen bonds in strengthening either cellulose or the cell wall. Many, however, were uncertain as to the location of these bonds and produced answers referring to linking the β-glucose residues. Part (ii) was usually well answered and most candidates were able to discuss the compact shape of starch molecules. There were, however, some answers incorrectly based on the idea of a large surface area to volume ratio.

Q65.

(a) Just over 60% of candidates scored full marks for this question. Many candidates understood that the active site has a specific or complementary shape, which ensures that only gangliosides can bind. Candidates who did not gain full credit usually referred to the enzyme rather than the active site. A minority of weaker candidates placed the active site on the substrate.

(b) Some candidates failed to score on parts (i) or (ii) through not reading the question stem carefully. Consequently, curves were drawn without labels or that did not start at the point required. A wide variety of curve shapes was seen for both question parts.

(c) Approximately one fifth of candidates scored full marks for this question. This was usually for taking the second route in the mark scheme and stating that enzymes are too large to be absorbed. Most candidates who took the first route were aware that enzymes could be digested if taken orally. However, relatively few recalled that

enzymes are proteins.

Q66.

(a) (i) Most candidates gained this mark by indicating that the response was more effective in children. However, a significant minority of candidates interpreted the graph as showing that adults had a more effective response to the treatment.

(ii) Considering a similar question was asked on the January 2010 paper it was disappointing to note that less than half the candidates gained both marks. Most candidates did refer to a line of best fit but many then failed to explain that the line should be extended to predict the haemoglobin content after 40 days. Credit was also given for detailed answers using the rate of increase per day to predict haemoglobin content.

(iii) Only a third of candidates clearly explained what is meant by a quaternary structure. Most candidates suggested that it meant four polypeptide chains or many proteins were present.

(b) (i) Almost a third of candidates obtained zero on this question, suggesting these candidates had not revised relevant principles from unit 1. A significant number of candidates interpreted isotonic as meaning a constant pH. Candidates who did know what isotonic meant were often able to provide a suitable explanation to gain at least two out of the three marks. However, there was still some confusion over the term osmosis with weaker candidates referring to salt moving by this process.

(ii) Most candidates were able to describe one difference between the two blood samples, often in relation to the variation in diameters. Many incorrectly referred to a difference in number of red blood cells, or their descriptions were too vague to gain a second mark point.

Q67.

(a) Most candidates correctly identified ammonia as the product of nitrogen fixation.

(b) Candidates appreciated the idea of substances with a similar shape fitting the active site of an enzyme. Some, however, incorrectly identified the active site as part of a substrate structure.

(c) (i) Better candidates identified ATP as the product of aerobic respiration and went on to suggest, appropriately, that as Azotobacter removes oxygen during aerobic respiration, nitrogenase would have the required anaerobic conditions and catalyse the fixation of nitrogen. Less able candidates did not make full use of information provided in the question introduction and had limited success.

(ii) Processes involved in growth, such as protein synthesis or the production of new cells, require energy. If this energy is used in nitrogen fixation, less will be available for growth. Consequently, growth will be slower. Better candidates expressed this idea clearly.

Q68.

(a) Students had to relate the high percentage of red light to the rate of photosynthesis. Credit was not given if this was only related to the rate of bubble production. Some

seemed confused by the data for white light and described how this lamp had the most even distribution of colours and was, therefore, 'most similar' to white light. This did not gain credit.

(b) Most students gained this mark.

Q69.

(a) (i) Most candidates scored this mark. Those who did not had usually misread the graph.

(ii) Many candidates made the link that a larger person would have more blood but the second marking point, that therefore there would be a lower concentration of glucose, was less frequently seen. Candidates frequently described the glucose as being more spread out. This was not given credit. A common misconception was that diffusion distances in larger people were greater. As in question 10, candidates who referred simply to different masses, rather than to masses being high or low, did not gain credit.

(b) Better candidates realised that there was considerable overlap between the groups and scored at least two marks. Less able candidates decided that in many cases the test was fine and ignored the overlap.

Q70.

(a) This was answered well with most candidates scoring the mark. Those who did not offered vague descriptions of trend, referring only to the shape of the curve. This should have been supported with data from the axes.

(b) This was a very straightforward question and candidates scored well. The commonest error was to refer to curves levelling off without any reference to this happening at the *same* value.

(c) There were some really good answers here with many candidates scoring the mark for respiration. Better candidates linked this idea to cells but others often confused ventilation and respiration. Statements such as glucose goes to the lungs and gets breathed out were not uncommon.

(d) Many candidates score the first mark stating there was a clear difference between the lactose deficient group and the IBS or control group. Good candidates achieved the second marking point of there being no overlap between the standard deviations. Candidates appeared to understand that a small standard deviation indicated reliable data. However, they were often uncertain of the implications of overlapping values.

Q71.

(a) This question was well answered with most candidates making the required connection.

(b) This question was not well answered. The commonest response was that it is not possible to generalise from rats to humans. Only the very best candidates grasped the concept of overlapping standard deviation. Although the concept of standard deviation was understood, only the best candidates were clear about an overlap in the standard deviation suggesting an uncertain conclusion.

Q72.

(a) This presented major difficulty to the vast majority of candidates, despite its inclusion as a required procedure in the specification (Section 3.3.2). Nevertheless most candidates made an attempt but this usually involved the incorrect use of magnification and observed size.

A minority of responses included the use of eyepiece graticules and stage micrometers or equivalent pieces of apparatus. Difficulty was experienced when trying to explain calibration.

Many candidates attempted to use a ruler directly for measurement of the drops rather than using it to estimate the field of view.

(b) (i) A large number gained both marks with ease. The calculation of the ratio of surface areas of the droplets proved difficult to others, many not gaining any marks at all. Some candidates gave the ratio in reverse.

(ii) There was a large variation in the responses of candidates in this part. Only a minority of candidates mentioned surface area to volume ratio for the first marking point. Many centres rewarded responses which made no reference to the volume.

Candidates who did not make reference to the surface area to volume ratio, but had realised that the surface area of the droplet was normally larger, were able to suggest that greater contact was possible with the lipase or enzyme. Most centres credited the fourth marking point too generously, awarding the mark when there was no reason for the fall in pH.

Q73.

(a) (i) It was disappointing that only one third of candidates scored full marks on this question, given that it was targeted at grade E and involved straightforward recall. However, most candidates gained at least one mark for correctly naming water as the reactant or galactose as the product. A common incorrect response for the missing reactant was ‘lactase’, despite this being given in the stem of the question. There was a wide variety of suggestions for the missing product. These included water, fructose, maltose and sucrose.

(ii) Over 70% of candidates correctly named the reaction as hydrolysis. The most common incorrect responses seen were ‘digestion’ and ‘condensation’.

(b) There was widespread failure to read the stem of each question part, which resulted in only a minority of candidates gaining full credit. It was also clear that many candidates had failed to distinguish between the terms ‘describe’ and ‘explain’ for part (i) and (ii) respectively.

(i) There were numerous references to the Benedict’s test for reducing sugars and, to a lesser extent, iodine solution and universal indicator. It was also clear from the colour changes given that many candidates were not familiar with basic food tests. Candidates who did refer to the biuret test often limited their answer to describing the method and naming the reagents involved. For those who did mention a purple colour, it was not often clear if they were referring to lactose or lactase.

(ii) Many candidates gave the answer to (b)(i) here but failed to explain why this result would be achieved.

Q74.

(a) (i) Most candidates gained one mark for describing that the rate of reaction increased and then remained constant. Unfortunately, a minority of candidates disqualified this mark by stating that the plateau was where the reaction had stopped or the rate had decreased. Surprisingly, very few candidates correctly identified the substrate concentration at which the rate of reaction started to level off. Many simply referred to point **B** on the graph, or typically gave a value from 20-25. A minority of candidates gave an explanation for the shape of the curve.

(ii) Most candidates were aware that substrate concentration was limiting the rate of reaction. Many then went on to explain correctly how this could be determined from the graph. A minority of candidates did not read the question stem carefully and referred to the curve **after** point **B**. References to temperature as the limiting factor were not credited as this could not be determined from the graph.

(iii) This proved to be a good discriminator. Just less than half of candidates gained this mark for explaining that all active sites were occupied or that enzyme concentration was a limiting factor. Weaker candidates were often let down by poor expression or a lack of detail e.g. ‘enzymes working flat out’, ‘all enzymes are active’, ‘enzymes are at saturation point’ and ‘maximum number of collisions’. As was the case for (a)(i), a minority of candidates thought that the reaction had stopped between points **C** and **D**. Other incorrect explanations seen included reference to enzyme denaturation and the presence of an inhibitor.

(b) Almost half of candidates scored one mark. Many candidates who failed to score were aware that the initial rate of reaction would be lower. However, they usually confused the two types of enzyme inhibitor and drew the plateau below that of the original curve.

(c) (i) Most candidates gained at least one mark for stating that the drug would bind to the active site. Weaker candidates sometimes missed out on this mark through a lack of detail e.g. ‘the drug binds to the enzyme’. Better candidates usually went on to score full marks for the idea that less enzyme-substrate complexes would form. References to the drug having a similar shape to the substrate were less frequent. However, some candidates disqualified this for stating that the drug was the same shape as the substrate or active site.

(ii) Just less than half of candidates gained the mark for explaining that the drug could only fit the active site of folate reductase. This was expressed in a variety of ways but typically in terms of the complementary shapes of drug and active site. Very few candidates gained the mark for explaining that the drug was a similar shape to only one substrate. Weaker candidates often wrote in general terms about enzyme specificity, without reference to the drug. Similarly, as in (c)(i), poor expression prevented some candidates from scoring. This was usually for referring to the enzyme rather than active site or for stating that the drug was the same shape as the active site.

Q75.

(a) (i) Most candidates correctly named part **R** as deoxyribose. Answers identifying part **R** as pentose or as a five carbon sugar were considered too imprecise due to the question clearly identifying the molecule as being DNA.

(ii) Most candidates correctly named part **Q** as a phosphate group or as

phosphoric acid. Unfortunately, some candidates incorrectly named parts **R** and **Q** the wrong way round.

(b) Almost every candidate correctly stated 'hydrogen bonds'.

(c) Approximately fifty percent of candidates obtained this mark. Although there was a wide range of incorrect answers, the most common error was to divide, rather than multiply the number of amino acids by three.

(d) Over 90 % of candidates were able to correctly work out the sequence of amino acids.

(e) This question proved to be an effective discriminator. Most candidates gained at least one mark, often by mentioning a change in the sequence in amino acids. However, a significant number of candidates incorrectly referred to 'different amino acids being formed'. Many of these candidates gained a second mark for describing that the active site or tertiary structure would be altered. Better candidates gained maximum marks either by linking this to enzyme-substrate complexes not being formed or to changes in hydrogen/disulfide bonds.

Q76.

(a) This question proved to be an effective discriminator with only a third of candidates obtaining maximum marks. Most candidates gained at least one mark often for stating that glucose has a complementary shape to the enzyme in the biosensor. Although many candidates did gain a second mark for referring to the active site a significant number did not and often suggested that an active site is present on the substrate.
There were, however, some excellent explanations of the way in which enzymes work including references to their tertiary structure and the formation of enzyme substrate complexes.

(b) The majority of candidates gained at least one mark often by stating that the Benedict's test only provides a colour or does not measure the concentration of blood glucose. Another common correct response was that the Benedict's test detects not only glucose but all reducing sugars. However, a number of candidates incorrectly stated that the Benedict's test detects all sugars. A few candidates indicated that the red colour produced during a positive Benedict's test would be masked by the colour of the blood. Responses which simply referred to the biosensor being more accurate or quicker without any further details were not credited.

(c) (i) Most candidates obtained this mark by suggesting that insulin would be digested or broken down by enzymes. A few candidates did suggest that it may be too large to be absorbed or that it could be denatured by acid in the stomach.
Candidates who failed to gain the mark often suggested that it would be broken down by amylase.

(ii) This was very well answered. Almost every candidate obtained at least one mark often by indicating that the study had not been carried out on humans. Many candidates then linked this to unknown long term or side effects to gain a second marking point. It was also pleasing to note the number of responses which displayed an understanding of 'How Science works' including references to the vested interests of scientists, unknown sample size and the need for further or repeat studies.

Q77.

(a) This question proved to be an effective discriminator. Most candidates gained at least one mark by mentioning the enzyme amylase. Many of these candidates gained a second mark for naming maltose as the product of the action of amylase on starch.
However, it was not uncommon to see starch being broken down directly into glucose by amylase. There were also a significant number of answers which included irrelevant references to bile, lipase and a range of proteases. A few candidates confused maltose and maltase but others had little difficulty in quickly accumulating maximum marks by describing the hydrolytic action of maltase in breaking maltose down into glucose.
Fortunately, the mark scheme did not penalise candidates for incorrect sites of enzyme production or incorrect sites of digestion. The action of enzymes on glycosidic bonds was infrequently mentioned by candidates. Almost twenty percent of candidates obtained maximum marks often displaying impressive use of terminology and understanding of this topic.

(b) This proved to be much more demanding that part (a) with a much lower mean mark being obtained. A number of candidates simply repeated their answer to part (a) or provided details on the digestion of other carbohydrates such as lactose and sucrose.
There were also a number of blank or very brief answers. The most accessible marking points related to the movement of glucose from the epithelial cells into the blood by (facilitated) diffusion. The process by which glucose entered the epithelial cells was less well understood. Many candidates had some idea that sodium ions are involved but it was not always clear where they were moving to or from. The role of active transport caused similar confusion for a number of candidates and there were also some references to osmosis. However, despite this there were some outstanding responses demonstrating a thorough understanding of co-transport.

Q79.

(a) Most candidates were able to identify glucose as one of the monomers from which a molecule of sucrose was formed, but there was less certainty about the other. Part (ii) was designed to be accessible to grade E candidates and, in view of this, it was disappointing to see so few gaining full credit. There were a number of predictable errors such as in describing the active site as being on the substrate, and in maintaining that active site and substrate were the same shape. Credit was generally lost however because of a lack of precision in the answers. There were many general references to specificity that were simply worded in terms of sucrose and lactose not being ‘specific to each other’ or enzymes being specific to a particular substrate. Good answers amplified the concepts of shape and fit with appropriate reference to complementarity and the active site of the enzyme.

(b) It is encouraging to note that most candidates were able to describe the data in the graph with appropriate precision and gained full credit for their answers to part (i). There were, however, candidates who failed to distinguish between the terms ‘describe’ and ‘explain’ and offered inappropriate responses both here and in part (ii). In part (ii), better candidates generally identified the role of absorption in raising the glucose concentration and respiration or storage resulting in the fall after 45 minutes. Difficulties arose where candidates referred imprecisely to sugar, and there were many answers where the examiners were left unclear as to whether glucose or sucrose was being discussed. It was also apparent that many candidates considered the graph to be showing some aspect of enzyme activity and responded in terms of the effect of a particular parameter on substrate or product concentration.

Q80.

(a) It was encouraging to note the many candidates who clearly understood the unfamiliar biology presented in parts (a) and (b) and were able to gain maximum credit. In part (a), the difficulty for many was determining the number of hydrogen bonds present. It was evident from some answers that there was much confusion with DNA, particularly with those responses that involved multiplying by two or dividing by three.

(b) Most candidates explained, often with considerable clarity, that all bonds would be broken with complete hydrolysis. Many were also able to derive the correct answer.

(c) Most candidates sketched an appropriate curve on the graph.

(d) Answers to part (d) gave cause for some concern. Many candidates offered a bullet-pointed list often involving an increase in kinetic energy, faster movement and more frequent collisions between enzyme and substrate. This suggested that they had done little more than set out a standard response to a temperature-related problem. Answers to this question reinforced the view expressed by many examiners, that many candidates see learning of past mark schemes as an effective substitute for understanding the relevant biological principles. Where attempts were made to explain how a low pH would affect the rate of the enzyme concerned, answers were often disappointingly superficial with answers such as that “the enzyme works more efficiently at a greater pH and so at pH 5 it is not working at its fastest” being typical.

(e) While most candidates successfully linked this part of the question to enzyme activity over a greater pH range, few took their answers to the required level and related this to washing conditions.

(f) The main difficulty experienced by candidates in attempting this part of the question was in tailoring responses to fit the theme of specificity. Thus, there were many descriptions of protein molecules and enzyme action which failed to comment on the uniqueness of either primary or tertiary structure. Non-competitive inhibition was described much better, although examiners were of the opinion that the facts cited by candidates were not always supported by genuine understanding. Encouragingly, there were few candidates who confused competitive and non-competitive inhibition although rather more were uncertain as to the location of the active site and frequently assigned this to the substrate.

Q81.

Many candidates copied the orientation of the two hexoses and gained one mark for the correct monosaccharides. However, several candidates inverted the second hexose and then failed to copy it correctly. It was more common to see water as a product rather than a reactant, although few candidates included this at all. A small but significant number of responses showed water being removed with the direct linking of carbons one and four.

Q82.

(a) Although there was some confusion with Benedict’s test and the use of iodine, the majority of candidates clearly associated the biuret test with proteins, and were able to explain that the resulting lilac colour was due to the xanthine oxidase being an enzyme and therefore a protein. A disappointing number, however, failed to commit themselves, describing both positive and negative results or suggesting that a lilac colour would be produced “if a protein was present“.

(b) Better candidates gave clear and succinct answers explaining specificity in terms of the concepts of molecular shape and binding to the active site. Others failed to gain

credit for the imprecise use of language.

(c) In many accounts, it was unclear as to whether the answer was referring to xanthine or to xanthine oxidase, or to the precise location of the active site with many candidates clearly of the opinion that it formed part of the substrate. Candidates must appreciate that they will be tested on their ability to apply their knowledge to material presented in an unfamiliar context. This is a specification requirement. Those who recognised that there was a basic similarity in the shape of the two molecules shown, were usually able to describe the role of the drug as a competitive inhibitor which would prevent the synthesis of uric acid. Others concentrated on differences between the molecules and attempted to draw on a knowledge of chemistry, much of it fanciful and all of it outside the realms of the specification, in attempting to explain how the drug either bound to xanthine or dissolved uric acid crystals.

Q83.

(a) Difficulties were experienced with this question where answers were frequently unselective, relating not only to quaternary structure but to aspects of secondary and tertiary structure as well. To gain credit here, candidates needed to confine their answers to the fact that keratin molecules consisted of several polypeptide chains.

(b) Most candidates clearly appreciated that the bonds formed between sulphur-containing amino acids were strong and helped to bind the individual polypeptide chains. Less able candidates often confused these bonds with peptide bonds or did little more than paraphrase the wording of the question.

(c) As was not infrequently the case with the answers to many of the questions in this paper, less able candidates gave the impression of relying on the recall of mark schemes from broadly similar past questions. In this case they either simply described the primary structure of a protein, which gained little credit, or described how the primary structure of a protein affected its tertiary structure which was potentially, at least, a better option. Those who read the question carefully were usually able to comment on differences in the amino acid sequence leading to differences in bonding and in molecular shape. There was some confusion, presumably among candidates who had also completed Module 2 or 3, between amino acids, proteins and bases.

(d) As in part (c), the principal requirement here was to answer the question as written. Unfortunately, the response offered by many was no more than a description of active transport. In this question candidates were expected to use this knowledge along with information available in the passage to explain why substances were unable to pass through the outer layer of skin cells. Those who approached the question in the right way generally pointed out that the cells were dead and progressed to make an appropriate comment about respiration and the release of energy or generation of ATP. A not infrequent misconception was that since movement against a concentration gradient involves active transport, active transport cannot be involved in movement down a gradient.

(e) The many good answers to this part of the question suggested that most candidates had a clear understanding of the principles of electron microscopy and were able to offer a lucid account of its advantages and limitations. Less able candidates were usually able to explain the advantages associated with high resolution but the limitations they suggested concerning expense, size, the production of black and white images and the need for technical support were of a more anecdotal nature and seldom gained significant credit.

Q84.

(a) Generally answered quite well, though, because the stem clearly indicated the yield of antibodies was higher with the secondary response, answers that simply stated ”more antibodies produced’ were not credited. Examiners were looking for the faster rate of production as this was not given in the stem.

(b) Although this question was attempted by most candidates it showed that some thought antibodies can die.

(c) The better candidates tended to respond in terms of eliciting an immune response to the antivenom and gained the mark. Some candidates responded in terms of ethical issues and vegetarianism. Examiners found many of these responses were too vague or below the level needed to gain credit.

Q85.

(a) Revealed an excellent understanding of non-competitive inhibition and there were many correct answers. Occasionally candidates involved both molecules **A** and **B** or attempted to make up an entirely different molecule which they attached to the side of the enzyme.

(b) Most answers indicated that fewer collisions resulted in fewer enzyme-substrate complexes being formed, even if this was explained simply in terms of lower kinetic energy, information provided in the question. It should be noted that answers based on an increase in temperature were unacceptable as were those responses based on denaturation.

(c) Although there were many excellent answers, less able candidates were often unable to apply their knowledge to this unfamiliar example. The most common incorrect responses were based on urea increasing the rate of reaction, either by somehow assisting enzymes in breaking hydrogen bonds in the substrate or in breaking the bonds binding substrates to active sites.

Q86.

(a) This proved an excellent discriminator. Some achieved three marks but there was a tendency to include interpretation rather than method or to suggest impractical steps such as adding the test plate to the solution. Flow charts seem to be unfamiliar to many candidates.

(b) Whilst a few scored two here, many failed to gain marks by discussing enzymes and active sites, failing to realise that antigens with a specific shape were involved.

Q87.

(a) Weak candidates revealed themselves immediately by confining their answers to descriptions of the data provided, and there were numerous references to producing four or five bubbles. In part (i), better candidates clearly appreciated that the sand would increase the surface area but were not always certain of what. Consequently there were frequent links with the enzyme, or with hydrogen peroxide. Relatively few candidates amplified the initial idea and indicated the consequences of an increased surface area. The allocation of three marks to part (ii) should have indicated that rather more was required than ‘denaturing’. Better candidates clearly appreciated this, and were able to offer appropriate detail. Less able candidates not infrequently ignored the fact that the liver had been boiled and concerned themselves solely with cooling.

(b) The words ‘control’ and ‘fair test’ turned up frequently in the answers to this part of the question and all but the weakest candidates attempted to relate the term to the investigation concerned. It was apparent, however, that a substantial number of candidates appeared to lack any real idea of the purpose of this particular control. Such statements as ‘to show that the sand didn’t contain an enzyme’ or even to show that ‘there was no hydrogen peroxide contained in the sand’ were not infrequent.

(c) Although there was wide use of the term activation energy, it was not always supported by the necessary understanding. However, most responses to part (i) contained sufficient correct biology to gain the mark. Failure to gain credit in part (ii) was usually attributable to one of two reasons. Many candidates did not follow the instruction and draw on information from the graph. Others were confused as to the source of the energy transferred as heat, with many being of the opinion that it resulted from friction between colliding molecules.

Q88.

(a) Imprecise expression frequently limited the marks awarded for part (i). Care clearly needed to be taken to avoid suggesting too few components, with answers such as that a polymer consisted of ‘two or more’ monomers. Those who did not make use of the term ‘monomer’ needed to indicate, in some way, the similarity of the constituents. They did not always do this. The most frequent reason for failing to gain credit for part (ii) was where candidates gave substances, such as haemoglobin and amylopectin, which were excluded by the wording of the question. Nevertheless, many candidates gave correct answers.

(b) In part (i), most candidates recognised the importance of buffers in maintaining pH, although some associated them with temperature. Better candidates could generally develop the idea and usually gained a second mark through reference to denaturation. Unfortunately, some saw parts (ii) and (iii) as a trick and pointed out that since starch was not a protein, it would give a negative result. Others made the same error by simply failing to focus on the right component of the mixture. Perhaps more disturbing is the continued failure of so many candidates at this level to learn the relevant information relating to basic biochemical tests. There was again much confusion over test and result, apparent both here and in the answers to Question **4** (b).

Q89.

(a) Although most candidates were able to identify active transport as the process by which potassium ions normally enter bacterial cells, they enjoyed less success in using Fick’s law to explain the leakage of these ions when the plasma membrane was damaged.

(b) Most candidates, in drawing the peptide bond in part (i), attempted to link the relevant groups, although they were not always certain as to the origin of the constituent atoms of the water molecule. In part (ii), candidates who sketched tyrocidin as a cyclic polypeptide generally, but by no means always, correctly determined the number of peptide bonds. Although nine was perhaps understandable as an incorrect response, it was difficult to identify the logic underlying the choice of two and five, which figured more frequently than might have been expected.

(c) The answers to this part of the question were in the text, the key points being that transport by vanilomycin depended on the fluid nature of the membrane while Gramicidin A formed a permanent pore. Although many candidates offered

comprehensive answers based on these ideas, others incorrectly identified one or other of the antibiotics concerned as an enzyme and, as a result, offered inappropriate explanations.

(d) Candidates clearly found part (f) demanding and although there were those who recognised that a pore lined by molecules of the polyene antibiotic would provide the most likely solution, most failed to distinguish between the possible and the extremely unlikely.

Q90.

(a) A surprisingly high proportion of candidates failed to identify the required reagent and either suggested the use of Benedict's reagent or iodine as a test for proteins. Others selected the appropriate test but disqualified their answers by referring incorrectly to the addition of substances such as hydrochloric acid or sodium chloride. Those who based their answers on the appropriate test were usually able to describe the expected result.

(b) The significant number of incorrect responses here suggested that many candidates were unable to apply their understanding of the general structure of an amino acid to the example shown. The most frequent incorrect responses involved writing out the complete structure of phenylalanine, giving the general formula of an amino acid, and copying the R-group from the tyrosine molecule.

(c) In part (i), able candidates demonstrated their familiarity with the structure of a peptide bond. Others not infrequently failed to answer the question and wasted much time in writing out the full structure of both amino acids. Most of the errors arose through linking carbon to nitrogen by way of an oxygen atom. In part (ii) the bond was usually correctly identified but there were occasional incorrect references to dipeptide and polypeptide bonds as well as to glycosidic bonds.

(d) There were good answers from candidates who made use of the stimulus material and described hydroxylation as the addition of an OH or hydroxyl group. Others referred rather imprecisely to the addition of oxygen and hydrogen; incorrectly to the removal of an OH group or, perhaps inevitably, confused hydroxylation and hydrolysis.

Q91.

(a) Most candidates correctly identified the breakdown of chitin as involving hydrolysis, but there were a number of references to condensation and to anabolism as well as weaker responses such as "enzyme reactions". Those who gained credit for part (ii) generally indicated that water would enter the fungal hyphae, but seldom progressed to complete the explanation by referring to the resulting increase in pressure or to the weakened wall. There was much uncertainty over the direction of water movement while some candidates merely re-iterated information provided in the question, with comments such as that there would be a more negative water potential in the cytoplasm of the fungus and that this would lead to death by osmosis. There were many excellent answers to part (iii) either in terms of the presence of cellulose in the plant cell wall, or the specificity of the enzyme to chitin. Less convincing answers were couched in vague terms about "substances" or referred to cell walls "not fitting" the active site of the enzyme. A popularly held belief was that the cell walls are made of starch.

(b) Candidates found it surprisingly difficult to describe the tertiary structure accurately and with sufficient precision as to distinguish it from other levels of protein organisation. Thus the term "3-D structure" used by many is equally appropriate to

secondary structure. To gain success, candidates needed to define the shape of the entire protein molecule.

(c) A significant proportion of candidates failed to analyse the requirements of part (i) with sufficient care and did not produce answers which explained how heating led to the denaturing of an enzyme. Too many answers focused on the effect of denaturation on enzyme activity. Consequently much that was written was largely irrelevant. Many candidates sought to answer part (ii) by simply restating information gleaned from the passage. Thus, although they were able to gain some credit for recognising that protein engineering involved the substitution of other amino acids, they failed to indicate how this would influence the bonds which maintained the tertiary structure. Particular difficulties resulted where candidates who had, presumably, completed either module 2 or 3 identified this question as one requiring discussion of either the immobilisation of enzymes or of genetic engineering. Candidates also showed a lack of understanding of the basic concept of a chemical bond. Thus there were numerous references to “replacing” amino acids with chemical bonds and to making use of “stronger hydrogen bonds”.

(d) The theme of genetic engineering was also incorrectly identified by some as the key to this section. Such candidates frequently equated base sequences with amino acid sequences and attempted, with inevitably limited success, to incorporate transcription and translation into their answers. There were some excellent, well-constructed and detailed responses to this question from the more able of those candidates who adopted a sensible approach, and a significant number of these gained maximum credit. From the others there was often a disconcerting amount of loose and imprecise expression, frequently stemming from failure to grasp the concept of a protein which could act as an inhibitor of one protein and a catalyst of another reaction. There was clear evidence that more limited candidates are in need of further practice in explaining ideas clearly and unambiguously.

Q92.

(a) A good number of candidates knew that the quaternary structure of a haemoglobin molecule involved the association of four polypeptide chains. Some failed to gain the mark by stating that four *proteins* were associated and some just wrote four ‘units’, which was clearly insufficient. A few candidates suggested that the quaternary structure is the fourth dimension of protein structure.

(b) There were some very good accounts of how hydrogen ions (produced as a result of the increased carbon dioxide concentration in active tissues) lead to the increased dissociation of oxyhaemoglobin; the oxygen so released diffuses down a concentration gradient from the cell, through the plasma and into the respiring cells.

(c) Most candidates knew that the amino acids formed as a result of the breakdown of haemoglobin are used to synthesise new proteins. Some gave examples and some also knew that these amino acids may be deaminated and the keto acid formed used as a respiratory substrate. Some displayed a basic lack of understanding by suggesting that the amino acids could be used to from urea.

Q93.

BYA6

(a) Many candidates understood the control of plasma glucose concentration in great detail and were able to reproduce this. However, the question did not simply ask ‘how is plasma glucose concentration maintained?’, but required an explanation of the role of negative feedback in this control. Better candidates realised the

distinction and began their answers by explaining the concept of negative feedback and then related this concept to the events shown in the graph. Naturally, they included the method of action of the hormones, but their responses showed a better balance between supplying detail and explaining principles than those who simply answered, once again, the question they assumed had been asked on the basis of one or two key words. Candidates failed to gain marks through confusion between glucagon and glycogen, despite the former being clearly named on the graph. There was also some confusion between what detected the changes in plasma glucose concentration and what subsequently secreted the hormones. Only better candidates were aware of the effect of insulin in stimulating the absorption of glucose from the plasma.

(b) In this question nearly all candidates knew that enzymes have an optimum temperature, but too many failed to relate this specifically to core body temperature. They were also frequently careless in their description of the effect of temperature on enzymes. The phrase 'enzymes are denatured by extremes of temperature' was all too common. Clearly an extreme temperature of –10°C does not denature enzymes. Candidates also need to be more precise in their descriptions of how and why reactions take place. Reactions, in this context, take place because *molecules* of the enzyme and substrate have sufficient kinetic energy to collide frequently and with sufficient energy. Finally, some candidates re-used the term 'maximum efficiency' used in the question, without explaining what this meant in terms of rate of reaction.

BYA7

(a) Most candidates were able to state that the release of insulin was triggered by increased plasma glucose concentrations and glucagon was triggered by a decrease. The more able then correctly identified the sites of secretion and their effects on the interconversions between glucose and glycogen. It was disappointing to see few candidates using the graph as instructed by the question and many candidates scored one less mark than perhaps they would have if they had used the graph more. As is often the case, frequent instances of imaginative intermediate spelling of glycogen and glucagon were observed and these were usually too ambiguous to be credited by the examiners.

(b) This question produced some very comprehensive answers. Candidates had a good knowledge of thermoregulation. Examiners did not credit the term 'cold centre' and this term tended to be used only by the weaker candidates. The detail of vasoconstriction was explained very clearly by approximately 50% of candidates. The other 50% had muddled thought on this topic, with constriction of capillaries and veins and movement of capillary networks towards the centre of the body appearing in their answers.

Candidates who did not realise that the question was about enzymes struggled to score marks. The majority of candidates gained some credit. One common error was to refer to the effects of temperature on enzyme activity without direction. Better answers gave the effects of low temperatures quite separately from the effects of high temperatures.

Q94.

(a) It was common to see answers that referred to galactose as the single breakdown product of ll lactose and answers of this nature did not gain credit.

(b) Part (i) tended to be well answered by candidates though part (ii) did not elicit the desired response in many instances. Many candidates answered in terms of surface

area. Some candidates realised the enzymes would pass out of the body but identified this as an example of excretion. Unfortunately these candidates often made the same error in 2 (a) (i).

(c) The assertion that mitochondria *made* energy prevented a significant number of candidates scoring one of the marks available. Many candidates scored both the marks available.

Q95.

(a) Although part (i) was generally well answered with the suggested curve showing an increase to a plateau, fewer candidates were able to offer a convincing explanation for the change in amount of product. Only the better candidates linked the reduction in substrate to a reduction in the formation of enzyme-substrate complexes. Candidates who confused substrate concentration and enzyme concentration produced arguments incorrectly based on a reduced rate of formation of enzyme-substrate complexes as a result of insufficient active sites.

(b) Most candidates appeared familiar with the idea of buffers being used to maintain a constant pH. However, among the less able candidates, many linked the presence of a buffer to the maintenance of unspecified experimental conditions. Others offered generalised answers in which they merely stated that buffers allowed enzymes to work better.

(c) Part (c) was targeted at the more able candidates and, in view of this, it was encouraging to note that the vast majority of candidates were able to discuss the situation described by the graph in general terms, identifying that an increased incubation time reduced the rate of reaction. There was, however, some imprecise wording, and it was not always clear as to which temperature was being discussed. It was clearly evident from part (ii) that many candidates held an extremely simplistic idea of denaturation. They obviously believed that all enzymes denature instantly once the temperature rises above 37 °C. Only in relatively rare cases was it clear that candidates appreciated that more enzymes would be denatured after 60 minutes incubation than after 5 minutes. Some answers obviously stemmed from misreading the question as referring to temperatures of 60 °C and 5 °C. There were also many spurious arguments related to increased kinetic energy provided by longer exposure to heat disrupting the substrate.

(d) The idea of enzyme inhibitors was obviously unfamiliar to the few who gave answers relating to the effect of extremes of temperature and pH on rate of reaction, but, for most, this was clearly an opportunity to show their knowledge. These candidates produced convincing answers. A wide range of terms was used to describe competitive and non-competitive inhibitors but, despite this, there was clear evidence of a good understanding of the underlying mechanisms. When errors did occur they were usually associated with descriptions which implied that competitive inhibitors and substrates were identical rather than chemically similar.

Q96.

(a) Many candidates were unable to give two correct polymers. Answers given were extremely varied and included starch, ammonia and lipids. A significant number of candidates gave protein and haemoglobin and were awarded one mark.

(b) Better candidates tended to write more concisely but still manage to gain most of the marks available. For part (ii) it was possible to answer the question and score full marks without describing all the events in the nephron.

(c) (i) This question was generally well answered.

(ii) Credit was given to all candidates who conveyed the idea of maintaining the concentration gradients. Incorrect responses generally stated that urea would flow back into the bloodstream after five hours or, that after five hours, the concentration of urea would rise to dangerously toxic levels.

(iii) Incorrect responses to this question showed some major misconceptions. It was clear from responses that some candidates assumed the kidneys were functioning normally in addition to the treatment or that the fluid was being administered into the kidneys.

Q97.

(a) Most candidates clearly appreciated that the samples would best be obtained by using random numbers to determine co-ordinates, although they were not always specific as to how these numbers would be generated. There were, however, frequent references to “throwing” a quadrat, a technique which does not give rise to a genuinely random distribution.

(b) In part (i), candidates revealed considerable difficulty in recognising the trend of a decrease followed by stabilisation from a depth of around 200 cm. The most frequent response was to ignore the change in gradient and refer simply to the population falling. Where a genuine attempt was made to offer an explanation for the difference in numbers in part (ii), answers were usually correctly related to the decreasing concentration of oxygen available for respiration.

(c) There was obvious confusion in the minds of some between the concepts of ecological succession and natural selection. While some of those who made this distinction produced excellent answers, others lost their way in rambling anthropomorphic accounts of bacteria “not finding conditions to their liking” or being “happier” with conditions at other depths. There were also many general references to “bacteria”. These lacked the necessary precision to gain significant credit.

(d) Part (i) was generally well answered and there were many accounts based on correct references to the surface layers being the only ones where numbers of aerobic bacteria increased. Part (ii) also produced some sound responses although candidates were inclined to embellish their answers with irrelevant detail relating to the anticipated change with time. Once again, a failure to gain marks most commonly stemmed from imprecise use of the word “bacteria”. In both parts (c) and (d) there was a need to refer them as being either aerobic or anaerobic.

(e) There was encouraging evidence of a good understanding of standard error and many candidates were able to show some appreciation of this demanding concept. However, answers were seldom targeted at explaining what the error bars revealed about the difference in activity at the times given. In spite of the wording of the last sentence of the question, the terms probability and chance were seldom incorporated into the explanation.

(f) The most frequent approach to this part of the question was to produce a mass of figures supporting a complex but inappropriate calculation. With these data the best approach was to construct a graph and draw a line of best fit. The likely number of bacteria could then have been established by reading off the appropriate value from the curve.

Q98.

This question relating to enzymes was answered well, even by relatively weak candidates.

(a) Most candidates gained the mark for the complementary shapes of substrate and the active site of an enzyme, although there were some inaccurate statements such as, ‘they are the same shape’.

(b) The majority of candidates were able to give good descriptions of non–competitive inhibition. There was much less confusion than in previous years. Many used the diagram well to explain their answers.

(c) (i) Most candidates were familiar with peptide bonds.

(ii) The bonds were generally named correctly, but some candidates did not make reference to folding or tertiary structure.

Q99.

(a) There was evidence of some confusion concerning the drawing of the plasmid in this question. In order not to disadvantage the candidates, any reasonable structure was accepted. The most common answers were ribosomes and plasmid for **D**. Not many candidates knew capsule for **E**. Common incorrect answers were ‘cell wall’ and ‘membrane’.

(b) Most candidates could give a function for the cell wall, but some gave vague statements such as ‘keeping the structure’.

(c) Many candidates realised that starch had been digested, but few could name amylase as the specific enzyme. Many gave a credible explanation for the piece of fungus not having a clear area; the most common answer was that the fungus had died or was unable to secrete an enzyme to digest the starch. Answers stating the starch had not been digested were not accepted.

Q100.

Both parts of the question discriminated well. In part (i), many candidates did not point out that the substrate entered the active site of the enzyme. A significant number stated that the enzyme/active site is 'used up'. In part (ii), few candidates scored two marks. Many knew the term competitive inhibitor, but did not explain it well. Several candidates thought ethanol was a non-competitive inhibitor or that oxalic acid inhibited the reaction.

Q101.

(a) Most candidates correctly described the effect of reduced temperature on enzyme activity. Many of these failed to develop their answer further to explain the effect on physiological processes and growth. Those that did often limited their answer to photosynthesis, and so were not able to score full marks. Some failed to read the question carefully and described the effect of factors other than temperature.

(b) Poor expression and incomplete answers were both a major feature, with many candidates having the right idea, but not expressing their answer with sufficient clarity to score the marks.

Q102.

(a) (ii) Generally well answered with most candidates able to identify the R group. Fewer candidates correctly labelled an H and the OH group.

(b) (i) Most candidates correctly named one substance, but many were unable to name the second. References to polypeptide, protein and occasionally carbon dioxide, were frequent.

(ii) This was well answered apart from occasional references to hydrogen bonds or dipeptide bonds. Some misread the question or and gave condensation or hydrolysis, as answers.

(c) Many candidates gained full marks, but answers were often poorly expressed and extended into discussions about enzymes and active sites. Some weaker candidates confused amino acid sequence with base sequence and discussed the role of DNA.

Q103.

(a) (i) Candidates found this question the most difficult with very few achieving good marks and a significant number only managing to gain marks in part (c).

(ii) Many candidates were unable to link respiration with the uptake of potassium ions. Many appeared to believe that potassium ions are necessary for respiration or attempted to explain the data by suggesting that potassium ions act as the inhibitor of respiration by blocking active sites. Candidates recognising that inhibition of respiration prevented active transport often failed to explain the decrease in concentration of potassium ions in the presence of an inhibitor as diffusion. The decrease was often attributed to the presence of a store of ATP which allowed some active transport to occur. Weaker candidates misread the data assuming that it referred to the concentration in the roots and tried to explain it in terms of loss of potassium ions. Others simply described the curves without providing an explanation.

(b) This proved to be the most demanding question in the paper. Candidates only performed well on this question if they had understood part (a). A number did recognise that the equilibrium had been reached but very few were able to explain that there was no net diffusion of ions due to the absence of a concentration gradient.

(c) This was better answered. Many candidates understood and were able to explain competitive inhibition, although a lack of clarity due to poor expression did penalise some. A minority lost marks by describing non-competitive inhibition.

Q104.

(a) This was a well answered question with a significant number achieving full marks.

Most candidates gained one mark by recognising that the fall in intensity was the result of the breakdown of starch. A frequent omission, which lost a mark, was a failure to give the reaction of the starch with iodine as the reason for the colour change.

(b) The curves were generally well drawn with candidates achieving both marks. Marks were lost by careless drawing of the origin which should start at the same point on the *y* axis as the existing line. Another error was to draw the pH line to meet the original after 16 minutes. A minority of candidates seemed to misunderstand the

graph, drawing and labelling the pH 2 line below the original line and the 35° C line above it, but then correctly explained the effect of these changes in part (c).

(c) This was a very well-answered question with candidates well prepared and able to make the main points, particularly in part (i). Thorough answers were often produced in part (ii) but there were more candidates unable to explain fully the effect of pH. There was less understanding of how a decrease in pH, resulting in an increase in *Yt* ions, affects the shape of the active site. A number of candidates, having given very good explanations, omitted to state the effect on the rate of activity which lost a mark if insufficient of the other marking points had been gained.

Q105.

(a) (i) Few candidates identified substance X as ammonium ions or ammonia. Nitrate was the most common incorrect answer.

(ii) Most candidates correctly identified substance Y as gluscose.

(b) Only the more able candidates successfully described the role of oxygen as the final hydrogen acceptor, producing water; many weaker candidates merely cited the equation for aerobic respiration. A surprising number of candidates responded incorrectly by discussing the role of oxygen in Krebs cycle or its use in lactic acid removal in muscles.

(c) This question was not well answered. Candidates failed to read the question and few realised that only glycolysis is operating during anaerobic respiration. The importance of NAD in allowing glycolysis to continue was missed and candidates concentrated instead on the production of ATP in the electron transfer chain.

(d) Most candidates recognised the active site as a feature of an enzyme that would contribute to its specificity; fewer scored the second mark explaining the significance of the active site by referring to its complementary shape.

(e) This was generally well answered, with most candidates aware of the action of non-competitive inhibitors.

Q106.

(a) Most candidates performed creditably on this question and many gained full or almost full marks. In general, candidates did appear to have absorbed the information provided before embarking on answering and the better candidates showed very good appreciation of experimental procedures, often giving more detailed explanations than was required by the mark scheme.

A majority gained full marks on this part. Most realised that the urea had diffused into the tubing, although a significant number suggested the urea entered by osmosis. The blue colour of the indicator inside the tubing was then usually correctly linked to the formation of an alkaline solution as a result of the production of ammonia. A number suggested that the carbon dioxide also contributed to the alkalinity. Some weaker candidates apparently thought that the solutions would be acid above pH 8.0, and therefore suggested that the urease had diffused out. Some attributed the yellow colour outside the tubing to carbon dioxide passing out, but it was pleasing to note that some of the better candidates added the explanation that the indicator stayed yellow outside because the timescale was too short for enough ammonia to pass out and raise the pH above 8.

(b) (i) Although a majority was familiar with the test for proteins, it was surprising that

so many candidates suggested using Benedict's or iodine solutions. Some of those who did opt for the biuret test wrongly suggested boiling the mixture.

(ii) Most recognised that enzymes are proteins and that therefore the urease solution inside tubing would give a positive result with the protein test. Better candidates explained that there would be no protein outside the tubing as the urease would not diffuse through the membrane, but weaker candidates often merely said that water is not or does not contain protein.

(c) There were many good answers to this question, but there were also many candidates who demonstrated very limited ability to plan a simple investigation. The examiners awarded one mark for a method of maintaining a suitable range of temperatures, such as using water baths, and one for a method of measuring the activity of the urease in order to determine the optimum temperature. Based on the information provided, the most obvious way of comparing activity at different temperatures seemed to be to measure the time taken for the indicator to turn blue, but relatively few chose this method. Many elected to use a colorimeter or standard solutions with some other indicator, or to collect the carbon dioxide. Any appropriate method was accepted. One mark was awarded for the basic principle of comparing the activity over a range of temperatures where a candidate failed to give any detail. The third mark was awarded for the idea of keeping other variables constant, or for refining the accuracy by narrowing the range of temperatures around the apparent optimum, although the latter point was rarely seen. Although not penalised, surprisingly large numbers used the same arrangement of tubing as in the original experiment, rather than just mixing urea and urease solutions. Weaker candidates often tried to use the biuret test as a method of measuring activity.

Q107.

(a) (i) This question was well answered. Glucose was the commonest incorrect response.

(ii) A significant number of candidates failed to gain the mark on this question. The most frequent error was to change the glycosidic bond to an H group instead of an OH group. A number failed to use the information in the diagram, drawing a glucose molecule or six-carbon ring. Inaccurate drawing was also a cause of candidates failing to gain the mark.

(b) Condensation was the most common mistake, but most candidates correctly stated hydrolysis. Hydrolysation was occasionally given.

(c) The responses to this question were surprisingly varied. Many candidates were either unfamiliar with reducing and non-reducing sugars and their respective tests, or misunderstood the action of the enzyme. Many gained a mark for the correct colour change but gave muddled accounts incorrectly describing the use of hydrochloric acid or omitting heat. Many candidates gave the Biuret test or stated the correct reagents. Answers suggesting the mixture should be heated were not penalised. The correct colour was usually given. The weakest candidates confused the two tests, and in some cases the test for starch was given.

Q108.

(a) Candidates appeared to understand the principle behind the question, with most making the link between the rate of reaction and saturation of active sites. There was some confusion about the limiting factor and lack of enzyme was often given as the reason for no further rise in the rate. Only the best candidates gave really clear explanations.

(b) This was well answered and many candidates gained full marks. How non-competitive inhibitors work seems well understood. Those failing to gain marks lacked clarity about the binding site of the inhibitor, and a minority blurred the distinction between non-competitive and competitive inhibition.

(c) This was poorly answered with many candidates unable to calculate a percentage difference. A very common error was to calculate $\frac{5.6}{7.6} \times 100$.

(d) The graph was poorly drawn with only a minority producing an acceptable curve.

Q109.

(a) (i) Build up of immunity in the community or advances in care were examples of acceptable responses. Again, 'vaccination', unqualified, was the most common answer and, again, this received no credit.

(ii) Most candidates gained one mark for stating that a mutant form or new strain was involved. Relatively few went on to complete the explanation in terms of non-recognition by memory cells.

(b) Weaker candidates continue to confuse the actions of T and B lymphocytes. However, even these candidates know that both types of cell clone in response to infection. References to phagocytosis by T lymphocytes were, unfortunately, quite common.

(c) Few candidates read the information given and therefore answered in terms of viruses being unable to enter cells. Those who answered correctly in terms of leaving the cell could rarely explain inhibition, rather merely re-stating that it would occur.

Q110.

The great majority of candidates chose to tackle the essay on enzymes and their importance rather the one on the contributions of microscopy. Most of those who did select the latter topic appeared to be weaker candidates, and as a result very few good, or even reasonably good, essays about microscopy were seen. On the other hand, the full range of marks was awarded for the enzyme essay and there was a significant proportion of good essays, although the proportion of superficial and poor essays was even greater. It is surprising that many candidates apparently fail to formulate any plan, or produce only a cursory attempt at a plan, and consequently present an essay which lacks coherence and which keeps returning to different aspects of the same theme. There are also some who adopt an inappropriate chatty approach that does not match up to the criterion of being in a scientific style using technical terminology.

The best candidates were able to give good accounts of how enzymes work, factors that affect their activity and a range of examples to illustrate their importance in plants and animals. There were some impressive essays in which the mode of action was clearly linked to the protein structure of enzymes, as were explanations of the effects of factors such as high temperature and pH. The examples given were sensibly related to the role and importance of the processes catalysed. On the other hand, a considerable number of weaker candidates demonstrated only a very superficial knowledge and often there was confusion with the roles of hormones, haemoglobin, chlorophyll, ATP, muscle proteins and almost any other substance that occurs in living organisms. Frequently essays were unbalanced, with by far the greater part being devoted to the mode of action and factors affecting it and very little to the importance of enzymes.

Overall, the best part of the essay was the account of the structure of enzyme molecules and an explanation of how the active site is involved in the formation of an enzyme-substrate complex. Many, however, failed to explain what happens after the formation of this complex. It was also common for candidates to imply that the only role of enzymes is to break down substances. The better candidates referred to specificity, related it to the tertiary protein structure, and explained activation energy. A common example of careless expression was to describe enzymes 'breaking down substances by the lock and key hypothesis'. Quite a few candidates failed to gain credit for relevance by including unnecessary detail about protein structure, for example by including diagrams of amino acid molecules and peptide bond formation as well as the quaternary structure of haemoglobin.

There was considerable variation with respect to which factors candidates decided to include. Not surprisingly, most referred to the effect of temperature, and there were some good accounts of the effect of increasing temperature in terms of kinetic energy and of denaturation. Quite often, however, it was suggested that enzymes were denatured at both high and low temperatures. Few of the candidates who referred to pH were able to give convincing explanations of how it affects enzyme molecules, but there were many good accounts of competitive and non-competitive inhibition.

Most candidates had greater difficulty when it came to discussing the importance of enzymes. Some simply resorted to listing a number of important processes, such as photosynthesis, respiration and digestion, and included, some such as reproduction, where the role of enzymes would be hard to pinpoint. Often, they merely stated that enzymes were needed for these processes and then emphasized the importance of each process. Many could only conceive of importance in terms of what would happen in the event of enzymes not existing for a particular process, often leading to the absurd notion that, for example, 'if we did not have the enzymes for respiration we would die'. The examples most often quoted were digestion, photosynthesis, respiration and synapses. Descriptions of digestive enzymes were often disappointing with surprisingly large numbers resorting to GCSE level detail and only referring to proteases, carbohydrases and lipase. There was much confusion about where different enzymes are produced and their roles. Those who did mention endopeptidases and exopeptidases frequently got their functions the wrong way round. A good proportion described the role of rubisco, but the majority appeared to believe that this is the only enzyme involved in photosynthesis. Similarly, very few recognised that respiration involves many enzymes, each catalysing one reaction within the metabolic pathway. By far the commonest reference was to acetyl coenzyme A, with the great majority failing to make any distinction between a coenzyme and an enzyme. There were some good explanations of the part played by acetylcholinesterase in synaptic transmission, but there were also many erroneous and half-understood ideas, as well as vague statements about it being vitally important in preventing paralysis and irrelevant comments about snake venoms for example. Because of the superficial nature of many of the references to particular enzymes or processes, the examiners looked for a significant description when assessing the contribution to the criteria for breadth.

Q111.

(a) The vast majority of candidates gained the mark, with only a few confusing hydrolysis with condensation.

(b) Most candidates scored full marks, the most common error occurring in (ii) where the substrate of amylase was identified as protein.

(c) The difference between the types of fatty acids was well understood in terms of double bonds but very few candidates then went on to mention the location of the bonds or describe saturation with reference to hydrogen. Weaker candidates

identified the bonds involved as hydrogen and therefore failed to obtain any marks.

Q112.

(a) Vague descriptions and poor use of terminology marred many answers. Many candidates failed to recognise that it is the specificity of the tertiary structure that provides an enzyme with its uniqueness, and it was often suggested that the active site and the substrate are the same shape.

(b) The majority of answers clearly linked denaturation to inability to form an enzyme/substrate complex. One mark was commonly inaccessible to candidates omitting to mention the breaking of bonds. A minority of candidates failed to use the information given and identified vinegar as an inhibitor and described the effects of competitive inhibition.

Q113.

(a) (i) Most candidates calculated the number of bases correctly. Many obtained a second mark for explaining that three bases on DNA (a triplet) code for each amino acid. A significant number did not get the second mark, because they stated or implied that bases are amino acids.

(ii) This proved very difficult for many candidates. Quite a large number obtained one mark for suggesting a deletion mutation but only the best candidates went on to suggest the deletion of a triplet of bases. Some candidates continued a misconception evident in (i) and stated that an amino acid was deleted. Credit was given to candidates who suggested another type of mutation affecting a terminal amino acid.

(b) There were many good answers to this question and many candidates obtained all four marks. Surprisingly few candidates made clear reference to complementary base-pairing between codon and anti-codon.

Q114.

(a) Most candidates gained good marks on this question, although there was a tendency for candidates to produce well-rehearsed descriptions of succession without always applying their ideas to the particular example given in the question. As a result, marks were sometimes missed by the use of inappropriate references, such as incorrect examples of colonising plants. The point that further changes in conditions were needed to enable forest to develop was a common omission by candidates not gaining full marks. A number of candidates expressed themselves poorly, referring to shrubs turning into trees or smaller plants being replaced by bigger ones.

(b) This question was generally well answered with very few candidates failing to gain the mark. Those who did not answer well often described the tolerance of Sphagnum without explaining the relevance of the term climax community.

(c) This question was poorly answered with a number of very disappointing ideas being presented. Many candidates made the link between the lack of oxygen and inability of the tree to respire but failed to refer to roots; the mark for active transport was often gained. A significant number of candidates, however, incorrectly referred to the role of bacteria, attributing the lack of survival of trees to the inability of bacteria to produce nitrates in the absence of oxygen or the action of denitrifying bacteria. The weakest answers suggested oxygen was needed for photosynthesis, in some cases by the roots.

(d) Most candidates gained at least one mark for appreciating the effect of acid conditions on decomposers and many correctly described the effect of pH on enzymes. Few candidates gained the third mark, with only a small minority referring to the anaerobic conditions.

Q115.

(a) Most candidates gained the idea of C_{12}, but not the condensation of the two sugars involving the loss of the water molecule, $C_{12}H_{24}O_{12}$ was therefore a common answer.

(b) The Benedict's test was well rehearsed, although heating was sometimes either omitted or just implied by use of a waterbath. Weaker candidates included the use of a hydrolysing agent as an initial stage in the test. The results of A and B were described by the better candidates in terms of amount of visible precipitate, but very few then attempted to explain the result.

Q116.

Quite a large number of candidates failed to perform well on this question because of poor use of language and terminology in parts (a) and (b).

(a) Most candidates obtained the mark for the idea that the mutation alters the amino acid sequence in Factor VIII protein. Good candidates then related this to a change in the tertiary structure (or three-dimensional shape) of the protein. Poorer candidates made vague references to changes in the protein, or it not being able to work.

(b) Most candidates scored one mark for the idea that the faulty Factor VIII leads to a failure of the activation of Factor X and blocking of the clotting pathway. Fewer candidates were able to give a reasonable description of Factor X not being activated, because non-functional Factor VIII cannot work with Factor IX. Weaker candidates misunderstood the diagram and thought that Factor IX and Factor VIII were used to make Factor X.

(c) Only the best candidates understood that the blood from each haemophiliac contained the functional factor that the other lacked. Some who understood this only gained one mark because they simply stated that the mixture contained both factors. The examiners wanted a clear statement for the second mark that blood from the boy with faulty Factor IX contained working Factor VIII and the blood from the haemophiliac with faulty Factor VIII contained working Factor IX. A common misconception was that the mutations to the genes for Factor VIII and Factor IX would produce proteins that were able to interact, because they were both the products of mutation.

Q117.

(a) Most candidates appreciated that the charge inside the neurone would be negative compared with the charge outside and they often gave a clear explanation about the pumping movement of sodium ions being the cause of this difference. The impermeable nature of the neurone membrane to the movement of sodium ions was less well understood and very few candidates gave an adequate explanation which compared the relative amounts of sodium ions on both sides of the membrane.

(b) (i) Surprisingly few candidates used the graph accurately to give the correct time between depolarisation and the beginning of muscle contraction; 1. 5 ms was a common error, which suggested candidates used the scale on the x axis carelessly. Those candidates who constructed lines on the graph to identify

the time period usually got the right answer.

(ii) Most candidates understood that speed was calculated as distance over time, but very few correctly converted ms to s.

(iii) This proved to discriminate well. Many candidates gave a valid suggestion about the role of a neuromuscular junction or the time it takes for muscle filaments to move. Unfortunately, a significant number missed the point of the question and discussed different types of neurone, the presence of a myelin sheath, the diameter of neurones, or the distance between nodes of Ranvier.

(c) A significant number of candidates began the description too early by including the detail about the movement of vesicles containing neurotransmitter towards the presynaptic membrane. Also, some failed to gain a mark by referring to the location of neurotransmitter receptors on the motor end plate rather than on a sarcolemma or a cell membrane. The depolarisation of a muscle fibre by the movement of calcium ions is a common misconception.

(d) Both parts of this question were answered well by a large proportion of candidates.

Q118.

More candidates attempted the essay on proteins than that on variation. The majority of candidates provided a plan, but these varied greatly in their usefulness. Most candidates attempted to provide essays with a reasonable breadth of knowledge and understanding, but many included irrelevant material. The quality of written communication was generally poor, as was the quality of much of the handwriting.

Most candidates had obviously prepared an essay on proteins, but attempts at relating structure to function were generally weak except for enzymes.

Most essays began with a detailed account of the structure of proteins, but relation to function generally only began with tertiary structure and proteins. Only the best candidates were able to give good accounts relating structure to function in structural proteins. Although the ‘lock and key’ and ‘induced fit’ models of enzyme action are generally well understood, only the very best candidates related enzyme structure to reduction of activation energy.

Most candidates stated that proteins were used in transporting substances across membranes, but very few gave structural details of these proteins. Usually, there was very little difference between descriptions of membrane proteins and enzymes, the term ‘active sites’ being used in both. It was rare to see descriptions of both channel and carrier proteins, and even more rare to see explanations of active transport.

Most candidates included material on receptor proteins from module four, usually describing blood sugar control or synaptic transmission, but rarely relating relevant protein structure to function.

Surprisingly few candidates made any real attempt to describe the proteins used in muscle contraction. Whereas most candidates can describe muscle contraction in answers to module four questions, relating the structures of actin, myosin and tropomyosin to their functions was beyond most candidates.