GENERAL COMMENTS

Responses to the June Chemistry examination suggested that it included some very good original/different questions. In this examination students are expected to be able to process information and apply chemical understandings to familiar and new contexts and the examination included appropriate 'new context' questions. Questions were consistent with the requirements of the new study design.

While generally students were able to complete the examination, and some students achieved full marks, the overall level of performance on some questions suggested that students were challenged by this exam. This was a very thorough examination which probed real understanding. Many of the questions required students to bring together their understanding from different key knowledge points.

The percentage of students achieving each grade was consistent with the 2008 examination but the cut-off scores for grade levels were lower. A score of 78 per cent was required to achieve an A^+ (compared to 87 per cent in 2008) and approximately 70 per cent was needed to receive an A (compared to 80 per cent in 2008). The mean score was 51 per cent (compared to 58 per cent in 2008).

Strong overall performance on Questions 14–18 and 20 in Section A indicated that students generally had a good understanding of the organic chemical pathways content. However, responses to other questions in Section A suggested that many students had significant question interpretation issues. For example, in Question 3 some students overlooked the fact that electrons move to higher energy levels when energy in the UV-Vis region of the spectrum is absorbed. In Question 4 some students assumed that the section of polylactic acid shown was in fact the monomer, overlooking the fact that this compound is a condensation polymer and the monomer would be expected to have two functional groups. In Question 6 some students did not recognise that H_2 could be used as a carrier gas for GC of a mixture of alkanes and in Question 10 some did not recognise the link between the change in pressure and the amount of CO_2. Some students overlooked the fact that different compounds with C=C double bonds can be involved in the one addition reaction in Question 13.

In Question 12 it was decided that two answers would be accepted as the number of different compounds in the question could be interpreted in two ways. While the intent of the question was the number of 'organic' compounds produced, some students quite validly interpreted the question as referring to 'all' compounds produced, including the inorganic by-product. HCl is also a product of the monosubstitution chlorination of alkanes. Teachers and students are reminded that this is a rare situation.

In Section B there was wide variation in performance. Question 5, linking the interpretation of MS, IR and NMR spectra to molecular structure, was very well done, suggesting that students are responding well to this component of the study content. While molecular structures were also generally well handled in Questions 1, 6, 8 and 9, systematic naming was an issue in Questions 6b. and 8b. Students were required to write balanced equations in Questions 3a., 7b. and 8a. This is a fundamental skill, however balancing oxygen in Question 7b. and electrons in Question 8a. was poorly done.

The different parts of Question 2 showed the full range of student performance. Most students handled Question 2a. well with the main problem being correct use of the density of ethanoic anhydride. However, Questions 2b. and 2c. proved very challenging for students. When asked to 'describe **how** the purity of the product could be **qualitatively** determined using TLC' (Question 2c.) and 'describe **how** the purity of the product could be **quantitatively** determined using UV-visible spectroscopy' (Question 2b.), most students ignored the cues and struggled to frame coherent responses. These questions were consistent with the required key knowledge in Area of Study 1 – Chemical analysis, principles and applications of chromatographic/spectroscopic techniques and interpretation of qualitative and quantitative data. Students should realise that producing and collecting a compound is not the end of the story. In Question 2d. few students recognised that the greater solubility of the sodium salt was directly associated with the negative ion (acetylsalicylate ion). Question 3 involved a very familiar reaction, but the context was different to what students might have previously experienced. The question was less well done than might have been expected, suggesting that many students did not effectively interpret the information. Students should be encouraged to express all answers to the correct number of significant figures.

Question 4 also required effective interpretation. Responses to Questions 4c. and 4d. suggested that most students, while recognising Question 4 as a 'stoichiometry' question, did not realise the significance of myrcene being an unsaturated hydrocarbon.

Question 10 was perhaps the most challenging 'interpretation' exercise on the examination. While the high-achieving students handled it well, many students found time to be a limiting factor.

SPECIFIC INFORMATION

Section A – Multiple-choice questions
The table below indicates the percentage of students who chose each option. The correct answer is indicated by shading.

Question	% A	% B	% C	% D	No answer	Comments
1	6	3	78	13	0	
2	14	71	11	4	1	Peaks on a mass spectrum are associated with ions – both parent molecular and fragment. These are the species deflected and separated in the magnetic field.
3	33	18	29	19	0	Statements I and II were correct. Statement III was incorrect as energy is absorbed during the transition of electrons from lower to higher energy levels. Statement IV was also incorrect as the spectrum shows two absorbance peaks, at wavelengths of approximately 250 nm and 400 nm. Either of those wavelengths may be used. Ideally the wavelength used should be one at which the compound absorbs strongly but other species in the solution do not. Interpretation of the UV-visible spectrum proved challenging for students. The combined popularity of options B and C suggest that many students were not clear about the link between the light absorbed and the direction of movement of electrons.

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Question	% A	% B	% C	% D	No answer	Comments
4	7	50	20	23	0	The section of the polymer, polylactic acid, shown in the question shows repeating ester groups which can be used to identify the monomer from which the condensation polymer is produced – the ester groups form by reaction between carboxyl and hydroxyl groups. Hence the monomer, lactic acid, is Each lactic acid molecule has four different H environments and would give four peaks in the ^{1}H NMR. The common selection of option B suggests that students interpreted the section of the polymer shown to be the monomer. Students should be aware that monomers for condensation polymerisation would have functional groups such as OH, -COOH, -NH$_2$.
5	51	36	5	7	0	The molecule in option A is non-polar and would be most strongly attracted to the non-polar stationary phase (and least strongly attracted to the polar mobile phase). It will have the greatest retention time. Options B, C and D all have some degree of polarity and hence greater attraction to the mobile phase. The choice of option B suggests that the students focused on molecular size/relative molecular mass as the sole determining factor of attraction to the non-polar stationary phase. While the molecule in option B does have the largest relative molecular mass, its stronger attraction to the mobile phase courtesy of –OH and –NH$_2$ reduces its interaction with the stationary phase.
6	38	12	35	15	0	Statement I is correct as the higher the retention time, the larger the molecules and the higher the boiling temperatures. Statement II is incorrect as at higher temperature the compounds move through the chromatograph faster and have lower retention times. Statement III is correct as the carrier gas must be unreactive with the compounds of the mixture. Alkanes do not react with H$_2$. The choice of option A suggests that H$_2$ was rejected as a possible carrier gas, presumably because these students assumed that it would react.

Question	% A	% B	% C	% D	No answer	Comments
7	18	24	51	8	0	$H^-(aq) + H_2O(l) \rightarrow OH^-(aq) + H_2(g)$ This is an acid-base reaction because $H^-(aq)$ accepts a proton (forming $H_2(g)$) and $H_2O(l)$ donates a proton (forming $OH^-(aq)$). It is also a redox reaction because the oxidation number of H increases (from -1 in H^- to 0 in H_2) and also decreases (from +1 in H_2O to 0 in H_2).
8	9	18	64	7	1	$n(NaOH) = 0.120 \times 14.80 \times 10^{-3}$ $\qquad = 1.78 \times 10^{-3}$ mol $n(RCOOH) = 1.78 \times 10^{-3}$ mol $M(RCOOH) = 0.132$ g $/ 1.78 \times 10^{-3}$ mol $\qquad = 74.3$ g mol^{-1} $M(\mathbf{C_2H_5COOH}) = 74.0$ g mol^{-1}
9	4	21	62	13	0	At the equivalence point all of the RCOOH will have reacted with NaOH(aq) according to $RCOOH(aq) + OH^-(aq) \rightarrow RCOO^-(aq) + H_2O(l)$. The pH at the equivalence point is due to $RCOO^-(aq)$ which as the conjugate base of the carboxylic acid is a weak base, hence the solution has **pH > 7**. During the titration the pH of the solution increases and to accurately identify the endpoint, as close as possible to the equivalence point, the indicator must change colour **once the pH becomes greater than 7**. **Phenolphthalein** fits this criteria. Perhaps students who chose option B did not recognise that even though carboxylic acids are weak acids they react to completion in the presence of the stoichiometric amount of a strong base.
10	42	33	16	7	2	The change in pressure in the container when the air is passed through LiOH is the same as the pressure exerted by the CO_2 in the air, that is, the partial pressure of the CO_2. $p(CO_2) = 1.10 \times 10^2 - 1.00 \times 10^2$ $\qquad = 0.10 \times 10^2$ $\qquad = 10$ kPa $n(CO_2) = p(CO_2) \times V(\text{container}) / RT$ $\qquad = 10 \times 5.00 / (8.31 \times 298)$ $\qquad = 0.0202$ mol $m(CO_2) = 0.0202 \times 44.0$ $\qquad = \mathbf{0.89}$ **g** Option B is consistent with using the total pressure in the container, that is, of the air before CO_2 removal, in the calculation.
11	6	58	12	24	0	Being an alkene, propene undergoes addition polymerisation, not condensation polymerisation. The choice of option D by 24 per cent of students was surprising. This may have been because, in checking the validity of the alternative, they tried to write a balanced equation, for example, $2C_3H_6(g) + 9O_2(g) \rightarrow 6CO_2(g) + 6H_2O(g)$, or perhaps when they considered this alternative they had forgotten that they were looking for an incorrect statement.
12	9	37	39	15	0	As the words 'different compounds' could be interpreted in two ways, two answers were accepted for

| Question	% A	% B	% C	% D	No answer	Comments
						this question. The first sentence of the question referred to 'compound of formula $C_6H_{13}Cl$'. 2,2-dimethylbutane can react with Cl_2 to produce **3 different monochloro compounds**. $CH_3-C(CH_3)(CH_3)-CH_2-CH_2Cl$ $CH_3-C(CH_3)(CH_3)-CH_2Cl-CH_3$ $CH_3-C(CH_3)(CH_2Cl)-CH_2-CH_3$ 1-chloro-3,3-dimethylbutane; 2-chloro-3,3-dimethylbutane; 1-chloro-2,2-dimethylbutane. However, each substitution reaction also produces hydrogen chloride, HCl, so a total of **4 different compounds** will be formed. It was determined that 'The number of different compounds that could be formed in this monosubstitution reaction ...' could be interpreted as referring to either 'the compounds of formula $C_6H_{13}Cl$' or 'all the compounds including HCl. Students are reminded that it is extremely rare that more than one multiple-choice answer is accepted and this should not be seen as a precedent.
13	25	16	53	6	1	Cinnamic acid contains a C=C double bond and may be expected to partake in similar chemical reactions to ethene $CH_2=CH_2$. Like ethene it can be involved in addition polymerisation and might be expected to react with ethene to form a copolymer. Cinnamic acid will undergo an addition reaction with Br_2. As cinnamic acid has a carboxyl –COOH group, it will react with methanol to produce the ester methyl cinnamate. The popularity of option C suggests that most students did not consider that cinnamic acid could react with ethene. However, the molecules of both compounds have the C=C double bond necessary for addition polymerisation.
14	9	2	10	79	0	
15	14	8	6	71	0	
16	5	77	11	7	1	Strong performance on this question reflects effective use of the Data Book.
17	65	13	12	9	1	Students should be aware that enzymes can also be denatured by changes in pH.
18	67	6	12	15	1	
19	10	52	24	12	1	The temperature of the vapour mixture decreases as it moves up the column. Hence, as the vapour rises up it, the relative amount of ethanol increases (and the amount of water vapour decreases). Therefore the percentage of ethanol present is greatest at Z and lowest at X, that is, it increases in order from X to Y to Z.
20	4	82	6	7	1	

Section B – Short-answer questions

Asterisks (*) are used in some questions to show where marks were awarded.

Question 1a.

Marks	0	1	Average
%	14	86	**0.9**
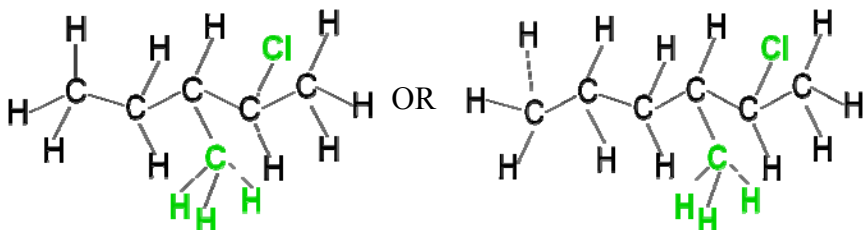
Question 1b.

Marks	0	1	Average
%	26	74	**0.8**

2-chloro-3-methylpentane because it has smaller molecules/lower molecular mass and so has weaker dispersion force attraction to the stationary phase and travels faster through the column

Some students simply referred to 'weaker attraction' to the stationary phase. An indication of why that attraction is weaker was required, that is, students needed to refer to a characteristic of the molecule which explains it.

Question 1c.

Marks	0	1	Average
%	61	39	**0.4**

1.06×10^{-3} mol $\rightarrow$ 922 units
0.57×10^{-3} mol $\rightarrow x$ units
$x / 0.57 \times 10^{-3} = 922 / 1.06 \times 10^{-3}$
$\quad\quad\quad x = (922 / 1.06) \times 0.57$
$\quad\quad\quad\quad = \mathbf{5.0 \times 10^{2}}$* **(496)** (units)

Most students did not work through an accurate ratio calculation. Many estimated that 0.57×10^{-3} mol was one half of 1.06×10^{-3} and gave the answer as 466 units. The large number of responses that simply stated that the area would be smaller was unexpected. Students may have struggled to interpret the question or been unable to link the data.

Question 2ai–iv.

Marks	0	1	2	3	4	Average
%	7	20	15	27	32	**2.6**

Question 2ai.

n(salicylic acid) $= 2.20 / 138$
$\quad\quad\quad\quad\quad = \mathbf{0.0159}$ * (mol)

Question 2aii.

m(ethanoic anhydride) = *Volume x Density*

= 4.20 x 1.08 g

n(ethanoic anhydride) = 4.20 x 1.08 / 102

= **0.0445** * (mol)

Question 2aiii.

Salicylic acid is the limiting reagent

n(aspirin) = n(salicylic acid)

= 0.0159 mol

m(aspirin) = 0.0159 x 180

= **2.86 g** * (2.87 g if unrounded numbers were used)

Question 2aiv.

% yield = [m(aspirin) collected/m(aspirin) theoretical] x 100

= (2.25 / 2.86) x 100

= **78.4** * % (78.7) (78.1)

The use of 2.20 g rather 2.25 g in this question was unexpectedly common. As suggested by the answers accepted for this question, some allowance was made for rounding off. However, while rounding 0.0159 to 0.16 was acceptable, rounding to 0.02 was not.

This question was generally well done and indicated that most students were familiar with the procedure. Most errors occurred in Question 2aii., either through incorrect or non-use use of the density, or assuming that the amount, in moles, of ethanoic anhydride used was the same as the amount of salicylic acid. The latter approach was not consistent with the question's requirement to 'Use the following data'.

Question 2b.

Marks	0	1	2	Average
%	49	33	18	**0.7**

Run a thin layer chromatogram of the product*, that is, the aspirin produced, and check the chromatogram under UV light

If the chromatogram shows two or more spots, the sample is impure*/(single spot, the sample may be assumed to be pure).

Most students struggled with this question. Marks were awarded for students providing a clear indication that a chromatogram of the product was obtained, and a coherent explanation of how the chromatogram could be interpreted to show that the sample was pure/impure. Allowance was made for sensible comparison of R_f values.

Many students referred to chromatograms of ethanoic anhydride and salicylic acid. Others used the information in the stem of the question and proposed running a chromatogram of both salicylic acid and aspirin, but many then struggled to explain how the chromatograms would be interpreted to check the purity of the sample. Most students did not refer to how the UV light could be used to assess purity.

Question 2c.

Marks	0	1	2	3	Average
%	57	21	13	9	**0.8**

Three of:
- identify the appropriate wavelength at which a solution of the purple compound (salicylic acid/$FeCl_3$) absorbs strongly
- make up a set of standards of salicylic acid/$FeCl_3$(aq) and measure absorbances to construct a calibration curve
- make up a solution of a measured amount of the product/$FeCl_3$(aq) and measure its absorbance
- use the absorbance to calculate the amount of salicylic acid (hence aspirin) in the compound.

Although broad interpretation/reference to the points given above was allowed, most students seemed to have little knowledge of the stages in quantitative analysis using UV-visible spectroscopy. Students are expected to be aware of the need to establish a calibration curve and to relate the absorbance of the sample being analysed to the calibration curve to ascertain the concentration/amount.

Many students did not recognise the significance of the salicylic acid and referred to solutions of $FeCl_3$. It may have been that some students, linking purity directly to the percentage of aspirin, did not recognise that it could also be determined by finding out how much salicylic acid was present in the product.

The question can be linked to the following key knowledge point.
- **Principles and applications of spectroscopic techniques** and **interpretation of qualitative and quantitative data** from atomic absorption spectroscopy (AAS), infrared spectroscopy (IR), mass spectroscopy, nuclear magnetic resonance spectroscopy (NMR), and visible and **ultraviolet** spectroscopy (visible-UV).

Question 2d.

Marks	0	1	2	Average
%	60	35	5	**0.5**

Question 2di.
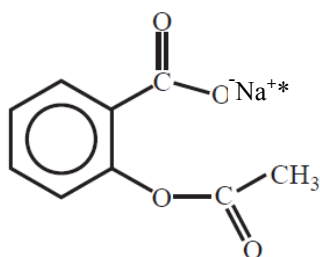
Question 2dii.
Ion-dipole bonds between -COO$^-$ and H_2O are stronger* than hydrogen bonds between between -COOH and H_2O.

Only a small proportion of students recognised that in the sodium salt, the carboxyl group on aspirin (acetylsalicylic acid) molecules had been deprotonated to COO$^-$ and so aspirin is present as acetylsalicylate ions.

While COONa was considered acceptable, many students showed an O–Na link as if there was a covalent bond between O and Na. Few students were able to relate the higher solubility of the sodium salt to the ion-dipole attraction (stronger attraction) between the acetylsalicylate ions and water.

Question 3a.

Marks	0	1	Average
%	35	65	**0.7**

HCl(aq) + NaOH(aq) → NaCl(aq) + H2O(l) or H+(aq) + OH-(aq) → H2O(l)
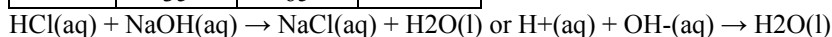
Some students gave the equation for the reaction between $NaHCO_3$(aq) and HCl(aq). This may be attributed to inaccurate interpretation of the information provided. However, there is no justification for states errors such as NaCl(s) or H_2O(aq) or for giving formulae such as $NaCl_2$ with such a common and familiar equation.

Question 3b.

Marks	0	1	2	Average
%	41	36	23	**0.8**

n(NaOH) in flask = 0.0222 x 900.0x10^{-3}
                = 0.0200 mol
n(HCl) reacted = **0.0200 mol***
n(HCl) added to flask = 1.00 x 100.0x10^{-3}
                = 0.100 mol
   n(HCl) remaining = 0.100 – 0.0200
                = 0.080 mol
        c(HCl) = **0.080*** (M)

The first mark was awarded for correctly calculating the **n(HCl) which reacted with the added NaOH**. A number of students calculated the n(NaOH) and did not proceed any further.

Most students seemed comfortable with expressing the result of a multiplication or division to the same number of significant figures as the measurement with the fewest significant figures. They seemed less familiar with the rule for addition or subtraction of data where the result should have the same number of decimal places as the measurement with the fewest decimal places.

Question 3c.

Marks	0	1	Average
%	64	36	**0.4**

Greater, since a larger volume of the HCl solution will be required

Some students assumed that the $NaHCO_3(aq)$ was in the burette and correctly argued that a smaller volume of $NaHCO_3(aq)$ would be required to reach the endpoint.

Question 4a.

Marks	0	1	Average
%	21	79	**0.8**

Addition/hydrogenation/redox

Question 4b.

Marks	0	1	Average
%	22	78	**0.8**

$n(\mathbf{H_2})$ = pV / RT
= 105.0 x 0.510 / (8.31 x [20.0 +273])
= **0.0220*** (mol)

Question 4c.

Marks	0	1	2	Average
%	86	3	10	**0.3**

$m(C_{10}H_{22}) = m(myrcene) + m(H_2)$
$m(\mathbf{H_2})$ = 0.0220 x 2.0 *
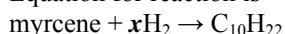= 0.044 g
$m(\mathbf{C_{10}H_{22}})$ = **1.00 + 0.0440**
= **1.04 g***

Many students assumed that the $n(C_{10}H_{22})$ was the same as the $n(H_2)$ and produced an answer of 3.12 g. This reflected poor interpretation of the question, particularly the significance of myrcene being polyunsaturated, and thus requiring at least 2 mol of H_2 per mole of myrcene to be converted to a saturated hydrocarbon. While most students had shown in Question 4a. that they recognised the reaction was an addition reaction, only a small proportion drew the link between addition reactions and the 'law of conversation of mass'.

Question 4d.

Marks	0	1	2	Average
%	81	11	8	**0.3**

$n(\mathbf{C_{10}H_{22}})$ = 1.044 / 142
= **7.35x10^{-3}*** mol
= n(myrcene)
Equation for reaction is
myrcene + xH$_2 \rightarrow$ C$_{10}$H$_{22}$
$n(H_2) / n(myrcene) = x / 1$
0.0220 / 0.0735 = x
3 = x

3 molecules of H_2 added to each myrcene molecule. Hence there are **3*** C=C double bonds.

The following is an alternate approach.
$n(C_{10}H_{22}) = 7.35x10^{-3}$ mol

$n(\text{myrcene}) = 7.35 \times 10^{-3}$
$M(\text{myrcene}) = 1.0 / 7.35 \times 10^{-3}$
$= 136 \text{ g mol}^{-1}$
$M(\text{myrcene})$ is 6 less than $M(C_{10}H_{22})$.
$\rightarrow$ 3 H_2 molecules added to each myrcene molecule
$\rightarrow$ 3 C=C double bonds.

One mark was awarded if 3 double bonds was stated, but to obtain the second mark a logical explanation of how the number of double bonds was determined was required.

Question 5a.

Marks	0	1	Average
%	25	75	**0.8**

$C_2H_4O_2$

Students should know the differences between molecular and semi-structural formulae.

Question 5b.

Marks	0	1	Average
%	21	79	**0.8**

2 different environments

Some students missed the peak at $\delta = 11.7$

Question 5c.

Marks	0	1	Average
%	32	68	**0.7**
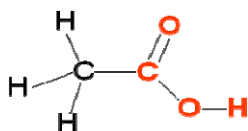
Question 5d.

Marks	0	1	Average
%	37	63	**0.7**

Broad peak at 2500-3300 $(\text{cm}^{-1)}$ indicates **O-H (acid)*** bond.

It was acceptable to show the O-H 'acid' absorption band on the IR spectrum. Reference to O-H in isolation was not sufficient; the 'acid' reference was also required unless the student referred to the C=O absorption band.

Question 5e.

Marks	0	1	Average
%	29	71	**0.7**

In Section B, students' overall performance was the best on Question 5. The majority of students were clearly comfortable with the interpretation of mass, NMR and IR spectra and linking together the information to deduce a molecular structure.
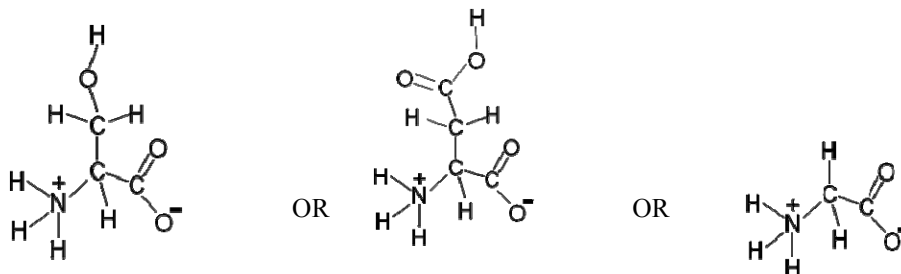
Question 6ai–ii.

Marks	0	1	2	Average
%	28	27	46	**1.2**

Question 6ai.
Serine, glycine, aspartic acid

Question 6aii.

A significant number of students identified serine and aspartic acid in Question 6ai. but missed glycine. The **net charge on a zwitterion is zero**, so on aspartic acid it is only the α-COOH group which is deprotonated to COO⁻.

Question 6b.

Marks	0	1	2	Average
%	31	31	38	**1.1**

Methanoic acid*
Methylpropan-1-ol/methyl-1-propanol/2-methylpropan-1-ol/2-methyl-1-propanol*

The most common error in this question was in the naming of the alcohol. Methylpropanol was common but not acceptable. Students should be aware that there are two possible alcohols derived from methylpropane, methylpropan-1-ol and methylpropan-2-ol, and the location of the –OH group should be reflected in the name. It was not essential to include '2-' in front of 'methyl' because on methylpropane, there is no other possible location for the methyl group.

Question 7a.

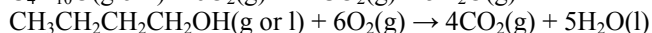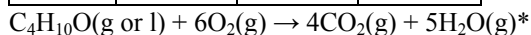| Marks	0	1	Average
%	50	50	**0.5**

Step 1/(Step 3/Step 5)

While the conversion of CO_2 to glucose is perhaps the obvious 'reduction' step – perhaps deduced from the fact that in the reverse process (respiration) glucose is oxidised to CO_2 – Steps 3 and 5 were also accepted as the production of alcohols by fermentation does involve reduction.

The fact that half of the students did not access this mark indicates that many found the diagram difficult to interpret or did not recognise the reduction within the redox reactions.

Question 7b.

Marks	0	1	Average
%	63	37	**0.4**

$C_4H_{10}O(g \text{ or } l) + 6O_2(g) \rightarrow 4CO_2(g) + 5H_2O(g)$*
$CH_3CH_2CH_2CH_2OH(g \text{ or } l) + 6O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$

Some students did not recognise that a combustion reaction was required and others could not write a correct formula for 1-butanol. Many students had the correct formulae for all the reactants and products but were unable to correctly balance the oxygen. Many students seemed to ignore the O in the alcohol and gave 13/2 (or 13 in an equation with $2C_4H_{10}O$) as the O_2 coefficient.

Question 7c.

Marks	0	1	Average
%	49	51	**0.5**

Sucrose has more hydroxyl (-OH) functional groups on each molecule*/a greater number of polar groups and so can form more hydrogen bonds with water.

Students were expected to refer to more –OH/polar groups on sucrose or fewer –OH/polar groups on 1-butanol. Simply stating that sucrose was more polar was not sufficient.

Question 7d.

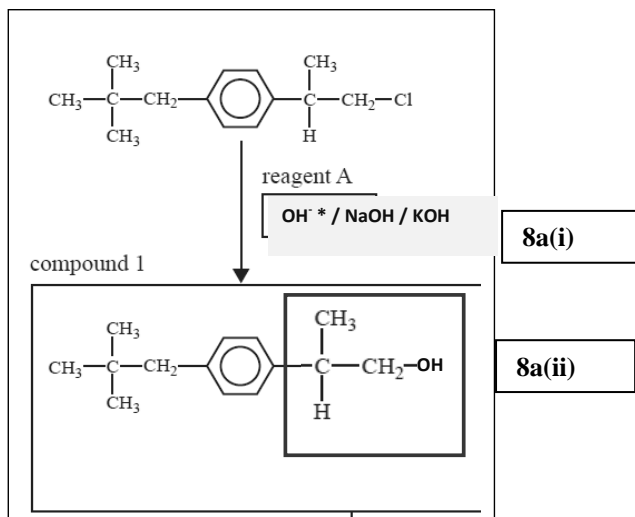| Marks	0	1	Average
%	68	32	**0.3**

H_2O is required for the (hydrolysis) reaction and sucrase catalyses the reaction.

Students were required to state the role of both the water and the sucrase. Many students identified one role only. Stating that sucrase is an enzyme was not sufficient.
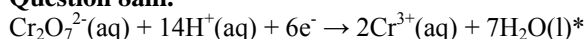
Question 8ai-iii.

Marks	0	1	2	3	Average
%	23	10	41	26	**1.7**

Question 8ai.-ii.

Question 8aiii.
$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$*

Students who attempted this question generally did well. The most common error was having $9e^-$ in the equation. Some students gave this answer with Cr^{3+} correctly balanced.

Question 8bi-ii.

Marks	0	1	2	Average
%	36	35	29	**1**

Question 8bi.
3-methylbutan-1-amine/3-methyl-1-butanamine/3-methylbutylamine

The names indicated here are consistent with IUPAC nomenclature rules.

Compounds in which the principal functional group is the $-NH_2-$ are called amines and so 'amine' should appear in the systematic name. Hence, names such as 1-amino-3-methylbutane are **not** systematic names. The term 'amino' is used in compounds which contain $-NH_2$ and a functional group of higher priority, e.g. $-COOH$ in amino acids.

Question 8bii.
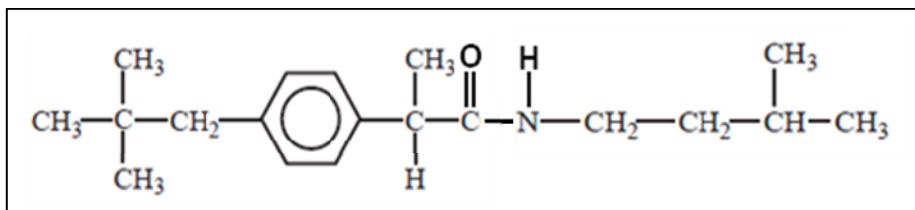
CO-NH was also acceptable in the structure.

Question 9ai–ii.

Marks	0	1	2	Average
%	25	41	34	**1.1**

Question 9ai.

A – **P**

B – **CH₂**

Many students identified P but not CH_2.

Question 9aii.
cytosine

This question required effective use of the Data Book to identify the base shown – guanine – and hence its complementary base.

Question 9b.

Marks	0	1	Average
%	43	57	**0.6**

Human DNA has a greater proportion of A-T (adenine-thymine) base pairs which have fewer hydrogen bonds.

Assessors looked for an indication that the students understood why the bonding in human viral DNA was weaker than the bonding in monkey viral DNA. Most students referred successfully to the relative numbers of A-T and/or G-C base pairs. However, descriptions such as 'double and triple bonds' between base pairs were of concern, and it was clear that some students believed the bonding to be covalent.

Question 9c.

Marks	0	1	Average
%	27	73	**0.8**

Thymine

Question 10a.

Marks	0	1	2	Average
%	36	31	33	**1**

$c(Ba^{2+})$ remaining = **19 mg L^{-1}***

$m(Ba^{2+})$ in 10.00 mL $= (19 / 1000) \times 10$

$\qquad\qquad\qquad\qquad = $ **0.19*** (mg)

Some students read the graph accurately then treated mg L^{-1} as if it was mol L^{-1} when determining the mass of Ba^{2+}.

Question 10b.

Marks	0	1	2	Average
%	71	14	15	**0.5**

$m(Ba^{2+})$ added to volumetric flask = (2.00 / 1000) x 200
                                                              = 0.400 mg
$m(Ba^{2+})$ remaining in volumetric flask = 0.19 mg
$\boldsymbol{m(Ba^{2+})}$ reacted = 0.400 – 0.19
                                        = **0.21 mg*** (0.00021 g)
$\boldsymbol{n(Ba^{2+})}$ reacted = 0.21×10^{-3} / 137.3
                                          = **1.5×10^{-6}*** (mol)

The second mark was awarded for accurately converting calculated $m(Ba^{2+})$ to $n(Ba^{2+})$, that is, accurately dividing the mass in grams by the molar mass.

Many students did not attempt this question. A number of students based their attempt on the amount of Ba^{2+} 'added' or the amount of Ba^{2+} 'remaining' and/or did not convert mg to g to calculate $n(Ba^{2+})$ reacted.

Question 10c.

Marks	0	1	2	Average
%	75	15	10	**0.4**

$n(S)$ in 25 mL surfactant = $n(BaSO_4)$ precipitated in volumetric flask
                                          = $n(Ba^{2+})$ reacted
                                          = 1.5×10^{-6} mol
$\boldsymbol{n(S)}$ in 100 g of grapes = $n(S)$ in 100 mL surfactant
                                              = **$4 \times 1.5 \times 10^{-6}$***
                                              = 6.0×10^{-6} mol
$\boldsymbol{m(S)}$ in 100 g of grapes = 6.0×10^{-6} x 32.1
                                               = 1.9×10^{-4} g
                                               = **0.19*** mg

The second mark was awarded for accurately converting n(S) to m(S) in mg.

Question 10d.

Marks	0	1	Average
%	47	53	**0.6**

AAS is more accurate/Gravimetric analysis is less accurate/AAS is more effective with low concentrations/A large amount of grapes is needed for effective gravimetric analysis