2008 Assessment Report

VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

2008 Chemistry GA 1: Examination

SPECIFIC INFORMATION

High-scoring performances on this examination, which was the first under the new study design, were as strong as in the final years of the previous study design. A score of approximately 87 per cent was needed to achieve an A+ and approximately 80 per cent was needed to receive an A. The mean score for this examination was 58.3 per cent, compared to 58.9 per cent in 2007. The mean score corresponded to a grade of a high C^+.

Although there were indications that some students may not have had enough time to complete the exam, there was also evidence that many students comfortably finished the examination. This may have been due to a number of factors.

A significant point for consideration is how efficiently students accessed information in the data book. A number of questions in both sections required students to access information from the data book. This may have resulted in time issues for some students due to, firstly, recognising the need to use the data book and, secondly, how quickly the relevant data/information was found. Future students should be encouraged to use the data book on all relevant tasks throughout the semester so that quick access to relevant data becomes second nature.

Most questions that required students to access information from the data book were well handled, although converting the provided structure of phenylalanine to a molecular formula was a notable exception. Some students included an extra H because of the benzene ring, while others left N out of the formula. Question 5 in Section B showed that there is a significant difference between accessing the information and then using it effectively. The structure of serine at pH 2 and the structure of the peptide (amide) group in the dipeptide proved problematic for about half of the students.

The importance of effectively reading the question is always emphasised in assessment reports. The majority of students heeded the direction to 'show all bonds', although some did not expand the hydroxyl group. There was significant emphasis on structures throughout Section B and the majority of students generally did well on these questions. It appears that there are two approaches being followed for providing a systematic name for the structure provided in Question 6aii. Given the fairly even split between the two approaches, both answers were accepted. This issue is discussed at some length later in the report.

Performance on stoichiometry questions generally mirrored that of previous years. The last question on the paper, a relatively straightforward 'back titration' question, was generally well done. Questions 1 and 2 in Section B proved more challenging. In Question 1, many students chose the incorrect piece of data to start the required calculations and quite often went round in circles. In Question 2, dealing with milligrams proved challenging for many students. This perhaps parallels the performance on Question 2 in Section A, where the conversion of nanograms to grams was required to arrive at the correct answer. Students should be encouraged to practise effective interpretation of experimental data and should be exposed to a variety of 'mass' units. Performance on these questions, along with Question 3 in Section A, might provide some insight into whether a heavy focus on the 'new' material resulted in insufficient practice on stoichiometry.

Questions on the new material, notably spectroscopy and aspects of biochemistry, were well handed by most students. Perhaps the most challenging of these questions were the use of the UV-visible absorption curve in Question 3c. and identification of 'fragment' in Question 7d. The popularity of H^+ as the response to this latter question indicates the need to address the simple changes that occur during fragmentation of the molecule ion. This is explored further later in the report.

Students did not perform well on the questions related to biochemical fuels, Questions 7a., 7b. and 7c. Although some students may have run out of time, students should have known the equation for the combustion of ethanol, how ethanol dissolves in petrol (given that most use is of E10 blends), the equation for the fermentation of glucose and why ethanol is referred to as a biochemical fuel.

The discussion associated with many of the questions throughout the rest of the report will provide further insights into student performance. The statistical data that is provided to schools on how individual classes performed on each question on the examination should be particularly useful for teachers in evaluating their students' responses to this examination. It was possible that the focus on 'new' content encouraged some students to be less diligent in preparing for other areas of the examination.

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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	4	89	6	1	0	
2	43	22	25	8	2	1.5 ng L^{-1} $\rightarrow$ 1.5 × 10^{-9} g L^{-1} (Table 4 of the data book) $\rightarrow$ 1.5 × 10^{-9} g in 1000 mL $\rightarrow$ 1.5 × 10^{-12} g serotonin in one millilitre of spinal fluid $n(\text{serotonin}) = \frac{1.5\times10^{-12}}{176}$ = 8.52 × 10^{-12} mol N(serotonin molecules) = 8.52 × 10^{-12} × 6.02 × 10^{23} = 5.13 × 10^{9} Students who chose option B perhaps missed the 'number of mole' step. Option C resulted from incorrect conversion of nanograms to grams.
3	3	5	42	49	1	M(C) = 12.0 g mol^{-1} 1 mol xylose molecules contains 5 mol C atoms m(5 mol C atoms) = 60.0 g 60.0 = 40% of M(xylose) 60.0 = 0.40 × M(xylose) $M(\text{xylose}) = \frac{60.0}{0.40}$ = 150 g mol^{-1} The popularity of option D suggests that many students did not identify the links between the mass of 5 mol of C atoms and the mass of 1 mol of xylose molecules.
4	8	6	22	64	0	The titration curve shows that the endpoint for the titration occurs in the pH range 6 to 11. Table 11 of the data book shows that phenolphthalein changes colour in the pH range 8.3–10.0, while methyl red changes colour in the pH range 4.2–6.3. Therefore, phenolphthalein is the better option. Since the acid is being added to the base, the pH will drop as the endpoint is passed through and hence phenolphthalein will change from red to colourless. With 22% of students choosing the incorrect colour change, perhaps more emphasis is needed on 'in context' interpretation of the information in Table 11.
5	4	14	13	69	1	The only difference between the two protein chains was valine in place of glutamic acid. Since the glutamic acid side group $-CH_2CH_2COOH$ has a greater relative mass than the valine side group $-CH(CH_3)_2$ (as seen in Table 8 of the data book), the normal protein chain has the greater molecular mass. The structural differences in the glutamic acid and valine side group would suggest that the two proteins would have a difference in their NMR spectra.
6	74	4	11	11	0	

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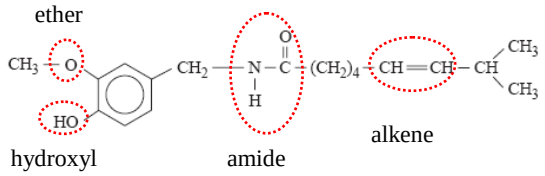
Question	% A	% B	% C	% D	% No Answer	Comments
7	8	16	71	5	0	
8	75	17	5	3	0	
9	31	5	1	63	0	200 base **pairs** means a total of 400 bases: 50 thymine, 50 adenine, 150 cytosine and 150 guanine. Option A overlooks the significance of the base 'pairs'.
10	5	71	9	15	0	G–C bonds (three sites of hydrogen bonding) are stronger than A–T bonds (two sites of hydrogen bonding), so piece 1 has the stronger bonds between the strands. Therefore, piece 2 is more readily separated by heating. Relative molecular masses of the bases are Guanine (151), Adenine (135), Thymine (126) and Cytosine (111) (as per Table 10 of the data book). So strand W has the highest relative molecular mass. This could be deduced by inspecting the relative sizes of the bases with guanine and adenine significantly larger than cytosine and thymine.
11	7	5	15	72	0	DNA fragments assume an overall 'negative' charge because of the phosphate groups. Fragments move from the negative terminal to the positive terminal and the smaller fragments move through the gel faster than the larger fragments.
12	87	3	3	7	0	
13	8	2	3	87	0	
14	7	7	81	5	0	
15	16	25	13	45	1	Radio wave frequencies are used in nuclear magnetic resonance spectroscopy in which the nuclei of C or H atoms are promoted to higher energy levels (option D). Option A indicated mass spectroscopy, option B indicated IR spectroscopy, and option C indicated atomic absorption or UV-Visible spectroscopy
16	18	27	31	23	0	Structural isomers refer to compounds which have the same molecular formulae but different structural formulae, i.e. atom connectivities. Options for C_5H_{10} are: $CH_3CH_2CH_2CH=CH_2$: 1–pentene $CH_3CH_2CH=CHCH_3$: 2–pentene $CH_3CH_2C(CH_3)=CH_2$: 2–methyl–1–butene $(CH_3)_2CHCH=CH_2$: 3–methyl–1–butene $(CH_3)_2C=CHCH_3$: 2–methyl–2–butene Therefore, there are five structural isomers containing a double bond.
17	17	63	10	9	1	$Br_2(aq)$ will react across a C=C double bond in an addition reaction. Na_2CO_3 will react with an acid, in this case a carboxyl functional group.

Question	% A	% B	% C	% D	% No Answer	Comments
18	6	15	47	31	1	Polymers formed from glucose are condensation polymers. The polymer formed from *n* $C_6H_{12}O_6$ molecules will condense out *n–1* H_2O molecules. $180 \times n - 18 \times (n - l) = 3.62 \times 10^5$ $180n - 18n + 18 = 3.62 \times 10^5$ $162n = 3.62 \times 10^5 - 18$ $n = \frac{3.62 \times 10^5 - 18}{162}$ $= 2235$ Option D did not take into account the water molecules released during the condensation polymerisation.
19	14	47	27	11	1	The reaction of 0.150 mol of the fatty acid with 0.300 mol I_2 indicates that each molecule of the fatty acid contains 2 C=C double bonds. Saturated fatty acids have the general formulae $C_nH_{2n}O_2$ or $C_nH_{2n+1}COOH$, so fatty acids with 2 C=C double bonds will have the general formulae $C_nH_{2n-4}O_2$ or $C_nH_{2n-3}COOH$. Only linoleic acid (option B), $C_{17}H_{31}COOH$ (that is, $C_{18}H_{32}O_2$), fits the general formula. Lauric acid is saturated, palmitoleic acid is monounsaturated and arachidonic acid has 4 C=C double bonds.
20	41	7	18	33	1	The first fraction collected in fractional distillation contains the smallest molecules in the mixture. Molecule size, molar mass and boiling point all increase in the order X < Y < Z. Volatility decreases in the order X > Y > Z (that is, Y is more volatile than Z). Fraction Z has the largest molecules and the strongest dispersion forces **between its molecules**, and hence the highest boiling temperature. Students who selected option D did not appear to understand that relative volatilities (and boiling points) of the different fractions are determined by the strength of bonds **between** the molecules.

Section B – Short answer questions

For each question, an outline answer (or answers) is provided. In some cases the answer given is not the only answer that could have been awarded marks. Asterisks (*) are used in some questions to show where marks were awarded

Question 1a.

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

To remove any traces of **impurities** from the precipitate.

A variety of responses were considered acceptable; however, students should note that impurities removed by washing a precipitate will be 'soluble' impurities.

Question 1b.

Marks	0	1	Average
%	30	70	**0.7**

Either of:

- all the SO_4^{2-} ions have been precipitated

- $BaCl_2$ is in excess.

There were some 'interpretation' issues here with references to 'weighing to constant mass' and 'endpoints'.

Question 1c.

Marks	0	1	2	3	4	Average
%	34	10	12	18	26	**2.0**

1ci.

$$n\left(SO_4^{2-}\right) \text{ in 20.00 mL sample} = n\left(BaSO_4\right)$$
$$= \frac{2.00}{233.4}$$
$$= 8.57\times10^{-3}*$$
$$n\left(SO_4^{2-}\right) \text{ in 500 mL} = \frac{8.57\times10^{-3}}{20}\times500$$
$$= 0.214*(\text{mol})$$

1cii.

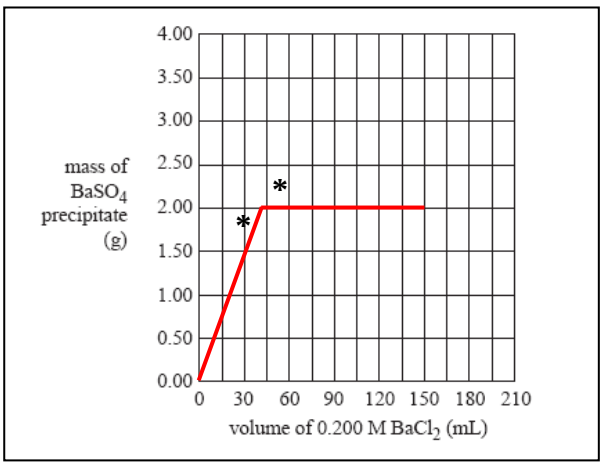
$$m\left(MgSO_4\right) = 0.214\times120.4*$$
$$= 25.8 \text{ g}$$
$$\%MgSO_4 = \frac{25.8}{32.50}\times100$$
$$= 79.4\%*$$

The starting point for this question proved challenging for many students. Using the mass of impure $MgSO_4$ and reading the V($BaCl_2$) off the graph were quite common approaches. Apart from the accuracy of the graph reading, the latter approach was relatively successful. 79.3% was also an accepted answer.

Part ii. was better handled than part i.

Question 1d.

Marks	0	1	2	Average
%	40	26	34	**1.0**



With 0.200 M $BaCl_2$, the graph levels off (at 2.00 g $BaSO_4$) when the *V*($BaCl_2$) added is half of that used with 0.100 M $BaCl_2$.

Marks were awarded for drawing a graph that levelled off when the V($BaCl_2$) added was slightly less than 45 mL, and the m($BaSO_4$) was 2.00 g.

Question 2a.

Marks	0	1	2	3	Average
%	17	21	26	35	**1.9**

2ai.
+7

2aii).
$IO_4^-(aq) + 2H^+(aq) + 2e^- \rightarrow IO_3^-(aq) + H_2O(l)$

2aiii.
It is an oxidant, as (any of):

- it oxidises Mn^{2+} to MnO_4^-
- it increases the oxidation number of Mn
- the oxidation number of I decreases.

Students' explanations of why IO_4^- was acting as an oxidant indicated some confusion with terminology. An incorrect number of electrons in the half-equation was relatively common.

Question 2b.

Marks	0	1	2	3	4	Average
%	27	21	23	20	10	**1.7**

2bi.
35 (mg L^{-1})

2bii.
The original solution had been diluted from 25 mL to 100 mL.

$$c\left(MnO_4^-\right) \text{ in original solution} = 35 \times \frac{100}{25}$$
$$= 140^* \left(\text{mg } L^{-1}\right)$$

$$m\left(MnO_4^-\right) \text{ in solution} = 140 \text{ mg}$$
$$n(Mn) = n\left(MnO_4^-\right)$$
$$= \frac{0.140}{118.9}$$
$$= 1.18 \times 10^{-3} \text{ mol}$$
$$m(Mn) = 1.18 \times 10^{-3} \times 54.9$$
$$= 0.0646 \text{ g}$$
$$= 65^* \text{ (mg) } [64.6]$$

2biii.

$$\%Mn = \frac{0.0646}{13.936} \times 100$$
$$= 0.46\%^* \ [0.463]$$

Many students struggled with part ii. and dealing with mg proved particularly problematic. Using the molar mass of Mg rather than Mn was quite common. Part iii. proved quite accessible through consequential considerations.

A small number of students used the alternative, quicker approach to part ii., namely $m(Mn) = 140 \times \frac{54.9}{118.9}$.

Question 3a.

Marks	0	1	Average
%	20	80	**0.8**

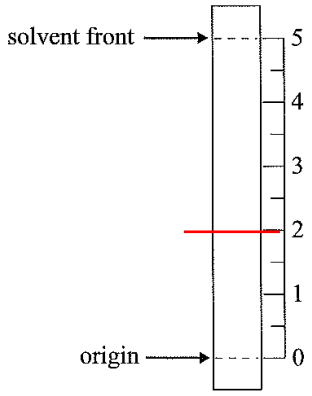
Either of:

- $CH_3COOH/C_2H_4O_2$/structural formula of ethanoic acid
- $CH_3CO.O.COCH_3/C_4H_6O_3$/structural formula of acetic anhydride.

Question 3b.

Marks	0	1	2	Average
%	15	22	62	**1.5**

3bi.



3bii.
It is larger; it moves further from the origin.

Question 3c.

Marks	0	1	Average
%	72	28	**0.3**

9.1 (μg mL^{-1})

In order to allow for graph reading issues, responses within the range 9–9.4 were accepted. Most students were unable to identify a way to solve this question. 15.1 μg mL^{-1} solution had an absorbance of 1.59 (accepted 1.55 – 1.6). So, for a solution with absorbance 0.96, paracetamol concentration $= \frac{0.96}{1.59} \times 15.1 = 9.1$ μg mL^{-1}.

Question 4a.

Marks	0	1	2	Average
%	22	17	60	**1.5**

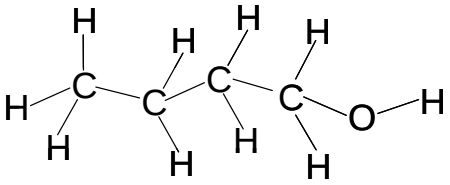
$$n = \frac{pV}{RT}$$
$$= \frac{115 \times 0.124}{8.31 \times 393}$$
$$= 4.37 \times 10^{-3} * \text{ mol}$$

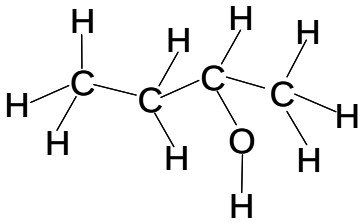
$$M = \frac{m}{n}$$
$$= \frac{0.376}{4.37 \times 10^{-3}}$$
$$= 86.1* \left(\text{g mol}^{-1}\right)$$

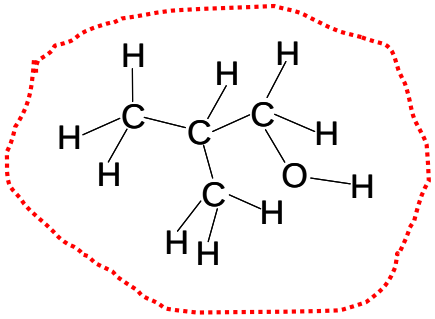
Question 4b.

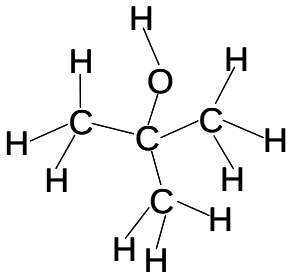
Marks	0	1	2	3	4	5	6	7	8	Average
%	5	4	6	7	10	13	19	21	14	**5.4**

4bi. Alkanol I Alkanol II









Alkanol III Alkanol IV

4bii.

^{13}C NMR

- the number of different carbon environments (three)
- could be methylpropan–1–ol

Reaction with $Cr_2O_7^{2-}/H^+$

- the compound must be a primary alkanol
- alcohol with –OH on C–1

4biii.

Structure

- as circled in part i. above

Name

- methylpropan–1–ol
- methyl–1–propanol
- 2–methyl–1–propanol

This question was generally well done. The main concerns were:

- repetition of structures in part i.
- not drawing out the O–H link in part i.
- responses to the evidence from the reaction with $Cr_2O_7^{2-}(aq)/H^+(aq)$ **not** being specific about the location of the –OH group or type of alkanol.

Students were awarded a mark in part iii. if they circled an incorrect alkanol but named that alkanol correctly.

Question 4c.

Marks	0	1	2	3	Average
%	17	23	39	21	**1.7**

4ci.

IR data

- +C=O is present
- carbonyl group

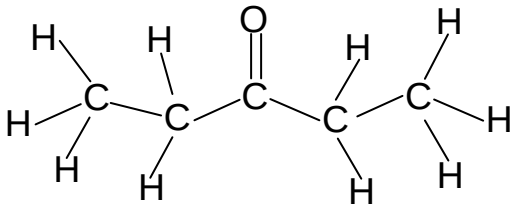
^1H NMR

- two different hydrogen environments

- splitting patterns quartet and triplet → CH_3CH_2 is present
- 6 H in one environment, 4 H in a different environment.

4cii.
$CH_3CH_2COCH_2CH_3$

or

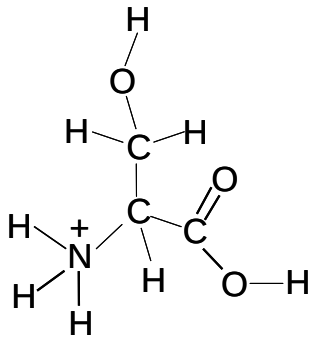


The first part of this question was generally well done, suggesting that the interpretation of IR and NMR data was well learnt. Deducing the structure proved challenging for most students.

Question 5a.

Marks	0	1	2	Average
%	41	29	30	**1.0**

5ai.



5aii.
hydroxyl (hydroxy)

Most students successfully accessed the structure of serine from Table 8 of the data book. However, showing the structure at pH 2 was not well done. Common errors in part i. included leaving the charge off $–NH_3^+$ and deprotonating the –COOH.

Question 5b.

Marks	0	1	Average
%	71	29	**0.3**

$C_9H_{11}NO_2$

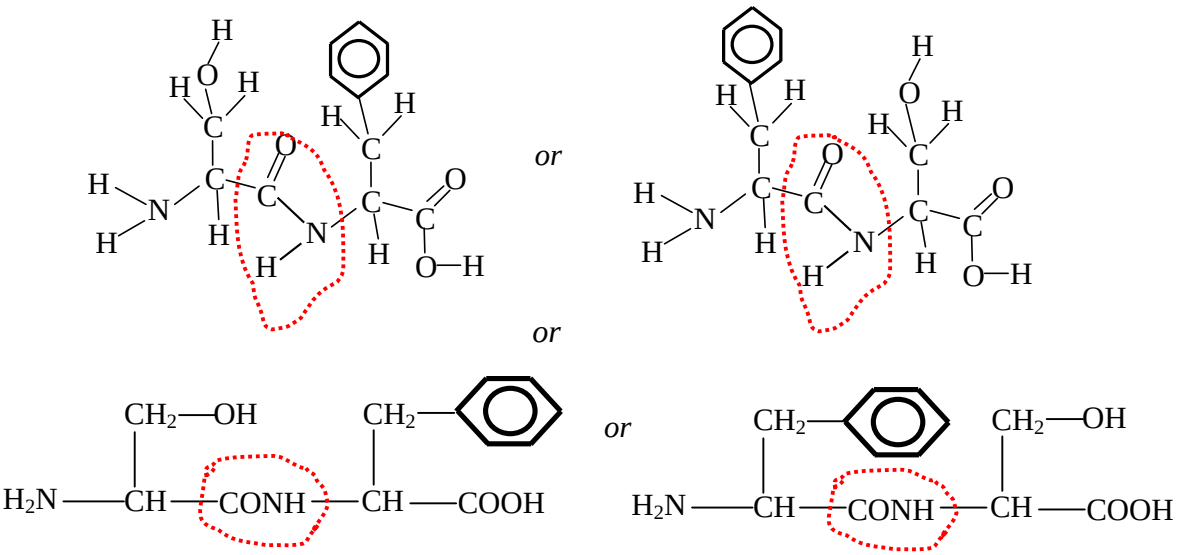
Responses to this question displayed a number of consistent errors, including:

- having 12 H in molecular formula, probably because the students did not recognise that for the C atom on the CH_2 to bond benzene it has substituted for a H atom on C_6H_6, converting it to C_6H_5
- leaving N out of the molecular formula
- providing a semistructural formula rather than a molecular formula.

Question 5c.

Marks	0	1	2	Average
%	37	13	50	**1.2**

5ci–ii.



Representations of the peptide (amide) functional group were a clear indicator of success in this question. A number of students were not able to correctly represent this significant functional group.

Question 5d.

Marks	0	1	Average
%	78	22	**0.3**

S—S

The mark was awarded for clearly showing a covalent link between two S atoms. Many students tried to represent the disulfide in the context of two interacting –SH groups on side chains with varying degrees of success. The most common error was leaving a H atom bonded to each S, overlooking the fact that each S atom forms two bonds, one to the other S atom and one to C.

Question 6a

Marks	0	1	2	3	4	Average
%	16	6	23	12	43	**2.7**

6ai.

Any of:

- aminoethane
- ethylamine
- ethanamine.

6aii.

Either of:

- 5–chloro–2–methylheptane
- 3–chloro–6–methylheptane.

Part i. was a straightforward question and most students received both of the available marks.

Common errors in part ii. included identifying the compound as a hexane rather than a heptane and the use of ‘septane’ rather than heptane.

Responses to part ii. revealed how difficult it can be to achieve consistency in systematic naming of some compounds, with an almost even split between 5–chloro–2–methylheptane and 3–chloro–6–methylheptane responses. The

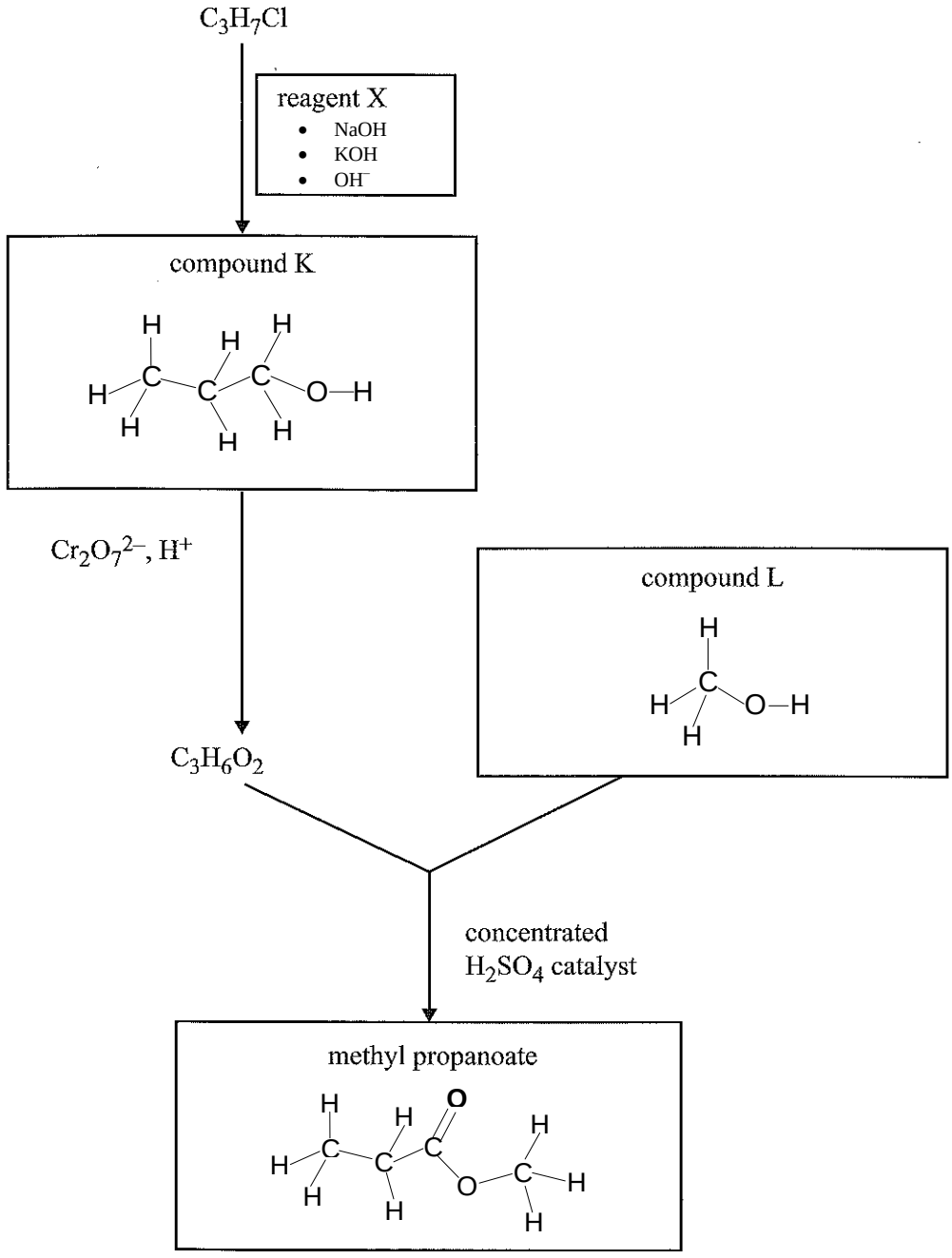
interpretation of systematic nomenclature rules tends to be influenced to a significant degree by the focus on functional groups in this course. Giving the chloro– functional group precedence leads to 3–chloro–6–methylheptane. Alternatively, treating the alkyl– and chloro– groups as having equal prominence leads to numbering the carbon chain from the end nearest a substituent group, which in this case will be from the end nearest the substituent methyl group, which is then located on C–2 and the chloro– group on C–5, leading to 5–chloro–2–methylheptane. Both approaches are reasonable at this level.

Students should remember that substituent groups should be listed in alphabetical order.

Question 6b.

Marks	0	1	2	3	4	Average
%	25	7	10	15	43	**2.6**

6bi–iii.



Although the majority of students seemed to know reaction pathways for the production of an ester and how to draw out molecular structures, a quarter of the students did not gain any marks for this question.

Question 7a.

Marks	0	1	2	Average
%	46	31	23	**0.8**

C_2H_6O(l *or* g) + $3O_2$(g) $\rightarrow$ $2CO_2$(g) + $3H_2O$(g *or* l)

One mark was awarded for a balanced equation and the second mark for correct states. Given the focus on ethanol as a biochemical fuel in the key knowledge of the study design, this was probably a fairly predictable question. A number of students did not gain the 'states' mark because they showed ethanol as (aq).

Question 7b.

Marks	0	1	2	Average
%	46	33	21	**0.8**

Both of:

- the polar –OH end forms (hydrogen) bonds with water
- the non-polar $–CH_2CH_3$ end mixes with petrol.

Marks were awarded for a clear indication that CH_3CH_2OH has a polar end that bonds with water and a non-polar end that bonds with petrol. The statement that 'ethanol bonds with water and petrol because it is polar' was very common. Although these students understood ethanol's solubility in water, they did not make clear the non-polar nature of petrol.

Question 7c.

Marks	0	1	2	Average
%	48	29	22	**0.8**

7ci.

$C_6H_{12}O_6$(aq) $\rightarrow$ $2CH_3CH_2OH$(aq) + $2CO_2$(g)

7cii.

Because it is produced from a biological source/biomass. Glucose is produced by plants.

There were a variety of responses to this question which did not deal with **why** ethanol is a biochemical fuel. Students seemed knowledgeable about environmental issues associated with ethanol, and terms such as 'carbon neutral', 'not contributing to global warming' and 'renewable' were common.

Question 7d.

Marks	0	1	Average
%	73	27	**0.3**

H or H atom

The peak at m/z 45 is caused by $C_2H_5O^+$, which requires the loss of a H atom from the molecular ion, which is $C_2H_6O^+$; that is, $C_2H_6O^+ \rightarrow C_2H_5O^+ + H$.

As the question may have been interpreted as requiring students to identify the fragment causing the peak at m/z 45, the answer $C_2H_5O^+$ was also accepted. The most common answer was H^+.

Question 8

Marks	0	1	2	3	4	5	Average
%	25	10	7	8	16	34	**3.0**

8ai.

$$n(\text{NaOH}) = 0.105 \times 100 \times 10^{-3}$$
$$= 0.0105 \ (\text{mol})$$

8aii.

$$n(\text{NaOH}) \text{ in excess} = n(\text{HC1})$$
$$= 0.197 \times 25.21 \times 10^{-3}$$
$$= 4.97 \times 10^{-3} * \ (\text{mol})(0.00497)$$

$$n(\text{NaOH}) \text{ reacting} = 0.0105 - 0.00497$$
$$= 5.53 \times 10^{-3} * \ (\text{mol})(0.00553)$$

8aiii.

$$n(\text{H}_2\text{X}) = \frac{1}{2} n(\text{NaOH})$$
$$= \frac{1}{2} \times 5.53 \times 10^{-3} *$$
$$= 2.765 \times 10^{-3} \ (\text{mol})$$

$$M(\text{H}_2\text{X}) = \frac{m}{n}$$
$$= \frac{0.415}{2.765 \times 10^{-3}}$$
$$= 150 * \ (\text{g mol}^{-1})$$

Students handled this question well. Most students seemed to understand the principles of simple back-titrations. The most common error was not recognising that $n(\text{H}_2\text{X})$ reacting with NaOH was $\frac{1}{2} n(\text{NaOH})$.