2007 **Chemistry GA 3: Written examination 2**

GENERAL COMMENTS

Students in 2007 continued to show evidence of a good understanding of chemical concepts. Some of the results from the very best students were worthy of what is normally expected from high-level first year tertiary responses.

Questions on stoichiometry continued to be well done. As in 2006, a general difficulty faced by students was in writing correct extended chemical structures, as shown in Questions 4c. and 5a. In addition, there is an on-going problem in the level of student understanding of basic electrochemistry as illustrated in responses to Questions 15–19 of the multiple-choice section. These issues will continue to need attention in the reaccredited *Chemistry VCE Study Design*.

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	Comments
1	6	65	20	8	
2	27	8	7	58	Many students incorrectly thought that the nuclear reaction was endothermic. This was incompatible with the second statement offered.
3	12	9	73	6	
4	13	16	19	51	The poor response to this item indicated unfamiliarity with the reactions of alkali metal oxides with water.
5	12	71	8	9	
6	9	6	7	78	
7	77	5	7	11	
8	7	15	28	50	By choosing option C or D, most students clearly identified that they understood vitamin C to be water-soluble. However, too many did not then recall that vitamin C protects many foodstuffs against atmospheric oxidation and hence must itself be a reductant.
9	46	6	29	18	A surprising proportion of students chose ‘carbohydrates’ (option C). However, since carbohydrates contain similar numbers of C and O, the low O percentage in the compound should have made this impossible.
10	11	20	18	51	The poor results for this question may have been caused by unfamiliarity with the way the question was framed, as the distinction between Lowry-Bronsted acid-base theory and the nature of redox reactions is usually very well understood by students.
11	67	5	9	19	
12	10	8	66	16	
13	4	56	26	14	
14	14	64	12	10	
15	44	21	21	14	Confusion between ‘positive’ and ‘negative’ and between ‘anode’ and ‘cathode’ is compounded by students not fully understanding the difference between galvanic cells (which generate energy and electricity) and electrolytic cells (in which energy is consumed). Students should have identified at the outset that the NiO(OH)etc electrode **must** have been the cathode (because the positive electrode in a galvanic cell is **always** the cathode at which reduction occurs); therefore the NiO(OH) must have been undergoing reduction (option A).
16	15	20	44	20	Questions 15 and 16 were linked – students who got the wrong direction for the cell in Question 15 were also likely to answer this question incorrectly.

Question	% A	% B	% C	% D	Comments
17	14	15	58	13	Responses to this item suggest an ongoing need for close attention to understanding of the terms ‘oxidation’, ‘reduction’, ‘positive’, ‘negative’, ‘anode’ and ‘cathode’ when dealing with galvanic and electrolytic cells.
18	7	4	6	83	
19	5	42	37	16	The high number of students who chose the incorrect option C may have been due to the superficial similarity of the equation in option C to the energy provided by a galvanic cell ($V \times I \times t$).
20	21	8	35	35	The poor response to this item may well have been due to problems in student interpretation of the wording; option D was the exact reverse of the correct response C. The importance of careful reading of the meaning of any question can never be overemphasised.

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 indicate where marks were awarded.

Question 1

Marks	0	1	2	3	4	5	6	Average
%	9	12	13	16	16	17	16	**3.4**

	Property	Chemical symbol of the element
i.	The element which forms an ion with electron configuration of $1s^2 2s^2 2p^6$ and a charge of 2+	Mg (or magnesium)
ii.	The third member of the actinides	U (or uranium) [Pa]
iii.	A period element which forms an ionic oxide that reacts with both acids and bases	Al (or aluminium)
iv.	In the ground state, atoms of this element have electrons in 2 shells and the first four ionisation energies are 0.80, 2.43, 3.66 and 25.02 MJ mol^{-1}	B (or boron)
v.	An element that is more electronegative than chlorine and its atoms have an outer-shell configuration of s^2p^4	O (or oxygen)
vi.	An element which is more metallic than germanium (Z = 32), has a higher first ionisation energy than bismuth (Z = 83) and atoms with an outer-shell configuration of s^2p^2	Sn (or tin)

Note that IUPAC regards the actinides as consisting of 15 elements starting with actinium (Ac), in which case the ‘technically’ correct response to ii. would be Pa, protactinium. However, not many students chose that response and U was always accepted as ‘correct’.

Question 2a.

Marks	0	1	2	Average
%	20	28	52	**1.4**

Any two of the following (or their equivalent):

- elements arranged in order of increasing atomic mass
- similar chemical properties arranged in vertical groups
- gaps left in table allowing for missing elements
- properties of missing elements predicted.

This question was quite well done by most students.

Question 2b.

Marks	0	1	2	3	4	5	6	7	8	Average
%	4	5	7	8	9	10	14	21	23	**5.5**

2bi.
Mass spectrometer (‘spectrograph’ was also accepted)

2bii.
- protons: 113
- electrons: 113
- neutrons: 171

All three answers had to be correct to be awarded the mark.

2biii.
- group III (or 13)
- period 7

2biv.
Tl (Thallium)

2bv.
The core charge increases across the period.

2bvi.
The outer electrons are further away from core charge.

2bvii.
$^{283}Uut_{113} \rightarrow {}^{4}He_{2} + {}^{279}Rg_{111}$

All parts of the equation had to be correct to get the mark.

Note that parts bv. and bvi. were both extremely well done by most students.

Question 3a.

Marks	0	1	2	3	Average
%	33	17	19	31	**1.6**

3ai.
$[He]2s^2 2p^2$

$[He]2s^2 p^2$ was also accepted.

3aii.
$[Ar]3d^6 4s^2$

$[Ar]4s^2 3d^6$ was also accepted.

3aiii.
$[Ar]3d^5$

The condensed method of representing the electronic structures was clearly not familiar to students. Even though the example demonstrating the method was given, it was not copied very well.

Question 3b.

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

- group VI (or 16)
- period 5

Both of the above answers had to be correct to gain the mark. Notwithstanding the problems with condensed representations in part a., this was part was very well done.

Question 4a.

Marks	0	1	2	3	4	Average
%	19	15	21	33	11	**2.1**

4ai.
$C_6H_{12}O_6$

4aii.
$C_{12}H_{22}O_{11}(s) + 12O_2(g) \rightarrow 12CO_2(g) + 11H_2O(g)$ or (l)

One mark was awarded for a correctly balanced equation and the second mark for correct states. Too many students lost a mark by omitting to note the standard instruction to include an indication of states in all chemical equations.

4aiii.
5632 or –5632 (2816 × 2), since maltose contains two monosaccharide/glucose molecules.

Any numerical value of approximately 5500 was accepted.

This question was very well done – a majority of students realised the need for a factor of two here and were duly rewarded.

Question 4b.

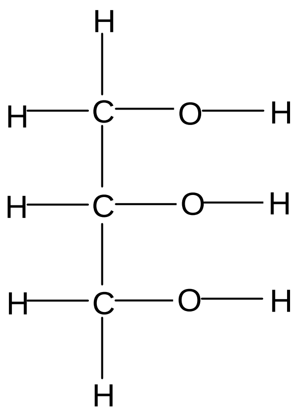
Marks	0	1	2	Average
%	48	34	18	**0.7**

4bi.
3

The correct formula for the appropriate acid (for example, $C_{15}H_{29}COOH$) was also accepted.

This part was not well done. Students must be able to recall or recognise the basic empirical formulas of fatty acids with zero, one and two or more carbon-carbon double bonds.

4bii.



The mark was awarded for a complete structure with all bonds correctly displayed.

This part was not as well done as expected as many students were unable to recall the structure of glycerol or forgot to put all bonds into the structure.

Question 4c.

Marks	0	1	2	3	Average
%	42	10	20	27	**1.4**

4ci.
$CH_3OH + C_{17}H_{35}COOH \rightarrow C_{17}H_{35}COOCH_3* + H_2O*$

One mark was awarded for the correct ester molecule and one for a correct equation.

This question was surprisingly poorly done. The equation needed was the formation of the ester formed from methanol and stearic acid. Most students had difficulty with this, perhaps due to unfamiliarity in using such a large fatty acid.

4cii.
This mark was awarded for correctly circling the ester (COO) part of the methyl stearate (see above).

This part was not well done. The difficulty so many students experienced in generating a meaningful semi-structural formula for methyl stearate meant that it was impossible to indicate the ester group satisfactorily.

Question 4d.

Marks	0	1	2	Average
%	30	6	64	1.4

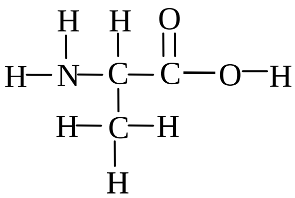
It contains both hydrophilic and hydrophobic parts/components.

This question proved to be easy for most students.

Question 5a.

Marks	0	1	2	3	Average
%	42	9	15	34	1.5

5ai.



All bonds were to be shown; except –OH was accepted for –O–H.

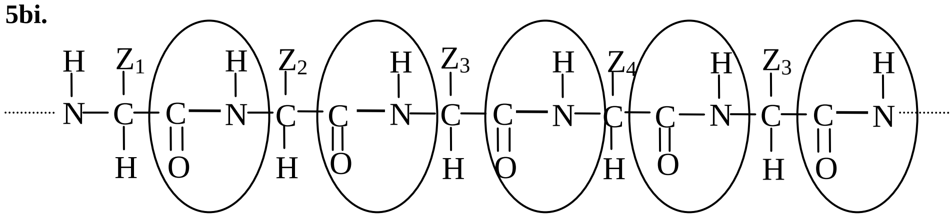
5aii.
One mark was awarded for correctly incorporating the structure of $C_2H_5NO_2$ and a further mark for either $NH_2CH(CH_3)CONHCH_2CO_2H$ or $NH_2CH_2CONHCH(CH_3)CO_2H$.

Structures were usually given by students in fully expanded versions, but semi-structural versions were acceptable. Unfortunately, although part ai. was reasonably well done, most students had difficulty correctly generating the dipeptide structures. Common errors included the inability to include a peptide link; inclusion of incorrect side chains; pentavalent carbon atoms; and divalent hydrogen atoms.

Question 5b.

Marks	0	1	2	3	4	5	Average
%	10	16	16	16	19	23	3.0

5bi.



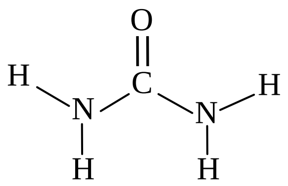
One mark was awarded for circling of one or more of the CONH groupings (one or more of the 'circlings' shown above was accepted). No marks were given if other significant parts of the structure were included in the circle.

5bii.
Z_2 or $–CH_2CH_2CH_2CH_2NH_2$

5biii.
Z_1 or $–CH_2SH$

5biv.
The different pH will change (or denature) the structure of the active site in the enzyme.

5bv.



All bonds had to be shown.

All parts of Question 5b. were very well done.

Question 6a.

Marks	0	1	2	3	4	5	Average
%	20	15	10	15	19	20	**2.7**

6ai.
Energy needed to heat the pot = 550 × 4.18 × (100.0 – 18.5)* + 150 × 0.900 × (100.0 – 18.5) = 198 kJ*

6aii.
$\frac{198}{1364} = 0.145 \text{ mol*}$

Mass of ethanol = 0.145 × 46.0 = 6.67 g*

6aiii.
$\frac{6.67}{0.35*} = 19.1 \text{ g}$ (The mark was awarded for the correct use of the 35% factor.)

All of part a. was fairly well done, and students understand these basic calculations well.

Question 6b.

Marks	0	1	2	Average
%	54	25	21	**0.7**

Energy from 10 g of ethanol = $\frac{10}{46} \times 1364 = 297 \text{ kJ *}$

ΔH for butane = $\frac{(2 \times 297 \times 58)}{6.00} = 5740 \text{ *}$

This was quite a difficult question that would have been unfamiliar to most students. Regrettably, some excellent students who correctly found a way through the hard part of the question then forgot the factor of two in the final equation and only scored one mark out of two.

Question 7a.

Marks	0	1	2	3	Average
%	11	25	59	6	**1.7**

7ai.
Pt, graphite, Pd or Au

7aii.
- 25°C
- 0 (zero)

Question 7b.

Marks	0	1	2	Average
%	47	17	36	**0.9**

- Cd
- H^+ has been reduced so it must have been reduced by the Cd.

Question 7c.

Marks	0	1	2	3	4	5	6	Average
%	33	16	14	7	19	2	9	**2.2**

7ci.
mole of X^{2+} used = (1.00 – 0.725) × 0.1* = 0.0275 mol*

7cii.
mole of electrons = $\frac{2654}{96500}$ = 0.0274 mol *. The ratio is therefore 1:1*

7ciii.
+3

X^{3+} was also accepted.

7civ.
$X^{2+} \rightarrow X^{3+} + e^-$

Part c. of Question 7 was probably the most difficult on the whole paper. Part ci. was usually partly correct, but when an answer was then out by a factor of 10 it was difficult for the student to make sense of the rest of part cii. Very few students answered part ciii. correctly. Even when an incorrect response from cii. was used, far too many students went on to write down a reduction reaction in part civ., even though the direction of electron flow clearly indicated an oxidation reaction.

Question 8a.

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

$Cu^{2+} + 2e^- \rightarrow Cu$

Question 8b.

Marks	0	1	2	3	Average
%	16	18	32	34	**1.9**

- charge through cell = 1.62 × 581 = 941 C
- mole Cu deposited = $\frac{0.306}{63.6}$ = 4.81×10^{-3}

The second mark for the second part of the question was awarded for an answer correct to three significant figures. Quite a few students did not gain this mark. However, even incorrect numerical responses given with three significant figures received this mark.

Question 8c.

Marks	0	1	2	Average
%	39	11	49	1.2

$F = \frac{941}{0.00481} \times 0.5^* = 9.78 \times 10^4 {}^*$

Question 8d.

Marks	0	1	Average
%	76	24	0.3

Some Cu may have been lost.

Question 8 was quite well done, apart from part d. where most students failed to realise the significance of Cu loss.

Queries/comments:
- Multiple choice, Question 15, highlighted: Is this correct?