2005 Assessment Report

VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

2005 Chemistry GA 3: Written examination

GENERAL COMMENTS

Students continued to do well in the Unit 3 examination. Students performed particularly well on the questions relating to stoichiometric calculations, which required a detailed understanding of the mole concept. It was pleasing to see such an important topic being well done.

SPECIFIC INFORMATION

Section A – Multiple-choice questions

Question	% A	% B	% C	% D	Comments
1	13	7	62	18	Given the molecular formula $C_6H_{12}O_6$ of the monosaccharide, glucose, the condensation of three of these molecules to form a trisaccharide must be a condensation reaction that should eliminate two water molecules. The most common error was to conclude that three water molecules were eliminated (response D).
2	79	10	9	2	
3	5	30	59	6	Cellulose (response C) provides the lowest amount of energy per gram as it is not significantly digested in the human body. About 30% of students incorrectly chose glycine.
4	17	9	31	42	Only 42% correctly chose response D. Reaction 1 is clearly an oxidation (N is oxidised from –3 to +5) and reaction 2 is a reduction (N is reduced from +5 to 0). Students who chose alternatives A or C seemed to think that reaction 1 was 'nitrogen fixation' even though 'nitrogen fixation' must involve a reaction of molecular nitrogen.
5	12	61	20	6	There is an excess of 20 mL of the 2.0 M HCl. Only 40 mL of the HCl is needed to react with the 40 mL of NaOH. The amount of heat evolved will thus be $\left(\frac{40}{1000}\right) \times 2 \times 56\,000 = 4480$ J. The temperature rise must then be $\frac{4480}{420} = 10.7^{\circ}$C. This is added to the initial temperature to give $21 + 10.7 = 31.7^{\circ}$C, which is the closest to the correct response, B. Students who chose response C failed to note the excess of HCl and used the 60 mL amount.
6	12	7	9	72	Au^+(aq) (response A) lies above the chlorine-chloride pair in the electrochemical series.
7	17	21	19	43	The half cell reaction, $Cd(s) + 2OH^-(aq) \rightarrow Cd(OH)_2(s) + 2e^-$, is an oxidation reaction and the electrode is therefore an anode (and also the negative electrode) of the cell. During the recharging process, this reaction must be reversed to become a reduction reaction. Thus the electrode will be then a cathode and a negative electrode with the half reaction: $Cd(OH)_2(s) + 2e^- \rightarrow Cd(s) + 2OH^-(aq)$, depositing cadmium. Therefore, **Option I** is correct. In the case of the cell reaction (in either direction), the same numbers of OH^- ions are formed and consumed – thus, when the cathode is generating OH^- ions the anode is consuming them at the same rate. Therefore, **Option II** is incorrect. Finally, in the recharging process, electrons are generated at the anode (the oxidation reaction) and consumed at the cathode (the reduction process) so that electrons will flow through the external circuit from the anode to the cathode. Therefore, **Option III** is correct. As options I and III are correct, response D was the correct answer.

8	19	55	12	14	A and C would be negative relative to the Fe^{3+}/Fe^{2+} half cell and D is not a proper half cell, so response B is correct.
9	11	11	11	67	The deposition of a metal from metal ions in solution onto an inert electrode is a reduction reaction and requires that the copper disc be made negative.
10	74	11	11	4	$\frac{0.150}{107.9} = 1.39 \times 10^{-3}$ mol of Ag to be deposited. This requires $1.39 \times 10^{-3} \times 96\,500 = 134.1$ C, since each mole of Ag deposited requires one mole of electrons. Thus the time taken will be $\frac{134.1}{1.5} = 89.4$ s, so 90 seconds (response A) is the closest answer. The stem of the question refers to the electrolyte containing a 'source' of $Ag^{+}(aq)$. Silver plating is usually carried out using a complex ion, (e.g. $Ag(CN)_2^{1-}$). This ensures that the actual 'free' concentration of $Ag^{+}(aq)$ is extremely low. In this case, where the disc referred to is copper, a high concentration of $Ag^{+}(aq)$ would have led to the spontaneous reaction $2Ag^{+}(aq) + Cu(s) \rightarrow 2Ag(s) + Cu2^{+}(aq)$, where the deposited Ag would have been rough and obviously crystalline.
11	11	22	45	21	Every mole of Au deposited requires three mole of electrons. 0.15 g of Ag requires 1.39×10^{-3} mole of Ag and hence 1.39×10^{-3} mole of electrons. 0.15 g of Au is $\frac{0.15}{197} = 7.61 \times 10^{-4}$ mol. This will need $3 \times 7.61 \times 10^{-4} = 2.28 \times 10^{-3}$ mole of electrons. Thus, the Au will need $\frac{2.28\times10^{-3}}{1.39\times10^{-3}} = 1.67$ times the number of electrons as Ag. Since the current is the same for both electrolyses, the time ratio will be closest to 1.6 to 1 (response C). Responses B and D both attracted a significant proportion of responses; B is the reverse of the correct result and D confuses mass with the number of mole. $Au^{+}(aq)$ at high concentrations would also react directly with the Cu. Gold plating is also carried out with a complex ion of Au^{+} so that the concentration of $Au^{+}(aq)$ in the solution is extremely small.
12	54	26	17	2	This is a direct reference to the standard electrolytic method of producing aluminium commercially. In this process, the anode is carbon and the cathode is a carbon lining over a steel base. Response B incorrectly indicated a steel cathode.
13	18	50	22	10	Response A gives the conversion of molecular iodine from solid to gas, obviously a reaction with a positive ΔH (a reaction that absorbs heat). Response C is the reverse of the exothermic reaction of carbon with O_2 to produce CO_2 so that the reaction as given must have a positive ΔH. The reverse of the reaction in D is the exothermic reaction between sodium and chlorine to make NaCl(s) so that the reaction as given must have a positive ΔH. In response B, the reaction is $Na^{+}(g)$ plus a gaseous electron to give Na(g). Students should know that the reverse of this reaction is the ionisation of a sodium atom, which has a positive ΔH; hence the reaction as given will be exothermic and have a negative ΔH. Thus the endothermic reaction B is correct.
14	7	44	36	13	Students who incorrectly chose response C (argon) correctly identified the electronic structure of Sc^{3+}, but failed to grasp that X was an ion; that is, Cl^{-}.

15	6	4	71	19	In response C, the chromium atom has a +3 oxidation state in all three substances. The order of oxidation states in the other three choices is: A: +3, +6, +6. B: +2, +3, +6. D: +6, +6, +3.
16	68	14	9	9	
17	6	14	70	10	Students who chose response B seemed to forget about helium.
18	30	9	20	41	The question clearly referred to a nuclear reaction so, given that the nuclear reaction involves the potassium nucleus, the correct result could not possibly be anything involving K – yet 30% of students chose K^+ as the answer. The loss of an electron by the nucleus must have raised its atomic number by one unit to the adjacent calcium (from 19 to 20), hence response D is correct.
19	12	66	11	10	
20	14	14	11	61	While F^-, CN^- and H_2O should all be reasonably familiar as ligands, NH_4^+ cannot act as a ligand at all because there are no electron pairs available for bonding and the ion has no dipole.

Section B – Short-answer questions

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

Question 1

Marks	0	1	2	3	4	5	Average
%	1	4	9	14	26	46	**4.1**

1a.
F (or F_2)

1b.
O or (O_2)

1c.
either Al or Be

1d.
either C, N, Si, or S

1e.
either N or S

Names were also accepted for these elements.

A score of less that four out of five generally indicated that the student was not going to do well on the rest of the paper.

Question 2
2a.

Marks	0	1	Average
%	29	71	**0.8**

A mass spectrometer (mass spectrometry and mass spectrograph were also accepted).

2b.

Marks	0	1	2	3	Average
%	16	4	35	45	**2.2**

$(0.7899 \times 23.985) + (0.1000 \times 24.986) + (0.1101 \times 25.983) = 24.3051$

Students were given one mark for the correct working (percentages were also accepted), one mark for the correct numerical result of 24.31 (or a result that rounds to this) and one mark for any final result given to four significant figures. As 24.3 is the RAM of Mg that could be copied directly from the data tables, this result was not awarded any marks unless it was accompanied by appropriate working.

This question was, in general, well done. Students were required by the question to provide some 'working'. As shown above, correct answers without working only received one mark (for the correct number of significant figures). Working had to be shown to obtain full marks here.

2ci.

Marks	0	1	Average
%	46	54	0.6

They have similar chemical properties.

Related chemical examples that emphasised chemical properties were also accepted.

2cii.

Marks	0	1	2	Average
%	38	20	42	1.1

The size of the calcium atom is greater than that of magnesium, hence electrons are less strongly attracted.

A common error was to claim that magnesium had a larger core charge than calcium.

2ciii.

Marks	0	1	Average
%	26	74	0.8

$1s^2 2s^2 p^6 3s^2 p^6 4s^2$

A surprising number of students gave the structure of calcium as $3p^6 3d^2$.

2civ.

Marks	0	1	Average
%	21	79	0.8

$1s^2 2s^2 p^6 3s^2 p^6$

2cv.

Marks	0	1	Average
%	40	60	0.6

Students had to provide some indication/implication that calcium has an extra occupied shell, or an explanation of the same 'nuclear' charge acting on more electrons in the calcium atom.

The 'extra shell' argument should have been obvious, but many students struggled with explanations that referred to 'core charge', often attempting to give a core charge to the Ca^{2+} ion. The concept of core charge is not always well understood or well applied.

Question 3

3a.

Marks	0	1	2	3	4	Average
%	23	10	14	25	27	2.3

1.6×10^6 g C → CO_2* = 1.33×10^5 mol* → $1.33 \times 10^5 \times 393 = 5.24 \times 10^7$ kJ*

0.40×10^6 g C → CO = 0.33×10^5 mol → $3.33 \times 10^3 \times \frac{232}{2}$ → 0.39×10^7 kJ

Total = 5.63×10^7 kJ*

One mark was given for correctly changing mass to moles; one mark for the 80:20 split; one mark for applying the energy per mol from ΔH; and one mark for giving the correct answer consistent with the correct use of information from ΔH.

This was not a particularly easy question, so students performed reasonably well. A common error was to use 1 tonne of coke rather that 2 tonne of coke in the calculations. Another mistake was to forget the factor of 2 by using 232 rather than $\frac{232}{2}$ in the CO calculation.

Although no marks were lost, too many students gave an unnecessary number of significant figures (up to 10!) in their final result. Students should be encouraged to use scientific notation when numbers are very large or very small.

3b.

Marks	0	1	2	Average
%	23	37	40	**1.2**

3bi.
mass loss/nuclear binding energy/nuclear energy

3bii.
It is not yet practical.

Too many students provided irrelevant information such as 'dangerous nuclear waste' and 'possible nuclear disasters'. To obtain the mark for this question, students had to recognise that nuclear fusion is not yet a practical possibility. Students who identified this and then went on to provide additional material were still awarded the mark.

3c.

Marks	0	1	2	3	4	Average
%	4	4	5	26	61	**3.4**

3ci.

chemical	thermal
thermal	mechanical
mechanical	electrical

Answers which gave 'kinetic' instead of 'thermal', but which correctly listed 'chemical', 'mechanical', and 'electrical', scored two out of three marks.

3cii.
It becomes waste heat.

This question was very well done in general.

Question 4
4ai.

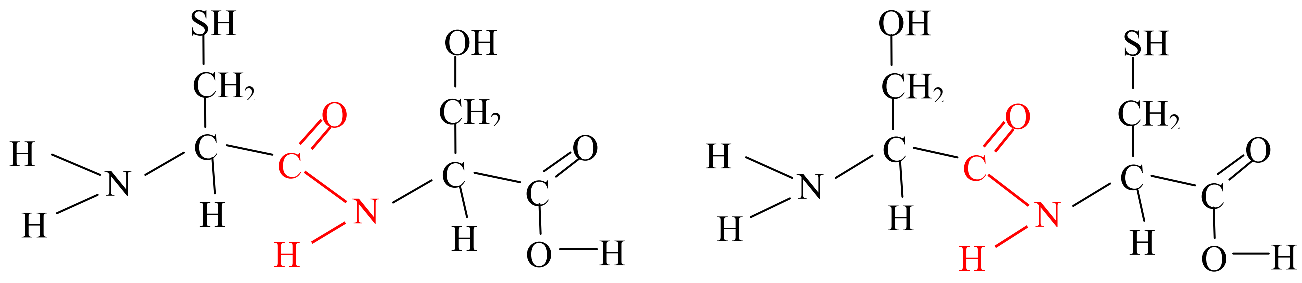
Marks	0	1	Average
%	65	35	**0.4**

It must have carboxy and amino groups attached/bonded to the same carbon atom.

A structure that clearly showed the amino and carboxyl groups attached to the same C atom was also accepted as correct. Only 35 per cent of students received the mark for this simple question, indicating that the concept was not well understood.

4aii.

Marks	0	1	2	Average
%	42	16	43	**1.1**



One mark was given for each of the two possible links. In general, structures had to be drawn out as indicated, but O–H as –OH was accepted. If two fully correct semi-structural formulas were shown, one mark only was awarded.

This part was not very well done. It was surprising how many students could not join two amino acids to form a peptide link, rather preferring to produce acid anhydrides or ester-like links. –C–N–H– and –C–O–C– were also commonly provided.

4b.

Marks	0	1	2	3	4	Average
%	13	11	17	24	34	**2.7**

4bi.
A: covalent bond and/or peptide (amide) link/bond
B: a hydrogen bond/dipole-dipole bonding
C: a covalent bond and/or a disulfide link/bond

4bii.
It provides a site at which a chemical reaction can occur/an active site.

These parts were well done; however, some students were unable to express their answers clearly.

Question 5
5a.

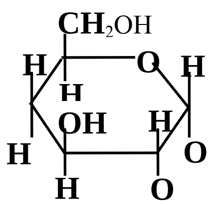
Marks	0	1	2	3	Average
%	9	13	26	53	**2.3**

5ai.
hydroxy(l) group

This question was very well done, although a small number of students used the term ‘alcohol’ to describe the hydroxy group. This was not accepted as an alcohol is a class of organic compound, not a functional group.

5aii.
carbohydrate

5aiii.



5b.

Marks	0	1	Average
%	18	82	**0.9**

water

5c.

Marks	0	1	2	Average
%	19	33	47	1.3

5ci.
There are more effective/fruitful collisions between reactants at 35°C, **or** reactions occur faster at a higher temperature.

5cii.
The enzyme would have partly denatured/degraded at 95°C.

Part c. was fairly well done, although too many students wrote something like '35°C is an optimum temperature for an enzyme reaction' rather than providing an explanation in terms of the effect of temperature on reaction rates and a high temperature denaturation process.

Question 6
6a.

Marks	0	1	Average
%	70	30	0.3

Most foods are not pure substances.

Most students seemed to miss the point here and provided very general answers. Many simply said that 'most people don't understand the term "mole"'. Although this is true, a more important point is the fact that few foods are pure substances and the use of 'mole' would be impossible.

6b.

Marks	0	1	Average
%	73	27	0.3

The reaction is too slow **or** the electrochemical series gives no indication of reaction rate.

Credit was also given for statements such as 'the activation energy barrier is too high to be overcome at room temperature', which is a perfectly correct assertion.

Common incorrect answers included 'the reaction is not at STP' and 'The E^o of hydrogen is zero at STP so no reaction will occur'.

6c.

Marks	0	1	2	Average
%	40	23	37	1.0

Iron is a transition metal which can lose electrons from both 4s and 3d subshells. Calcium can only lose electrons from the 4s subshell.

Students needed to mention **both** iron and calcium to obtain both marks.

Although this question is often asked, many students struggled to put an explanation into words. One common incorrect answer was that the multiple oxidation states of iron were due to the similarity of the 4s and 3d energy levels causing electrons to oscillate between the two levels.

Question 7
7a.

Marks	0	1	Average
%	25	75	0.8

Students had to correctly label the positive electrode on the left as the anode and the negative electrode as the cathode.

7b.

Marks	0	1	2	Average
%	44	19	37	1.0

- positive electrode: $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$
- negative electrode: $Pb^{2+} + 2e^- \rightarrow Pb$ or
  $2H^+ + 2e^- \rightarrow H_2$

Because the acid concentration in the final solution was uncertain, either the Pb^{2+}or the H^+ depositions were accepted. It was not necessary to use 'states' in order to gain full marks.

7c.

Marks	0	1	Average
%	59	41	**0.4**

$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ or
$Pb^{2+} + 2e^- \rightarrow Pb$

The mark was not awarded for Pb^{2+}/Pb here if it was already given in part b.

7d.

Marks	0	1	Average
%	54	46	**0.5**

The reaction $Cu \rightarrow Cu^{2+} + 2e^-$ would have occurred (or copper would be oxidised/a stronger reductant).

Question 8
8a.

Marks	0	1	2	Average
%	59	9	31	**0.8**

$C_2H_5OH + H_2O \rightarrow CH_3COOH + 4H^+ + 4e^-$

Only one mark was given if the correct chemicals were used but the equation was unbalanced. Quite a few students gave the cathode reaction.

8b.

Marks	0	1	2	3	Average
%	43	10	16	31	**1.4**

$$\frac{3\times10^{-5}}{46} * = 6.52 \times 10^{-7} \text{ mol s}^{-1} \rightarrow 6.52 \times 10^{-7} \text{ mol s}^{-1} \times 4 \times 96\,500 \text{ C mol}^{-1} * = 0.25 \text{ C s}^{-1} = 0.25 \text{ A} *$$

Consequential mistakes that occurred due to an incorrect answer in part a. were given full marks if the working in part b. was correct.

8c.

Marks	0	1	2	Average
%	40	28	32	**1.0**

Any two of:

- carry current
- catalyse electrode reactions
- porous to oxygen/air
- unreactive.

Question 9
9a.

Marks	0	1	2	Average
%	23	23	54	**1.4**

$C_6H_{12}O_6(aq) + 6O_2(g \text{ or } aq) \rightarrow 6CO_2(g \text{ or } aq) + 6H_2O(l \text{ or } g)$

One mark was given for the correct equation and one for 'states'.

Quite a few students wrote the respiration equation (as requested) and labelled it 'animals' and then wrote the photosynthesis reactions (not requested) and labelled it 'plants' – perhaps thinking that plants do not respire. Students was not penalised for this.

9b.

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

$4\,^{1}_{1}H \rightarrow \,^{4}_{2}He + 2\,^{0}_{1}e$

9c.

Marks	0	1	Average
%	77	23	**0.3**

$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

Surprisingly, only about 20 per cent of students were able to write a chemical equation for the reaction of ammonia with sulphuric acid correctly.

9d.

Marks	0	1	2	Average
%	38	46	16	**0.8**

- $2NaOH + SO_2 \rightarrow Na_2SO_3 + H_2O$
- $2OH^- + SO_2 \rightarrow SO_3^{2-} + H_2O$
- $NaOH + SO_2 \rightarrow NaHSO_3$
- $OH^- + SO_2 \rightarrow HSO_3^-$
- $2NaOH + SO_3 \rightarrow Na_2SO_4 + H_2O$
- $2OH^- + SO_3 \rightarrow SO_4^{2-} + H_2O$
- $OH^- + SO_3 \rightarrow HSO_4^-$
- $NaOH + SO_3 \rightarrow NaHSO_4$

One mark was given the correct oxide sulphur, SO_2 or SO_3, and one mark for any one of the above fully correct reactions.

This question was very poorly done. Many students did not even get SO_2 or SO_3. Only 16 per cent of students gave both a correct oxide and a correct equation.