2026 VCE Chemistry (NHT) external assessment report

This report provides sample answers, or an indication of what answers may have included. Unless otherwise stated, these are not intended to be exemplary or complete responses.

Section A

Question	Correct answer	Comments
1	A	Cellular respiration and combustion of glucose are based on fundamentally the same equation. $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ In this equation, oxygen is reduced, as the oxidation number of oxygen changes from 0 to –2.
2	C	During photosynthesis, energy (sunlight) is converted into chemical energy, which is stored in the chemical bonds. Option D is incorrect as 4.1 g of glucose is formed from 6 g of carbon dioxide.
3	D	For each glycosidic link, one H_2O molecule is lost and hence joining 50 glucose units will mean 49 H_2O molecules are lost. Therefore, the chemical formula of the amylose section will be: 6 x 50 carbons = 300 carbons, 12 x 50 – 49 x 2 = 502 hydrogens and 6 x 50 – 49 = 251 oxygens
4	A	During fermentation, glucose is broken down via the following equation: $C_6H_{12}O_6 \rightarrow 2CH_3CH_2OH + 2CO_2$
5	C	The total energy released in Reaction 1 is 300 kJ, whereas in Reaction 2 it is only 200 kJ. While Reaction 2 will take place at a faster rate (under the same conditions), this is based on the lower activation energy, not the number of bonds that have to be broken.
6	C	To react all the hydrazine, 0.750 mol of mercury(II) is needed, which we don't have. Therefore, mercury(II) is the limiting reagent and hydrazine is in excess. On the basis of this, $n(N_2) = ½ \times n(Hg^{2+}) = 0.3125$ mol and $m(N_2) = 0.3125 \times 28 = 8.75$ g.
7	D	One serve is 50 g. Data supplied is for 100 g. Therefore: 16 x 58 ÷2 = 464 kJ of carbohydrate, 17 x 10 ÷2 = 85 kJ of protein and 37 x 14 ÷ 2 = 259 kJ of fat. Total energy = 464 + 85 + 259 = 808 = 8.1 x 10^2 kJ.
8	D	$\Delta T = q \div (mC) = 18{,}000 \div (100 \times 4.184) = 43$ °C Since the initial temperature was 25 °C, this means the final temperature will be 68 °C.

Question	Correct answer	Comments
9	A	Ions are always needed to balance the charges forming at the electrodes in any electrochemical cell. Primary cells cannot be recharged, electrodes can be made of materials other than metals and products do not always remain in contact with electrodes.
10	B	MnO_4^- is the most powerful oxidising agent. The voltage produced is not over 1.0 V, it is only 0.97 V under SLC conditions and galvanic cells do generate both electrical energy and thermal energy as they react.
11	C	At the cathode, reduction must be occurring, so option A and B are eliminated as possibilities. Under alkaline conditions, no H^+ ions are present. Therefore, only option C is a valid response.
12	A	The units for *K* dictate that the equilibrium expression must be given by $[SO_3]^2/([SO_2]^2[O_2])$. $Q = 1.00^2 / (1.00^2 \times 0.373) = 2.68\ M^{-1}$. This means the reaction needs to shift forward in order to achieve equilibrium. For every one molecule of SO_3 being produced, one molecule of SO_2 must be used up is a stoichiometrically correct statement. $[SO_2]$ will decrease at half the rate that $[O_2]$ decreases. $m(O_2)$ will decrease at a quarter of the rate that the $m(SO_2)$ decreases due to stoichiometry and molar mass differences. $m(SO_2)$ will not be 80% the $m(SO_3)$ at equilibrium. This value of 80% is only true when $[SO_2] = [SO_3]$ and this only occurs before the system reaches equilibrium. At equilibrium, the $m(SO_2)$ will be 65.5% the $m(SO_3)$.
13	B	$Q = It = 2.00 \times 1800 = 3600$ C. Therefore, $n(e) = Q \div F = 3600 \div 96{,}500 = 0.0373$ mol. $n(Cu) = ½ \times 0.0373 = 1.87 \times 10^{-2}$ mol.
14	B	During both discharge and recharge, the cations, Na^+, always move towards the cathode. During recharge, electron flow reverses and the left-hand side of the cell will contain the cathode. Therefore, the cations, Na^+, will move to the left.
15	Invalid	Without relevant ½ equations or an overall equation, it is not possible to ascertain exactly what happens to the concentration of the sodium ions in the electrolyte.
16	C	Given that all of the statements are true, the only reasons that would support the move to the sodium-based cell would be the stability of the sodium and the fact that the lithium cell is more likely to overheat. Statements I and IV would support the use of the lithium cell.

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Question	Correct answer	Comments
17	A	The NaCl solution will react with the following two ½ equations: Anode $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$ Cathode $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ The NaOH solution will react with the following two ½ equations: Anode $4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$ Cathode $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$
18	C	The longest carbon chain is 7, so the compound must be a heptane. Prefixes must be placed in alphabetical order when naming, so 'chloro' must be placed before 'methyl'.
19	C	Both hydroxy groups are secondary alcohols and so can potentially form ketones, not aldehydes. Numbering of the carbonyl must be kept as low as possible, so option C provides the best combination of numbers for the functional groups present when the compound is oxidised.
20	B	Alkanes only have dispersion forces existing between molecules. The larger the molecule, the greater the number of dispersion forces that can form and so the intermolecular forces will increase and result in a greater amount of energy needed to separate them.
21	D	$n(I_2) = 0.0100 \times 15.00 \div 1000 = 0.00015$ mol $n(\text{cysteine}) = 2 \times n(I_2) = 0.00030$ mol $[\text{cysteine}] = 0.00030 \div 0.02000 = 0.0150$ M
22	A	The stem of the question states that if oxygen is present it will react and therefore this unwanted reaction will result in the formation of a systematic error. Water in the flask does not affect the mol of either reactant added, so no error in results will occur. Non-concordant titre values are a random error.
23	B	Based on the flow chart given, Compound S is a secondary alcohol and Compound R is a primary alcohol. Secondary alcohols cannot pack together as well as primary alcohols, therefore form weaker intermolecular forces of attraction and will have lower melting points. Compound X will be an aldehyde and Compound T will be a ketone. These functional groups will have different intermolecular forces and so have different melting points. Step 1 is an addition reaction. Step 3 is an oxidation reaction.
24	B	Compound T is propanone, CH_3COCH_3.

Question	Correct answer	Comments
25	D	Compounds X and T have different functional groups and are classed as an aldehyde and ketone. Therefore, these are not part of the same homologous series (i.e. they do not have the same functional group and don't differ by a CH_2 unit). Based on the flow chart and considering the oxidation reactions happening within this flow chart, dichromate cannot further oxidise a ketone, Compound T.
26	B	The fact that the new solvent is less toxic and it breaks down safely when released into the environment means this is a clear example of designing safer chemicals.
27	C	An increase in energy requirements does not make a process more green. Observations are subjective and are not best practice when it comes to generating scientific evidence. Conducting experiments and gathering independent data is considered to be good practice when generating scientific evidence. A company's claim needs to be substantiated before it can be used as evidence.
28	Invalid	Bromine tests for the presence of double bonds and will decolourise in their presence. Therefore, both terpinen-4-ol and nerol will show decolourisation. Acidified permanganate tests for the presence of primary and secondary alcohols but also tests for the presence of double bonds. This will mean it changes to a pale pink in the presence of both of these functional groups. Therefore, none of the options indicates a correct choice for the identification of just the terpinen-4-ol.
29	A	Functional groups present in the R-groups are correctly named in these residues as 'amino' for a $–NH_2$, 'amide' for a $–CO-NH_2$ and 'hydroxyl' for an –OH.
30	D	The only response correctly linking rate and temperature is option D, which identifies that at a higher temperature, the reaction will reach completion in a shorter period of time.

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Section B

Question 1a.

Either of the following thermochemical equations were required:

- $C_{13}H_{26}(l) + {}^{39}/_{2}\ O_2(g) \rightarrow 13CO_2(g) + 13H_2O(l)$ $\Delta H = -8217$ kJ
- $2C_{13}H_{26}(l) + 39O_2(g) \rightarrow 26CO_2(g) + 26H_2O(l)$ $\Delta H = -16{,}434$ kJ

The first mark was awarded for the correct balanced chemical equation.

The second mark was awarded for the correct enthalpy value associated with the correct states in the equation.

Question 1b.

The first mark was awarded for determining the $n(CO_2)$ and $n(H_2O)$:

$n(CO_2) = 6.04 \times 13 = 78.52$ mol and $n(H_2O) = 6.04 \times 13 = 78.52$ mol

The second mark was awarded for determining the correct mass of both CO_2 and H_2O:

$m(CO_2) = 78.52 \times 44 = 3454.88$ g and $m(H_2O) = 78.52 \times 18 = 1413.36$ g

The third mark was awarded for determining the total mass:

mass of greenhouse gases produced = 3454.88 + 1413.36 = 4868.24 g = 4.87 kg

One of the most common errors occurred due to students not understanding that at 650 °C, the water would be in a gaseous state and hence is a greenhouse gas.

Question 1ci.

One or 1

Question 1cii.

The first mark was awarded for determining the $n(C_{13}H_{26})$:

$n(C_{13}H_{26}) = 1000 \div 182 = 5.495$ mol

The second mark was awarded for determining the $m(I_2)$ expressed as two significant figures.

From Question 1ci., $n(C_{13}H_{26}) = n(I_2)$ (one C=C present), therefore $n(I_2) = 5.495$ mol.

$m(I_2) = 5.495 \times 2 \times 126.9 = 1394.5$ g = 1.4 kg

The answer needed to be shown with two significant figures and in kg.

Question 1d.

The first mark was awarded for expressing why SAFs are deemed to be renewable.

The biomass being used in making SAFs is renewable because this material can be replenished in a short period of time / less than one year.

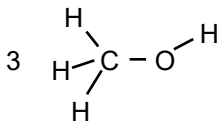
The second mark was awarded for expressing why traditional aviation fuel is deemed to be non-renewable.

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Traditional aviation fuel is derived from crude oil / fossil fuel and therefore cannot be replenished for millions of years.

Responses were required to provide some reference to time in order to be awarded marks.

Question 1ei.



A full structural formula with the coefficient of 3 was required for this mark.

The most common issues were the failure to show the stoichiometric coefficient and incorrectly drawn structures for methanol.

Question 1eii.

The first mark was awarded for the identification of glycerol, $C_3H_8O_3$, or a structure of this compound.

The second mark was awarded for the identification of the specific methyl ester being formed, methyl palmitate, $CH_3OO(CH_2)_{14}CH_3$, or a structure of this compound.

Marks were not awarded for the generic term ‘FAME’ or ‘fatty acid methyl ester’ for a product; a specific name or formula for the methyl ester was required.

Question 1eiii.

This response required the understanding that a transesterification reaction involves transforming an existing ester into a different ester.

In a transesterification reaction, both the reactant and product are esters.

This concept was not well understood.

Question 2a.

This response required the understanding that in a circular economy, waste can be recycled. The following is an example of what a correct response could have included:

The by-product from the desalination plant, sodium hydroxide, was reprocessed into pellets, which could then be sold to another industry rather than being released as waste into the ocean.

Question 2b.

The first mark was awarded for the correct calculation of the energy released:

$E = VIt = 6.0 \times 2.0 \times 3.0 \times 60 = 2160$ J

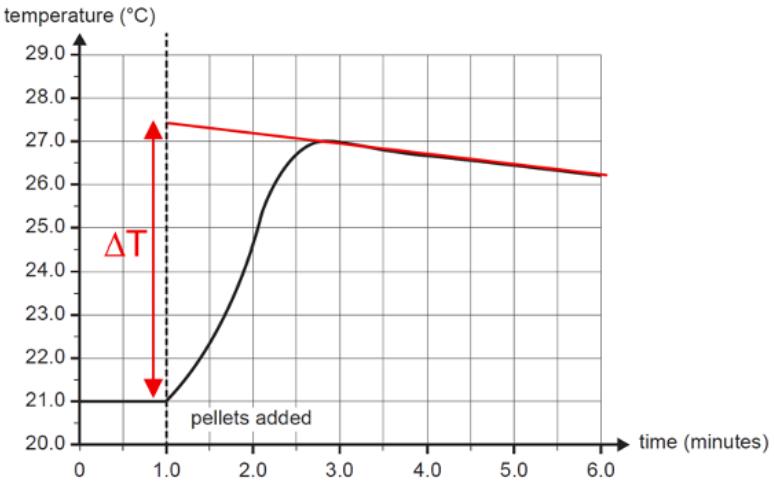
The second mark was awarded for the correct calculation of the calibration factor, with units:

$C.F. = E \div \Delta T = 2160 \div 5.7 = 378.9 = 380$ J °C^{-1} or 0.38 kJ °C^{-1}

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Question 2c.

The first mark was awarded for the correct determination of the temperature change:



$\Delta T = 27.5 - 21.0 = 6.5$ °C

The second mark was awarded for the correct calculation for the charge, q:

$q = CF \times \Delta T = 379 \times 6.5 = 2463.5$ J

The third mark was awarded for the correct calculation for the energy, E:

$E = q \div m = 2463.5 \div 2.4 = 1.026 = 1.0$ kJ g^{-1}

The most common error was caused by the incorrect determination of the temperature change as being just 6 °C.

Question 2di.

This response required the correct calculation associated with the unit change:

ΔH in kJ g^{-1} = 57.3 kJ mol^{-1} ÷ 40.0 g mol^{-1} = 1.432 = 1.4 kJ g^{-1}

The most common error occurred when the response given was –1.4 kJ g^{-1}. A negative energy cannot be accepted when the stem of the question asked for the energy released.

Question 2dii.

The first mark was awarded for the correct calculation for the % purity using the formula given:

% purity = (1.026 ÷ 1.432) x 100% = 71.6 = 72%

The second mark was awarded for a statement made relating to the claim that the pellets were 90% pure, such as ‘Claim not supported due to the calculated answer being less than 90%’.

The most common issue was that no comparative statement was made.

Question 2e.

Two valid reasons and their associated justifications were required.

One mark was awarded for each valid reason as to why the % purity was less than 90%.

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One mark was awarded for each valid justification of that reason.

The following is an example of what a correct response could have included:

Reason 1 Invalid calibration factor

Justification 1 A 100 mL calorimeter has a minimum C.F. of 420 J $°C^{-1}$. Therefore, using a C.F. that is lower (389 J $°C^{-1}$) will result in lower energy change being associated for a given temperature change, hence producing a purity of less than 90%.

Reason 2 Water will be absorbed by pellets. (Pellets are 'hygroscopic' or 'deliquescent'.)

Justification 2 Experimental mass includes both NaOH and water, so the ΔT being observed will only be due to the NaOH. Therefore, ΔH (exp) will be lower due to being divided by a larger/overestimated mass and hence a lower % purity will be calculated.

Another possible reason was that the 10% impurities present in the pellets may have reacted during the experiment via an endothermic process. The justification for this is that this endothermic reaction would have reduced the overall heat energy produced and thereby lowered the ΔH (exp) and the % purity calculation.

Reasons such as 'heat loss' could not be accepted because if this heat loss occurred during the calibration portion of the experiment, it would have meant a lower ΔT being produced and hence a higher C.F. being calculated. This higher C.F. would not have accounted for the lower % purity.

If the heat loss was claimed for during the second part of the experiment, this was already being accounted for in the processing of the data shown in the temperature versus time plot.

'Incomplete reactions' was also not accepted as a valid reason as the hydrochloric acid was in clear excess, 0.10 mol HCl and 0.06 mol of NaOH.

Question 3a.

The first mark was awarded for recognition of the nature of the conflict occurring with exothermic equilibrium reactions.

The conflict occurs as a result of this being an exothermic equilibrium process/reaction; therefore, if a high temperature is used, there is a good rate of reaction but a poor yield. If a low temperature is used, there will be a high yield but a low rate of reaction.

The second mark was awarded for recognition of the reasoning behind 450 °C being used.

450 °C is deemed to be sufficiently high to produce a good rate of reaction, but still low enough to enable a good yield.

The most common issue occurred when no attempt was made to justify why the temperature of 450 °C was being used.

Question 3b.

One mark was awarded for each correct identification:

- Rate of reaction: increase
- Yield of reaction: no change

Question 3c.

The two marks were awarded for recognition of how the lower temperature will produce an outcome that is desirable for the industry:

- Less energy will be required during the manufacture of ammonia.
- The lower temperature will result in an improved yield of ammonia.

Responses often did not link directly to a 'desirable' outcome for the industry and therefore could not be awarded full marks.

Question 4ai.

This response required the correct equilibrium expression to be shown:

$$K = \frac{[CO][H_2]^3}{[CH_4][H_2O]}$$

Question 4aii.

The first mark was awarded for correct conversion of the amounts into concentrations:

$[CH_4] = 0.15 \div 5 = 0.030$ M

$[H_2O] = 0.33 \div 5 = 0.066$ M

$[CO] = 0.30 \div 5 = 0.060$ M

$[H_2] = 0.10 \div 5 = 0.020$ M

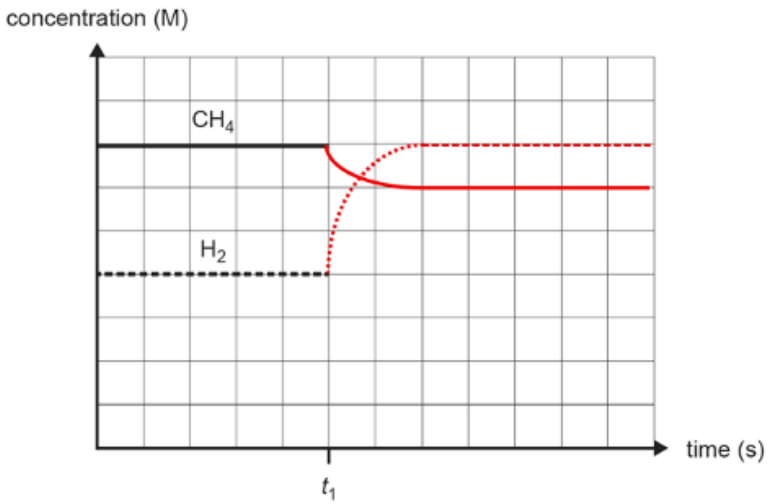
The second mark was awarded for correct calculation of the equilibrium constant with units:

$K = (0.060 \times 0.020^3) \div (0.030 \times 0.066) = 0.00024\ M^2 = 2.4 \times 10^{-3}\ M^2$

Question 4aiii.

The first mark was awarded for the correct shift being shown.

The second mark was awarded for the correct ratio and reaching equilibrium at the same time.



Question 4b.

The first mark was awarded for understanding of the change in the rate of reaction:

Increasing the pressure will increase the rate of reaction.

The second mark was awarded for the understanding of why the rate changed:

Increasing the pressure will increase the frequency of successful collisions.

Question 4ci.

The first mark was awarded for the understanding of how Le Chatelier's principle will respond to the addition of a reactant:

Le Chatelier's principle states that the system will attempt to oppose the addition of extra H_2O by shifting the position of the equilibrium in the forward direction, thereby partially decreasing the concentration of H_2O.

The second mark was awarded for the understanding of how this shift changes the yield of H_2:

With the forward shift in the position of the equilibrium, the concentration of products increases, thereby increasing the yield of H_2.

Issues arose when students did not refer directly to Le Chatelier's principle or failed to fully justify why the shift occurs.

Question 4cii.

The first mark was awarded for identifying any valid reason why the reaction might not be sustainable. Examples include:

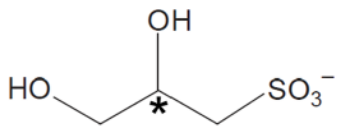
- the source of methane being a fossil fuel
- the energy used in step 2 or to produce steam being derived from a non-renewable source
- CO_2 being produced, therefore contributing to climate change issues
- the reaction having a low atom economy, therefore generating a lot of waste
- the source of water.

The second mark was awarded for identifying any valid way to improve sustainability. Examples include:

- capturing CO_2
- using renewable energy to supply energy needs
- using biomethane
- capturing energy from exothermic steps to reuse elsewhere
- using catalysts to lower energy needs
- recycling of unused reactants
- improving yield by shifting equilibrium to the right.

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Question 5a.



The asterisk needed to be located adjacent to the central carbon atom.

Question 5b.

Carbonyl or C=O

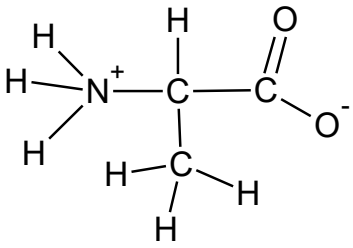
Question 5c.

The first mark was awarded for identifying that structures X and Z are optical isomers or enantiomers.

The second mark was awarded for the recognition that either:

- optical isomers have the same physical properties, therefore the melting points cannot be used to distinguish X from Z
- the compounds X and Z have the same structure and therefore the bonding between these molecules will be the same, hence the melting points cannot be used to distinguish X from Z.

Question 5di.



The positive charge must be shown adjacent to the nitrogen atom and the negative charge must be shown adjacent to the single bonded oxygen atom.

Question 5dii.

The first mark was awarded for identifying that the R-group on arginine has the potential to form hydrogen bonds (or ion-dipole or dipole-dipole interactions) with the DHPS molecule.

The second mark was awarded for identifying that the R-group on alanine can only form weak dispersion forces and therefore will have a much weaker interaction with the DHPS molecule.

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Question 5e.

Examples of correct responses included:

- using a chemical that inhibits the function of the enzyme by competitive inhibition (or non-competitive inhibition)
- adding salts/acid to change the binding of the functional groups
- pH
- heat.

Question 6a.

Acceptable techniques are either solvent extraction or steam distillation.

Issues arose when students provided too brief a response. For example, ‘extraction’ or ‘distillation’ by themselves were not awarded the mark.

Question 6b.

The first mark was awarded for identifying that Sample V has more coumarin than Sample W.

The second mark was awarded for a justification based on peak area. Either of the following responses were accepted:

- The Q peak is the same in both samples, therefore the peak area for coumarin in Sample V indicates a higher relative amount of coumarin compared to the reference concentration of Q.
- The peak area in Sample V is larger than in Sample W, and because peak area is directly related to amount, this indicates a higher relative amount of coumarin.

Question 6c.

The first mark was awarded for identifying that structures 1 and 6 can be eliminated.

The second mark was awarded for a justification of this choice. Either of the following responses were accepted:

- In the spectrum, no broad O–H bond (alcohol) was seen in the region of 3200–3600 cm^{-1}.
- In the spectrum, a peak in the region 1600–1800 cm^{-1} is seen, which indicates that a carbonyl group is present. Structures 1 and 6 don’t show this functional group in their structures.

A common issue arose when students quoted a range of 2500–3500 cm^{-1} for the –O–H group, which could not be accepted as it refers to the –O–H of an acid, which is not present on any structure.

Question 6di.

m/z = 132

Question 6dii.

Any plausible structure with a molar mass of 55 g mol^{-1} with or without the free radical representation was accepted.

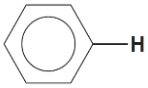
$[C_3H_3O]$•, CHCHCHO• or $[C_4H_7]$•

If students represented their fragment with a positive charge, this could not be accepted.

Question 6ei.

The mark was awarded for showing an understanding that the integration curve values of 1, 5, 1, 1 represent the ratio of hydrogens present in each environment and, in this case, the actual number of hydrogens present in each environment, because there are a total of 8 hydrogens in the chemical formula.

Question 6eii.

Benzene Hs, aromatic Hs or 

Question 6eiii.

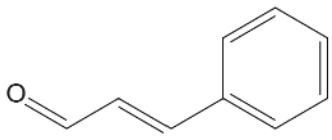
The mark was awarded for understanding that a doublet at 9.7 ppm must be due to the hydrogen in this environment being situated adjacent to a single H in another environment (non-equivalent).

Question 6f.

Aldehyde

Structures representing an aldehyde were not accepted, as a 'name' was specifically asked for in the stem of the question.

Question 6g.



structure 5

Either name or structure was accepted.

Question 7a.

The mark was awarded for the correct calculation for the mol of H_2:

- $n(MgH_2) = 0.150 / 26.3 = 0.005703$ mol
- $n(H_2) = 2 \times n(MgH_2) = 0.0114$ mol

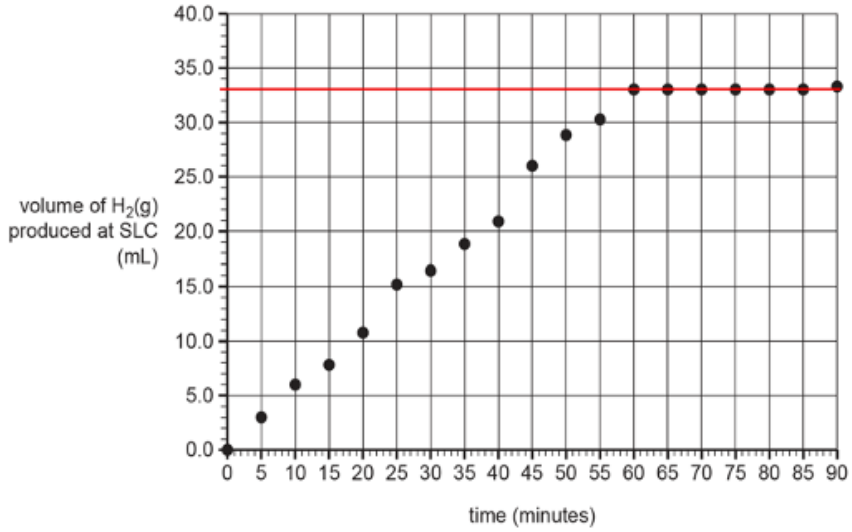
Question 7b.

Examples of correct responses included the following:

- Minimise the production rate of H_2 gas to low levels for safety / so it doesn't over pressurise the flask and/or become an explosion hazard.
- The reaction is exothermic and dangerous, so minimise the heat generated.
- H_2 is flammable.

Question 7c.

The first mark was awarded for correctly determining the volume of H_2 produced from the graph provided.



Vol(H_2) = 33 mL (or 33.5 mL)

The second mark was awarded for correctly determining the total n(H_2) produced.

n(H_2) = 0.033 ÷ 24.8 = 0.00133 mol

Values within a range of 1.33 x 10^{-3} to 1.35 x 10^{-3} mol were accepted.

Question 7d.

The mark was awarded for correctly determining the % yield:

% yield = 100 x 0.00135 ÷ 0.0114 = 11.8%

Values within a range of 11.7% to 11.8% were accepted.

Question 7ei.

The first two marks were awarded for identifying any two of the following factors:

- the surface area of the electrodes
- the material of the electrode
- the rate of the reactions at the electrodes electron transfer

- the flow rate of gases
- the temperature of the reaction
- any other factor that related specifically to the number of electrons being generated per unit time

The third mark was awarded for identifying how one of the two factors could be successfully controlled.

Question 7eii.

The first mark was awarded for correctly identifying that changing the electrolyte concentration had no impact on the current being generated.

The second mark was awarded for correctly identifying any one of the following:

- cheaper to use a less concentrated solution
- using a lower concentration NaOH means less risk of injury (i.e. less hazardous)
- less waste produced or fewer materials needed
- any other valid reason

Question 7f.

The first mark was awarded for correctly determining the total charge generated:

$Q = It = 0.014 \times 90 \times 60 = 75.6$ C

The second mark was awarded for correctly determining the mol of electrons:

$n(e) = Q \div F = 75.6 \div 96500 = 7.834 \times 10^{-4}$ mol

The third mark was awarded for correctly determining the $n(H_2)$ reacted:

$n(H_2) = ½ \times 7.834 \times 10^{-4} = 3.9 \times 10^{-4}$ mol

Question 7gi.

The mark was awarded for any of the following:

- It is assumed that the quantity of H_2 reacted at the fuel cell equals the quantity of H_2 produced in the reaction.
- The only gas produced (in the gas syringe) is H_2.
- It is assumed that in both methods, the reactions occurred under the same conditions.
- It is assumed that the properties of all reactants involved are consistent.
- It is assumed that all measuring equipment are reliable and accurate.
- The source of metal hydride is the same.
- The temperature is kept constant.

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Question 7gii.

The first mark was awarded for stating that Method A was more accurate than Method B.

The second mark was awarded for providing a justification based on the methodology of the two experiments. An example of a correct response could be:

In Method B, at t = 90 mins, there was no sign that the reaction had gone to completion. The voltage and current were still constant. On this basis, the experimental data was incomplete and n(H_2) found in 7f would be lower than it should have been and hence was further away from the true value.

Other responses could also have been accepted if a valid justification of a fault in the methodology was shown.

Question 8a.

The first three marks were awarded for each of the following points:

- Energy input (sunlight) is required.
- Cathode reaction $2H^+(aq) + 2e^- \rightarrow H_2(g)$
- Anode reaction $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

The fourth mark was awarded for any of the following operating principles of this cell:

- Internal circuit requires the movement of ions.
- Membrane allows selective movement of ions.
- Membrane keeps the products separated so they don’t spontaneously react.

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Question 8b.

The first two marks were awarded for details about the feedstocks:

- PEM requires high purity water, which is a scare resource, and purifying it is an issue due to cost, energy and drought.
- MEC uses waste biomass / biomass. This is renewable and sustainable.

The next two marks were awarded for listing an advantage of each system:

- PEM – any one of:
  - higher purity product
  - established technology
  - less biohazardous raw material
  - any other suitable answer
- MEC – any one of:
  - requires less energy input than PEM
  - feedstock easier to source / readily available
  - waste water treated at the same time as producing H_2
  - anode material easier to source and cheaper

The final mark was awarded for a recommendation for the feedstocks and one of the advantages listed, based on the information given. An example of a correct response is as follows:

- With a sustainable feedstock and lower energy consumption or cheaper electrode, MEC is the recommended process for obtaining H_2.
- With just water as a feedstock and no carbon-based waste products, PEM is the recommended process for obtaining H_2.

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