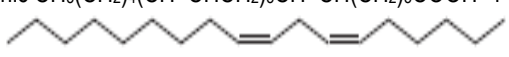


# 2023 VCE Chemistry (NHT) external assessment report

## Specific information

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.

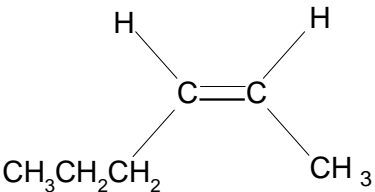
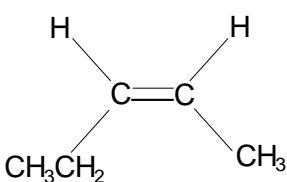
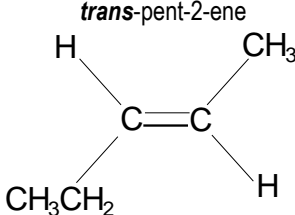
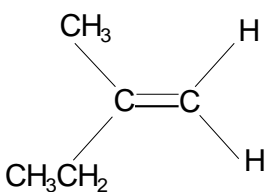
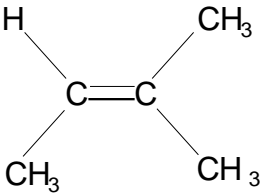
### Section A

Question	Correct answer	Comments
1	B	Combustion of a fuel involves reaction with O <sub>2</sub> to produce energy. N <sub>2</sub> is not a fuel as its reaction with oxygen does not release energy.
2	D	In a secondary cell, chemical energy is transformed into electrical energy during discharge and <b>electrical energy is transformed into chemical energy during recharging.</b>
3	B	According to the concentration–time graphs both reactant concentrations decrease by the same amount and so must react in the same mole ratio. The product concentration increases twice as much as each of the reactant concentrations decreases. H <sub>2</sub> (g) + I <sub>2</sub> (g) ⇌ 2HI(g) is consistent with the graphs.
4	A	Bioethanol production C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> (aq) → 2CH <sub>3</sub> CH <sub>2</sub> OH + 2CO <sub>2</sub> (g). Fermentation.
5	D	CH <sub>3</sub> CH=CH <sub>2</sub> (g) + H <sub>2</sub> (g) → CH <sub>3</sub> CH <sub>2</sub> CH <sub>3</sub> . Single product, therefore 100% atom economy.
6	B	During reaction the reading on the balance decreases due to the release of HCl(g). Since the reading stops changing by 10 seconds it is reasonable to deduce that the reaction has a <b>fast reaction rate.</b> With respect to extent of reaction, the fact the level of liquid in the beaker – due to the reactant H <sub>2</sub> SO <sub>4</sub> (l) – does not decrease during the reaction means it is reasonable to deduce that there was a <b>low extent of reaction.</b>
7	C	The fatty acids that are part of the triglyceride are: HOOC(CH <sub>2</sub> ) <sub>7</sub> CH=CH(CH <sub>2</sub> ) <sub>5</sub> CH <sub>3</sub> Palmitoleic CH <sub>3</sub> (CH <sub>2</sub> ) <sub>4</sub> CH <sub>2</sub> CH=CHCH <sub>2</sub> (CH <sub>2</sub> ) <sub>5</sub> CH <sub>2</sub> COOH 1 C=C HOOC C <sub>19</sub> H <sub>31</sub> Arachidonic CH <sub>3</sub> (CH <sub>2</sub> ) <sub>4</sub> (CH=CHCH <sub>2</sub> ) <sub>3</sub> CH=CH(CH <sub>2</sub> ) <sub>3</sub> COOH 4 C=C  HOOClinoleic CH <sub>3</sub> (CH <sub>2</sub> ) <sub>4</sub> (CH=CHCH <sub>2</sub> ) <sub>2</sub> (CH <sub>2</sub> ) <sub>6</sub> COOH 2 C=C

Question	Correct answer	Comments
8	D	To generate 1.5 V [1.36 – (–0.42)] the half equations must be: $\text{Sn(s)} \rightarrow \text{Sn}^{2+}(\text{aq}) + 2\text{e}^-$ at the Sn anode $\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^+(\text{aq}) + 6\text{e}^- \rightarrow 2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O(l)}$ at the Pt cathode
9	D	In the cell, the strongest oxidising agent – $\text{H}_2\text{O}_2(\text{aq})$ – reacts with the strongest reducing agent – Ni(s)
10	A	Antioxidants, which are reducing agents, are added to substances containing C=C double bonds to prevent oxidative rancidity.
11	A	Both secondary cells and fuel cells require reactants (half-cells) to be separated and connected via an external circuit. Both also require reactants. However, the anode in a secondary cell is negative during discharge but positive during recharge.
12	D	The relevant half-equations in the electrochemical series are: $\text{Cl}_2(\text{aq}) + 2\text{e}^- \rightleftharpoons 2\text{Cl}^-(\text{aq})$ 1.36 V $\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 2\text{e}^- \rightleftharpoons 2\text{H}_2\text{O(l)}$ 1.23 V $\text{Br}_2(\text{l}) + 2\text{e}^- \rightleftharpoons 2\text{Br}^-(\text{aq})$ 1.09 V $2\text{H}_2\text{O(l)} + 2\text{e}^- \rightleftharpoons \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$ –0.82 V $\text{K}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{K(s)}$ –2.93 V Initial reaction is between the strongest oxidising agent present – $\text{H}_2\text{O(l)}$ – and the strongest reducing agent present – $\text{Br}^-(\text{aq})$ . Half-equations: Anode: $2\text{Br}^-(\text{aq}) \rightarrow \text{Br}_2(\text{l}) + 2\text{e}^-$ ... coloured (brown) liquid Cathode: $2\text{H}_2\text{O(l)} + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$ ... colourless bubbles
13	C	In the presence of the catalyst: Activation energy, the difference between the maximum potential energy and the potential energy of the reactants, is lowered to less than $50 \text{ kJ mol}^{-1}$ The enthalpy change, the difference between the potential energy of the products and the potential energy of the reactants, remains the same at $+10 \text{ kJ mol}^{-1}$ .
14	A	A Maxwell-Boltzmann distribution curve shows the number of particles – vertical axis, with different energies – horizontal axis, at a specified <b>constant temperature</b> . The area under the curve represents the total number of particles in the gas mixture.
15	D	Maltose is a disaccharide formed from the single monosaccharide glucose.
16	C	The structure of aspartame molecules is part of Table 10 in the Data Book. The structure shows the capacity for intermolecular hydrogen bonding, but it does not contain a glycosidic link. As a substitute for glucose, a much smaller amount of aspartame is required to provide the same sweetness. However, the energy contents per gram of aspartame and glucose are very similar.
17	B	The half-equations occurring during electrolysis of concentrated $\text{NaCl(aq)}$ are: Anode (+): $2\text{Cl}^-(\text{aq}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$ Cathode (–): $2\text{H}_2\text{O(l)} + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$ $n(\text{e}^-) = n(\text{NaOH}) = 1 \text{ mol}$

Question	Correct answer	Comments
		Charge on 1 mol $e^- = F = 96500 \text{ C} = 9.7 \times 10^4 \text{ C}$
18	C	Semi-structural formula $(\text{CH}_3)_2\text{CHOHCH}_2\text{NH}_2$ 3 C in chain $\rightarrow$ propane derivative -OH on C2 propan-2-ol -NH <sub>2</sub> on C1 1-amino -CH <sub>3</sub> on C2 2-methyl Hence, 1-amino-2-methylpropan-2-ol
19	B	J has the higher boiling point. J has a higher molecular mass than L and so has stronger dispersion forces. J has more sites for intermolecular hydrogen bonding including O on C=O, and N and the H atoms on NH <sub>2</sub> .
20	D	The products of hydrolysis are: CH <sub>2</sub> OHCHOHCH <sub>2</sub> OH glycerol C <sub>3</sub> H <sub>8</sub> O CH <sub>3</sub> (CH <sub>2</sub> ) <sub>7</sub> CH=CH(CH <sub>2</sub> ) <sub>7</sub> COOH oleic acid; omega 9, C <sub>18</sub> H <sub>34</sub> O <sub>2</sub> CH <sub>3</sub> (CH <sub>2</sub> ) <sub>17</sub> CH <sub>2</sub> COOH arachidic acid C <sub>20</sub> H <sub>40</sub> O <sub>2</sub> CH <sub>3</sub> (CH <sub>2</sub> ) <sub>4</sub> CH <sub>2</sub> CH=CHCH <sub>2</sub> (CH <sub>2</sub> ) <sub>5</sub> COOH palmitoleic acid omega 9; C <sub>16</sub> H <sub>30</sub> O <sub>2</sub>
21	C	$\text{CO}(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons \text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) K_1 = 3.90 \text{ M}^{-3}$ $\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + 3\text{H}_2(\text{g}) K = 1 / K_1$ $3\text{CH}_4(\text{g}) + 3\text{H}_2\text{O}(\text{g}) \rightleftharpoons 3\text{CO}(\text{g}) + 9\text{H}_2(\text{g}) K_2 = K^3 = (1 / K_1)^3 = 1 / (K_1)^3$
22	D	$n(\text{CH}_3\text{COOH})$ available to react = $3.00 / 60.0 = 0.050 \text{ mol}$ $n(\text{CH}_3\text{CONH}_2)$ produced = $n(\text{CH}_3\text{COOH})$ reacting Theoretical $m(\text{CH}_3\text{CONH}_2) = 0.050 \times 59 = 2.95 \text{ g}$ % yield = $(\text{actual mass} / \text{theoretical mass}) \times 100$ = $(2.40 / 2.95) \times 100$ = 81.4 %
23	C	$\text{CH}_3\text{COOH}(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{CH}_3\text{COONa}(\text{aq}) + \text{H}_2\text{O}(\text{l})$ $n(\text{CH}_3\text{COOH})$ reacting = $0.103 \times 25.00 \times 10^{-3} = 2.58 \times 10^{-3} \text{ mol}$ $n(\text{NaOH})$ required = $2.58 \times 10^{-3} \text{ mol}$ $V(\text{NaOH})$ required = $n(\text{NaOH}) / c(\text{NaOH}) = 2.58 \times 10^{-3} / 0.236$ = 0.0109 L = 10.9 mL The actual titre was 11.60 mL If the burette had been rinsed with NaOH, the actual titre would be lower. Phenolphthalein indicator is commonly used for titration of a weak acid with a strong base. Other indicators (from Table 7 Data Book) would change colour at a lower pH, hence using less titre. Air bubbles in the burette would cause the volume of titre to be higher.

Question	Correct answer	Comments
		If the pipette was rinsed with water, the amount of CH <sub>3</sub> COOH in the aliquot would be lower and a smaller titre would be used.
24	C	$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}); \Delta H = -197 \text{ kJ mol}^{-1}$ I Increasing the temperature will increase reaction rate but <b>lower the yield</b> since the forward reaction is exothermic. II Increasing the volume will reduce concentrations and decrease the reaction rate. The system will respond to counteract the concentration/pressure decrease by favouring the side with more particles, and so reduce yield. III Since N <sub>2</sub> is not part of, and does not react with any species in, the equilibrium system, its <b>addition does not affect the equilibrium yield</b> . IV Catalysts speed up the reaction but do not affect the equilibrium yield or the equilibrium constant.
25	D	Energy released by ethanol = $1.3 \text{ g} \times 29.6 \text{ kJ g}^{-1} = 38.5 \text{ kJ}$ Energy absorbed by water = $4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ $= 4.18 \times 0.500 \times 20.3$ $= 42.4 \text{ kJ}$ Since heat would be lost in the set-up, the fact that more energy was absorbed by the water than ethanol could release indicates that a more energy-dense fuel was mistakenly used. Octane, energy density $47.9 \text{ kJ g}^{-1}$ , would release $1.3 \times 47.9 = 62.3 \text{ kJ}$ , of which $42.4 \text{ kJ}$ was absorbed by water and the rest by the beaker and lost to heat or the environment.
26	A	The IR spectrum shows peaks consistent with CH <sub>2</sub> =CHCH <sub>2</sub> COOH C=C ( $1620\text{-}1680 \text{ cm}^{-1}$ ) C=O(acids) ( $1680\text{-}1740 \text{ cm}^{-1}$ ) C-H ( $2850\text{-}3090 \text{ cm}^{-1}$ ) and O-H acids ( $2500\text{-}3500 \text{ cm}^{-1}$ ). Spectrum does not show a peak consistent with N-H ( $3300\text{-}3500 \text{ cm}^{-1}$ )
27	A	Column length affects the retention time and peak separation. A longer column means more interaction between the components of the mixture and the stationary phase resulting in higher retention times and greater separation of peaks. A shorter column means less interaction between the components of the mixture and the stationary phase leading to lower retention times and smaller separation of peaks.
28	D	The cow's milk must be diluted to reduce the concentration of Q so that it fits within the calibration curve, i.e. to less than $50 \text{ mg L}^{-1}$ $Q \text{ } 2.60 \text{ g in } 240 \text{ mL} \rightarrow (2600 / 240 \times 1000) = 10800 \text{ mg L}^{-1}$ 1 mL of Q needs to be diluted by a factor $> 10800 / 50$ i.e. $> 216$ . Use a 500 mL volumetric flask Dilution to 500 mL $\rightarrow$ concentration of Q = $10800 / 500 = 21.6 \text{ mg L}^{-1}$
29	B	$\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + 3\text{H}_2(\text{g})$ Initially [CH <sub>4</sub> ] system X = 2 M; system Y = 1 M [H <sub>2</sub> O] system X = 1 M; system Y = 1 M

Question	Correct answer	Comments
		<p>The rate of initial reaction is higher in system X.</p> <p>Because of the higher initial <math>[CH_4]</math>, more <math>H_2O</math> will react in getting to equilibrium in system X, so the <math>[H_2O]</math> at equilibrium is lower.</p> <p>While the rates of forward and reverse reactions would be same in each system at equilibrium, the rates in system X and system Y are not the same.</p> <p>The mole ratio in the equilibrium does not indicate the relative concentrations at equilibrium.</p>
30	B	<p>Pent-1-ene</p>  <p><i>cis</i>-pent-2-ene</p>  <p><i>trans</i>-pent-2-ene</p>  <p>2-methyl-but-1-ene</p>  <p>2-methyl-but-2-ene</p> 

## Section B

### Question 1a.

Hydrolysis

### Question 1b.

Cellulose cannot release energy since it cannot be digested. This is because the enzyme required for its hydrolysis (cellulase) is not present in the body.

### Question 1c.

Vitamin C is water soluble, but Vitamin D is not soluble in water.

Vitamin C is essential and must be part of the diet. Vitamin D is non-essential since it can be produced by the body.

Alternatively: Vitamin D is insoluble because its molecules are largely non-polar, but Vitamin C has many polar groups in its molecules and is soluble in water.

### Question 1d.

Marks were awarded for two of three possible points:

- Coenzymes are organic molecules that bind to enzymes and change the shape / binding properties of the active site to accept the substrate / activate catalytic activity for the enzyme.
- The catalysed reaction will not proceed in the absence of the coenzymes.
- Coenzymes can act as carriers for electrons / functional groups.

### Question 2a.

Propyl ethanoate

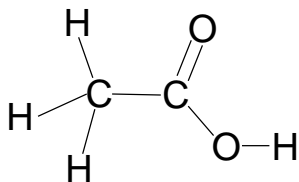
### Question 2b.

Aldehyde/carbonyl

### Question 2c.

$\text{MnO}_4^- / \text{H}^+$  or  $\text{Cr}_2\text{O}_7^{2-} / \text{H}^+$

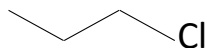
### Question 2d.



### Question 2e.

Substitution

### Question 2fi.



### Question 2fi.

No.

Molecules of Q ( $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$ ) are **not** chiral because **none of the carbon atoms is attached to four different atoms/groups.**

### Question 3ai.

**1.05 V** [ $0.80 - (-0.25)$ ]

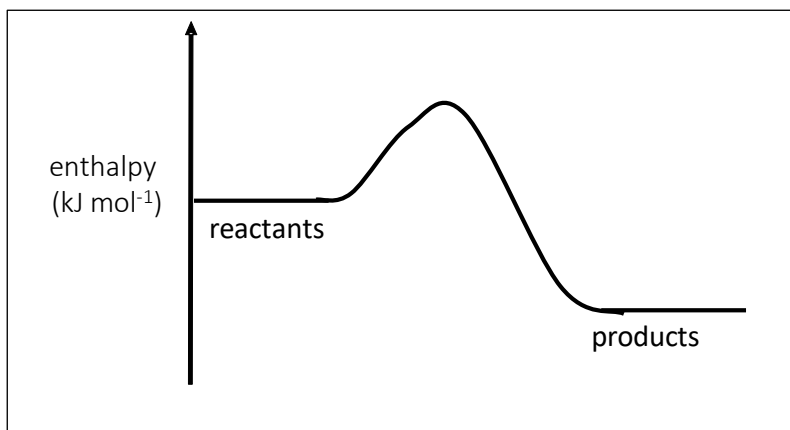
### Question 3b.

$2\text{Ag}^+(\text{aq}) + \text{Ni}(\text{s}) \rightarrow 2\text{Ag}(\text{s}) + \text{Ni}^{2+}(\text{aq})$

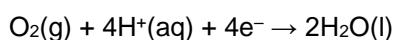
### Question 3ci.

$\text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6\text{O}_2(\text{g}) \rightarrow 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l})$

### Question 3cii.



### Question 3d.



### Question 3e.

One mark was awarded for indication of the need to produce/harness electrical energy.

One mark was awarded for explanation of how the electrical energy is harnessed *or* the need to keep  $\text{O}_2$  away from the oxidation half-cell / anaerobic bacteria.

Acceptable responses included the following:

- The half-cells need to be separated so that electrons can travel between the two half-cells in connecting wires (through the load) and the electrical energy harnessed.
- The bacteria are anaerobic, and the oxygen needs to be excluded from the oxidation half-cell; if the half-cells are not separated, electricity will not be produced.
- If there was no separation of the two half-cells, oxidation and reduction would occur together and electrons would not move through the external circuit.

### Question 3f.

One mark was awarded for indicating the feature as an 'electrode – anode / cathode, or electrodes'.

One mark was awarded for linking the feature to movement of  $\text{H}^+$  ions.

For example:

- As the electrons enter the cathode, the  $\text{O}_2$  half-cell becomes negatively charged. The mobile  $\text{H}^+$  ions are attracted to the cathode from the biomass half-cell and pass through the membrane.
- As electrons leave the anode, the biomass half-cell becomes positively charged. The mobile  $\text{H}^+$  ions are repelled from the anode and biomass half-cell and pass through the membrane.
- At the cathode the  $[\text{H}^+]$  decreases and at the anode the  $[\text{H}^+]$  increases. The  $\text{H}^+$  ions move from the higher concentration through the membrane to the lower concentration.



### Question 3g.

Possible responses included the following:

- As long as oxygen and biomass are supplied, the MFC will keep working, whereas the galvanic cell will run out of reactants.
- The MFC produces energy from a renewable resource, whereas the galvanic cell does not.
- The reagents (biomass, oxygen) for a MFC are cheaper and more sustainable than the reagents (silver in the form of  $\text{Ag}^+$ , nickel) for an  $\text{Ag}^+(\text{aq})/\text{Ag}(\text{s})/\text{Ni}^{2+}(\text{aq})/\text{Ni}(\text{s})$  galvanic cell.
- The operation of a MFC decomposes organic matter, which is a way of processing/recycling waste, and is more sustainable than the operation of an  $\text{Ag}^+(\text{aq})/\text{Ag}(\text{s})/\text{Ni}^{2+}(\text{aq})/\text{Ni}(\text{s})$  galvanic cell.

### Question 4a.

$$E = CF \times \Delta T = 3540 \times 1.77$$

$$= 6.27 \times 10^3 \text{ J}$$

$$E = VIt$$

$$I = E / Vt$$

$$= 6.27 \times 10^3 / (6.50 \times 240)$$

$$= \mathbf{4.02 \text{ A}}$$

### Question 4bi.

$$\text{Energy in 2.50 g sample} = CF \times \Delta T$$

$$= 3540 \times 5.00$$

$$= 17700 \text{ J}$$

$$\text{Energy in 100.0 g} = 17700 \times (100 / 2.50)$$

$$= 7.08 \times 10^5 \text{ J}$$

$$= \mathbf{708 \text{ kJ}}$$

### Question 4bii.

$$\text{Energy due to protein} = 20 \% \text{ of } 708 \text{ kJ}$$

$$= 0.2 \times 708$$

$$= 141.6 \text{ kJ}$$

$$\text{Mass of protein} = 141.6 \text{ kJ} / 17 \text{ kJ g}^{-1}$$

$$= \mathbf{8.3 \text{ g}}$$

### Question 4ci.

The chemical products of metabolism are monomers (amino acids, glucose, etc.) that can then be used by the body to produce large biomolecules (such as protein and glycogen) in a **condensation reaction**.

### Question 4cii.

Energy

## Question 5a.

Marks were awarded for linking relative reaction rates to peak heights and time taken for the intensity to reach zero.

Compare the peaks of the curve – highest reaction rate corresponds to highest peak / light intensity.

Compare time taken for curve to reach zero, which is a measure of the time taken for the completion of the reaction – longer the time, the lower the reaction rate.

## Question 5b.

Marks were awarded for accurate explanation of the reaction rate trend at 30 °C.

Reaction rate increases from zero to a peak at about three seconds.

Linking reaction rate increase to reactants mixing, for example, rate increased as reactants were mixed together **or** it takes approximately three seconds for all the NaOCl to be added **or** it takes three seconds for reactants to be fully mixed.

At three seconds the rate of reaction began to decrease.

Linking reaction rate decrease to decreasing reactant concentrations.

## Question 5c.

The higher the temperature, the higher the reaction rate.

## Question 5d.

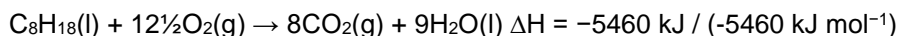
One mark was awarded for each of two appropriate sources of error.

Possible responses included the following:

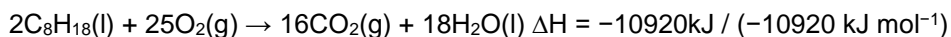
- The reactants were not mixed properly.
- It may have taken different amounts of time to add the sodium hypochlorite to the reaction vessel from the pipette.
- The temperature of the sodium hypochlorite may have changed between the time it was taken from the water bath and added to the reaction vessel / heat loss.
- The light intensity sensor only measures some of the total light intensity emitted by the reaction. It is presumed that the fraction of light measured in all three runs is essentially the same. However, opening and cleaning/rinsing the reaction vessel between each run could result in the light intensity sensor being in a slightly different location for each run, and could result in a different fraction of light being measured for different runs. This error can be avoided by placing the light intensity sensor to the same location for each run.

### Question 6a.

One mark was awarded for correct balanced equation. One mark was awarded for correct  $\Delta H$ .



or



### Question 6b.

$$n(\text{CO}_2) = 8 \times n(\text{C}_8\text{H}_{18}) = 8 \text{ mol}$$

$$P = 255 \text{ kPa}, V = 100 \text{ L}$$

$$T = PV/nR = 255 \times 100 / (8 \times 8.31)$$

$$= 384 \text{ K or } 111 \text{ }^\circ\text{C}$$

### Question 6c.

$$\text{Mass of water} = 11750 \text{ mL} \times 0.997 \text{ g mL}^{-1}$$

$$= 1.1714 \times 10^4 \text{ g}$$

$$= 11.714 \text{ kg}$$

$$\Delta T = 57.2 - 25$$

$$= 32.2 \text{ K (}^\circ\text{C)}$$

$$\text{Energy} = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1} \times 11.714 \text{ kg} \times 32.2 \text{ K}$$

$$= 1.577 \times 10^3 \text{ kJ}$$

$$\text{Heat of combustion} = \text{energy} / m(\text{C}_{12}\text{H}_{26})$$

$$= 1.577 \times 10^3 \text{ kJ} / 34.0 \text{ g}$$

$$= 46.4 \text{ kJ g}^{-1}$$

### Question 6d.

One mark was awarded for correct renewability comparison:

- Biodiesel is renewable; petrodiesel is not renewable.

One mark was awarded for correct sourcing comparison:

- Petrodiesel is sourced from crude oil / fossil fuels, which are extracted from the ground.
- Biodiesel is manufactured from renewable / recently living materials by transesterification.

### Question 6ei.

The ability to absorb water (moisture) from the air.

## Question 6eii.

One mark was awarded for accurate hygroscopic comparison:

- Biodiesel is more hygroscopic than petrodiesel.

One mark was awarded for correctly explaining the difference in hygroscopic properties:

- Biodiesel molecules have polar ester groups, which allow for stronger intermolecular forces with the polar water molecules.
- Petrodiesel is predominately non-polar; it has a weaker intermolecular attraction to the polar water molecules than biodiesel.

## Question 7a.

Power supply / battery

## Question 7b.

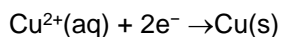
Provides a source of  $\text{Cu}^{2+}$  to the solution/electrolyte, which allows the cell to operate longer.

An alternative response: allows the  $c(\text{Cu}^{2+})$  in the electrolyte to remain constant.

## Question 7c.

$$n(\text{Cu}) = 5.08 \text{ g} / 63.5 \text{ g mol}^{-1}$$

$$= 0.0800 \text{ mol}$$



$$n(\text{e}^{-}) = 0.0800 \times 2$$

$$= 0.160 \text{ mol}$$

$$Q = n(\text{e}^{-}) \times F = 0.160 \times 96500$$

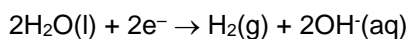
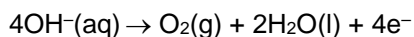
$$= 15440 \text{ C}$$

$$t = Q / I = 15440 / 4.0$$

$$= 3.9 \times 10^3 \text{ sec}$$

## Question 7d.

One mark was awarded for each fully correct half-equation.



## Question 8a.

O-H (alcohol) bond **or** hydroxyl / alcohol functional group

## Question 8bi.



## Question 8bii.

$m/z = 57$

## Question 8biii.

One mark was awarded for correct atoms and atom ratio.

One mark was awarded for indicating it is a radical by including the dot symbol.

●CH<sub>2</sub>OH / ●CH<sub>3</sub>O

## Question 8c.

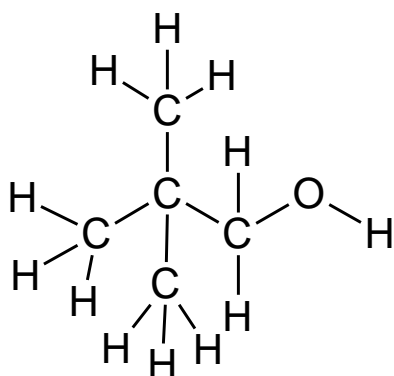
Acceptable responses included:

- odd number of nucleons (odd mass number)
- they spin in a magnetic field
- they have two different nuclear spin energy levels
- peaks are the result of the transition between energy levels in a magnetic field.

## Question 8di.

One mark was awarded for structure consistent with molecular formula and three carbon environments.

One mark was awarded for correct structure.



## Question 8dii.

One mark was awarded for identifying the group of atoms associated with the signal on the spectrum:

- The peak at approximately 0.9 ppm is due to methyl groups, or CH<sub>3</sub>, CH<sub>3</sub>-C-CH<sub>2</sub>

One mark was awarded for explaining why a singlet is produced:

- A single peak because there are no H atoms on the adjacent C atom / no neighbouring H atoms / according to the n+1 rule,  $n = 0 + 1 = 1$

## Question 9a.

The teacher must follow the recommended protocols for handling cobalt(II) chloride as specified on the Safety Data Sheet / MSDS sheet / Product Safety Data Sheet.

## Question 9b.

Acceptable responses included:

- the position of equilibrium
- the colour of the solution
- $[\text{Co}(\text{H}_2\text{O})_6^{2+}(\text{aq})] / [\text{CoCl}_4^{2-}(\text{aq})]$  at equilibrium
- colour change.

## Question 9c.

Concentration of chloride ions /  $c(\text{Cl}^-)$  /  $V(\text{HCl})$  added.

## Question 9d.

The addition of HCl increased the concentration of  $\text{Cl}^-$  ions.

According to Le Chatelier's principle, the equilibrium would move to oppose the increase in  $\text{Cl}^-$  ions by shifting to the right.

The colour change from pink to blue indicated that the position of equilibrium moved to the right.

## Question 9ei.

Accurate data is measured data that is **close to the true value**.

## Question 9eii.

The data **cannot** be described as accurate.

Acceptable reasons included the following:

- The colour change is assessed by eye, which is a subjective measure.
- The amount of HCl added is not measured except in drops.
- The data (colour change) is qualitative and is not quantified. Only quantitative data can be described as accurate since quantitative data is repeatable and measurable.

## Question 9f.

The forward reaction is endothermic. / The backward reaction is exothermic.

When the temperature decreased the equilibrium position moved left, as shown by the colour change to pink. This indicates that the backward reaction was exothermic.

## Question 10a.

One mark was awarded for describing how the combination of different amino acids in the primary structure makes each protein unique:

- Proteins have unique shapes since the sequencing of amino acids, with different R groups, in the primary structure is different. The primary structure is held together by covalent bonds between C and N in the peptide links.

One mark was awarded for discussion of the role of hydrogen bonding and the secondary structure:

- Due to the different sequencing of amino acids the different residues can hydrogen bond via C=O and N-H groups on different peptide links in the secondary structure to give a set shape (folds and pleats).

One mark was awarded for discussion of how the R group interactions of the structures (hydrogen bonding, dipole-dipole, etc.) give the 3-dimensional shape of the protein:

- The 3-dimensional shape of proteins can be explained by the bonding interactions between the R groups in the tertiary structure. For example:
  - hydrogen bonds between  $-OH$ ,  $-NH$  and  $-C=O$
  - dipole-dipole interactions between polar groups such as  $-SH$ ,  $-OH$  and  $-NH$
  - ionic attractions between  $-NH_3^+$  and a  $-COO^-$  group in neutral pH
  - covalent cross-links between neighbouring cysteine groups and dispersion forces between non-polar groups.

As proteins have different amino acids, containing different R groups, then their shapes are different, which affects the function of proteins.

One mark was awarded for discussion of how the combination of levels of structure give a protein its unique shape:

- Some proteins function as single polypeptides with primary, secondary and tertiary structures. Others require multiple polypeptides to function. The quaternary structure describes the way in which polypeptide subunits are arranged in the native protein. Dispersion forces between non-polar R groups are the main intermolecular forces between adjacent polypeptide chains.
- The combination of the amino acid sequence in the primary structure and the interactions in the secondary, tertiary and quaternary structures give proteins unique shapes.

## Question 10b.

One mark was awarded for explanation of the lock and key model:

- In the lock and key model, the substrate molecule (key) binds to the active site of the enzyme (lock), forming an enzyme-substrate complex (or lock and key). The enzyme catalyses the reaction.
- Products are released from the active site and the enzyme is regenerated so that it can be reused.

One mark was awarded for explaining that an enzyme catalyses a specific reaction because the 3-dimensional shape of the active site complements the 3-dimensional shape of the substrate:

- An enzyme catalyses a specific reaction since its active site has a unique 3-dimensional shape and size, which matches the 3-dimensional shape and size of the substrate molecule.

One mark was awarded for recognition that the chiral centres of the active site bind to only one substrate enantiomer because it contains at least one chiral C atom:

- Many substrate molecules have more than one chiral centre and will have different interactions with the chiral centres in the active sites of enzymes.
- Enzymes will catalyse specific reactions because only one enantiomer of the substrate molecule will bind/match/complement the chiral centres of the active site.