

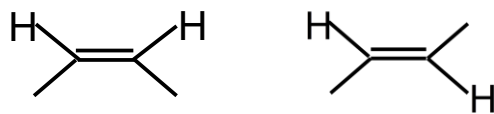
2018 VCE Chemistry (NHT) examination report

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 – Multiple-choice questions

Question	Answer	Comments
1	D	
2	A	
3	AC	<p>Looking at two components of the question to be considered in isolation:</p> <ul style="list-style-type: none"> $O_2(g) + 2NO(g) \rightleftharpoons 2NO_2(g)$: this implies that the reaction is 'reversible' (option A) $K_c = 9.1 \times 10^6 M^{-1}$ at $450^\circ C$: this implies that the ratio of products to reactants at equilibrium is so high that the reaction may be considered to be 'effectively' irreversible (option C) <p>Both options A and C may be considered correct.</p>
4	B	<p>Addition of a catalyst has no effect on the relative energies of the reactants and products.</p> <p>Hence $\Delta H = 1000 - 600 = 400 \text{ kJ mol}^{-1}$.</p>
5	A	Octane has the strongest intermolecular attraction (dispersion forces).
6	D	According to the electrochemical series, the reductants Fe and Zn are below the oxidant $Ni^{2+}(aq)$ and will be oxidised to $Fe^{2+}(aq)$ and $Ni^{2+}(aq)$.
7	A	$CH_2(CH_2)_4(CH=CHCH_2)_2(CH_2)_6COOH$: The first C=C starts with the sixth C atom on the hydrocarbon chain. Linoleic acid is an omega-6, polyunsaturated fatty acid and is not synthesised in the body.
8	D	Coenzymes are non-protein organic molecules that bind with protein molecules (that are not enzymes in their own right) to form an active enzyme.
9	B	Option B (repeat the titration using a different standard solution) was the only alternative that could increase accuracy.
10	B	E_{a2} is lower than E_{a1} so a catalyst has been added. The lower activation energy causes an increase in the proportion of total collisions that are successful.

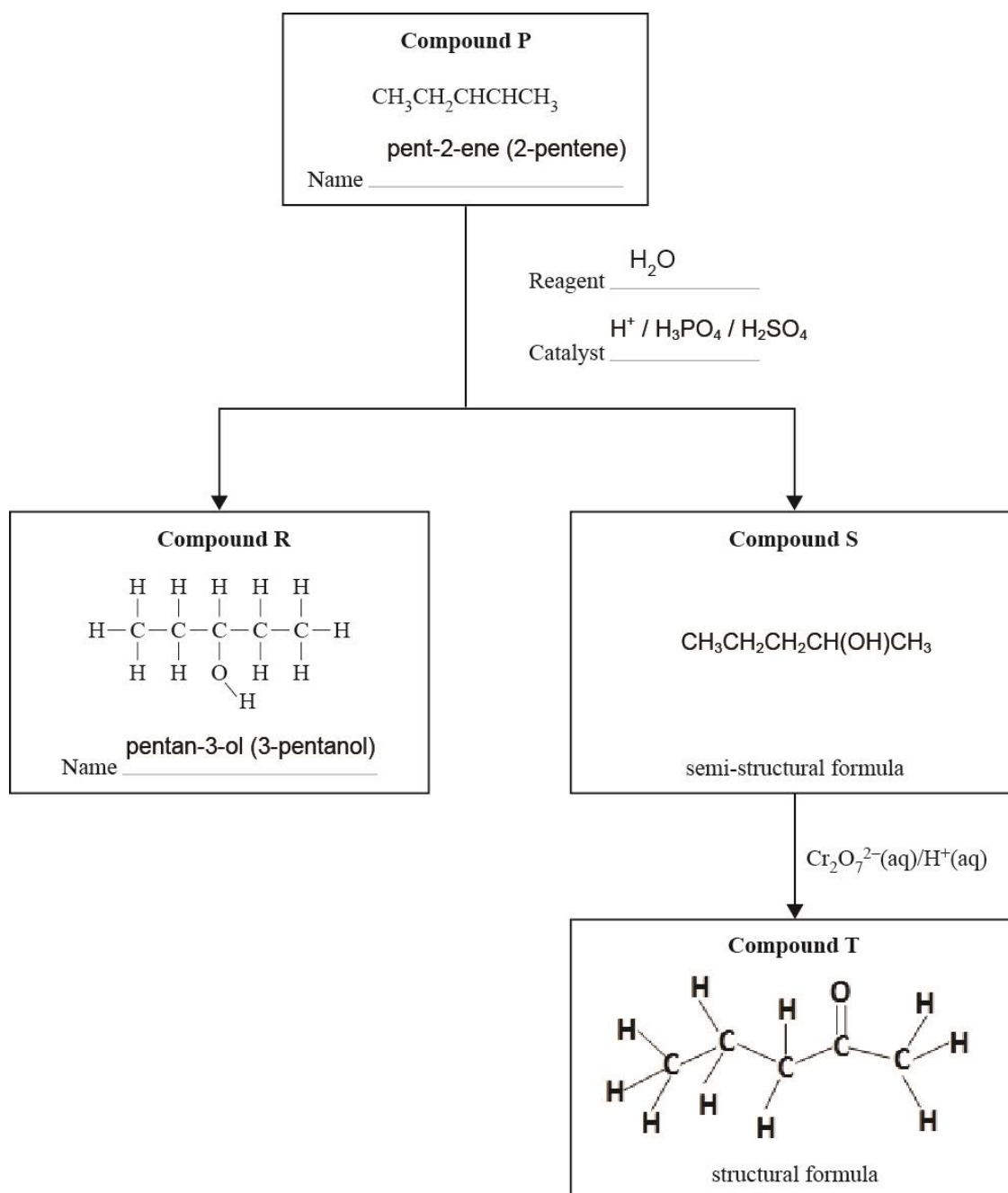
11	C	The oxidation half-equation does not include the oxidant, O ₂ .
12	B	$\text{NH}_2\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$ <p style="text-align: center;">4 3 2 1</p>
13	C	<p>Atom economy = $[M(\text{ethanol})/M(\text{reactants})] \times 100$</p> <p>The atom economies of the four reactions are given below.</p> <p>A – 100%, B – $92/180 = 51\%$, C – $46 / 104.5 = 44\%$, D – $46 / 92 = 50\%$</p>
14	C	<p>The NMR spectrum indicates that there are 3 carbon environments.</p> <p>The IR spectrum supports the presence of C=O and the lack of O-H (acid) or O-H (alcohol).</p> <p>CH₃COOCH₃ (option C) is the only option. CH₃COCH₃ (option D) is incorrect as this has only 2 C environments.</p>
15	B	<p>In the zinc-carbon cell, Zn is the reductant and MnO₂ is the oxidant.</p> <p>From the data book, $E^\circ(\text{reductant half-cell: Zn}^{2+}(\text{aq})/\text{Zn}(\text{s})) = -0.76 \text{ V}$</p> <p>$E(\text{cell}) = E^\circ(\text{oxidant half-cell}) - E^\circ(\text{reductant half-cell})$</p> <p>$1.50 \text{ V} = E^\circ(\text{oxidant}) - (-0.76)$</p> <p>$E^\circ(\text{oxidant}) = 1.50 + (-0.76) = 1.50 - 0.76 = 0.74 \text{ V}$</p>
16	C	<p><i>cis</i>-but-2-ene <i>trans</i>-but-2-ene</p> 
17	A	<p>$m(\text{CO}_2) = 1375 - 1350 = 25 \text{ g}$</p> <p>$n(\text{CO}_2) = 25/44.0 \text{ mol}$</p> <p>$V(\text{CO}_2) \text{ at SLC} = (25/44.0) \times 24.8 = 14 \text{ L}$</p>
18	C	<p>$n(\text{C}_6\text{H}_{12}\text{O}_6) = 72.0/180.0 = 0.400 \text{ mol}$</p> <p>Energy released per mol = $1.126 \times 10^3/0.400 = 2.82 \times 10^3 \text{ kJ mol}^{-1}$;</p> <p>$\Delta H = -2.82 \times 10^3 \text{ kJ mol}^{-1}$</p>
19	B	<p>$K = [\text{NO}_2]^2/[\text{N}_2\text{O}_4] \rightarrow 3.15 = [\text{NO}_2]^2/0.350$</p> <p>$[\text{NO}_2] = \sqrt{(3.15 \times 0.350)} = 1.05 \text{ M}$</p>
20	A	Carbohydrates, fats and proteins undergo hydrolysis reactions, i.e. react with water. Glycine is a product of protein hydrolysis.
21	D	<p>For reaction to occur, the strongest oxidant present must be higher on the electrochemical series than the strongest reductant.</p> <p>Option A: Cu²⁺/Fe, electrical energy released</p> <p>Option B: Zn²⁺/Ni, no reaction</p>

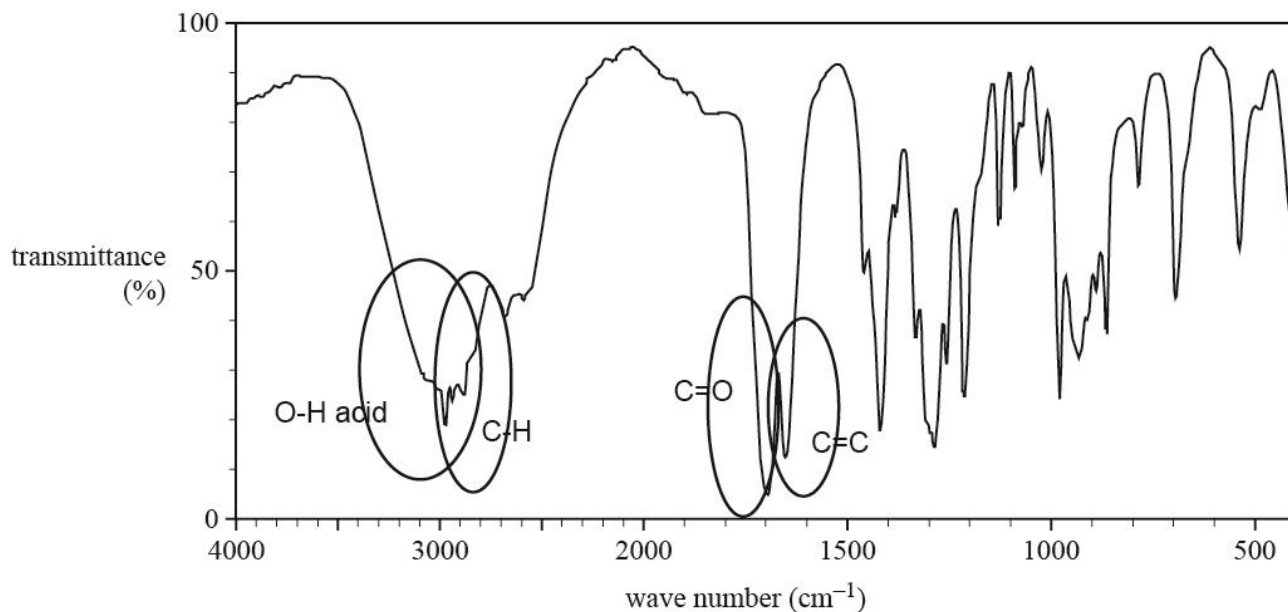
		Option C: Pb^{2+}/Co , electrical energy released D: Fe^{2+}/Al , heat energy released
22	B	Vitamin C in 12 g sample = $12 \times 30/100 = 3.6 \text{ g}$ In 25 mL solution $\rightarrow 3.6/25 = 0.144 \text{ g mL}^{-1}$ In 100 mL solution $\rightarrow 3.6/100 = 0.036 \text{ g mL}^{-1}$, the only one between 0.020 and 0.10 mg mL^{-1} In 250 mL solution $\rightarrow 3.6/250 = 0.0144 \text{ g mL}^{-1}$ In 500 mL solution $\rightarrow 3.6/500 = 0.0072 \text{ g mL}^{-1}$
23	D	Base peak is identified from the signal with the highest relative intensity, i.e. at $m/z = 55$. This peak is consistent with C_4H_7^+ , which will be the most abundant species.
24	D	$n(e^-) = 5.0 \times 600 / 96500 = 0.031 \text{ mol}$ Ag^+ : $n(\text{Ag}) = 0.31 \text{ mol}$, $m(\text{Ag}) = 0.031 \times 107.9 = 3.4 \text{ g}$ Ni^{2+} : $n(\text{Ni}) = 0.31/2 \text{ mol}$, $m(\text{Ni}) = (0.031/2) \times 58.7 = 0.91 \text{ g}$ Pb^{2+} : $n(\text{Pb}) = 0.31/2 \text{ mol}$, $m(\text{Pb}) = (0.031/2) \times 207.1 = 3.22 \text{ g}$ Cr^{3+} : $n(\text{Cr}) = 0.31/3 \text{ mol}$, $m(\text{Cr}) = (0.031/3) \times 52.0 = 0.54 \text{ g}$
25	C	$m(\text{C}_8\text{H}_{18}) = 0.91 \times 2.5 \text{ kg}$; Energy released = $0.91 \times 2.5 \times 1000 \text{ g} \times 47.9 \text{ kJ g}^{-1} = 1.09 \times 10^5 \text{ kJ}$ $m(\text{CH}_3\text{CH}_2\text{OH}) = 0.09 \times 2.5 \text{ kg}$; Energy released = $0.09 \times 2.5 \times 1000 \text{ g} \times 29.6 \text{ kJ g}^{-1} = 6.7 \times 10^3 \text{ kJ}$ Total energy released = $1.09 \times 10^5 + 6.7 \times 10^3 = 1.16 \times 10^5 \text{ kJ} = 1.16 \times 10^2 \text{ MJ} = 116 \text{ MJ}$
26	A	From Data Book: pH 8.9 at equivalence point is picked up by thymol blue.
27	D	$n(\text{tristearan}) = 10.0/890.0 = 0.0112 \text{ mol}$ $1 \text{ tristearan} + 3 \text{ H}_2\text{O} \rightarrow 3 \text{ stearic acid} + 1 \text{ glycerol}$ 0.0112 0.0336 0.0336 0.0112 mol $m(\text{glycerol}) = 0.0112 \text{ mol} \times 92.0 \text{ g mol}^{-1} = 1.03 \text{ g}$ $N(\text{stearic acid}) = 0.0336 \times 6.02 \times 10^{23} = 2.03 \times 10^{22} \text{ molecules}$
28	B	To increase $[\text{H}_3\text{O}^+]$ the second equilibrium must move to the right. Bubbling in $\text{CO}_2(\text{g})$ will increase the concentration of $\text{CO}_2(\text{aq})$, pushing the first equilibrium to the right and increasing the $[\text{H}_2\text{CO}_3]$. The increase in $[\text{H}_2\text{CO}_3]$ pushes the second equilibrium to the right.
29	A	Cycle 1: Energy (electrical) is produced spontaneously since electrons are moving from the (-) electrode to the (+) electrode. Since cations move towards cathode, the anode is negative. Cycle 2: Requires energy since electrons are moving from the (+) electrode to

		the (-) electrode. Since cations move towards cathode, the anode is positive.
30	C	The cloud point reflects the strength of intermolecular attraction. Low cloud point fuels flow more readily at colder temperatures because of the lower viscosity associated with weaker intermolecular attraction. Petrodiesel has weaker intermolecular attraction (dispersion forces) than biodiesel (dispersion forces and dipole–dipole forces).

Section B

Questions 1a.–d.



Question 2a.

One mark was awarded for any two of the following clearly labelled on the graph with an appropriate circle and the correct bond labelled:

- O-H (acid)
- C-H
- C=O
- C=C

Question 2bi.

5

Question 2bii.

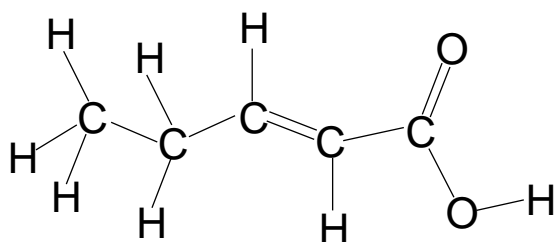
- There are two equivalent hydrogen atoms at that chemical shift.
- There are four equivalent hydrogen atoms on adjacent carbon atoms.

Question 2c.

One mark each was awarded for:

- correct functional group and double bond
- correct placement of bonds

Students applying the $n+1$ rule and excluding coupling constants, as specified in the study design, drew the following structural formula.



Question 3ai.

Experiment 2 has a higher initial concentration of NOCl molecules, so there will be a higher frequency of collisions (higher number of collisions per unit time) and so a higher frequency of successful collisions (higher number of successful collisions per unit time) producing a faster rate of reaction/rate of production of Cl₂.

One mark each was awarded for:

- Experiment 2
- correctly justifying the higher initial rate in Experiment 2.

Question 3aii.

[NOCl] is higher than [NO].

Experiment 2 is like adding an extra 2 mol NOCl to the equilibrium in Experiment 1. This immediately increases the ratio $[\text{NOCl}]^2/([\text{NO}]^2[\text{Cl}_2])$. Because the reaction shifts to the left the [Cl₂] will be higher at equilibrium in Experiment 2. However, since $[\text{NOCl}]^2/([\text{NO}]^2[\text{Cl}_2])$ at equilibrium must be the same at both equilibria, the ratio $[\text{NOCl}]^2/[\text{NO}]^2$ must increase and so [NOCl] must be greater than [NO] at equilibrium in Experiment 2.

$$K = \frac{[\text{NOCl}]^2}{([\text{NO}][\text{Cl}_2])}$$

Experiment 1 [NOCl] = [NO] so $K = 1/[\text{Cl}_2]$

In experiment 2, the higher initial [NOCl] leads to a higher [Cl₂] at equilibrium.

Since $[\text{NOCl}]^2/([\text{NO}][\text{Cl}_2])$ is constant at equilibrium the ratio $[\text{NOCl}]^2 / [\text{NO}]^2$ must be larger in Experiment 2, so [NOCl] is greater than [NO]

$$\text{Alternatively } K = \frac{[\text{NO}]^2[\text{Cl}_2]}{[\text{NOCl}]^2}$$

Experiment 1 [NOCl] = [NO] so $K = [\text{Cl}_2]$

Since $[\text{NO}]^2[\text{Cl}_2]/[\text{NOCl}]^2$ is constant the ratio

$[\text{NO}]^2/[\text{NOCl}]^2$ must be smaller so [NOCl] is greater than [NO].

One mark each was awarded for:

- [NOCl] > [NO]
- for a valid explanation.

Question 3b.

No change

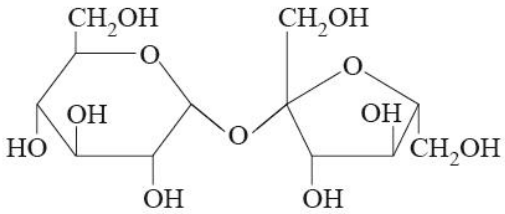
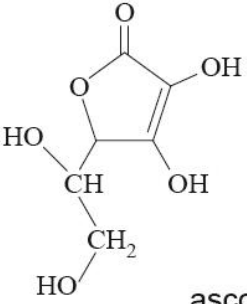
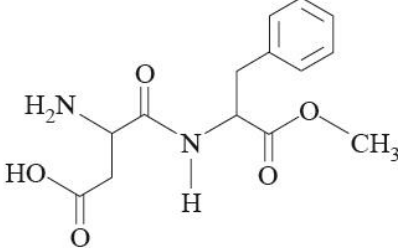
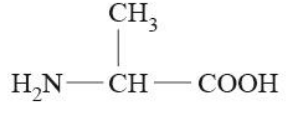
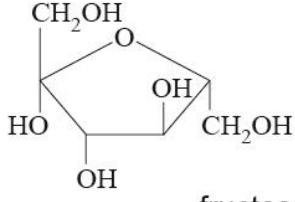
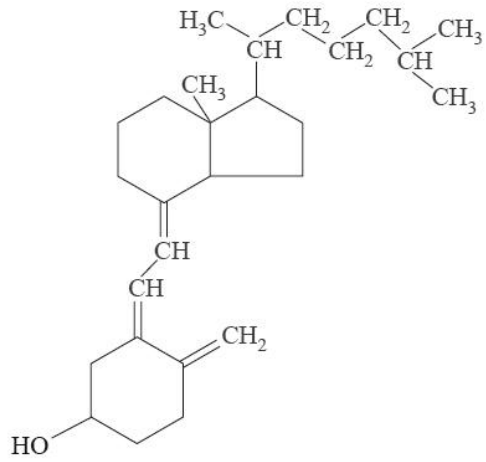
There are more collisions due to added particles but not more successful collisions since collisions involving inert gas particles do not affect equilibrium. Inert gas molecules are not part of the equilibrium reaction.

Question 3c.

Endothermic reaction so an increase in temperature shifts equilibrium to the right

Hence [NOCl] will increase.

Question 4

<p>A.</p>  <p>sucrose</p>	<p>B.</p>  <p>ascorbic</p>	
<p>C.</p> $\text{CH}_3(\text{CH}_2)_{14}\text{COOCH}_3$ <p>methyl palmitate</p>	<p>D.</p>  <p>aspartame</p>	
<p>E.</p>  <p>alanine</p>	<p>F.</p>  <p>fructose</p>	<p>G.</p> $\text{C}_{17}\text{H}_{29}\text{COOH}$ <p>linolenic acid</p>
<p>H.</p>  <p>vitamin D₃</p>		

Characteristic	Biomolecule letter(s) (A.–H.)
contains a glycosidic linkage	A.
is an essential dietary component	two of B., G., H.
is soluble in water	two of A., B., D., E., F.
is able to form a zwitterion	either D. or E.
contains an ester linkage	two of B., C., D.
can be a key constituent of biodiesel	C.
has phenylalanine as a component	D.

Question 5ai.

- KI as electrolyte would produce $I_2(s)$ which would contaminate the solution / react with OH^-
- KBr as electrolyte would produce $Br_2(l)$ which would contaminate the solution / react with OH^-
- Using KCl leads to production of $Cl_2(g)$ which would bubble off from the solution

One mark each was awarded for:

- either or both products – **solid I_2 or liquid Br_2** OR indication that **Cl_2 is a gas**
- **associated effect** – contamination of solution / reaction with $OH^-(aq)$ / escape of $Cl_2(g)$

Question 5aii.

O_2 is formed.

Question 5aiii.

Cl_2 gas is being produced because $Cl^-(aq)$ ions are being oxidised in preference to H_2O as the conditions are non-standard/concentration not 1 M.

One mark each was awarded for:

- Cl^- ions being oxidised in preference to H_2O
- non-standard conditions or concentration effect.

Question 5aiv.

Either:

- $2H_2O(l) + 2KCl(aq) \rightarrow 2KOH(aq) + H_2(g) + Cl_2(g)$
- $2H_2O(l) + 2Cl^-(aq) \rightarrow 2OH^-(aq) + H_2(g) + Cl_2(g)$

One mark each was awarded for:

- correct species
- correct balancing.

Question 5av.

H_2 and Cl_2 gases can form an explosive mixture and should be collected separately. H_2 is explosive if sparked in air and should be collected away from any source of ignition. Cl_2 is poisonous so a fume hood/appropriate extraction should be used.

One mark each was awarded for:

- accurate safety issue with gases given in part aiv.

- a reasonable method of overcoming this safety issue.

Question 5b.

- prevent Cl₂ gas reacting with OH⁻ ions
- prevent unwanted reactions
- separate gases

Question 5ci.

Cd

Question 5cii

Cd(OH)₂

Question 5ciii.

- electrolyte
- a source of OH⁻(aq) ions

Question 6ai.

$$n(\text{C}_{10}\text{H}_8) = 0.212/128 = 0.001656 \text{ mol}$$

$$E \text{ released} = 0.001656 \times 5133 = 8.502 \text{ kJ}$$

$$CF = E / \Delta T = 8.502 / 4.0 \text{ (from graph)} = 2.13 \text{ kJ } ^\circ\text{C}^{-1}$$

Question 6aii.

The data is not reliable because only one set of values was used/one set of data was collected, so no check on reliability was made.

Question 6bi.

$$\begin{aligned} \text{Energy in serving size of 27 g} &= (1.9 \times 17 + 8.9 \times 37 + 14.0 \times 16) \\ &= 585.6 \text{ kJ} \end{aligned}$$

$$\text{Energy in 2.7 g} = 585.6/10 = 59 \text{ kJ or } 5.9 \times 10^3 \text{ J (5900 J)}$$

Question 6bii.

$$18 \text{ } ^\circ\text{C} (\Delta T = E/CF = 59/3.3 = 18 \text{ } ^\circ\text{C})$$

Question 6ci.

Glucose

Question 6cii.

Starch contains amylose and the more easily digestible branched chain, amylopectin.

The higher amylopectin content (73%) of the starch means it is more rapidly hydrolysed to glucose, therefore glucose levels increase more rapidly, and so higher GI.

One mark each was awarded for:

- recognition that the higher amylopectin content of the starch leads to higher GI
- linking the faster digestibility of amylopectin to its structure.

Question 6d.

Less energy released

Not all components of food that undergo combustion, e.g. cellulose, cannot be digested (humans lack the necessary enzyme) by the body, hence less energy would be available to the body.

Some of the food ingested (e.g. fats/proteins) is not fully digested in the body, so provides less energy to the body than is released in the calorimeter.

Question 7ai.

Either:

- $\text{Pb(s)} + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{PbSO}_4(\text{s}) + 2\text{H}^+(\text{aq}) + 2\text{e}^-$
- $\text{Pb(s)} + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{PbSO}_4(\text{s}) + 2\text{e}^-$

Question 7aii.

Either:

- $\text{PbO}_2(\text{s}) + \text{H}_2\text{SO}_4(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{PbSO}_4(\text{s}) + 2\text{H}_2\text{O}(\text{l})$
- $\text{PbO}_2(\text{s}) + \text{SO}_4^{2-}(\text{aq}) + 4\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{PbSO}_4(\text{s}) + 2\text{H}_2\text{O}(\text{l})$

Question 7bi.

- $\text{C}_8\text{H}_{18} + 25/2\text{O}_2 \rightarrow 8\text{CO}_2 + 9\text{H}_2\text{O} \quad \Delta H = -5460 \text{ kJ mol}^{-1}$ or
- $2\text{C}_8\text{H}_{18} + 25\text{O}_2 \rightarrow 16\text{CO}_2 + 18\text{H}_2\text{O} \quad \Delta H = -10\,920 \text{ kJ mol}^{-1}$

Question 7bii.

$$n(\text{C}_8\text{H}_{18}) = 1000/114 = 8.77 \text{ mol}$$

$$m(\text{CO}_2) = 8.77 \times 44.0 \times 8 = 3.09 \times 10^3 \text{ g} = 3.09 \text{ kg}$$

Question 7biii.

$$n(\text{CH}_3\text{CH}_2\text{OH}) = 1000/46.0 = 21.74 \text{ mol}$$

$$m(\text{CO}_2) = 21.74 \times 44.0 \times 2 = 1.91 \times 10^2 \text{ g} = 1.91 \text{ kg}$$

Question 7biv.

$$\text{Petrol } 3.09 \times 15.5 = 47.9 \text{ kJ g}^{-1}; \text{ ethanol } 1.91 \times 15.5 = 29.6 \text{ kJ g}^{-1}$$

Petrol provides more energy per kg of fuel or less petrol is needed to produce the same amount of energy.

Question 7ci.

$$n(\text{H}_2) = (100 \times 582) / (8.31 \times 291) = 24.1 \text{ mol}$$

$$\text{Energy} = 24.1 \times 282 = 6.79 \times 10^3 \text{ kJ} = 6.79 \text{ MJ}$$

Question 7cii.

Method 1 – impact depends on the source of methane

- If the source of CH_4 is biogas generated from waste, the environmental impact is low because CO_2 is a less harmful greenhouse gas than methane.
- If the source of methane is fossil-fuel-based (or high temperatures are generated using fossil fuels) the environmental impact is significant because CO_2 produced adds to overall greenhouse gas levels.

Method 2 – impact depends on source of electrical energy

- If the electrical energy source is renewable (e.g. wind/solar/hydro), there is no environmental impact because no CO₂ is produced.
- If the electrical energy source is coal or gas, the environmental impact is significant because CO₂ produced during combustion of the fossil fuel adds to overall greenhouse gas levels

Question 8ai.

Either:

- complete drying with propanone in a fume hood
- do not use propanone near a naked flame.

Question 8aii.

Use a designated organic liquids disposal bottle.

Question 8bi.

Current

Question 8bii.

- time – to ensure the charge (from $Q = It$) variation between trial is determined by the current only
- supplied voltage – to ensure voltage impact is the same in each trial and only current changes
- electrode area/electrode separation/temperature

Repeated using different currents implies concentration, distance between electrodes, surface area are also controlled.

Question 8biii.

Aim: To find the effect of varying the current on the mass of copper deposited during electrolysis.

Question 8c.

Either:

- by a graph (of mass of Cu plated against current)
- only showing current and mass plated in table.

Question 8d.

- The class data can be collated and an average mass of Cu for each current could be calculated.
- If the collated data was consistent and showed that mass of copper plated increased with current, it would suggest the experiment was reliable/reproducible.

Question 8e.

In this experiment, the mass of copper deposited during electrolysis increased as the current increased. This was a linear relationship/mass of copper is directly proportional to current.

Question 8f.

Validity is increased by measuring the mass of both electrodes (as stated in the aim). If the increase in the mass in one electrode is not equal to the decrease in mass in the other electrode (within the uncertainty of the balance) then a random error is likely.

Since the mass of the plated copper is the difference between two measured masses, systematic error should be minimised unless some copper produced does not adhere to the cathode or some copper falls off the anode without being oxidised.

Question 9a.

Chemical bonding in tertiary structures

The tertiary structure is made by the folding and twisting of the primary and secondary structures into shapes held in place by specific interaction between various Z-group residues. The actual bonding present will depend on the amino acids present in the primary structure. For example:

- covalent bonds can form between Cys and Met, Cys and Cys residues
- ionic bonds can form, depending on pH (between Asp and Asn)
- hydrogen bonds can form (between His and Thr).

Significance of the tertiary structure to the function of enzymes by maintaining the shape of the active site

The shape of the active site, which is where the reaction occurs, is crucial to the function of the enzyme. It is shaped in such a way that the substrate 'fits' into the active site and attaches so that the reaction can occur. The tertiary structure of the enzyme is crucial for this.

Interaction between the substrate and enzyme

- 'Attach' at the active site. The substrate interacts with the active site of the enzyme. The bonds that form can be ion-ion, dipole-dipole, hydrogen bonding, ion-dipole (or electrostatic)
- comparison of lock-and-key and induced fit models

Question 9b.

Possible factors: temperature, co-enzyme, substrate source/concentration, inhibiting factors such as heavy metals

An explanation consistent with factor identified was required, for example:

Factor temperature

- Enzyme activity decreases if temperatures rise above 40 °C, as the active site is affected by denaturation.
- Enzyme activity decreases at temperatures lower than 40 °C due to reduced frequency of successful collisions.