Neap

VCE Chemistry Units 3&4

Suggested Solutions

2024 Trial Examination

Section A – Multiple-choice questions

1	A	B	C	**D**	16	A	B	C	**D**
2	A	B	**C**	D	17	A	B	C	**D**
3	**A**	B	C	D	18	A	**B**	C	D
4	A	B	C	**D**	19	**A**	B	C	D
5	A	B	**C**	D	20	A	**B**	C	D
6	**A**	B	C	D	21	A	B	C	**D**
7	A	**B**	C	D	22	A	**B**	C	D
8	A	B	**C**	D	23	A	B	C	**D**
9	A	B	C	**D**	24	**A**	B	C	D
10	A	**B**	C	D	25	A	**B**	C	D
11	A	**B**	C	D	26	A	B	C	**D**
12	A	B	**C**	D	27	A	**B**	C	D
13	**A**	B	C	D	28	**A**	B	C	D
14	A	B	**C**	D	29	A	B	**C**	D
15	A	**B**	C	D	30	A	B	**C**	D

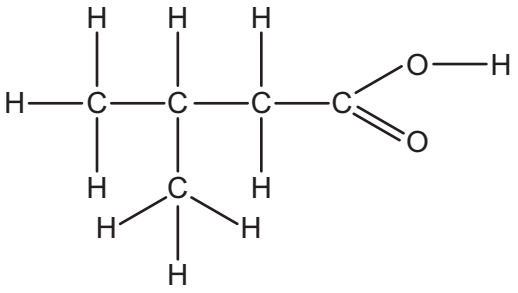
Question 1 D

D is correct, and **A** and **B** are incorrect. Denaturation of a protein can result when temperature is increased. An increase in temperature causes bonds in the protein to break and new bonds to form; this alters the structure of the protein permanently. Denaturation can also result when pH is changed. Changes in pH cause protonation or deprotonation of groups of atoms in the protein, subsequently causing different bonds to form.

C is incorrect. A decrease in temperature will decrease the activity of a protein but will not permanently change its structure.

Question 2 C

The compound is 3-methylbutanoic acid. Its structural formula is shown below.



$(10 \times H) + (5 \times C) + (2 \times O) = (10 \times 1.0) + (5 \times 12.0) + (2 \times 16.0) = 102$

Question 3 A

The equation for the original reaction has been reversed and the coefficients halved. Therefore, the equilibrium constant, K, for the second reaction is calculated as follows.

$$\left(\frac{1}{K}\right)^{\frac{1}{2}} = \left(\frac{1}{1.75}\right)^{\frac{1}{2}} = 0.756$$

Question 4 D

At 900°C, the equilibrium constant is greater than it is at 1000°C. Thus, at the lower temperature, the concentration of the product increases and the concentration of the reactants decreases. According to Le Chatelier's principle, when an exothermic equilibrium reaction is cooled, the system responds to partially oppose the change by producing some heat. That is, the forward reaction is favoured. Exothermic reactions have a negative enthalpy change.

Question 5 C

C is correct. The tertiary structure of an enzyme results from the interactions between the side groups of the various amino acid residues in the protein chain. In an enzyme-catalysed reaction, these side groups make temporary bonds with substrates so that catalysis can occur. Thus, the tertiary structure is altered.

A, **B** and **D** are incorrect. The primary structure of an enzyme results from the number, type and sequence of amino acid residues in the protein. The secondary structure results from the interactions between the atoms in the peptide bonds of non-adjacent amino acids in the protein. These are not altered during catalysis.

Question 6 A

A is correct. Le Chatelier's principle is used to predict the position of equilibrium or its movement; it is not used to predict rates of reaction.

B, **C** and **D** are incorrect. Each of these variables can be predicted using Le Chatelier's principle as they relate to the position of equilibrium.

Question 7 B

B is correct. Change I would result in an increased reaction rate because the ethanol would have a greater surface area, causing the reaction rate to increase.

Change IV would result in an increased reaction rate because heating the ethanol to a higher temperature would mean that more of the substance would be at a sufficient temperature for combustion and so the rate of reaction would increase.

A, **C** and **D** are incorrect. Change II would not result in an increased reaction rate because the surface area of the ethanol would be the same and so the rate of reaction would be unchanged.

Change III would not result in an increased reaction rate because the dilution would mean that there would be less ethanol at the surface and so the reaction rate would decrease.

Question 8 C

C is correct. A chromium block would have been the positive electrode (anode) where oxidation occurred. The cell's power supply would have removed electrons from the block and forced them onto the negative electrode (cathode), which was the house key.

A is incorrect. The house key was the cathode and would have attracted positive chromium ions. The positive chromium ions would have been reduced to chromium metal, which then coated the house key.

B is incorrect. Water would have been oxidised at the positive anode, meaning that oxygen gas would have been produced.

D is incorrect. Chromium ions would have been the oxidising agents, meaning that they would have been reduced to chromium metal. Water would have been the reducing agent, meaning that it was oxidised to produce oxygen gas.

Question 9 D

M = activation energy, $E_a = 30$ kJ mol^{-1}

N = energy of enthalpy change, $\Delta H = 60$ kJ mol^{-1}

Q = enthalpy of the products = 50 kJ mol^{-1}

Therefore, M + N + Q = 30 + 60 + 50 = 140 kJ mol^{-1}.

Question 10 B

E_a(reverse reaction) = M + N = 30 + 60 = 90 kJ mol^{-1}

ΔH = N, so, because the reaction is endothermic, $\Delta H = +60$ kJ mol^{-1}.

Question 11 B

B is correct. Statement II is true for fuel cells but not for galvanic cells. In fuel cells, the oxidation of a chemical that is not the electrode occurs. In galvanic cells, the metal electrode is often a component of the conjugate redox pair in a half-cell. At the anode, the electrode is oxidised to ions.

Statement III is true for fuel cells but not for galvanic cells. In fuel cells, the reactants are positioned outside the cell and are fed into the cell as required. In galvanic cells, the reactants are located in the half-cells.

A, **C** and **D** are incorrect. Statement I is not true for fuel cells or galvanic cells. In both cell types, electrons are released during oxidation and so make the electrode negative.

Statement IV is true for fuel cells and galvanic cells. In both cell types, the stored energy of the products is always less than the stored energy of the reactants. The reactions are spontaneous and release the difference in energy. This chemical energy is converted to electrical energy.

Statement V is true for fuel cells and galvanic cells. In fuel cells, each electrode is in contact with either the oxidising or reducing agent, which is contained in the fuels that are continuously fed into the cell. In galvanic cells, each electrode is submerged in an electrolyte containing either the oxidising or reducing agent.

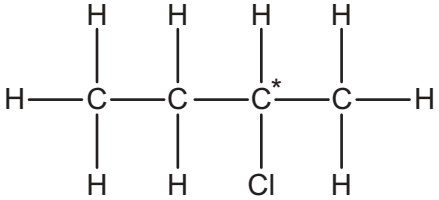
Question 12 C

The compound has four isomers. Their semi-structural (condensed) formulas are:

- $CH_3CH_2CH_2CH_2Cl$
- $CH_3CH_2CHClCH_3$
- $(CH_3)_2CHCH_2Cl$
- $(CH_3)_3CCl$.

Question 13 A

Only $CH_3CH_2CHClCH_3$ has a chiral centre because it has a carbon that is attached to four different groups, as shown in its structural formula below.



The peak area ratio on this isomer's proton NMR would be 3 : 2 : 1 : 3, which is based on the number of hydrogens in each hydrogen environment.

Question 14 C

C is correct. Systematic errors result from limitations of instruments or materials, incorrect calibration or inappropriate methods. Thus, readings differ from the true value in a systematic manner and, when repeated, the error remains the same.

A is incorrect. If an experiment has a systematic error, repeating the same experiment will produce the same error.

B is incorrect. This option describes random errors.

D is incorrect. Random errors can be minimised by taking an average of the experimental readings and data; systematic errors cannot be minimised in this way.

Question 15 B

B is correct.

$Q = It = 2.5 \times 90 \times 60 = 13\,500$ C

$$n(e^-) = \frac{Q}{F} = \frac{13\,500}{96\,500} = 0.13\ldots \text{mol}$$

$$n(\text{Fe}) = \frac{1}{2} \times n(e^-) = \frac{0.13\ldots}{2} = 0.069\ldots \text{mol}$$

$m(\text{Fe}) = 0.069\ldots \times 55.8 = 3.9$ g

A is incorrect. $m(\text{Ag}) = 15$ g

C is incorrect. $m(\text{Pb}) = 14$ g

D is incorrect. $m(\text{Zn}) = 4.6$ g

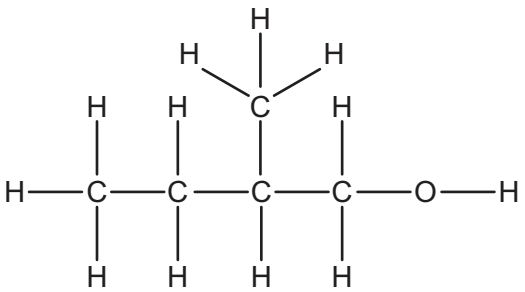
Question 16 D

D is correct, and **A** and **B** are incorrect. Aluminium ions, $Al^{3+}(aq)$, are weaker oxidising agents than water and so, in the electrolytic cell, water molecules would have gained electrons more easily than $Al^{3+}(aq)$, forming hydrogen gas and hydroxide ions. Subsequently, no aluminium would have been deposited.

C is incorrect. Aluminium is a stronger reducing agent than water but this is not relevant to what occurs at the cathode during electrolysis.

Question 17 D

2-methylbutan-1-ol has five different carbon environments, as seen in its structural formula below.



Question 18 B

$$n(\text{Mn}) = \frac{m}{M} = \frac{0.462}{54.9} = 8.42 \times 10^{-3} \text{ mol}$$

$$n(e^-) = \frac{Q}{F} = \frac{1621}{96\,500} = 1.68 \times 10^{-2}$$

$n(e^-) = 2.00 \times n(\text{Mn})$, hence, the charge of the manganese ions was +2.

Question 19 A

From the initial stage of the graph, the reaction occurs according to the equation

$C(g) \rightleftharpoons A(g) + B(g)$.

Therefore, at 25 minutes:

$$K = \frac{[A][B]}{[C]}$$
$$= \frac{0.15 \times 0.25}{0.35}$$
$$= 0.11\,\text{M}$$

Question 20 B

B is correct. From the graph, it can be seen that the concentration of gas B decreases instantly at 15 minutes while no change is observed in the other gases at that instant. This indicates that some of gas B was removed from the container. Immediately after 30 minutes, the concentrations of all three gases changed, indicating a change in temperature.

A is incorrect. If the volume of the container was reduced at 15 minutes, the concentrations of all three gases would have increased. A catalyst reduces the amount of time it takes for a reaction to reach equilibrium, but does not affect the concentrations of the reactants and products.

C is incorrect. If the temperature had increased at 15 minutes, the concentrations of all three gases would have changed after 15 minutes, but no changes would occur instantly. If more of gas C was injected into the container at 30 minutes, its concentration would increase instantly.

D is incorrect. Based on the graph, it cannot be determined whether a catalyst was used during the experiment. If the equilibrium mixture had been compressed at 30 minutes, the concentrations of all three gases would have increased.

Question 21 D

Conclusion I is incorrect. After 30 minutes, the temperature was changed and so the equilibrium constant also changed.

Conclusion II is incorrect. Between 10 and 15 minutes, there is no change in the concentrations of the gases; however, new molecules are being made while others are being broken down.

Conclusion III is incorrect. This conclusion cannot be made because it cannot be determined whether the temperature was decreased or increased at 30 minutes.

Question 22 B

B is correct. The cathode is positively charged in a galvanic cell, and so cobalt ions, Co^{2+}, must form cobalt metal, Co, for this electrode to be positive. Thus, the other half-cell must contain a metal that is a stronger reducing agent than Co. Zinc and aluminium are stronger reducing agents than Co.

A, **C** and **D** are incorrect. Based on the electrochemical series, copper and lead are weaker reducing agents than Co.

Question 23 D

From the electrochemical series, the standard electrode potential, E^0, values for the standard reactions are as follows.

- copper: +0.34 V
- zinc: –0.76 V
- lead: –0.13 V
- aluminium: –1.66 V

Therefore, for the half-cells in combination with the Co half-cell ($E^0 = -0.28$ V), the cell voltages are as follows.

- copper: $+0.34 - (-0.28) = 0.62$ V
- zinc: $-0.28 - (-0.76) = 0.48$ V
- lead: $-0.13 - (-0.28) = 0.15$ V
- aluminium: $-0.28 - (-1.66) = 1.38$ V

Question 24 A

In an electrolytic cell, reduction occurs at the cathode and so the stronger oxidising agent is reduced preferentially. Based on the electrochemical series, magnesium ions are stronger oxidising agents than calcium ions; therefore, magnesium ions were reduced to magnesium metal at the cathode. At the anode of an electrolytic cell, oxidation occurs, and so the stronger reducing agent is oxidised preferentially. Chloride ions are stronger reducing agents than fluoride ions; therefore, chloride ions were oxidised to chlorine gas at the anode.

Question 25 B

$n(C_6H_8O_6) = n(I_2)$

$n(I_2) = cV = 3.47 \times 10^{-4} \times 0.0178 = 6.17\ldots \times 10^{-6}$ mol

$m(C_6H_8O_6) = n \times M = 6.17\ldots \times 10^{-6} \times 176 = 1.09 \times 10^{-3}$ g

Question 26 D

D is correct. Using an iodine solution that is twice as concentrated would mean that the titre volume would be halved. Assuming that the uncertainty in reading the burette is a constant value, the percentage uncertainty would be doubled. Thus, the results would be less accurate.

A is incorrect. Repeating an experiment reduces the effect of random errors, making the results more precise.

B is incorrect. Rinsing glassware with water only would result in dilution of the solutions, thus introducing error. This would reduce the accuracy of the experiment's results.

C is incorrect. The misreading of a measurement by the experimenter is a parallax error. By ensuring that the experimenter's eye is level with the meniscus, the effect of this error is reduced. Thus, the results would be more precise.

Question 27 B

B is correct.

$n(\text{hydrochloric acid, HCl}) = cV = 1.00 \times 0.0500 = 0.0500 \text{ mol}$

$E(\text{produced}) = n \times \Delta H = 0.0500 \times 57.25 = 2.863 \text{ kJ} = 2863 \text{ J}$

$$\Delta T = \frac{E}{\text{CF}} = \frac{2863}{600} = 4.77 \ldots ^\circ\text{C}$$

$T(\text{final}) = 18.0 + 4.77 \ldots = 22.77 \ldots = 23^\circ\text{C}$

Question 28 A

The descending order of the acids' melting points is stearic > oleic > linoleic > linolenic. Of the four acids, linolenic acid has the most carbon-to-carbon double bonds in its molecule. Double bonds prevent the hydrocarbon chains of fatty acids from packing close together, and so dispersion forces are weaker. As linolenic acid has the most carbon-to-carbon double bonds, it has the weakest dispersion forces; therefore, it has the lowest melting point.

Question 29 C

The independent variable is the variable that is manipulated by the experimenter and must be shown on the horizontal axis of a graph. In this scenario, the independent variable is the amount of glucose supplied because it was manipulated by the students. The dependent variable is the variable that changes as a result of the independent variable's manipulation and must be shown on the vertical axis of a graph. In this scenario, the dependent variable is the amount of alcohol produced because it changes based on the amount of glucose supplied.

Question 30 C

C is correct. Competitive enzyme inhibitors are organic compounds that bind to the active site of a specific enzyme through the lock-and-key mechanism. This prevents the substrate from binding to the active site.

A, **B** and **D** are incorrect. These options do not correctly explain how a competitive enzyme inhibitor functions.

Section B

Question 1 (7 marks)

a. $K = \dfrac{[CO][H_2]^3}{[CH_4][H_2O]} = \dfrac{[CO] \times 0.300^3}{0.100 \times 0.200} = 0.256$ 1 mark

$[CO] = \dfrac{0.256 \times 0.100 \times 0.200}{0.300^3} = 0.189 \ldots M$ 1 mark

$n(CO) = cV = 0.379$ mol 1 mark

b.

Statement	Correct or incorrect	Justification
At equilibrium, the rates of the forward and reverse reactions are zero.	**incorrect**	**At equilibrium, the rates of the forward and reverse reactions are equal but are not zero, as reactant and product molecules are being made and broken down.**
Increasing the pressure by introducing an inert gas into the equilibrium mixture will move the position of equilibrium towards the reactants.	**incorrect**	**An inert gas will not affect the concentrations of the reactants or products, and so will have no effect on the equilibrium constant or the position of equilibrium.**

4 marks

1 mark for each correct cell.

Question 2 (15 marks)

a. Petrol is derived from crude oil, which was formed from the remains of living organisms millions of years ago. 1 mark

Crude oil is a finite resource because it cannot be replaced quickly; therefore petrol is not a sustainable fuel. 1 mark

b. **i.** $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$

2 marks

1 mark for the correct reactants and products.
1 mark for correct balancing and states.

ii. The fermentation of glucose occurs in an aqueous mixture and naturally ceases once a certain concentration of ethanol is reached. 1 mark

The mixture of products from the reaction must undergo distillation so that the ethanol is separated from the other products; this ensures that a very high concentration of ethanol is obtained and will be able to undergo combustion in a transport vehicle.

1 mark

iii. $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l) \qquad \Delta H = -1370 \text{ kJ}$

2 marks

1 mark for the correct reactants, products, balancing and states.
1 mark for the correct ΔH.

iv. $q\left(\text{octane, } C_8H_{18}\right) = \Delta H \times n = \Delta H \times \frac{m}{M} = 5470 \times \frac{90.0}{114.0} = 4318.42 \ldots \text{kJ}$ 1 mark

$q\left(\text{ethanol, } C_2H_5OH\right) = 1370 \times \frac{10.0}{46.0} = 297.8 \ldots \text{kJ}$ 1 mark

$q(\text{total}) = 4318.42 \ldots + 297.8 \ldots = 4.62 \times 10^3 \text{ kJ}$ 1 mark

c. **i.** *(The half-equation given in the question is for the reduction reaction, which occurs at the cathode. Therefore, the half-equation for the oxidation reaction at the anode is required.)*

$C_2H_5OH(g) + 12OH^-(aq) \rightarrow 2CO_2(g) + 9H_2O(g) + 12e^-$

2 marks

1 mark for the correct reactants and products.
1 mark for correct balancing and states.

ii. *For example, any one of:*

- are porous to gases
- allow conduction of a current
- have embedded catalysts

1 mark

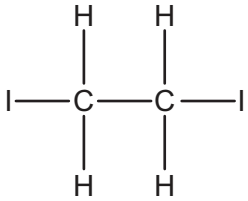
iii. Hydroxide ions are able to move freely through the polymer membrane. 1 mark

Question 3 (11 marks)

a. **i.** When shaken with a sample of ethane gas, the coloured iodine solution would remain coloured. 1 mark

When shaken with a sample of ethene gas, the coloured iodine solution would become colourless. 1 mark

ii.



1 mark

IUPAC name: 1,2-diiodoethane 1 mark

b. **i.** The unsaturated oil is a non-polar liquid that does not mix with water, or substances dissolved in water, because water is a polar solvent. In order for the iodine to react fully with the oil, ethanol was used as the solvent because the oil can dissolve in ethanol. 1 mark

ii. $n(\text{oil}) = \dfrac{m}{M} = \dfrac{1.109}{900.0} = 1.232 \times 10^{-3}$ mol 1 mark

$n(I_2) = cV = 0.382 \times 0.01950 = 7.449 \times 10^{-3}$ mol 1 mark

$n(\text{oil}) : n(I_2) = 1 : 6.05$, so there are six carbon-to-carbon double bonds in one molecule of the oil. 1 mark

c. Reacting an unsaturated oil with hydrogen gas converts all the carbon-to-carbon double bonds in the oil to single bonds. 1 mark

The double bonds in the oil's hydrocarbon chains prevent the chains from packing closely together, meaning that the dispersion forces between the chains are weaker. This results in the oil being a liquid as the dispersion forces are easily disrupted at room temperature. 1 mark

Once the double bonds are converted to single bonds, the chains can pack closer together and the dispersion forces are stronger. This results in a solid compound, as the dispersion forces require temperatures higher than room temperature in order to be disrupted. 1 mark

Question 4 (9 marks)

a. **i.** molecular ion peak *(The molecular ion peak is the significant peak with the highest mass-to-charge ratio (m/z value) in the spectrum. It results from the molecule carrying a single positive charge, and so the molar mass is this m/z value in grams per mole.)* 1 mark

ii. It is likely that a very small peak would appear with a slightly higher m/z value than the molecular ion peak *(as a small number of the carbon atoms are ^{13}C rather than the usual ^{12}C)*. 1 mark

b. There are three different carbon environments. 1 mark

c. *Any three of:*

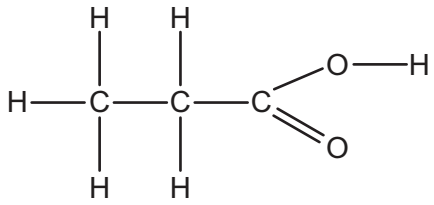
- There are three different hydrogen environments.
- The hydrogen atoms are in the ratio 3 : 2 : 1.
- There are six hydrogen atoms or a multiple of six hydrogen atoms per molecule.
- On adjacent carbon atoms, there must be:
  - 2 protons for the triplet at 1.2 ppm
  - 3 protons for the quartet at 2.4 ppm
  - 0 protons for the singlet at 11.8 ppm.

3 marks
1 mark for each feature identified.

d. **i.** O–H *(acid)* 1 mark

ii. C=O *(acid)* 1 mark

e.



1 mark

Question 5 (8 marks)

a. substitution 1 mark

b. HCl 1 mark

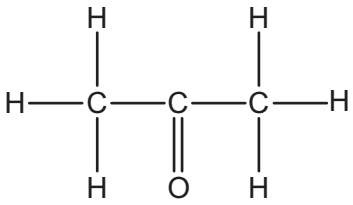
c. **i.**

1 mark

ii. CH_3CHCH_2 1 mark

iii. 2-chloropropane 1 mark

iv.



1 mark

d. *Any one of:*

- reaction I 1 mark
  As well as the main organic product *(2-chloropropane)*, reaction I produces the non-organic product HCl, and so the reaction's atom economy is less than 100%. 1 mark
- reaction III 1 mark
  As well as the main organic product *(propan-2-ol)*, reaction III produces the non-organic product Cl^-, and so the reaction's atom economy is less than 100%. 1 mark

Question 6 (12 marks)

a. **i.** $V^{2+}(aq) \rightarrow V^{3+}(aq) + e^-$ 1 mark

ii. electrode Q 1 mark

During discharge, electrode P is the negative electrode *(anode)*, where oxidation occurs. Therefore, electrode Q is the positive electrode *(cathode)*, where reduction occurs. 1 mark

iii. $E^0_{cell} = +1.004 - (-0.255) = 1.259$ V 1 mark

iv. The electrochemical series can be used to predict cell voltage under standard laboratory conditions (SLC). 1 mark

If the cell's operating conditions vary from SLC, then the cell will not produce the predicted voltage. 1 mark

b. **i.** photovoltaic cells **OR** a wind turbine attached to a generator 1 mark

ii. $VO^{2+}(aq) + H_2O(l) \rightarrow VO_2^+(aq) + 2H^+(aq) + e^-$ 1 mark

iii. The forward reaction of the battery is a spontaneous redox reaction that produces electrical energy at a certain voltage. 1 mark

Using the same voltage for recharge would only prevent the forward reaction from occurring, and so a greater voltage must be used to cause the spontaneous forward reaction to reverse. 1 mark

c. The vanadium redox battery is a secondary cell because it can be recharged with the application of electrical energy from a power source. 1 mark

It is also a fuel cell because the reactants are continuously fed to the electrodes where spontaneous reactions occur to produce electrical energy. 1 mark

Question 7 (8 marks)

a. **i.** The diethyl ether molecule has some polarity around the oxygen atom but is mostly non-polar. So, the intermolecular forces between the molecules can be disrupted by low temperatures, resulting in a low boiling point. 1 mark

The hydroxyl group in butan-1-ol enables hydrogen bonding to occur between molecules. High temperatures are required to disrupt this hydrogen bonding, resulting in a higher boiling point. 1 mark

ii. The ether molecules are slightly polar, and so they are not strongly attracted to each other, resulting in a liquid of lower density that can float on top of a higher density solution. 1 mark

Water molecules in the aqueous layer are smaller than the ether molecules and are attracted to each other by hydrogen bonding. This means that the water molecules are arranged more closely, resulting in a liquid that has a higher density than the ether liquid. 1 mark

iii. Since the diethyl ether is being used in separation, it must be removed so that a pure compound can be isolated. Its low boiling point means that it can evaporate quickly. 1 mark

b. HCl reacts with the amino functional group in compound A to form an NH_3 group that has a full positive charge. 1 mark

The highly polar water molecules surround this charged group and form ion–dipole interactions, meaning that the compound is much more soluble in water. 1 mark

c. Distillation relies on the components of a mixture having different boiling points due to their different structures and levels of attraction between their molecules and the molecules of other components. 1 mark

Question 8 (13 marks)

a. **i.** $q = (9.4 \times 37) + (74.1 \times 16) + (8.9 \times 17)$ 1 mark

$= 1684.7$

$= 1685\ \text{kJ}$ 1 mark

ii. The energy content from **part a.i.** used values for fat, carbohydrate and protein, and it was assumed that these were the only components of the biscuit that release energy. 1 mark

Other components, such as dietary fibre, could release energy when a sample of the biscuit is combusted in a calorimeter. 1 mark

b. **i.** $q(\text{to heat the water}) = mc\Delta t$

$= 100 \times 4.18 \times 28.4$ 1 mark

$= 11871.2\ \text{J}$

$= 11.9\ \text{kJ}$ 1 mark

Note: This energy is assumed to be the energy released from burning the biscuit.

ii. $q(\text{per 100 g of biscuit}) = \dfrac{11.9}{3.48 - 1.29} \times 100 = 543\ \text{kJ}$ 1 mark

The calculated energy content per 100 g based on the student's results is significantly lower than the published value. 1 mark

The discrepancy is most likely due to the loss of heat energy to the equipment and the surrounding environment *(as the experiment's method relies on all of the heat released by burning the biscuit being transferred to the water)*. 1 mark

Note: Consequential on answer to ***Question 8b.i.***

c. **i.** *For example, any two of:*

- the mass of water in the metal can
- the size of the metal can
- the distance between the biscuit and the metal can
- the physical state of the biscuit

2 marks

1 mark for each controlled variable identified.

ii. Crushing the biscuit into a powder would increase the surface area of the biscuit. This would increase the rate of the combustion reaction. 1 mark

However, this would not affect the calculated amount of energy released because the mass of biscuit burned, not the physical state of the biscuit, affects how much energy is released. 1 mark

Question 9 (7 marks)

a. *For example, the following similarities:*

- Both catalysts catalyse reactions by providing an alternative pathway that has a lower activation energy.
- Both catalysts remain unchanged after the catalysed reaction is complete.

For example, the following differences:

- The biological catalyst denatures due to the high temperatures required for the process, whereas the inorganic catalyst is not affected by high temperatures.
- The biological catalyst would increase the reaction rate significantly more than the inorganic catalyst.

4 marks
1 mark for each similarity identified.
1 mark for each difference identified.

b. *For example:*

The reactant H_2 could be obtained from the electrolysis of water using a renewable electricity supply such as solar-generated electricity. 1 mark

As methane largely comes from fossil fuels, it is non-renewable 1 mark
and so replacing it with a renewable source would improve the production method's sustainability. 1 mark

