Neap:

Trial Examination 2018

VCE Chemistry Units 3&4

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

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

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Question 1 **B**

The renewable resources are:

A – methane gas generated in a digester

B – none

C – biofuels

D – biogas, bioethanol, diesel composed of methyl esters

Question 2 **D**

$n(C_6H_6) = \frac{m}{M} = \frac{100.0}{78.0}$ mol

$n(C_6H_5OH) = n(C_6H_6)$

$m(C_6H_5OH) = n \times M = \frac{100.0}{78.0} \times 94.0 = 120.5$ g

$\%\text{ yield} = \frac{111.0}{120.5} \times 100 = 92.1\%$

Question 3 **A**

$$\%\text{ atom economy} = \frac{M(\text{desired product})}{M(\text{all reactants})} \times 100 = \frac{94.0}{78.0 + 98.1 + (40.0 \times 2)} \times 100 = 36.7\%$$

Question 4 **A**

Bromothymol blue changes colour in the pH range 6.0–7.6. This colour change will occur before the equivalence point is reached, resulting in a titre (volume of NaOH) which is less than the true value. The methanoic acid will therefore appear to be less concentrated than it is. **C** and **D** are incorrect. Use of an incorrect indicator is a systematic error. The error in the experiment will always result in an underestimate of the concentration, and will not be corrected by repetition and averaging of values.

Question 5 **D**

Each of the stated properties depends on the strength of intermolecular forces and, as the relative molecular mass increases, the strength of these forces increases. Thus, none of the properties will decrease.

Question 6 **C**

A homologous series is a group of related compounds (not only hydrocarbons) with each successive member differing in the chemical formula by a $–CH_2$ entity. **A** and **B** are incorrect. Complete combustion of the fuel would produce carbon dioxide, not carbon monoxide. **D** is also incorrect. A fuel stores a large amount of energy which can be released in a relatively simple way. **C** is correct.

Question 7 **B**

Oxidative rancidity involves the C=C bonds in unsaturated fats being attacked by atmospheric oxygen, which results in the production of compounds with unpleasant aromas. **B** is the correct answer and **D** is incorrect. **A** is incorrect as antioxidants will decrease oxidative rancidity. Coenzymes are not antioxidants, even though some vitamins are precursors of coenzymes and some vitamins can act as antioxidants. **C** is incorrect.

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Question 8 C

The line after the reactants were mixed to produce the maximum temperature follows a downward trend and shows that heat was lost to the surroundings. Therefore **A** is a correct statement. The temperature rises after the reactants are mixed and so this is an exothermic reaction which has a negative enthalpy change. **B** is a correct statement. The graph should continue a downward trend after 4.0 minutes as more heat is lost. It will not plateau. **C** is incorrect and so is the required answer. The temperature taken before $t = 0$ minutes indicates that the reactants were at 18.0°C. **D** is a correct statement.

Question 9 D

With the same number of carbon atoms per molecule, each of the alcohols will have identical empirical formulas and identical molecular formulas. **A** and **B** are incorrect. The primary alcohol can be partially oxidised to produce an aldehyde, and complete oxidation of the secondary alcohol yields a ketone. The tertiary alcohol is not oxidised. **C** is not correct. There are structural differences between the three alcohols. For the carbon atom which is bonded to the hydroxyl group, only one other carbon atom is attached in primary alcohols, while in secondary alcohols only two other carbon atoms are attached. In tertiary alcohols three other carbon atoms are attached. Thus **D** is the correct answer.

Question 10 A

Amylopectin is a component of starch which is hydrolysed to produce glucose. **A** is correct. Cellulose is not hydrolysed in the human body as the enzymes required for the reaction are not present. **B** is incorrect. Cysteine is an amino acid. **C** is incorrect. Amylase is an enzyme – a protein which is hydrolysed to amino acids. **D** is incorrect.

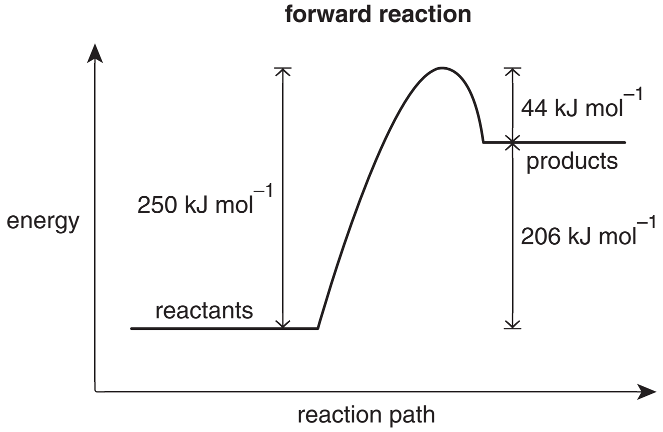
Question 11 B

Aspartame is used as an alternative sweetener to sucrose. Even though both compounds contain approximately the same amount of energy per gram, aspartame is about 200 times sweeter than sucrose. Thus, less mass of aspartame is used to achieve the same level of sweetness and fewer kilojoules are consumed.

Question 12 C

Both the enthalpy change and activation energy for a particular reaction are not altered by a temperature change. It is an endothermic reaction and so lowering the temperature to 800°C will move the equilibrium in the reverse direction as the change will be partially opposed by producing some heat. The value of K_c is decreased when the temperature is lowered.

Question 13 A



Question 14 C

CO bonds to the haemoglobin, which usually carries oxygen to the tissues for respiration. The enzymes are not denatured, but insufficient oxygen is delivered to cells for respiration. **C** is the required answer**.**

Question 15 C

If a gas was added or removed, there would be a sudden change in the amount of gas. This is not evident in the graphs and so **A** and **B** are incorrect. A change in temperature for a system at equilibrium will favour one side of the reaction and there will be gradual changes in the amounts of gas until a new equilibrium is reached. This is evident from the graphs and so **C** is the correct answer. **D** is incorrect as a catalyst will not change the position of equilibrium because a catalyst affects the forward and reverse reactions equally.

Question 16 B

Changing the temperature will alter the value of K_c. So there are two time sequences in which equilibrium has been established, and each will have a different K_c value. (Alternatively, the equilibrium constants could be calculated from the data in the graphs because the amounts of gas can be used in the equilibrium expression instead of concentrations. Letting V = volume of the vessel results in this pronumeral being cancelled out in the equilibrium expression which uses concentration values.)

Question 17 D

None of the graphs would rise instantaneously as the number of mole of gas does not change when the volume is halved. I and II are incorrect. III is incorrect as the temperature has not changed and so the value of K_c would remain the same. All possibilities are incorrect, so **D** is the required response.

Question 18 A

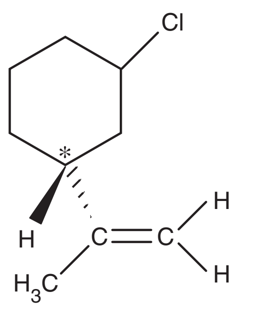
In the induced fit model of enzyme action, the active site changes shape in order to more exactly fit the structure of the substrate. In the lock-and-key model, the active site is unchanged. The formation of two organic products from one substrate molecule is likely to be a hydrolysis reaction.

Question 19 C

Low or high pH can alter the structure of the side groups in the amino acid residues by protonation or deprotonation, and so can change the tertiary structure of a protein. The active site is due to the secondary and tertiary structure of the protein and thus could be affected. Similarly, high temperatures can disrupt the bonding which is responsible for the structure of the active site. Low temperatures are unlikely to alter any of the bonding involved.

Question 20 A

Optical isomerism is possible as the molecule has a chiral carbon, shown with an * in the diagram below. Cis–trans geometric isomerism is not possible as the two H atoms are on the same carbon of the double bond. **A** is the required response.



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Question 21 D

energy = $mc\Delta T = 25.0 \times 4.18 \times 14.2 = 1483 = 1.48 \times 10^3$ J

Question 22 C

energy in 0.238 g of peanuts = $23.1 \times 1000 \times 0.238 = 5497$ J

calibration factor = $\frac{5497}{6.35} = 865.7$ J °C^{-1}

Question 23 D

Crushing the peanuts allows the combustion reaction to occur much more quickly, but the large discrepancy is not caused by using a whole peanut. **A** is incorrect. The peanuts which were used in both methods are representative samples of the substance, and using different peanuts should not be a main cause of the discrepancy. **B** is also incorrect. The discrepancy was noted for the value of energy per gram of peanuts and so using a greater mass of peanuts in method 2 is not relevant. **C** is incorrect. Method 1 suffered significant heat losses, but would have given a more accurate result if the equipment had been calibrated by burning a set mass of a substance with a known heat content and comparing the actual and theoretical temperature rises. **D** is the required answer.

Question 24 B

In both of the fatty acids the carbon atoms which are adjacent to the C=C bonds are on the same side, and so all of these double bonds are in the cis configuration and not the trans configuration. **B** is correct. To be an omega-6 fatty acid, a double bond must be present on the sixth carbon atom counting from the end of the molecule which is opposite to the –COOH end. Fatty acid P has a double bond on the fifth carbon from the appropriate end. **A** is incorrect. The presence of C=C bonds prevents the hydrocarbon chains from packing tightly and so the dispersion forces are weaker. As the chains lengths are identical but fatty acid Q has fewer C=C bonds, its dispersion forces would be stronger and so would require more energy to disrupt, resulting in a higher melting temperature. **C** is incorrect. Both fatty acids could react with methanol to produce biodiesel. **D** is incorrect.

Question 25 A

Cu^{2+} ions are stronger oxidising agents than Sn^{2+} ions and so flask 1 contains the stronger oxidising agent and stronger reducing agent (Sn); therefore a reaction is predicted. Ag^+ ions are stronger oxidising agents than Cd^{2+} ions and so flask 2 contains the stronger oxidising agent and stronger reducing agent (Cd); therefore a reaction is predicted. Fe^{3+} ions are weaker oxidising agents than Cl_2. Flask 3 contains the weaker oxidising agent and weaker reducing agent (Cl^-); therefore no reaction is predicted.

Question 26 D

The state of the iodine should not make a large difference in predictions, provided that iodine molecules were available for reaction. **A** is incorrect. There is a difference of 0.20 V (+0.54 – (+0.34)) in the $E°$ values for the two half-reactions. An exothermic reaction ($\Delta H < 0$) is predicted to occur as the stronger oxidant (I_2) is mixed with the stronger reductant (Cu). **B** is also incorrect. The alloy of copper is still a source of copper atoms which should react with iodine according to the electrochemical series. **C** is incorrect. The electrochemical series does not predict the rate of reactions and so it is most likely that the predicted reaction is slow. Hence no reaction was evident in a short period of time. **D** is the required answer.

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Question 27 B

A fuel readily releases a large amount of energy in an exothermic reaction. Diagram 1 releases a small amount of energy using a large activation energy. Diagram 2 releases a large amount of energy using a small activation energy and so is most likely to be the energy profile for a fuel. Diagram 3 is an endothermic reaction. Diagram 4 releases a small amount of energy for a small activation energy.

Question 28 B

The activation energy of the forward reaction is shown by the height difference between the horizontal line on the left of the diagram and the peak. The magnitude of the enthalpy change of the reverse reaction is shown by the height difference between the horizontal lines. Only in diagrams 1 and 3 is the activation energy for the forward reaction greater than the magnitude of the enthalpy change for the reverse reaction.

Question 29 A

Vitamin D can be manufactured in the body but is not a protein or an enzyme with an active site. **B** and **C** are incorrect. A cursory inspection of the structures of vitamins D and C in the Data Booklet shows that the compounds have some functional groups in common, but not all are the same. **D** is incorrect. Vitamin D will dissolve in oil because it is mostly non-polar. The single hydroxyl functional group in a large, non-polar compound does not enable sufficient interaction with water molecules for the compound to dissolve in water. **A** is correct and is the required answer

Question 30 B

The molecule contains one C=C bond and so the $n(Br_2)$ which would react is 0.150 mol.

$m(Br_2) = n \times M = 0.150 \times (2 \times 79.9) = 23.97$ g

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SECTION B

Question 1 (13 marks)

a. **i.** plant material — 1 mark

ii. glycosidic (or ether) linkage — 1 mark

b. **i.** Hydrogen bonding is responsible for the secondary structure and partly responsible for the tertiary structure of the enzyme. Ethanol can form hydrogen bonds with the atoms in the enzyme which are hydrogen-bonded normally. — 1 mark

The active site in the enzyme, which is configured by the secondary and tertiary structure, is disrupted by ethanol and catalysis stops. Hence the fermentation reaction effectively stops. — 1 mark

ii. $n(CO_2) = \frac{V}{V_M} = \frac{75.9}{24.8} = 3.060$ mol — 1 mark

$n(\text{glucose}) = \frac{1}{2} \times n(CO_2) = 1.530$ mol — 1 mark

$m(\text{glucose}) = n \times M = 1.530 \times 180 = 275.4 = 275$ g — 1 mark

c. **i.** $C_2H_4(g) + HCl(g) \rightarrow C_2H_5Cl(g)$ — 1 mark

ii. $n(C_2H_5Cl) = \frac{m}{M} = \frac{150.0}{64.5} = 2.326$ mol — 1 mark

$n(O_2) = \frac{m}{M} = \frac{250.0}{32.0} = 7.813$ mol

$3 \times 2.326 = 6.978$ mol < 7.813 mol, hence oxygen is in excess. — 1 mark

1 mol of C_2H_5Cl releases 1430 kJ.

2.326 mol releases $2.326 \times 1430 = 3326 = 3.33 \times 10^3$ kJ — 1 mark

d. Crude oil is a finite resource which was formed over many millions of years, and so any process using crude oil is not viable long-term because it will not be replaced in the short-term. — 1 mark

Cellulose is found in plant material which can be regrown in a short time span, and so the process of generating ethene from cellulose is viable long-term. — 1 mark

Question 2 (7 marks)

a. **i.**

	$4NH_3$	$5O_2$	$4NO$	$6H_2O$
n initially	**0.300**	**0.400**	**0**	**0**
change	–0.200	$-\frac{5}{4} \times 0.200$	+0.200	$+\frac{6}{4} \times 0.200$
n equilibrium	0.100	0.150	**0.200**	0.300
equil. conc. = $\frac{n}{V}$	0.0500	0.075	0.100	0.150

3 marks

1 mark each for correct mol of NH_3, O_2 and H_2O.

ii. $K_c = \dfrac{[NO]^4[H_2O]^6}{[NH_3]^4[O_2]^5}$ 1 mark

$= \dfrac{(0.100)^4 \times (0.150)^6}{(0.050)^4 \times (0.075)^5}$

$= 76.8$ M 1 mark

b.

Change	**Quantity**	**Effect of change on the quantity**		
		Increase	**No difference**	**Decrease**
1. Add NO(g).	K_c		✓	
2. Increase pressure by adding an inert gas.	pressure of O_2 in container		✓	

2 marks

(*The value of K is only changed by a change in temperature. An inert gas changes the total pressure in the container but does not change the partial pressure or concentration of each component in the equilibrium mixture. Thus the system does not respond as it would if the total pressure was changed by decreasing the volume of the container, in which case it would favour the side of the equation which has fewer mole of gas.*)

Question 3 (12 marks)

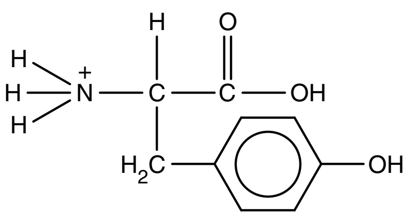
a.

Level of protein structure	**Description**
primary	the number, sequence and type of amino acids bonded by peptide linkages in the polypeptide chains, shown as the thick dark lines in the structure of insulin
tertiary	the interaction between the side groups producing the overall three-dimensional structure of the protein; this results from a range of weak and strong types of bonding, such as the disulfide bond in insulin between amino acid residues within one of the polypeptide chains
quaternary	the complex structure of a protein where two or more polypeptide chains are linked, such as the two polypeptide chains in insulin joined by the two disulfide bonds between them

3 marks

1 mark for each correctly filled row.

b.



2 marks

1 mark for correct amino acid.

1 mark for correct protonation of NH_2.

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c. The digestive system contains enzymes which cause hydrolysis of proteins. 1 mark

As insulin is a protein, it would be hydrolysed and could not produce the desired effect on blood sugar levels. 1 mark

d. **i.** As each of the insulin molecules has a different retention time, the structure of each must be different. 1 mark

ii. The areas of the peaks are proportional to the concentration of each compound in the mixture. 1 mark

Lowering the temperature of the analysis or the flow rate will have no effect on the concentrations and thus no effect on the area of the peak. 1 mark

iii. 1750 units corresponds to 17.5×10^{-4} g L^{-1} of insulin. 1 mark

5.0×10^{-4} mL = 5.0×10^{-7} L

mass of insulin present in the sample $= 1.75 \times 10^{-3} \times 5.0 \times 10^{-7}$

$= 8.75 \times 10^{-10}$ g

$= 8.8 \times 10^{-10}$ g 1 mark

Question 4 (10 marks)

a. **i.** $4Al(s) + 3O_2(g) + 6H_2O(l) \rightarrow 4Al(OH)_3(s)$ 1 mark

ii.

Positive electrode	Negative electrode
$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$	

1 mark

iii. Oxygen gas must pass through it in order to be present at the surface of the electrode in contact with the KOH electrolyte for the cell reaction to occur. 1 mark

b. **i.** The product of the cell reaction remains in contact with the electrode. 1 mark

ii. $4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$ 1 mark

c. The reactants in the cell reaction must be in contact with aluminium atoms in the electrode for a reaction to occur. 1 mark

If an impervious layer prevented this, the cell reaction would cease and the efficiency of the cell would be decreased. 1 mark

d. **i.** The cell does not operate at 100% efficiency and some electrical energy is converted to other forms of energy, such as heat. 1 mark

ii. 3 mol of electrons carries $3 \times 96\,500 = 289\,500$ C of charge. 1 mark

energy $= Q \times V = 289\,500 \times 1.3 = 376\,350$ J 1 mark

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Question 5 (13 marks)

a. *For example:*

Check the pH – only ethanoic acid would have a low pH. 1 mark

For the other two, add acidified $KMnO_4$ solution and heat. 1 mark

Butan-1-ol will react to produce butanoic acid, while the ester will not react. 1 mark

b. The mass spectrum of each compound would contain a peak with the largest m/z ratio – this is the molecular ion peak. 1 mark

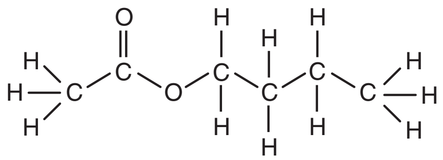
The molecular ion peak indicates the relative molecular mass of each compound. Each compound has a different molecular mass, and so can be distinguished. 1 mark

OR

The fragmentation of the molecules in the mass spectrometer will result in a number of different fragment peaks. 1 mark

These peaks will have different m/z ratios, allowing distinction between the compounds. For example, a fragment at m/z = 43 (CH_3CO) would be found for the ester, but would not be expected for the alcohol. 1 mark

c.



1 mark

d. Both ethanoic acid and butan-1-ol form hydrogen bonds between molecules and these intermolecular bonds require a large amount of energy to disrupt when changing state, resulting in higher boiling points for a given molar mass. 1 mark

As the ester is mostly non-polar, most intermolecular bonding is by dispersion forces. These are weaker than hydrogen bonding and require much less energy to disrupt, and hence a lower boiling point for a given molar mass. 1 mark

e. i. esterification or condensation 1 mark

ii. *For example:*

Heating the reaction mixture would cause evaporation of reactants which would then leave the reaction vessel, decreasing their availability in the equilibrium mixture. The condenser returns reactants to the flask. 1 mark

iii. The components of the reaction could be flammable and, by using a hotplate, no naked flame is present which could ignite any flammable compounds. 1 mark

f. The –OH group of an acid should have a broad band at 2500 to 3500 cm^{-1}, and the –OH group of the alcohol should have a band at 3200 to 3600 cm^{-1}. 1 mark

As neither of these bands are present in the IR spectrum shown, it can be deduced that the sample is not contaminated. 1 mark

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Question 6 (8 marks)

a. $Q = It = 0.627 \times 30.0 \times 60 = 1128$ C

$n(e^-) = \frac{Q}{F} = \frac{1128}{96\ 500} = 0.01169$ mol — 1 mark

$n(V) = \frac{m}{M} = \frac{0.201}{50.9} = 0.003948$ mol — 1 mark

$V^{x+}(aq) + xe^- \rightarrow V(s)$

$x = \frac{0.01169}{0.003948} = 2.960 = 3$ (approx.) and so the ion is V^{3+}. — 1 mark

b. $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$ — 1 mark

Water was oxidised at the anode to produce hydrogen ions, which lowers the pH nearby as the hydrogen ion concentration increases. — 1 mark

c. **i.** Water is a stronger oxidising agent than magnesium ions. — 1 mark

The stronger oxidising agent will be reduced at the cathode preferentially, and so no magnesium will be produced. — 1 mark

ii. Electrolysis of molten magnesium chloride is used. Magnesium is produced by reduction of the magnesium ion at the cathode. — 1 mark

Question 7 (8 marks)

a. **i.** triglyceride (or lipid or fat) — 1 mark

ii. $C_3H_8O_3$ (glycerol) — 1 mark

b. **i.** compound C — 1 mark

(*If only single C–C bonds are in the hydrocarbon tail, there should be 2n + 1 hydrogen atoms for n carbon atoms. For a monounsaturated fatty acid, there should be 2n – 1 hydrogen atoms, and less than 2n – 1 indicates a polyunsaturated fatty acid. Compound C has 2n – 5 and so is polyunsaturated.*)

ii. Compound E is saturated and has the molecular formula $C_{21}H_{42}O_2$.

$2C_{21}H_{42}O_2(l) + 61O_2(g) \rightarrow 42CO_2(g) + 42H_2O(g)$ — 2 marks

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

iii. Most of the molecule is non-polar but the ester linkage is polar. — 1 mark

This region of the molecule can form intermolecular bonds with water molecules from the air and so some moisture is absorbed. — 1 mark

c. $C_{12}H_{26}$ — 1 mark

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Question 8 (7 marks)

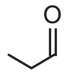
a. $M = \frac{mRT}{pV} = \frac{1.37 \times 8.31 \times 373}{100 \times 0.566} = 75 \text{ g mol}^{-1}$ 1 mark

$M(C_3H_6O_2) = 74$, and the molar mass of the compound is found to be 75. The molecular formula must be the same as the empirical formula; that is, $C_3H_6O_2$. 1 mark

b. **i.** *For example:*

$Cr_2O_7^{2-}/H^+$ or MnO_4^-/H^+ 1 mark

ii. propanal



1 mark

c. *For example, any three of:*

- There are three hydrogen environments.
- The ratio of hydrogen atoms in the molecule is 1 : 2 : 3.
- The triplet at 1.3 ppm shows that the adjacent carbon atom has two equivalent protons attached.
- The quartet at 4.2 shows that the adjacent carbon atom has three equivalent protons attached.
- The singlet at 8.1 ppm shows that the adjacent carbon atom has no proton attached.
- The chemical shifts show the specific proton environments.

3 marks

Question 9 (12 marks)

a. **i.** the time for glucose to be produced 1 mark

(The dependent variable responds to the variable which is deliberately changed by the experimenter.)

ii. temperature of HCl 1 mark

(This is the variable deliberately changed by the experimenter.)

iii. *For example, one of:*

- volume of HCl used
- concentration of HCl used
- mass of starch used

1 mark

b. 90°C 1 mark

(The highest rate of reaction occurs at the temperature which converts starch to glucose in the shortest time.)

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

- uncertainty in the measurement of 25.0 mL of the acid
- inconsistent stirring of the solution may affect sampling
- uncertainty in the measurement of 0.1 mL samples
- temperature may not remain exactly the same throughout each test

2 marks

ii. repeating the experiment and averaging the results 1 mark

d. **i.** Increasing the concentration of the acid will increase the number of reactant particles in a given volume, and so increase the frequency of collisions. 1 mark

With an increased frequency of collisions, the number of successful collisions will increase and thus the rate of reaction increases; that is, time for glucose production decreases. 1 mark

ii. All of the procedures and conditions in the original experiment remain unchanged except for those listed below. 1 mark

The HCl is heated to the same temperature for all four tests; 90°C would be best as it produced results in the shortest time. 1 mark

Instead of using 1.0 M HCl, four different concentrations are used: for example, 1.5 M, 2.0 M, 2.5 M and 3.0 M. 1 mark

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