Neap

Trial Examination 2020

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**

Question 1 D

Combustion reactions are exothermic but there are other types of reactions that are also exothermic. **A** is incorrect. Exothermic reactions occur when the chemical energy of the products is less than the chemical energy of the reactants with no relation to the size of the activation energy nor the rate of reaction. **B** and **C** are incorrect and **D** is the required answer.

Question 2 C

As both fossil fuels and biofuels are used as fuels there must be a high energy content in each type. **C** is the correct answer. Fossil fuels are often simply carbon, or hydrocarbons with a carbon backbone, whereas biofuels can be alcohols, esters and hydrocarbons. **A** and **B** are incorrect. Fossil fuel reserves are finite but biofuels are renewable and so the concept of fuel reserves for biofuels is not relevant. **D** is also incorrect.

Question 3 C

The secondary structure of a protein is due to the interaction between the atoms in the peptide bonds at different points in the polypeptide chain. An oxygen atom in one peptide bond interacts with a hydrogen atom in another peptide bond, and so hydrogen bonds hold the protein in a pleated shape or helical configuration.

Question 4 C

Denaturation occurs when the weaker bonds within the protein are disrupted, usually by heating. **C** is the correct answer. The structure of the protein would be unaffected by lowering the temperature and so **B** is incorrect. The covalent bonds between the amino acid residues can only be broken by harsh treatment or by using enzymes. Denaturation leaves the primary structure of a protein intact. **A** and **D** are incorrect.

Question 5 A

Each of the fatty acids has 17 carbons in the hydrocarbon chain. The level of attraction between individual molecules influences the melting points. Linolenic acid has the highest number of C=C bonds of any of the fatty acids and so these hydrocarbon chains would not be as closely packed as fatty acids with fewer double bonds. Thus, the intensity of the dispersion forces is less and so they would be disrupted at lower temperatures.

Question 6 A

The reactants methanol and oxygen in the air must be able to come into contact with the polymer membrane, and so the electrodes must be porous and must allow electrons to flow through them. **A** is the required answer and **B** is incorrect. Usually the electrodes will be catalytic as methanol will not react with oxygen unless the activation barrier is overcome. Electrons must be able to flow from the site of production on the electrode to the site of consumption on the other electrode. **C** and **D** are incorrect.

Question 7 A

Oxidation occurs at the anode, the negative electrode in a fuel cell. **B** and **C** are incorrect as they show reduction occurring and the equation in **C** is not balanced. Methanol and oxygen are reactants in the cell. **A** is correct and **D** is incorrect.

Question 8 B

Both types of cell use a spontaneous redox reaction to generate movement of electrons along a conductor. **A** is incorrect. In both cells, oxidation occurs at the anode or negative electrode. **C** and **D** are incorrect. Electrons travel along a conductor that connects the cathode to the anode and the electron movement is towards the cathode. **B** is the required answer.

Question 9 B

Statement I is correct as the overall chemical reaction for both combustion and the cell reaction is identical. Statements II and III are incorrect because heat energy would also be produced in the fuel cell as it is not 100% efficient at generating electricity.

Question 10 A

Step 1 involves freeing the fatty acids bound to glycerol in the triglycerides in canola oil. This is a hydrolysis reaction as water is a reactant.

Question 11 A

Mixture X would contain free fatty acids and glycerol from the hydrolysis of triglycerides as well as unused KOH. Mixture Y would contain glycerol and methyl esters, but not ethyl esters (as methanol has been used as a reactant) and not a high level of free fatty acids, assuming the esterification reaction in step 2 was efficient.

Question 12 D

The ester linkage in biodiesel contains oxygen, although most of the molecule is a non-polar hydrocarbon chain. Thus biodiesel is not soluble in water as highlighted in the flow chart. **A** and **B** are incorrect. **C** is factually incorrect. Due to the polar nature of the ester bond in biodiesel, the attraction between individual molecules is more intense at lower temperatures and so the viscosity increases markedly. Petrodiesel is less affected because it is non-polar. **D** is correct and is the required answer.

Question 13 B

$n(I_2) = c \times V = 0.0500 \times 0.02450 = 1.225 \times 10^{-3}$ mol

$n(C_6H_8O_6) = n(I_2)$

$m(C_6H_8O_6) = n \times M = 1.225 \times 10^{-3} \times 176 = 0.2156$ g

$$\% \text{ by mass} = \frac{0.2156}{1.286} \times 100 = 16.77\%$$

Question 14 B

$$\text{Energy per gram} = \frac{7.022}{0.152} = 46.2 \text{ kJ g}^{-1}$$, which is the value for liquid kerosene.

In the Data Booklet, the other relevant values are: 49.9 (ethyne), 45.0 (diesel liquid) and 54.0 (natural gas).

Question 15 C

Results for student W are neither precise nor very accurate (there is considerable variation in values and the average is 37.23). **A** is incorrect. The test 3 result for student X is likely to be an error made in the measurements, not a systematic error, as only one value is affected. **B** is incorrect. Results for student Y show precision (the values are close to each other) and accuracy (as the average is 37.50). **C** is the required answer. The results show differences in precision and accuracy. **D** is incorrect.

Question 16 B

A relates to the accuracy of the data and **C** relates to the precision of the data. All measurement is subject to random error, and so **D** is incorrect. A valid experiment tests the effects of one variable (the independent variable) on the quantity being measured (the dependent variable), while keeping all other variables constant. **B** is the required answer.

Question 17 D

Due to the many hydroxyl groups, the compound is likely to be highly soluble in water as hydrogen bonds will form. It will not be soluble in the non-polar hexane as significant intermolecular bonding will not occur. **A** is incorrect. Tertiary alcohols are not oxidised to form carboxylic acids, aldehydes or ketones. **B** is incorrect. Bromine reacts with unsaturated compounds by adding across any C=C bonds present. This compound does not contain C=C bonds and so **C** is incorrect. As the compound contains four oxygen atoms and four carbon atoms, and the mass of an oxygen atom is greater than the mass of a carbon atom, percentage oxygen by mass will be greater than percentage carbon by mass. **D** is the correct response.

Question 18 B

Both cell types use a spontaneous, exothermic reaction to generate electrical energy; however, neither cell achieves a 100% conversion, as some heat will be produced. **B** is correct, while **A** is incorrect. In the secondary cell, products remain in contact with the electrodes, allowing recharging to occur. This is not the case for primary cells. **C** is incorrect. The cathode has a positive charge in both cell types when delivering current. **D** is incorrect.

Question 19 D

$$n(\text{Ag}) = \frac{1.47}{107.9} = 0.01362 \text{ mol}$$

$$n(e^-) = n(\text{Ag})$$

$$t = \frac{n(e^-) \times F}{I} = \frac{0.01362 \times 96\,500}{4.0} = 329 \text{ s}$$

The efficiency is only 80% and so more time will be needed.

$$\text{time needed} = 329 \times \frac{100}{80} = 411 \text{ s}$$

Question 20 A

$$n(e^-) \text{ required for deposition} = n(\text{Ag}) = \frac{1.47}{107.9} = 0.01362 \text{ mol}$$

Each Cr^{3+} ion requires 3 mol of electrons to be discharged and so:

$$n(\text{Cr}) \text{ deposited} = \frac{0.01362}{3} = 4.54 \times 10^{-3} \text{ mol}$$

$$m(\text{Cr}) = 4.54 \times 10^{-3} \times 52.0 = 0.236 \text{ g}$$

Question 21 C

Sodium metal will not be formed in the cell as water is a stronger oxidising agent than sodium ions and so hydrogen gas will be produced at the cathode. Even though water is a stronger reducing agent than chloride ions, there is not much difference in strength. It would be expected that mostly oxygen gas would be produced at the anode, but some chlorine gas is also possible.

Question 22 D

$E = VIt = 5.8 \times 3.4 \times 3.0 \times 60 = 3549.6$ J

$$\text{CF} = \frac{E}{\Delta T} = \frac{3549.6}{0.39} = 9101.5 \text{ J °C}^{-1} = 9.1 \text{ kJ °C}^{-1}$$

Question 23 A

Insufficient oxygen would mean that some glucose was not burnt and so a lower temperature rise would occur. The calculated value of the heat of combustion would be lower and so **A** is the correct answer. As there is less water, the temperature would rise higher and so the experimental value would be higher. **B** is incorrect. A larger mass of glucose would produce a higher temperature rise and so the value would be higher. **C** is also incorrect. The heating coil is not used during the reaction stage of the calorimeter operation. **D** is incorrect.

Question 24 D

The order of the half-reactions in the electrochemical series is as follows:

$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$

$Cd^{2+}(aq) + 2e^- \rightleftharpoons Cd(s)$

The weakest reducing agent is Fe^{2+} and the weakest oxidising agent is Cd^{2+}.

Question 25 D

voltage = +0.77 – (–0.40) = 1.17 V

As Cd is the stronger reducing agent, it is the anode where oxidation occurs and electrons are generated.

Question 26 C

The linkages in both compounds are known as ether or glycosidic, not ester. Thus **C** is incorrect and is the required answer. Glucose is the monomer that is polymerised in condensation reactions to form both glycogen and starch. **A** and **B** are correct. Starch is the storage material in plants, while glycogen serves a similar function in humans. **D** is also correct.

Question 27 B

Both compounds will produce three peaks on their low-resolution spectrum, with peak areas in a 3 : 3 : 2 ratio. The splitting pattern on the high-resolution spectrum of each compound will be a singlet, a triplet and a quartet. **A**, **C** and **D** are incorrect as they will not distinguish between these compounds. The chemical shift for the peaks on each spectrum will differ; for example, the $CH_3OC{=}O$ protons of methyl propanoate produce a peak at around 4 ppm, while the CH_3COO protons of ethyl ethanoate produce a peak at 2.0 ppm. **B** is the required response.

Question 28 B

In both fats and oils, ester linkages bond three fatty acids to the glycerol molecule, and so **A** and **C** are incorrect. The only elements in both fats and oils are carbon, hydrogen and oxygen. **D** is also incorrect. It is the strength of intermolecular forces that are different in fats and oils, and so these compounds differ in their melting temperatures. Oils melt at a lower temperature than fats as their intermolecular forces are weaker and can be disrupted with less heat energy. **B** is the required answer.

Question 29 C

In the lock-and-key model of enzyme action, the active site is quite rigid and does not change shape in order to fit the substrate molecule. **C** is correct and **A** is incorrect**. B** is also incorrect as the number of products generated in an enzyme-catalysed reaction could be one or more than two. The structure of an enzyme is identical before and after it catalyses a chemical reaction and so **D** is incorrect.

Question 30 D

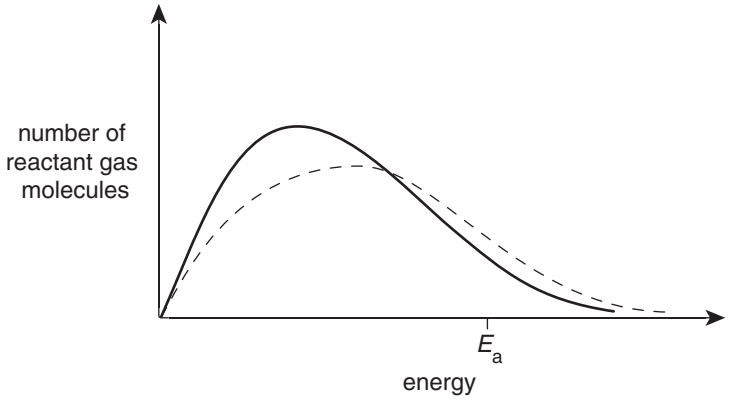
Arachidonic acid has four double bonds per molecule. Thus a mole of the fatty acid requires four moles of H_2 gas (that is, 8 grams) to react fully.

SECTION B

Question 1 (8 marks)

a. the energy that must be provided to break the bonds in the reactants so that a chemical reaction can be initiated 1 mark

b.



1 mark

Note: Mark is awarded for curve flattening out with peak moving to the right.

c. The claim is incorrect. Even though the increased number of collisions does have some impact on the rate of reaction, it is not the major reason for the change in rate. 1 mark

The most substantial reason for the increased rate of reaction is that the number of particles with energies equal to, or greater than, the activation energy has increased, as shown by the increased area under the graph to the right of E_a for the graph drawn in **part b.** 1 mark

Thus the number of successful collisions is increased and so more product particles are formed (in a given time). 1 mark

d. **i.** Spreading the particles thinly increases the surface area of the catalyst and so increases the efficiency of the catalyst. 1 mark

ii. The reaction is exothermic, as evidenced by the increase in exit gas temperatures. The differences between the entry and exit gas temperatures reduces as more products are formed and the reaction proceeds towards equilibrium. 1 mark

With fewer reactant particles available for collision, there will not be as much heat generated with each successive pass of the gas mixture over the catalyst in the tray. 1 mark

Question 2 (12 marks)

a. **i.** A high pressure means that the particles are moving in a smaller volume and so will collide more often. 1 mark

As the frequency of collisions is increased, the number of successful collisions is larger and so the rate of reaction increases. 1 mark

ii. There are five gas reactant particles for every three gas product particles and so, using Le Chatelier's principle (LCP), increasing the pressure will favour the side of the reaction with fewer gas particles in order to partially oppose the increase. 1 mark

When the position of equilibrium moves to the right, the equilibrium yield of the reaction increases. 1 mark

iii. The equipment required to produce, withstand and maintain very high pressures is expensive. An acceptable rate and yield can be achieved at an economically beneficial lower pressure. 1 mark

b. i. Methane gas in biogas produced from animal or plant waste is renewable, as the materials needed for the process are generated in a relatively short period of time (that is, at a faster rate than they are used). 1 mark

The industrial production of methane could be renewable depending on the source of hydrogen gas and given that carbon dioxide gas is plentiful. 1 mark

If the hydrogen gas is generated by electrolysis of water using solar or wind energy for electricity, then it is renewable; however, if the gas is produced from fossil fuels (which have finite reserves), then it is not renewable. 1 mark

ii. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \qquad \Delta H = -890 \text{ kJ mol}^{-1}$ 2 marks

1 mark for correct reactants, products, balancing and state symbols.
1 mark for correct ΔH with correct sign.

iii. Animal waste left in the fields is broken down to products that include methane, which is a very potent greenhouse gas. To reduce the greenhouse effect, it is better to collect the animal waste and use bacterial digestion to generate biogas methane, which is then isolated from the environment. 1 mark

When the biogas is burnt, carbon dioxide and water are released, but these greenhouse gases have a much less potent impact on warming the environment than methane. 1 mark

Question 3 (10 marks)

a. There is no enzyme in the human body that will catalyse the hydrolysis of cellulose. 1 mark

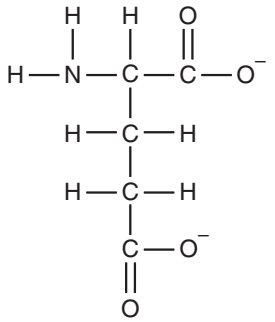
b. In 30 g there is 14.3 – 2.7 = 11.6 g of unsaturated fat (contains C=C bonds). 1 mark

% unsaturated fat = $\frac{11.6}{30} \times 100 = 39\%$ 1 mark

c. In 200 g, there is $200 \times \frac{9.1}{30} = 60.66$ g of protein. 1 mark

energy in protein = 60.66 × 17 = 1031 kJ = 1.0 MJ 1 mark

d. i.



2 marks
1 mark for correct arrangement of atoms and bonds.
1 mark for ionisation of both carboxyl groups.

ii.

Feature of side group	Met	Glu	Val	None of Met, Glu or Val
Forms disulfide bonds with Cys				✓
Non-polar			✓	
Able to form hydrogen bonds with Asn side group		✓		

3 marks
1 mark for each correct tick.

Question 4 (7 marks)

a. $K_c = \dfrac{[C]}{[A][B]}$ 1 mark

$= \dfrac{0.40}{0.10 \times 0.20} = 20\ M^{-1}$ 1 mark

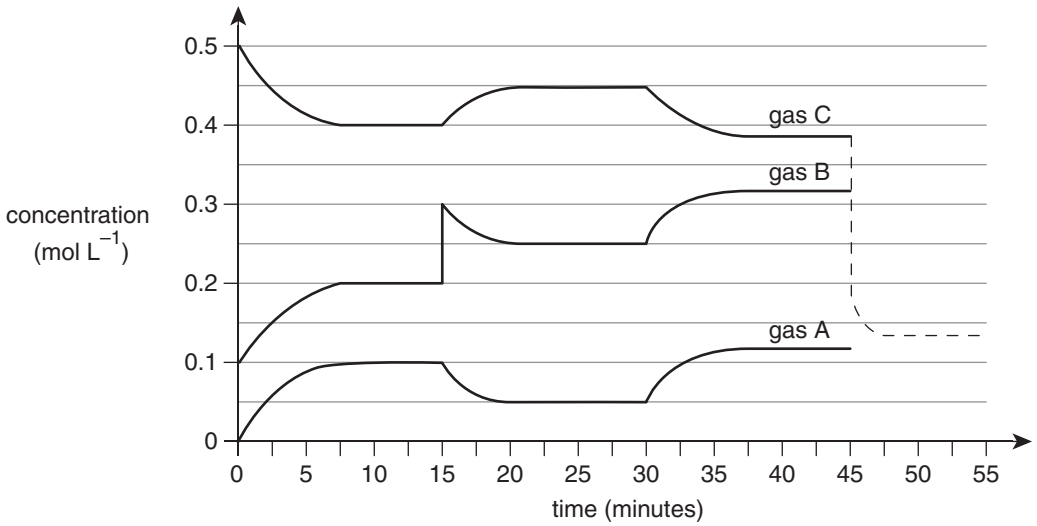
b. At 15 minutes, some gas B was instantaneously introduced into the reaction mixture. By LCP, the system moved to partly oppose the change and so some of gas B was used. Therefore, the concentration fell. 1 mark

As more reactants were used, more product C formed until the system again reached equilibrium at about 19 minutes. 1 mark

c. exothermic 1 mark

(By LCP, the system moved to oppose the change. The addition of heat resulted in a net movement to the reactant side, reducing temperature. As the reverse reaction was temperature-reducing, the forward reaction was temperature-increasing; that is, exothermic.)

d.



(Doubling the volume of the vessel will halve the concentration of all the gases as there is the same number of moles of gas in twice the volume. By LCP the system will respond by moving in the direction of the greater number of moles of gas to oppose the concentration decrease; that is, reactants are favoured and so the concentration of the product, gas C, falls.)

2 marks
1 mark for the concentration of gas C falling vertically to 0.195 M.
1 mark for the concentration continuing to fall smoothly and gradually after the vertical fall until a plateau is formed.

Question 5 (9 marks)

a. **i.** +4 to 0 1 mark

ii. $Zr(s) + 4OH^-(aq) \rightarrow ZrO_2.H_2O(s) + H_2O(l) + 4e^-$

$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

$3H_2O(l) + Zr(s) \rightarrow ZrO_2.H_2O(s) + 2H_2(g)$ 2 marks

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

iii. $n(\text{Zr}) = \dfrac{m}{M} = \dfrac{1.00 \times 10^6}{91.2}$ mol 1 mark

$n(H_2) = 2 \times n(\text{Zr})$ 1 mark

$V(H_2) = \dfrac{nRT}{p} = \dfrac{2 \times 1.00 \times 10^6 \times 8.31 \times 1273}{91.2 \times 101.3} = 2.29 \times 10^6$ L 1 mark

b. **i.** This may also remove silver from the coin, damaging the coin surface. 1 mark

ii. cathode *(as reduction is occurring here)* 1 mark

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

Question 6 (12 marks)

a. $n(C) = n(CO_2) = \frac{V}{V_M} = \frac{30.8}{24.8} = 1.24$ mol 1 mark

$m(H) = m(\text{H in 21.1 g of } H_2O_2) = \frac{2}{34} \times 21.1 = 1.24$ g

$n(H) = \frac{m}{M} = \frac{1.24}{1.0} = 1.24$ mol 1 mark

$m(O) = m(\text{O in 21.1 g of } H_2O_2) = \frac{32}{34} \times 21.1 = 19.86$ g

$n(O) = \frac{m}{M} = \frac{19.86}{16.0} = 1.24$ mol

The empirical formula is CHO. 1 mark

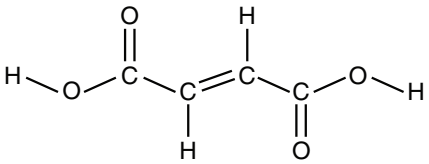
As 0.31 mol of the compound contains 1.24 mol of carbon, then the molecular formula of the compound is $C_4H_4O_4$. 1 mark

b.

Property of the compound	Conclusion
It reacts with HBr in equimolar amounts to produce a single product.	One C=C bond per molecule is present.
At 25°C, a 1 M solution of the compound has a pH between 4 and 7.	An ionisable hydrogen atom is present, probably in a –COOH group.
Two moles of NaOH react with one mole of the compound.	Each molecule contains two –COOH groups.

3 marks
1 mark for each correct conclusion.

c.



2 marks
1 mark for correct arrangement of atoms in ratio of 4 : 4 : 4.
1 mark for inclusion of functional groups.

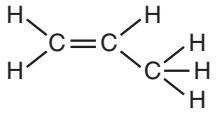
d. 1690 cm^{-1}: Signal due to C=O grouping in carboxylic acids 1 mark

3000 cm^{-1}: Signal due to O–H grouping in carboxylic acids 1 mark

e. There are only two carbon atom environments *(even though there are four carbon atoms per molecule)*. 1 mark

Question 7 (7 marks)

a.

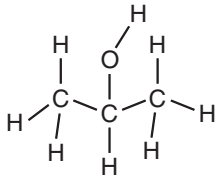


1 mark

b. propane 1 mark

c. $CH_3CHClCH_3$ 1 mark

d.



1 mark

e. ketones 1 mark

f. OH^-(aq) or KOH(aq) 1 mark

g. substitution 1 mark

Question 8 (8 marks)

a. energy needed = $m \times c \times \Delta T = 500 \times 4.18 \times (100 - 20) = 167\ 200$ J = 167.2 kJ 1 mark

As some heat is 'lost', energy required = $\frac{167.2}{0.60} = 278.7$ kJ 1 mark

m(butane) = $\frac{278.7}{49.7} = 5.607 = 5.6$ g 1 mark

b. energy in butane = $49.7 \times 50.0 = 2485$ kJ 1 mark

m(ethanol) = $\frac{2485}{29.6} = 83.95$ g 1 mark

v(ethanol) = $\frac{83.95}{0.785} = 107$ mL 1 mark

c. Butane is mostly extracted from crude oil that is mined with oil rigs. These rigs can affect wildlife and create environmental damage, especially when oil spills and explosions occur. 1 mark

Bioethanol is produced from fermentation of plant products, which is beneficial for the environment if waste products are used, but may affect wildlife and habitats if farmland is used for crop production. 1 mark

Question 9 (8 marks)

a. The carbohydrate compounds are soluble in water due to the presence of many –OH groups on relatively small molecules. 1 mark

A polar mobile phase is therefore suitable to carry the compounds over the non-polar stationary phase so that separation can occur. 1 mark

b. **i.** condensation 1 mark

ii. The compound peaks at 9 to 11 minutes retention time are both monosaccharides, whereas those at 17 to 21 minutes are disaccharides. 1 mark

It appears the compounds are being separated on the basis of molecular size. 1 mark

c. The area under the peak indicates the concentration of the compound, so injecting a larger volume should have no effect on the peak area for glucose. 1 mark

d. In the first analysis of the carbohydrate mixture, lactose has a retention time at about 21 minutes. In the analysis of the food, there is no peak at a retention time of 21 minutes. 1 mark

It can therefore be deduced that this food contains no lactose and so is suitable for people who are lactose-intolerant. 1 mark

Question 10 (9 marks)

a. **i.** volume of oxygen produced in 10 seconds 1 mark

ii. *For example, any two of*:

- temperature of solutions
- concentration of catalase solution
- concentration of hydrogen peroxide solution
- gas-volume measuring equipment
- any other suitable response

2 marks

iii. *For example, any one of:*

- measurement of gas volume
- uncertainty in the timing of 10 seconds
- minor temperature fluctuation

1 mark

b. The interaction of the side groups of the amino acid residues in a protein determines the tertiary structure. 1 mark

The pH of the environment of the protein can alter the groups of atoms in the side groups by removing an ionisable hydrogen or adding a proton to a basic entity. The charge on the side groups can thus be altered, and ionic bonds can be made or destroyed. 1 mark

Changes in the configuration of the protein, and possibly of the active site, as a result of these altered bonds are likely to have occurred with catalase in this experiment, and could account for the changing activity of the enzyme observed (as shown by the changing amounts of oxygen produced at different pH values). 1 mark

c. Each enzyme has an active site into which only one substrate can fit. 1 mark

Even though the molecules of hydrogen peroxide and water are similar, there are sufficient differences to prevent catalase from catalysing the splitting of water molecules into hydrogen and oxygen gases. 1 mark