Quality Assessment Tasks

NAME: _____

VCE® Chemistry

UNITS 3 & 4 Practice Examination

Reading time: 15 minutes **Writing time: 2 hours 30 minutes**

QUESTION AND ANSWER BOOKLET

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	30	30	30
B	10	10	90
		Total	120

- Students are permitted to bring into the examination room: blue or black pens, pencils, highlighters, erasers, sharpeners and ruler. A scientific calculator is allowed.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied

- Question and answer book of 31 pages.
- A Data Book PROVIDED BY YOUR TEACHER.
- Answer sheet for multiple choice questions.

Instructions

- Write your **student name** in the space provided above on this page.
- Check that your **name** is printed on your answer sheet for multiple-choice questions.
- All written responses must be in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions inside the front cover of this book.
- You may keep the data book.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

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SECTION A - Multiple-choice questions

Instructions for Section A
Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.

Question 1

Burning of which of the following fuels produces the least amount of carbon dioxide per unit of energy?

A. Cooking oil

B. natural gas (methane)

C. coal

D. All of these fuels release the same amount of carbon dioxide.

Question 2

How many nitrogen molecules are in a 3.55 L container of nitrogen gas at a pressure of 110.5 kPa and a temperature of 30.0 °C?

A. 3.86×10^{24}

B. 9.47×10^{23}

C. 9.38×10^{22}

D. 4.14×10^{23}

Question 3

Which of the following molecules can form hydrogen bonding?

A. CH_2Cl_2

B. $(CH_3)_2NH$

C. $CH_3CH_2OCH_2CH_3$

D. HCl

Question 4

Consider the following statement and choose the best answer:

1st statement	**2nd statement**
Both $CH_3(CH_2)_3OH$ and $(CH_3)_3OH$ can be oxidized with acidified $K_2Cr_2O_7$(aq).	Both $CH_3(CH_2)_3OH$ and $(CH_3)_3OH$ have the same functional group.

A. Both statements are true and the 2nd statement is a correct explanation of the 1st statement.

B. Both statements are true but the 2nd statement is NOT a correct explanation of the 1st statement.

C. The first statement is incorrect but the 2nd statement is true.

D. Both statements are incorrect.

Question 5

The coefficients for each of the species in the following equation are

$$\_\_Mg(s) + \_\_Fe^{3+}(aq) + \_\_Cl^{-}(aq) \rightarrow \_\_Mg^{2+}(aq) + \_\_Fe(s) + \_\_Cl^{-}(aq)$$

A. 2, 1, 1, 1, 3, 1

B. 1, 1, 1, 2, 2, 2

C. 3, 2, 3, 3, 3, 2

D. 3, 2, 6, 3, 2, 6

Question 6

The thermal decomposition of limestone (calcium carbonate) to lime (calcium oxide) and carbon dioxide is an endothermic reaction requiring 178 kJ mol^{-1}. How many kilojoules of energy is released when 73.0 g of calcium oxide reacts with carbon dioxide?

A. 231 kJ

B. –231 kJ

C. –178 kJ

D. 129 kJ

Question 7

Which of the following statements concerning an acidic hydrogen-oxygen fuel cell is INCORRECT?

A. It converts chemical energy directly to electrical energy.

B. Water is formed during discharge.

C. Oxygen gas is passed to the anode.

D. Hydrogen gas acts as the reducing agent.

Question 8

Hexane and 3-methylpentane are examples of

A. diastereomeres.

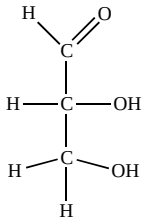
B. structural isomers.

C. stereoisomers.

D. enantiomers.

Question 9

A compound has the following structure:



Which of the following statements concerning this compound is correct?

A. It has a aldehyde functional group.

B. It has 2 chiral centres.

C. It has a keton functional group.

D. It is insoluble in water.

Question 10

One section of a scientific poster or scientific report is the conclusion. What is the purpose of the conclusion in a scientific investigation?

A. To explain the reason for doing the investigation.

B. To state an expected outcome of the investigation.

C. To give sources of information to be used in the investigation.

D. To make a statement which shows whether the data collected supports the hypothesis.

Question 11

Alanine, $CH_3CH(NH_2)COOH$, is an α-amino acid involved in the biosynthesis of many proteins.

X number of molecules of alanine undergo polymerisation to form a polypeptide. M_r (alanine) = 89 and M_r (polypeptide) = 1580. The value of x is

A. 22

B. 20

C. 18

D. 16

Question 12

Which of the following analytical techniques would be most useful to identify and quantify the presence of a known impurity in a drug substance?

A. High performance liquid chromatography.

B. ^{1}H-NMR.

C. Infrared spectroscopy.

D. Mass spectrometry.

Question 13

Sucrose is a natural sugar whereas aspartame is a synthetic artificial sweetener. Which of the following statements is correct?

A. Sucrose and aspartame are both disaccharides.

B. Sucrose and aspartame are both sweeteners but have different functional groups and structure.

C. Sucrose is a disaccharide and aspartame is a polysaccharide.

D. A given mass of aspartame releases more energy than the equivalent amount of sugar.

Question 14

In an electrolytical cell, an electrical current is passed through an aqueous $CuSO_4$ solution and 12.7 g of Cu metal was deposited on a graphite electrode. If the same amount of electrical current is passed through a $AgNO_3$ solution, the amount of Ag that can be deposited on a graphite electrode is closest to

A. 21.6 g

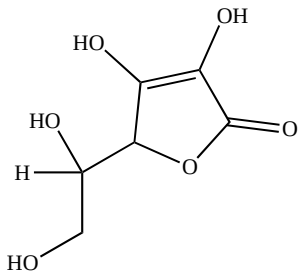
B. 32.4 g

C. 43.2 g

D. 64.8 g

Question 15

The structure of vitamin C is shown on the right.



Which of the following statements is true about vitamin C?

A. Vitamin C is insoluble in water due to its large molecular structure.

B. Vitamin C has an ester functional group.

C. Vitamin C is not a natural antioxidant.

D. Vitamin C has 1 chiral centre.

Question 16

The compound that is not an aromatic compound is

A. phenol, C_6H_5OH

B. cyclohexane, C_6H_{12}

C. benzene, C_6H_6

D. benzoic acid, C_6H_5COOH

Question 17

The product of the oxidation of 3-methyl-butan-2-ol is

A. butan-2-ol

B. 3-methyl-2-butene

C. 3-methyl-2-butanone

D. 2-pentanone

Question 18

Which of the following compounds has an optical isomer?

A. $CH(CH_3)_3$

B. $CH_3(CH_2)_3CH(CH_3)(C_2H_5)$

C. $CH_3CH(OH)_2$

D. $CH_3(CH_2)_2CHCl_2$

Question 19

Rancidity of food is due to

A. hydrogenation of unsaturated fatty acids.

B. reduction of saturated fatty acids.

C. oxidation of unsaturated fatty acids.

D. dehydrogenation of saturated fatty acids.

Question 20

Which of the following reactions below will give a spontaneous reaction?

A. $2PbSO_4(s) + 2H_2O(l) \rightarrow Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq)$

B. $Cu^{2+}(aq) + 2Fe^{2+}(aq) \rightarrow 2Fe^{3+}(aq) + Cu(s)$

C. $2ZnCl_2(aq) + H_2O_2(aq) \rightarrow 2Zn(s) + O_2(g) + 4HCl(aq)$

D. $Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$

Question 21

The condensation reaction between a carboxylic acid and an amine gives a(n)

A. amide

B. carboxylic acid amine

C. anhydride

D. ester

Question 22

Which of the following statements is NOT correct?

A. The bigger the activation energy, the faster the reaction will be.

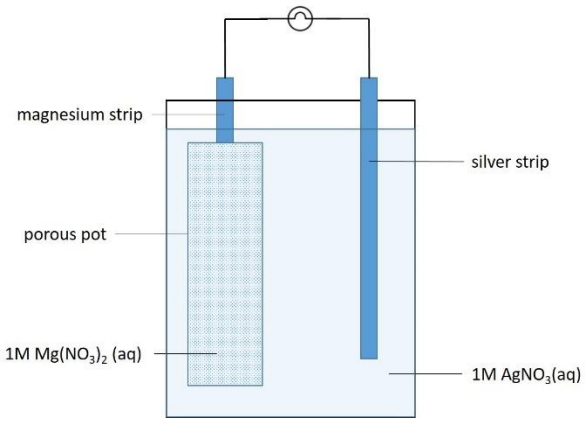
B. The rate of reaction is determined by the slowest reaction step.

C. Catalysts accelerate the rate of reaction.

D. Catalysts do not change the reaction enthalpy.

Question 23

The diagram below shows a set up with the bulb lighting up.



Which of the following statements concerning the set-up is correct?

A. Hydrogen gas is formed at the silver strip.

B. Silver ions migrate towards the porous pot.

C. The mass of the magnesium strip decreases.

D. The mass of the silver strip decreases.

Question 24

The name of the compound on the right is

A. *cis*-3-hexene

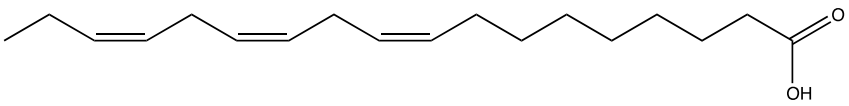
B. *cis*-2-hexene

C. 1-ethyl-1-propene

D. *trans*-3-hexene

Question 25

Omega-3 and omega-6 fatty acids are essential fats which the human body cannot make naturally. They must be obtained from food such as fish, nuts, flax seeds etc. The skeletal structure of one of these fatty



acids is shown below.

Which of the following statement(s) is true for the above fatty acid?

(1) The fatty acid is an omega-3 fatty acid.
(2) It contains a carboxylic acid functional group on the α-carbon.
(3) It is a liquid /oil at room temperature.

A. (1) only

B. (1) and (2) only

C. (1) and (3) only

D. All statements are correct.

Question 26

The equation below below shows the reaction involving four liquids.

$$W(l) + X(l) \rightleftharpoons Y(l) + Z(l) \qquad \Delta H = +54 \text{ kJ mol}^{-1}$$

In an experiment, 1.0 mol of **W**(l) and 1.0 mol of **X**(l) are placed in a closed container at a constant temperature of 25°C. When equilibrium is attained, which of the following would increase the number of moles of **Y**(l)?

(1) Removing **Z**(l) from the reaction mixture.
(2) Increasing the volume of the container.
(3) Increasing the temperature of the reaction mixture.

A. (1) only

B. (2) only

C. (1) and (3) only

D. (2) and (3) only

Question 27

A student used a burette containing 0.1 M sulfuric acid (H_2SO_4), and wanted to use the same burette immediately for a subsequent titration using 0.1 M potassium permanganate solution ($KMnO_4$). To ensure accuracy for these titrations, the students should

A. rinse the burette thoroughly with water and leave it in an oven until completely dry.

B. rinse the burette with 0.1M NaOH to neutralise the acid and then fill with $KMnO_4$.

C. rinse the burette with $KMnO_4$ then with water, then refill with $KMnO_4$.

D. rinse the burette with water then with $KMnO_4$, then refill with $KMnO_4$.

Question 28

The solubility of fatty acids in water

A. increases with increase in chain length and increases with the number of double bonds.

B. increases with increase in chain length and fewer double bonds.

C. decreases with increase in chain length and fewer double bonds.

D. decreases with increase in chain length and increases with the number of double bonds.

Question 29

Which of the following statements about ideal gases is not part of the Kinetic Molecular Theory?

A. Particles in a gas are not stationary.

B. The total volume of gas particles themselves is negligible compared to the volume of the container.

C. The average kinetic energies of different gases are different at the same temperature.

D. The bonding forces between the gas molecules are extremely weak.

Question 30

Barley grain is the main ingredient in single malt whiskey. The starch in the grain is turned into alcohol through the fermentation process.

Three 5.00 g samples of whiskey were acidified and then titrated with 1.70 M potassium dichromate ($K_2Cr_2O_7$) solution in order to determine the amount of ethanol that the whiskey contained. Titres of 20.25 mL, 20.22 mL and 20.27 ml were obtained. The equation for the reaction that occurs during titration is

$$2Cr_2O_7^{2-}(aq) + 3C_2H_5OH(aq) + 16H^+ \rightarrow 4Cr^{3+}(aq) + 3CH_3COOH(aq) + 11H_2O(l)$$

What is the percentage by mass of ethanol in this sample of whiskey based on this results?

A. 47.6 %

B. 2.38 %

C. 21.2 %

D. 23.8 %

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided. Write using a black or blue pen.
To obtain full marks for your responses you should:
- give simplified answers, with an appropriate number of significant figures, to all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answer to numerical questions; no credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that formulas for individual substances include an indication of state; for example, $H_2(g)$; NaCl(s).

Question 1 (5 marks)

A solution containing 3.18 g of barium chloride is added to a second solution containing excess sodium sulfate. A white precipitate of barium sulfate is formed.

a. For the precipitation reaction described, write the net ionic equation. 2 marks

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b. Calculate the theoretical yield in grams of barium sulfate. 2 marks

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c. If the actual yield is 3.37 g, calculate the percentage yield. 1 mark

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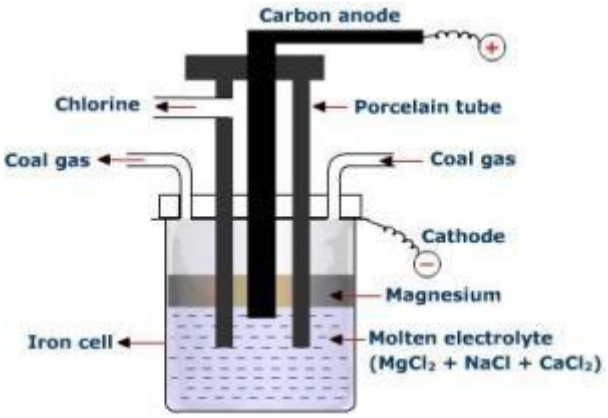
Question 2 (6 marks)

Classify each of the following statements as true or false

	Statement	True / False
a.	The most common secondary protein structures are the α-helix and the β-pleated sheet.	
b.	Sulfur-sulfur covalent bonds called disulfide linkages are important in the tertiary protein structures of many proteins.	
c.	An enzyme substrate is the product of an enzyme-catalysed reaction.	
d.	In a mass spectrum, the most common fragment ion is assigned an abundance of 100, and it is referred to as the molecular ion peak.	
e.	In a generator run by biogas combustion there is a direct energy conversion from chemical to electrical energy.	
f.	A standard solution used for titration is prepared by dissolving an accurately measured mass of a primary standard in an accurately measured volume of water.	

Question 3 (9 marks)

Magnesium can be produced by electrolysis of a molten salt mixture containing the chlorides of magnesium, sodium and calcium. The diagram below shows a typical set up of the electrolytic cell.



a. Why, with reference to the electrochemical series, is the product at the cathode magnesium, rather than sodium or calcium? 1 mark

_____

_____

_____

b. Write a balanced half-equation for the reaction occurring at the cathode. 1 mark

_____

c. Write a balanced half-equation for the reaction occurring at the anode. 1 mark

_____

d. Assuming that there is 100% conversion of electrical to chemical energy, calculate how long it would take to produce 1 tonne of magnesium at an operating voltage of 5V and a current of 30 000 A. 3 marks

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e. Using chemical equations, explain what would be produced at the electrodes if the cell contents were changed to 1 M aqueous solutions of the same salts. 3 marks

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Question 4 (13 marks)

In an experimental investigation of food two students decide to investigate which of the two brands of breakfast cereals from different popular companies has the least amount of fat. They took a 10.0 g sample of each food and measured the heat content by burning the food in a bomb calorimeter in the presence of excess oxygen.

a. A bomb calorimeter was calibrated by the complete combustion of 1 mol of benzoic acid, C_6H_5COOH. The reaction released 3227 kJ of energy. Write the thermochemical equation for the complete combustion of benzoic acid. 2 marks

_____

b. The initial temperature of the water in the calorimeter was 20.00 °C and the final temperature was 36.81°C. Determine the calibration factor (in J $°C^{-1}$) of the bomb calorimeter. 2 marks

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_____

Following the calibration of the calorimeter the students obtained the following results during the burning process:

	Cereal 'X'	**Cereal 'Z'**
Initial temperature (calorimeter + sample)	25.24 °C	23.22 °C
Final temperature	27.43 °C	25.25 °C

c. Calculate the heat energy released per gram of both cereal samples. 2 marks

d. Do the results obtained in c) give enough evidence for the students to conclude which of the cereal sample contains more fat? If not, briefly explain why not. 2 marks

e. The food label of cereal 'X' states that 9.6 g of the total fat content comes from saturated fatty acids. What is the meaning of *saturated* ? 1 mark

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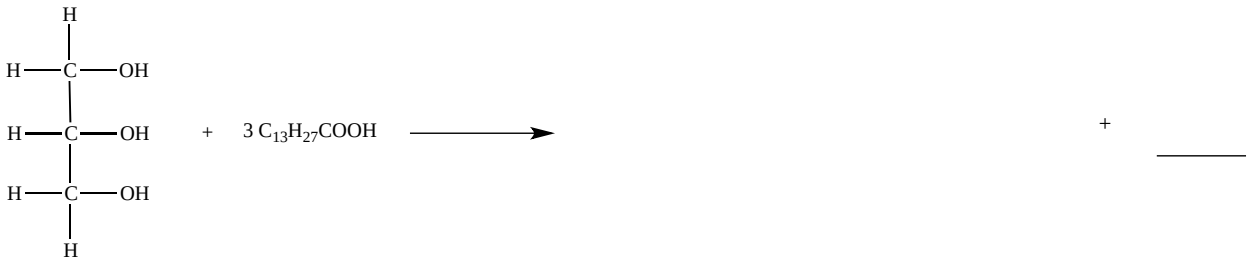
_____

_____

f. **i.** The chemical equation below shows the reaction between glycerol and myristic acid. Complete and balance the equation by drawing the formula of the resulting triglyceride and the by-product formed. 2 marks



glycerol myristic acid triglyceride

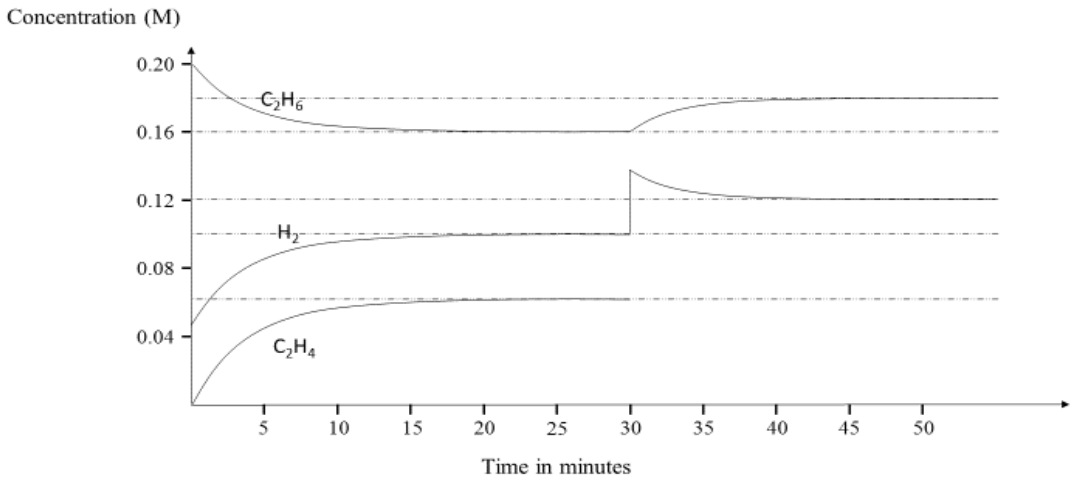
ii. Label and name the functional group in the triglyceride. 1 mark

iii. Name the type of reaction occurring. 1 mark

_____

Question 5 (10 marks)

The diagram below shows the concentration changes during a study of the equilibrium behaviour of a gasous system. The gases involved were ethane (C_2H_6), ethylene (C_2H_4) and hydrogen (H_2) at temperature of 1000°C.



a. Write a balanced chemical equation for the reaction that is occurring between t = 0 and t = 25 minutes. 1 mark

_____

b. Determine the concentrations of each of the gases at t = 25 min. 1 mark

_____

_____

_____

c. Calculate the value of the equilibrium constant for t = 25 min at 1000°C. 2 marks

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_____

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_____

d. What happened at t = 30 minutes? 1 mark

_____

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e. Calculate the final concentration of ethylene at t = 50 minutes and complete the graph for ethylene in the diagram above between t = 30 and t = 50 minutes. 2 marks

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f. What would you expect to happen to the value of the equilibrium constant if a catalyst was used in the above reaction? Give a reason for your answer. 1 mark

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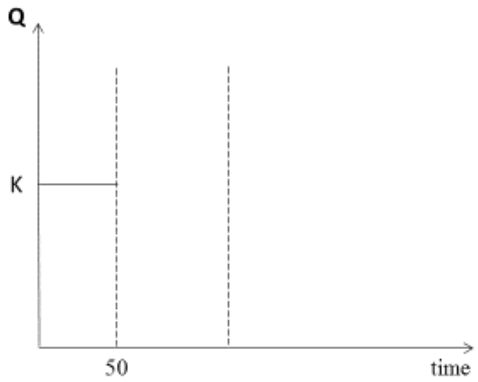
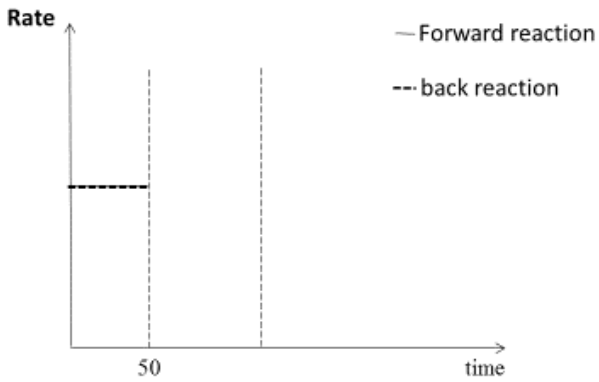
g. Use the diagrams below to plot the changes that occur to **Q** (on Graph 1) and the rate of the forward and back reaction (on Graph 2), when at t = 50 min some ethane gas is added to the equilibrium mixture. 2 marks

Graph 1

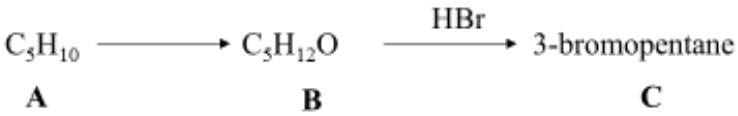


Graph 2



Question 6 (6 marks)

Consider the following reaction pathway:



a. Draw the skeletal structure for **C**. 1 mark

b. **i.** Deduce the skeletal structure of **B**. 1 mark

ii. Name the type of reaction for the conversion of **B** to **C**. 1 mark

_____

c. **i.** Deduce the skeletal structure for **A** and name this compound. 2 marks

ii. State the reagent(s) required for the conversion of **A** to **B**. 1 mark

_____

Question 7 (19 marks)

For reagent bottles each contain one of the following liquids (A – D) listed below:

A: $HOCH_2CH_2CH_2OH$ **C:** $CH_3CO_2CH_3$

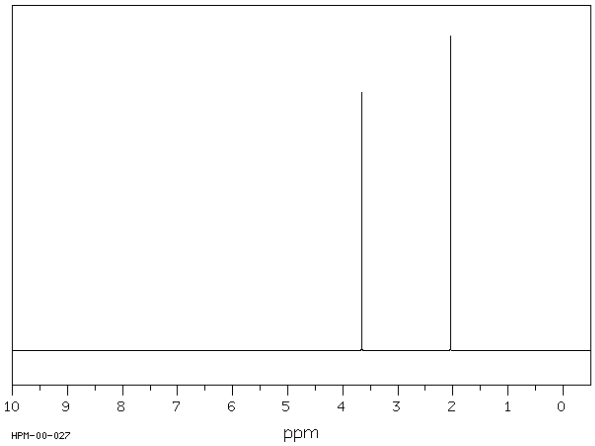
B: $CH_3CH_2CO_2H$ **D:** $CH_2=CHCO_2H$

a. How many signals would be present in the ^{13}C NMR spectrum for each compound? 4 marks

A: _____ **B**: _____

C: _____ **D:** _____

b. The ^{1}H NMR of one of the compounds, A to D, is shown below.



http://www.organicchem.org/oc1web/exp/spectra/spectrades.html

i. Which of the compounds (A – D) will give this ^{1}H NMR spectrum? Explain your choice.

2 marks

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_____

_____

_____

_____

_____

ii. Draw the structural formula for this compound and name it using the IUPAC system. 2 marks

Structure**:**

Name: _____

c. In mass spectrometry, the formed molecular ions are instable and some of them will break up into smaller pieces. Use a chemical equation to show the break up of the molecular ion of compound A leading to a peak at m/z = 31. 2 marks

_____

d. Compound B is able to react with sodium carbonate.

i. Write a balanced chemical equation for this reaction. 2 marks

_____

ii. Name this type of reaction. 1 mark

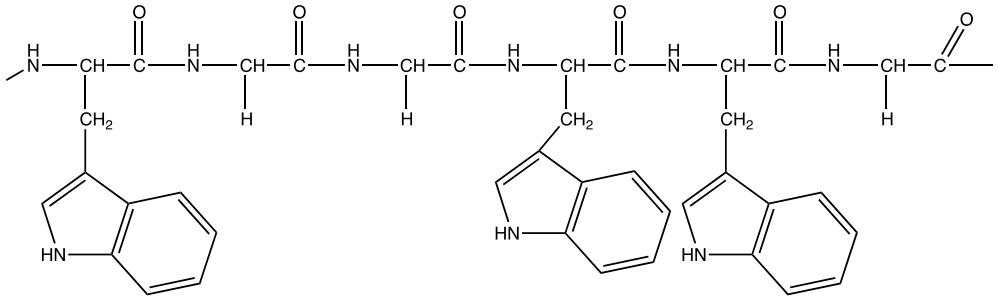
_____

e. Compound D is acrylic acid and can self-polymerise. Draw a section of the polymer formed containing 3 acrylic acid units. 2 marks

f. How can IR spectroscopy be applied to distinguish between the four compounds. Focus in your answer on the different functional groups in each of the compounds. 4 marks

Question 8 (5 marks)

The primary structure of proteins is a long chain of amino acids joined by peptide links. The structure of part of a protein composed of two different amino acids is shown below:



a. In the structure above, circle a peptide link and explain how it is formed. 2 marks

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b. How could this protein be converted into its constituent amino acids? 1 mark

_____

_____

_____

_____

c. Draw the formulas of both amino acids from which the above protein is made and name them.

2 marks

Structure:	Structure:
Name:	Name:

Question 9 (11 marks)

Petrodiesel is produced by fractional distillation of crude oil. It is a mixture of long carbon chains (10 – 28 carbon atoms) and other additives such as aromatic compounds.

a. The complete combustion of petrodiesel is a redox reaction. Assuming petrodiesel is mostly decane use the overall chemical equation shown below to deduce which species is being reduced. Explain your choice. 2 marks

$$C_{10}H_{22}\,(l) + 15.5O_2(g) \rightarrow 10CO_2(g) + 11H_2O(g)$$

_____

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b. What volume of carbon dioxide is produced from the complete combustion of 1.00 kg of decane at 5°C and 100 kPa? 3 marks

_____

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Biodiesel has steadily gained popularity as an alternative fuel source to petrodiesel for motor vehicles. Biodiesel, like petrodiesel, is made from long chain hydrocarbons however it is sourced from renewable plants, vegetable or animal oil. The oil undergoes transesterification where fatty acid molecules are broken off the glycerol. The fatty acid molecules are then reacted with methanol to produce so called methyl esters.

c. Draw the structure of the methylester formed when stearic acid reacts with methanol. 2 marks

_____

d. At the end of the transesterification process the reaction mixture contains glycerol and the biodiesel forming two layers. Referring to the structures of glycerol and the methylester, which of these two compounds will be less dense and floating on top and therefore be able to be separated from the other compound? Explain your choice. 2 marks

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e. Give one advantage and one disadvantage associated with the use of biodiesel as a fuel. 2 marks

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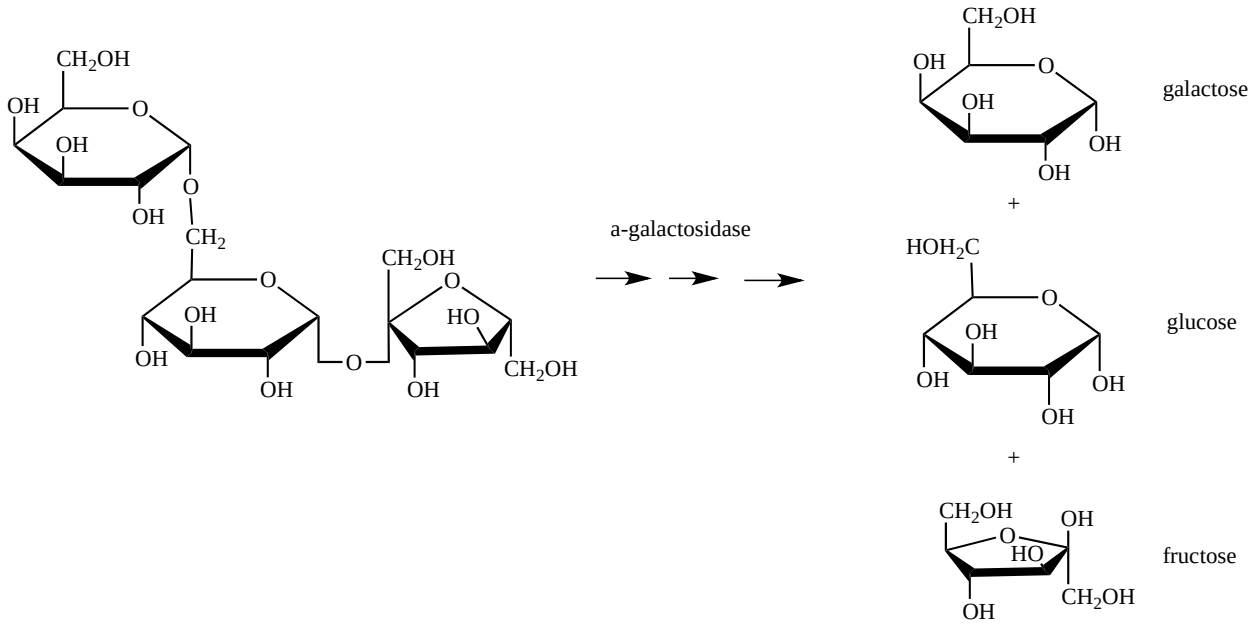
Question 10 (6 marks)

Raffinose is a trisaccharide and is a non-digestible short-chain carbohydrate. It can be found in beans, cabbage, brussel sprouts, green split peas, broccoli, asparagus, and other plants. Two enzymes, α-galactosidase and sucrase, are required to completely break down raffinose into monosaccharides, which then can be easily absorbed into the blood stream. However, the human intestines do not contain these enzymes and the break down of raffinose and other complex sugars is incomplete. Commercial products are available supplying enzymes which when ingested help to catalyse the break up of raffinose (see diagram below) into its monosaccharides, galatose, fructose and glucose.



Two students were investigating the effect of a commercially available enzyme product containing α-galactosidase on the hydrolysis of raffinose in green split peas into its corresponding monosaccharides. The reaction rate of this hydrolysis reaction could be determined by measuring the concentration of glucose over a period of time using a glucometer.

a. What would be their independent; dependent, and controlled variable for this investigation? 3 marks

Independent: _____

Dependent: _____

Controlled: _____

An abstract of the students' method is given below:

Method

1. *25 raw split green peas of about the same size were crushed and placed in a 250 mL beaker.*
2. *Water was added to the beaker until the 200 mL mark was reached and the crushed peas were allowed to soak overnight.*
3. *300 mg of α-galactosidase was placed in a 10.00 mL volumetric flask, water was added to the mark and the flask was shaken to dissolve all the enzyme.*
4. *The liquid from the split pea mixture was distributed into 8 test tubes which were placed in a water bath at 37 degrees for 30 minutes.*
5. *An equal volume of the enzyme solution was poured from the beaker into each test tube and the tubes were left in the water bath for 40 minutes.*
6. *During this 40 minutes 4 test tubes were removed from the water bath and one drop of the solutions were tested for glucose concentration with a glucometer at intervals of 5 minutes.*
7. *Then the other 4 test tubes were removed from the water bath and one drop of the solutions were tested for glucose concentration with a glucometer for the remainder of the 40 minutes*
8. *The following results were obtained:*

Test tube number	Time tested (min)	Concentration of glucose
1	5.0	70
2	10.0	110
3	15	140
4	20	170
5	25	220
6	30	250
7	35	252
8	40	250

b. Before using the glucometer, how will the students determine the accuracy of this device? 1 mark

_____

_____

_____

_____

_____

c. Suggest one change/improvement to the method to improve the accuracy of the investigation.

1 mark

_____

_____

_____

_____

_____

_____

d. Suggest 1 change/improvement to improve reliability of the results obtained in this investigation.

1 mark

_____

_____

_____

_____

_____

Section A: Multiple Choice Answer Sheet

NAME: _____

For each multiple choice question, shade letter of your choice.

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

END OF QUESTION AND ANSWER BOOK

Solution Pathway

Below are sample answers. Please consider the merit of alternative responses.

Note: *Teachers will need to provide the VCAA data booklet, unmarked, for student use during this Exam.*

SECTION A: Multiple Choice Answers

Question 1 Answer: B

Question 2 Answer: C

n = pV / RT = 110.5 x 3.55 / 8.31 x 303 = 0.1558 mol

$N = n \times N_A = 0.1558 \times 6.02 \times 10^{23} = 9.38 \times 10^{22}$ molecules of nitrogen molecules.

Question 3 Answer: B

Question 4 Answer: C

Both $CH_3(CH_2)_3OH$ and $(CH_3)_3OH$ are alcohols, so the 2nd statement is correct. $CH_3(CH_2)_3OH$ is a primary alcohol (1-butanol) and can be oxidised to butanoic acid with acidified $K_2Cr_2O_7$(aq). However, $(CH_3)_3OH$ is a tertiary alcohol and cannot be oxidized with acidified $K_2Cr_2O_7$(aq). Therefore, statement 1 is incorrect.

Question 5 Answer: D

This reaction is a redox reaction. Both half equations are needed to determine the coefficient for each species; the Cl^-(aq) ions are spectator ions.

$Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$ /x3
$Fe^{3+}(aq) + 3e^- \rightarrow Fe(s)$ /x2
Full equation: $3\,Mg(s) + 2Fe^{3+}(aq) + 6Cl^-(aq) \rightarrow 3Mg^{2+}(aq) + 2Fe(s) + 6Cl^-(aq)$

Question 6 Answer: A

73.0 / 56.1 = 1.30 mol 178 kJ x 1.30 mol = 231 kJ
The question asks for energy released and not ΔH. The value has to be positive.

Question 7 Answer: C

Fuels cells convert chemical energy directly into electrical energy, answer A correct. The two half equations are:

Cathode / Reduction: $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$
Anode / Oxidation: $H_2(g) \rightarrow 2H^+(aq)$
Full equation: $O_2(g) + H_2(g) \rightarrow 2H_2O(l)$

Answer B and D are correct as water is produced and hydrogen being oxidised acts as a reducing agent. Reduction happens at cathode and NOT anode, therefore, answer C is incorrect statement.

Question 8 Answer: B

Hexane and 3-methylpentane have the same molecular formula but different chemical structures. Both have NO chiral centre and therefore are no stereoisomers, nor enantiomers nor diastereomeres.

Question 9 Answer: A

The molecule has 2 hydroxy groups and one aldehyde functional group. Only the middle carbon has four different R-groups and therefore has only one chiral centre. Due to its polar functional groups the molecule is soluble in water.

Question 10 Answer: D

Question 11 Answer: D

n monomers alanine forming 1 polymer + (n-1) water
n x (89) = 1580 + (n-1) x 18 = 89n – 18n = 1580 – 18 = 71n = 1562
n = 1562 / 71 = 16

Question 12 Answer: A

Question 13 Answer: B

Both structures are in the data book. Sucrose is a carbohydrate and a disaccharide whilst aspartame has an ester, amide and amine functional group and is therefore not a saccharide. Even so it is metabolised in the human body it releases much less energy than sucrose.

Question 14 Answer: C

$Q = n \times z \times F$ $Q_{Cu} = Q_{Ag}$, therefore $n_{Ag} \times 1 \times 96500 = n_{Cu} \times 2 \times 96500$
$n_{Cu} = 12.7 / 63.55 = 0.1998$ mol
$n_{Ag} = 0.1998 \times 2 / 1 = 0.3997$ mol
$m_{Ag} = 0.3997 \times 107.9 =$ **43.2 g**

Question 15 Answer: B

Vitamin C has several hydroxy functional groups which make it soluble in water (A incorrect). It is a natural antioxidant and has two chiral centres, at adjacent carbon atoms (C, D are incorrect). Vitamin C has an ester functional group (B correct).

Question 16 Answer: B

Question 17 Answer: C

3-methyl-butan-2-ol is a secondary alcohol and is oxidised to a ketone. It will keep its methyl sidechain at the third carbon.

Question 18 Answer: B

Question 19 Answer: C

Question 20 Answer: D

According to the electrochemical series, the reaction between $CuSO_4$ and Fe(s) will be spontaneous as the strongest oxidant reacts with the strongest reductant.

Question 21 Answer: A

Question 22 Answer: A

Question 23 Answer: C

Galvanic cell, oxidation reaction: $Mg \rightarrow Mg^{2+} + 2e^-$, reduction reaction: $Ag^+ + e^- \rightarrow Ag$
negative nitrate ions will migrate to anode (Mg) (ox reaction) and positive ions will migrate to cathode (Ag).

Question 24 Answer: A

Question 25 Answer: D

The fatty acid is an omega-3 fatty acid, which contains a carboxylic acid group at the first carbon (α-carbon) and due to its high degree of unsaturation is an oil at room temperature.

Question 26 Answer: C

Removing a product will favour the forward reaction leading to an increase of mol in Y (1 correct). Increasing the volume of the container will not affect the equilibrium as both sides of the reaction have the same number of particles (2 incorrect). The reaction is an endothermic reaction. An increase of the temperature will add additional energy to the system and therefore the forward reaction is favoured trying to compensate for the increase of heat (3 is correct). Answer C with 1 and 3 correct.

Question 27 Answer: D

Question 28 Answer: C

Fatty acids are partially soluble in water due to the presence of -COOH group, which are able to form hydrogen bonds with the water molecules. The hydrocarbon chain of the fatty acids are completely insoluble in water, therefore with increasing chain length, the fatty acid becomes less soluble.

Question 29 Answer: C

Question 30 Answer: A

SECTION B

Question 1 (5 marks)

a. $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ **(2)**

1 mark for correct reactant and product.
1 mark for states.
1 mark only if correct full equation is given.

b. $n(BaCl_2) = 3.18 / 208.2 = 0.0153$ mol **(1)**
$n(BaCl_2) = n(BaSO_4) = 0.0153$ mol
$m(BaSO_4) = 0.0153 \times 233.4$ g/mol $= 3.57$ g **(1)**

c. *%yield = m(practical) / m(theoretical) x 100% = 3.37 / 3.57 x 100 = 94.4%* **(1)**

Question 2 (6 marks)

a. *True* **d.** *False*
b. *True* **e.** *False*
c. *False* **f.** *True*
½ mark each for correct answer. **(6)**

Question 3 (9 marks)

a. *A.According the electrochemical series, the magnesium ion (Mg^{2+}) is a stronger oxidant */2 than Ca^{2+} and Na^+, and therefore is preferentially reduced */2 over Ca^{2+} and Na^+.*

(1)

b. $Mg^{2+}(l) + 2e^- \rightarrow Mg(l)$ Note no marks if state is (aq) or (s). **(1)**

c. $2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$ Note no marks if state is (aq) or (s). **(1)**

d. *It = n x z x F*

*n(Mg) = 1 x 10^6 g / 24.3gmol^{-1} = 4.12 x 10^4 mol ** **(1)**
*t = 4.12 x 10^4 x 2 x 96 500 / 30000 * = 2.65 x 10^5 seconds =* ***73.5 hours **** **(2)**

e. *<u>At the cathode</u>: water*$^{*/2}$ *would be reduced instead of* Mg^{2+} *because it has a higher* E^0 *value / is a stronger oxidant*$^{*/2}$ *than* Mg^{2+} *and is therefore preferentially reduced*$^{*/2}$ *to hydrogen gas and* $OH^-(aq)$ *ions*

$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ $^{*/2}$ 4 x ½ mark = **(2)**

<u>At the anode</u>: water would be oxidised instead of Cl^- *because it has a lower* E^0 *value / is a stronger reductant*$^{*/2}$ *than* Mg^{2+} *and is therefore preferentially oxidised to oxygen gas and* $H^+(aq)$ *ions*

$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$ $^{*/2}$ 2 x ½ mark = **(1)**

Question 4 (13 marks)

a. $C_6H_5COOH(s) + 7.5O_2(g) \rightarrow 7CO_2(g) + 3H_2O(g)$ $\Delta H = -3227\ kJ\ mol^{-1}$ ***or***

$2C_6H_5COOH(s) + 15O_2(g) \rightarrow 14CO_2(g) + 6H_2O(g)$ $\Delta H = -6454\ kJ\ mol^{-1}$

1 mark for correct balanced equation including states.
1 mark for correct ΔH value. **(2)**

b. $\Delta T = 36.81 - 20.00 = 16.81\ °C\ or\ K$ **(1)**

$CF = E/\Delta T = 3227 / 16.81 = 192.0\ kJ\ K^{-1} = 1.92 \times 10^5\ J\ K^{-1}$ **(1)**

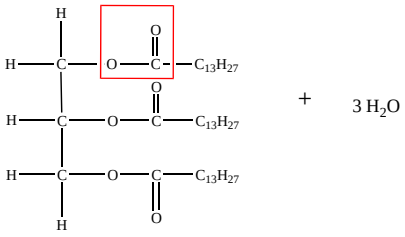
c. *Cereal 'X':* $(27.43 - 25.24) = 2.19\ K \times 1.92 \times 10^5\ J\ K^{-1} / 10 = 42.0\ kJ\ g^{-1}$ **(1)**

Cereal 'Z': $(25.25 - 23.22) = 2.03\ K \times 1.92 \times 10^5\ J\ K^{-1} / 10 = 39.0\ J\ g^{-1}$ **(1)**

d. *No*, because some of the heat could have come from compounds in food other than fat (carbohydrates, proteins) *.* **(2)**

e. *Saturated fatty acids have hydrocarbon chains that contain only <u>single carbon–carbon</u> bonds** **(1)**

f. **i.**



1 mark for correct structure of triglyceride
1 mark for **3 H_2O**
Total: **(2)**

ii. See diagram above $^{*/2}$, Name: *ester group* $^{*/2}$ **(1)**

iii. *Condensation / esterification reaction* **(1)**

Question 5 (10 marks)

a. $C_2H_6(g) \rightleftharpoons C_2H_4(g) + H_2(g)$ **(1)**

½ mark for correct reactants and products.
½ mark for correct states and equilibrium arrow.

b. *$[C_2H_4] = 0.060\ M \quad [C_2H_6] = 0.16\ M \qquad [H_2] = 0.10\ M$* **(1)**

c. *$K = [C_2H_4] \times [H_2] / [C_2H_6]$ * = (0.06 x 0.10) / 0.16 = 0.0375 M** **(2)**

d. *Some hydrogen gas has been added to the equilibrium system.* **(1)**

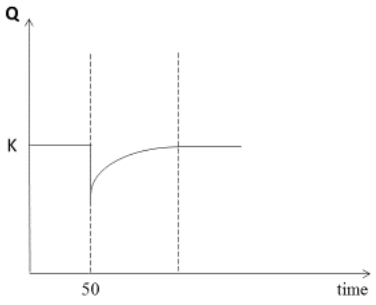
e. At t = 50 min, $[C_2H_6]$ = 0.18 M and $[H_2]$ = 0.12 *, because the temperature has not changed K at 25 min = K at 50 min , therefore *$[C_2H_4] = (K \times [C_2H_6]) / [H_2]$*
*$[C_2H_4] = (0.0375 \times 0.18) / 0.12) = 0.056\ M$** **(2)**

f. *The addition of a catalyst <u>does not affect the position</u>*/2 of the equilibrium. It only <u>speeds</u> <u>up the forward and back reaction at the same rate</u>*/2.*. **(1)**

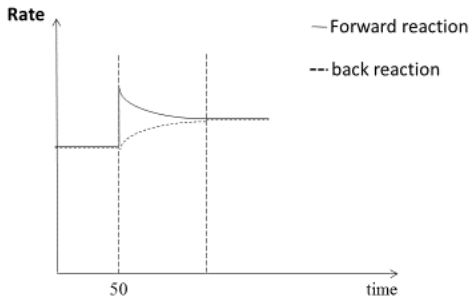
g. See graphs below. 1 mark per graph, total = **(2)**

½ mark each for initial change (Q decreasing, forward reaction increasing).
½ mark for gradual changes to re-establish equilibrium (K_1 must be equal to K_2) and rate of forward and back reaction at new equilibrium needs to be higher than before adding of C_2H_6.

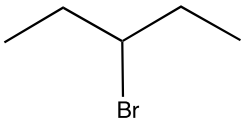
Graph 1



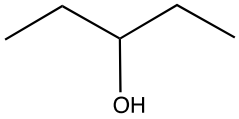
Graph 2



Question 6 (6 marks)

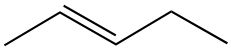
a. 

(1)

b. i. 

(1)

ii. *Substitution reaction* **(1)**

c. i.  **(1)**

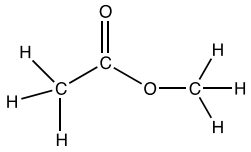
Name: *pent-2-ene* **(1)**

ii. *steam ($H_2O(g)$)*$^{*/2}$*, catalyst / H_3PO_4, 300°C* $^{*/2}$ **(1)**

Question 7 (19 marks)

a. ***A:*** *2* ***B:*** *3* ***C:*** *3* ***D:*** *3* **(4)**

b. i. *Compound C *, has two different H – environments,*
according to data book: C*H*$_3$-COOR at 2 ppm$^{*/2}$ and R-COOC*H*$_3$ at ~3.7 ppm$^{*/2}$ **(2)**

ii. Structure:  *

name: *methyl ethanoate** **(2)**

c. $HOCH_2CH_2CH_2OH^+ \rightarrow HOCH_2^+ + \bullet CH_2CH_2OH$ **(2)**

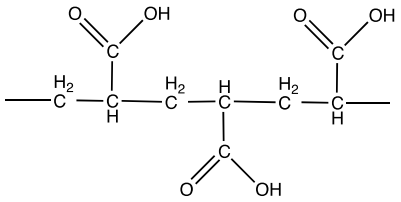
the molecular ion and the fragment $HOCH_2^+$ must have a positive charge.

d. i. $2CH_3CH_2CO_2H + Na_2CO_3 \rightarrow 2CH_3CH_2OCONa + H_2O + CO_2$ **(2)**

1 mark for correct reactants and products.
1 mark for correctly balanced, states are not required.

ii. *acid-base reaction* **(1)**

e. **(2)**



f. To obtain full marks, students should focus on functional groups only which are present in the molecules, recognition of C-H or C-C bond should not receive marks as all organic compounds contain these bonds. **(4)**

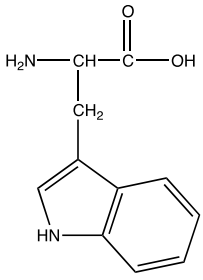
Compound A	*Alcohol - shows only a broad peak at ~ 3200 – 3600 cm^{-1} for -OH group*
Compound B	*Carboxylic acid – strong C=O peak at ~1700 cm^{-1} and broad peak at ~3000 cm^{-1} for O-H (acid)*
Compound C	*Ester – shows only a strong C=O peak at ~1700 cm^{-1}*
Compound D	*Carboxylic acid with a C-C double bond: strong C=O peak at ~1700 cm^{-1} and broad peak at ~3000 cm^{-1} for O-H (acid) as well as strong C=C peak at around 1650 cm^{-1}*

Question 8 (5 marks)

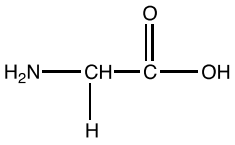
a. Peptide link*: -CO-NH-** **(1)**
Condensation reaction occurs between the -COOH group of one amino acid and the -NH_2 group from another amino acid$^{*/2}$*, forming the peptide / amide bond and water*$^{*/2}$*.* **(1)**

b. *Hydrolysis reaction using enzymes or acid.* **(1)**

c. Amino acids t*ryptophan* and *glycine* are in the data book and must be drawn correctly to obtain full marks. **(2)**



tryptophan



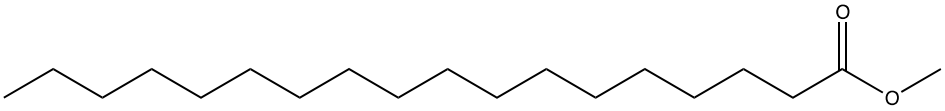
glycine

Question 9 (11 marks)

a. *$O_2(g)$* is reduced as its <u>oxidation number decreases</u> * from 0 in O_2 to -2 in O_2 / H_2O* **(2)**

b. *1.00 kg = 1.00 x 10^3 g*
*n(CO_2) = 1.00 x 10^3 / 142 = 7.04 mol **
V(CO_2) = nRT / p = (7.03 x 8.31 x 278K) / 100 kPa = 163 L (3 sig fig) ** **(3)**

c. **(2)**



Also accept semi-structural formula or condensed formula: *$CH_3(CH_2)_{16}COOCH_3$, $CH_3(CH_2)_{16}OCOCH_3$ or $CH_3OOC(CH_2)_{16}CH_3$*

d. *Biodiesel* will float on top as it is less dense then glycerol.*
*Glycerol (structure available from the data book) has a <u>short carbon chain and 3 hydroxyl groups (-OH)</u>. Each -OH group can form <u>strong hydrogen bonds</u> to -OH groups of other glycerol molecules resulting in a <u>tight packing</u> and being more dense then esters.*OR
Methyl esters of fatty acids also have a polar ester group however in addition they have a <u>very long non-polar carbon chain</u> making the molecules overall non-polar. Intermolecular forces between methyl ester molecules are weak dispersion forces and therefore packing is much less dense.
1 mark for correct identification of biodiesel floating on top.
½ mark – identifying polarity of glycerol and methyl ester molecules.
½ mark – linking packing arrangement to density. Total: **(2)**

e. Advantage: Any **one** of the following: *Produces less toxic pollutants or less greenhouse gases; produced from renewable resources; grown, produced and distributed locally; biodegradable and less toxic etc.* **(1)**

Disadvantage: Any **one** of the following: *Not suitable for use in lower temperature; solidifies at low temperature; food shortage; fuel distribution; more biodiesel is required to produce the equivalent amount of energy than petrodiesel.* **(1)**

Question 10 (6 marks)

a. Independent: *Time* **(3)**
Dependant: *Concentration of glucose*
Control: any **one** of the following*: Temperature, concentration of enzyme, concentration of green pea solution / raffinose solution etc.*

b. *Calibrating the glucometer*/2 by measuring a series of glucose solutions with known concentrations and plotting a standard curve*/2.* **(1)**

c. ONE of: *Using more accurate measuring devices such as measuring cylinders, repetition of tests, use mass for peas rather than counting, accurate volumes of water, liquid from soaked split peas etc*.

(1)

d. ONE of: *Not leaving half the test tubes outside the water bath but rather keeping them all at a constant temperature, measuring the temperature of each test tube etc*. **(1)**