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2019 Trial Examination

STUDENT NUMBER | | | | | | | | | Letter |

CHEMISTRY

Units 3 & 4 – Written examination

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

QUESTION AND ANSWER BOOK

Structure of book

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: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

Materials supplied

- Question and answer book of 28 pages.
- Data Book
- Answer sheet for multiple choice questions

Instructions

- Print your name and student number in the space provided on the top of this page.
- All written response must be in English.

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

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 **best answers** the question.
A correct answer scores 1, an incorrect answer scores 0.
No mark will be given if more than one answer is completed for any question.
Marks will **not** be deducted for incorrect answers.
Unless otherwise indicated, the diagrams in this book are not drawn to scale.

Question 1

Biodiesel is produced from:

- **A.** fatty acids and methanol
- **B.** fermentation of sugars
- **C.** the breakdown of organic waste
- **D.** fatty acids and glycerol

Question 2

The list containing only energy sources that can be renewable is:

- **A.** ethanol, methane, shale gas, natural gas
- **B.** natural gas, ethanol, biodiesel, coal seam gas
- **C.** shale gas, biogas, hydrogen, methanol
- **D.** ethanol, methane, hydrogen, biodiesel

Question 3

The energy conversion with the greatest efficiency occurs in**:**

- **A.** a hydrogen powered combustion engine
- **B.** a hydrogen powered fuel cell
- **C.** coal powered electricity generation
- **D.** a electric (battery) powered car

Question 4

H_2 undergoes combustion according to:

$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)} \quad \Delta H = -286 \text{ kJ mol}^{-1}$

If 1.0 kg of hydrogen gas is burnt, the mass of oxygen consumed in kg is:

- **A.** 4.0
- **B.** 8.0
- **C.** 16
- **D.** 32

SECTION A – continued

Question 5

Ethanol can be used as a fuel in internal combustion engines. If 500 mL of gaseous ethanol undergoes complete combustion, the increase in the volume of gas is**:**

A. 500 mL

B. 2000 mL

C. 2500 mL

D. No overall increase

Question 6

When coal is burnt, the reaction can be written as $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$.
The energy produced when 2.50 tonne of coal is burnt is 64 GJ. The heat of combustion of coal in MJ kg^{-1} is**:**

A. 25.6

B. 25 600

C. 160

D. 160 000

Question 7

Hydrogen undergoes combustion readily. The activation energy for the reverse reaction was found to be +362 kJ mol^{-1} and the ΔH for the reverse reaction was +282 kJ mol^{-1}. The activation energy for the forward reaction in kJ mol^{-1} is**:**

A. 80

B. -80

C. 644

D. -644

Question 8

The volume of oxygen consumed, in litres, at SLC when 50.0 g of methane undergoes incomplete combustion to form carbon monoxide and water is**:**

A. 51.7

B. 75

C. 77.5

D. 116

Question 9

The lead acid battery consists of 6 cells connected in series. It is commonly used in cars and is able to be recharged. The reactions occurring when the cell is discharging are**:**

Cathode: $PbO_{2(s)} + H_2SO_{4(aq)} + 2H^+_{(aq)} + 2e^- \rightarrow PbSO_{4(aq)} + 2H_2O_{(l)}$

Anode: $Pb_{(s)} + H_2SO_{4(aq)} \rightarrow PbSO_{4(aq)} + 2H^+_{(aq)} + 2e^-$

When the battery is being recharged;

A. The lead electrode is still the cathode and the lead oxide electrode is still the anode

B. Electrons flow from the lead electrode to the lead oxide electrode

C. The lead electrode has a negative polarity and the lead oxide electrode has a positive polarity

D. The pH in each cell of the battery will increase

Question 10

A student reacted 4 metals (A, B, C and D) with 1M solutions of their corresponding ion. A table of results was set up with a tick placed against any reaction that occurred.

Metal / Solution	A^{2+}	B^+	C^{2+}	D^{3+}
A			√	√
B	√		√	√
C				√
D				

The weakest reductant and strongest oxidant respectively are**:**

A. B and B^+

B. D and D^{3+}

C. B and D^{3+}

D. D and B^+

Question 11

The reaction occurring in the alkaline cell is:

$$2MnO_{2(s)} + H_2O_{(l)} + Zn_{(s)} \rightarrow Zn(OH)_{2(s)} + Mn_2O_{3(s)}$$

The reaction occurring at the anode would be**:**

A. $2MnO_{2(s)} + H^+_{(aq)} + 2e^- \rightarrow Mn_2O_{3(s)} + OH^-_{(aq)}$

B. $MnO_{2(s)} + H_2O_{(l)} + 2e^- \rightarrow Mn_2O_{3(s)} + 2OH^-_{(aq)}$

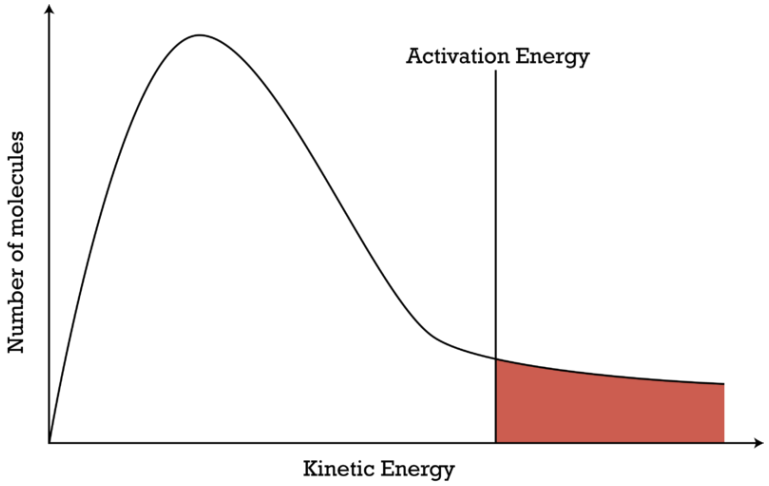
C. $Zn_{(s)} + 2OH^-_{(aq)} \rightarrow Zn(OH)_{2(s)} + 2e^-$

D. $Zn_{(s)} + 2H_2O_{(l)} \rightarrow Zn(OH)_{2(s)} + 2H^+ + 2e^-$

SECTION A – continued

Question 12

The kinetic energy of the particles involved in the reaction can be represented by the diagram below:



If a catalyst is added**:**

A. the whole graph will shift to the right meaning that more molecules will have enough energy to react

B. the activation energy shifts to the right meaning that more molecules will have enough energy to react

C. the activation energy shifts to the left meaning that more molecules will have enough energy to react

D. the activation energy line stays where it is but the height of the graph at the activation energy point will increase meaning that more molecules will have enough energy to react

Question 13

Consider the reaction**:**

$CO_{(g)} + 2H_{2(g)} \rightleftharpoons CH_3OH_{(g)}$ $K_c = 2.0 \times 10^4\ M^{-2}$ at 10°C

The equilibrium constant for the reaction

$3CH_3OH_{(g)} \rightleftharpoons 3CO_{(g)} + 6H_{2(g)}$ is**:**

A. $5.0 \times 10^{-4}\ M^2$

B. $4 \times 10^{7}\ M^{-2}$

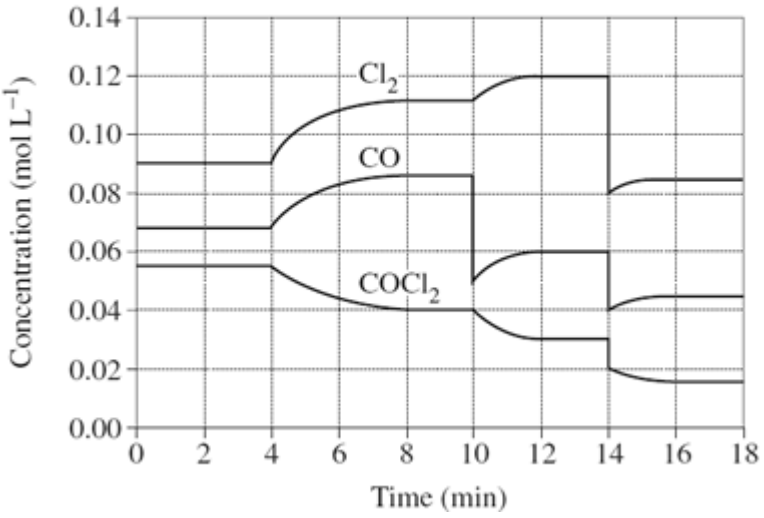
C. $1.3 \times 10^{-13}\ M^6$

D. $8.0 \times 10^{10}\ M^6$

The following information refers to the next two questions.

Consider the graph below**:**

$COCl_2(g) \rightleftharpoons Cl_2(g) + CO(g) \quad \Delta H = +108$ kJ



Question 14

At t = 10 minutes and t = 14 minutes the following changes occur:

A. addition of Cl_2 and an increase in pressure

B. removal of CO and decrease in pressure

C. removal of CO and increase in pressure

D. addition of Cl_2 and an decrease in pressure

Question 15

The equilibrium constant, K_c, changes at the following times (in minutes):

A. 4, 10 and 14 minutes

B. 14 minutes only

C. 10 minutes only

D. 4 minutes only

Question 16

Carbon monoxide poisoning can occur due to incomplete combustion of fuels. Haemoglobin reacts with oxygen to form oxyhaemoglobin and will also react with carbon monoxide to form carboxyhaemoglobin.

Equation 1**:** $Hb_{4(aq)} + 4O_{2(g)} \rightleftarrows Hb_4O_{8(aq)}$

Equation 2**:** $Hb_{4(aq)} + 4CO_{(g)} \rightleftarrows Hb_4(CO)_{4(aq)}$

It is true that**:**

A. when carbon monoxide poisoning occurs, the equilibrium in equation 2 is driven to the right increasing the equilibrium constant

B. the presence of CO can force the equilibrium in reaction 1 to right

C. the equilibrium in equation 2 can be driven to the left by providing the patient with pure oxygen

D. the equilibrium constant for equation 1 is about 20 000 times the equilibrium constant of equation 2

Question 17

The number of structural isomers of $C_2H_3Cl_3$ is:

A. 1

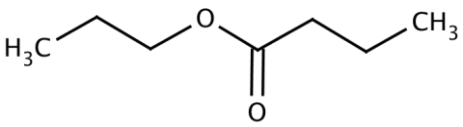
B. 2

C. 3

D. 4

Question 18

The name of the molecule shown below is:



A. butyl butanoate

B. propyl propanoate

C. butyl propanoate

D. propyl butanoate

The following information refers to the next two questions.

The level of acetic acid in vinegar was determined by titration with standardised sodium hydroxide. 20mL of sodium hydroxide is pipetted into a 100mL conical flask and a suitable indicator is added. The vinegar is added to the burette and titrated until a permanent colour change is observed.

Question 19

A suitable indicator would be**:**

A. methyl orange
B. methyl red
C. bromothymol blue
D. phenolphthalein

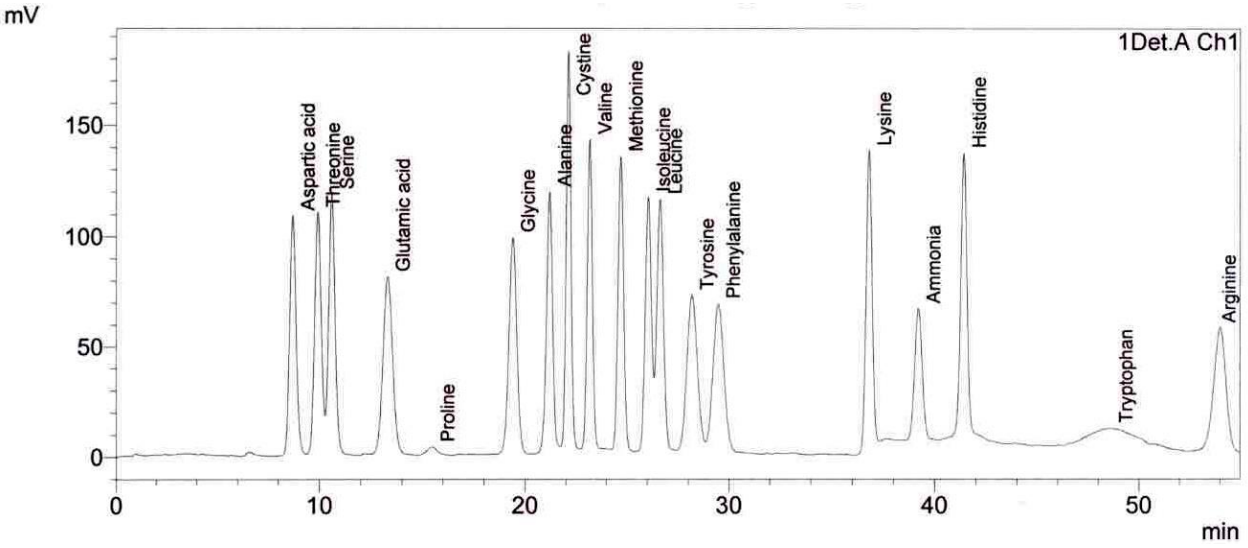
Question 20

The pipette, conical flask and burette, should be finally washed with (in order)**:**

A. sodium hydroxide, water, vinegar
B. water, sodium hydroxide, vinegar
C. water, water, water
D. sodium hydroxide, sodium hydroxide, vinegar

Question 21

The following chromatogram was obtained by analysing a sample containing several amino acids.



From this chromatogram, it would be reasonable to conclude that**:**

A. the solvent is polar

B. arginine is least strongly adsorbed onto the stationary phase

C. the molecule with the shortest retention time is the least polar

D. cysteine must be the most abundant amino acid in the sample

Question 22

Oleic acid is naturally found in a range of animals and plants. Oleic acid**:**

A. is a polyunsaturated fatty acid

B. has a trans formation around the double bond

C. is an omega-6 fatty acid

D. is more likely to be oxidised than lauric acid

Question 23

The zwitterion of glutamine would have an overall charge of**:**

A. -1

B. 0

C. +1

D. +2

Question 24

Vitamin C is**:**

- **A.** Soluble in fat tissue
- **B.** An essential vitamin
- **C.** A non-polar molecule overall
- **D.** Synthesised by the body after exposure to UV radiation

Question 25

Vitamin C acts as an antioxidant. It does this by**:**

- **A.** providing hydrogen atoms to react with free radicals
- **B.** adding hydrogen atoms to each end of the double bond in unsaturated fats
- **C.** stopping the hydrolysis of triglycerides into fatty acids
- **D.** assisting the action of enzymes

Question 26

The primary structure of an amino acid can be broken down when**:**

- **A.** the peptide links are broken
- **B.** the hydrogen bonds holding the protein helix in a helix are broken
- **C.** the range of bonds holding the shape of the protein together are broken
- **D.** the bonds between 2 or more polypeptide chains are broken

Question 27

The number of chiral centres in isoleucine is**:**

- **A.** 0
- **B.** 1
- **C.** 2
- **D.** 3

Question 28

A bomb calorimeter is calibrated by burning 1.05 g of benzoic acid (molar mass of 122 g mol^{-1} and ΔH_c of -3227 kJ mol^{-1}) If the temperature rose by 3.45°C, the calibration factor of the calorimeter in kJ $°C^{-1}$ is**:**

- **A.** 0.137
- **B.** 8.05
- **C.** 27.1
- **D.** 95.9

SECTION A – continued

Question 29

A chemist needs to produce a yield of compound D from compound A of at least 70%. The conversion of A to B is 80% efficient, the conversion of B to C is 85% efficient, the conversion of C to D is 90% efficient, the conversion of A to C is 80% efficient and the conversion of B to D is 85%. The best way to prepare substance D involves the pathway**:**

A. A → B → C → D

B. A → C → D

C. A → B → D

D. None of the options give a yield of at least 70%

Question 30

When heating a mixture of a carboxylic acid and an alcohol to produce an ester, several precautions are necessary. To reduce the risk of being exposed to corrosive, flammable and volatile substances, **one** of the things a student could do include**:**

A. stopper any test tubes being heated

B. use a Bunsen burner in the fume cupboard

C. close all windows and doors so the gases don't affect students in other classes

D. use small quantities of chemicals

END OF SECTION A
TURN OVER

SECTION B - Short-answer questions

Instructions for Section B

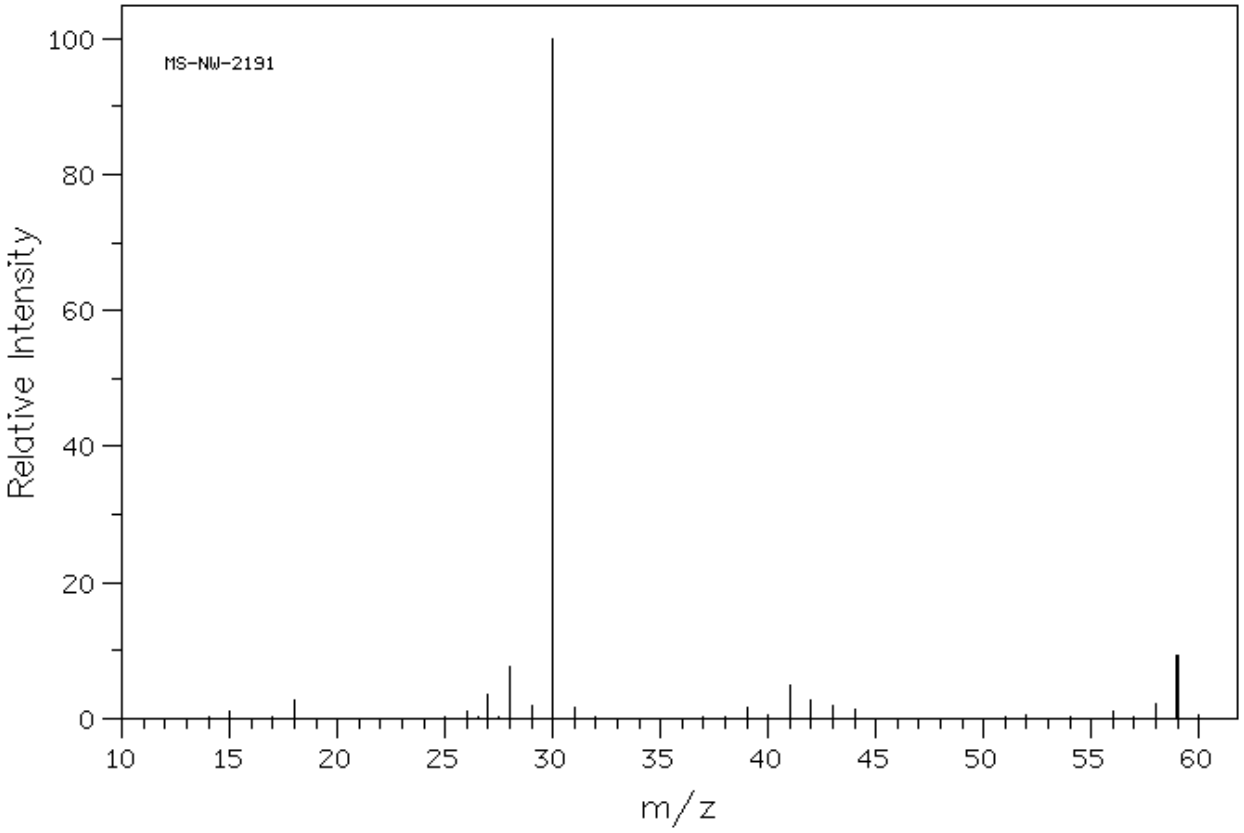
Questions must be answered in the spaces provided in this book.
Write using blue or black pen.

- Give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
- Show all workings in your answers 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 the formulas for individual substances include an indication of state; for example, $H_2(g)$, NaCl(s)

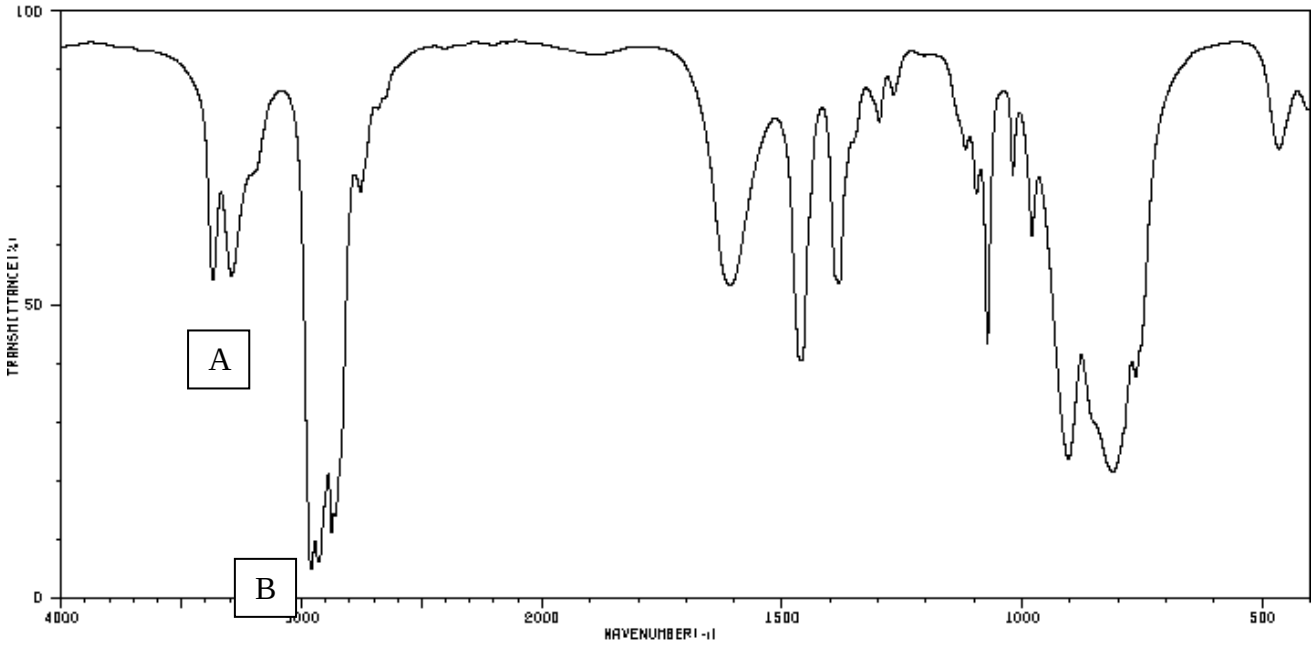
Unless otherwise indicated, diagrams in this book are not drawn to scale.

Question 1 (7 marks)

Examine the mass spectrum and infra-red spectrum of an organic molecule.



SECTION B - Question 1- continued



a. What is the m/z value of the peak caused by the molecular ion in the mass spectrum?

_____

1 mark

b. On the infra-red spectrum, **name** the functional group most likely to have caused the peaks at

i. A _____

ii. B _____

2 marks

c. Write the semi-structural formula of the species that produces the peak at m/z of 30 in the mass spectrum.

_____

1 mark

d. The C-NMR spectrum of this organic molecule consists of 3 peaks. What does this tell you about the structure of the organic molecule?

_____

1 mark

SECTION B - Question 1- continued

TURN OVER

e. The H – NMR spectrum of this organic molecule has 4 major peaks with a peak height ratio of 2:2:2:3. Draw the structure of the organic molecule.

1 mark

f. One of the major peaks in the H – NMR is split into a sextuplet. Explain why this occurs.

_____

_____

1 mark

Question 2 (11 marks)

A major component of biodiesel has a molecular formula of $C_{19}H_{32}O_2$.

a. A 8.82g sample of $C_{19}H_{32}O_2$ is burnt in a bomb calorimeter which has a calibration factor of 200.0 kJ $°C^{-1}$. If the temperature rise in the calorimeter is 1.897°C, calculate the energy content in kJ g^{-1}.

_____

_____

2 marks

b. Biodiesel can be used as a replacement for petrodiesel.

i. Write a balanced chemical equation for the combustion of this component of biodiesel. (Assume there is an excess of oxygen)

_____

SECTION B - Question 2- continued

ii. Calculate the volume of carbon dioxide produced at 100 kPa and 50°C, when 1 MJ of energy is released from this reaction.

_____

_____

_____

_____

iii. The combustion of petrodiesel produces a similar volume of carbon dioxide per MJ of energy to the combustion of biodiesel. Why might biodiesel be preferred to petrodiesel as a fuel?

_____

_____

1 + 4 + 1 = 6 marks

c. i. What is the functional group found in this biodiesel molecule?

_____

ii. Write a balanced equation using molecular formulae to show how the biodiesel molecule, $C_{19}H_{32}O_2$, could be produced from an appropriate fatty acid and methanol.

_____

_____

1+ 1 = 2 marks

d. A component of petrodiesel has the molecular formula $C_{13}H_{28}$. Compare the viscosity of the $C_{13}H_{28}$ and $C_{19}H_{32}O_2$.

_____

1 mark

SECTION B - continued

TURN OVER

Question 3 (9 marks)

The concentration of ethanol (CH_3CH_2OH) in an old bottle of wine was determined by titration with a solution of acidified potassium permanganate. The ethanol was oxidised to ethanal (CH_3CHO) and the MnO_4^- ions were reduced to Mn^{2+}. The $KMnO_4$ solution was prepared by dissolving 28.8g of $KMnO_4$ in a standard flask of 250mL. A 20.00mL aliquot of ethanol solution was titrated with the $KMnO_4$. Titres of 11.68, 11.07, 11.18 and 11.11 mL were obtained.

a. Determine the molar concentration of the $KMnO_4$ solution prepared in mol L^{-1}.

_____

_____

2 marks

b. Write two half ionic equations for oxidation and reduction and a full ionic equation for the reaction.

_____

_____

_____

3 marks

c. What was the concentration of the ethanol solution in grams per 100ml (%w/v)?

_____

_____

_____

_____

3 marks

d. The level of alcohol in the wine was stated as 13.5%(w/v). Account for any difference in the value you calculated.

_____

_____

1 mark

Total 9 marks

SECTION B - continued

Question 4 (10 marks)

The reaction $PCl_{3(g)} + Cl_{2(g)} \rightleftharpoons PCl_{5(g)}$ is exothermic.

a. In a 1.0 litre container, 0.35 mol of PCl_3 is mixed with 0.25 mol of Cl_2 at a temperature of 50°C. The reaction is allowed to reach equilibrium and at this point, there is 0.05 mol of PCl_5 present. Calculate the equilibrium constant (K_c).

_____

_____

_____

_____

3 marks

b. Complete the table below to show what effect a change of reactions conditions would have on the production of PCl_5.

Change made	Effect on yield of PCl_5 (increase, decrease or no change)	Effect on the equilibrium constant (increase, decrease or no change)
Increase in temperature		
Addition of a catalyst		
Increase in pressure		

3 marks

c. In industry, the rate of reaction is critical, however there is often competition between rate and yield. Looking at the production of PCl_5, Give an example of a reaction condition that**:**

i. increases the rate and yield and explain why the rate is increased.

_____

_____

ii. increases the yield but not the rate and explain why the rate decreases.

_____

_____

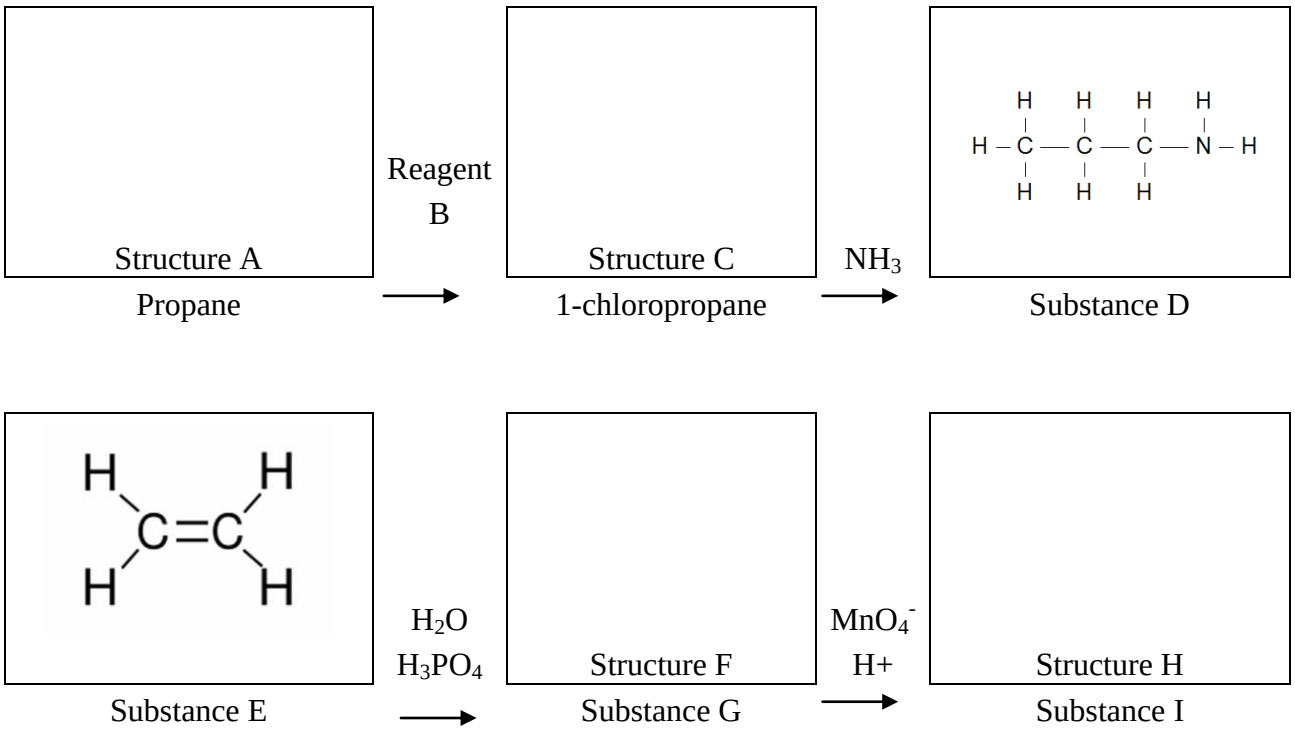
2 + 2 = 4 marks

SECTION B - continued

TURN OVER

Question 5 (11 marks)

Examine the flow chart below.



a. Draw the structures of structure A, C, F and H in the boxes provided.

4 marks

b. Name the following:

i. Reagent B _____

ii. Substance D _____

iii. Substance E _____

iv. Substance G _____

v. Substance I _____

5 marks

SECTION B - Question 5- continued

c. Structures D and I are reacted together to form an amide.

i. Draw the structure of this amide.

ii. Is this a primary, secondary or tertiary amide?

_____

1 + 1 = 2 marks

SECTION B - continued

TURN OVER

Question 6 (9 marks)
Direct-ethanol fuel cells or DEFCs are a category of fuel cells in which ethanol, is fed directly to the fuel cell. The DEFC relies upon the oxidation of ethanol to carbon dioxide. Protons (H^+) are transported across a proton exchange membrane to the cathode where they react with oxygen to produce water.

a. Write ionic half equations to represent the reaction occurring at the:

i. negative electrode _____

ii. positive electrode _____

1 + 1 = 2 marks

b. i. As well as being a conductor of electricity, what role do the electrodes perform?

_____

ii. Why are the electrodes porous?

_____

1+1 = 2 marks

c. i. Ethanol is also used as a fuel in internal combustion engines and is often mixed with petroleum to form "E10 fuel". Why might the DEFC be a preferred way of using ethanol in transport?

_____

ii. Why are fuel cells like the DEFC not commonly used at this time?

_____

1+1 = 2 marks

d. Briefly outline one disadvantage of using ethanol in a fuel cell rather than hydrogen gas.

_____

1 mark

e. The ethanol can be produced from a range of materials including sugar cane. Write equations using molecular formulae to show:

i. the conversion of sucrose into fructose and glucose

_____

ii. the conversion of glucose into ethanol

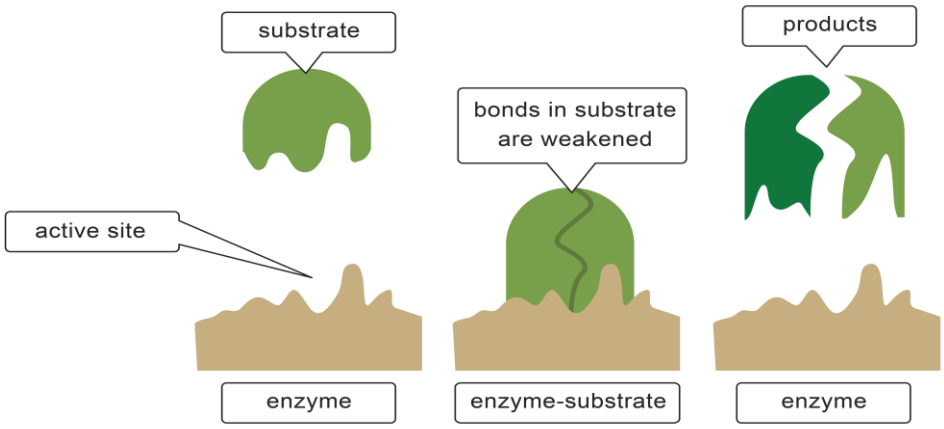
_____

2 marks

SECTION B - continued

Question 7 (9 marks)

A model for the action of enzymes is shown below:



a. Using an example of an appropriate biochemical, describe what is meant by the substrate.

_____

_____

2 marks

b. Bonds form between the substrate and enzyme. Describe the type or types of bonding that can form between the substrate and the enzyme.

_____

_____

2 marks

c. The shape of the enzyme is critical to its function.

i. How is the shape of an enzyme determined?

_____

_____

ii. Is it still possible for a substrate to fit into an enzyme even if the substrate is not a perfect fit for the enzyme? Why?

_____

_____

iii. Some people lack the ability to produce a certain enzyme and so need to ingest or inject these enzymes into their body. Why might these enzymes needed to directly injected into the bloodstream rather than eaten?

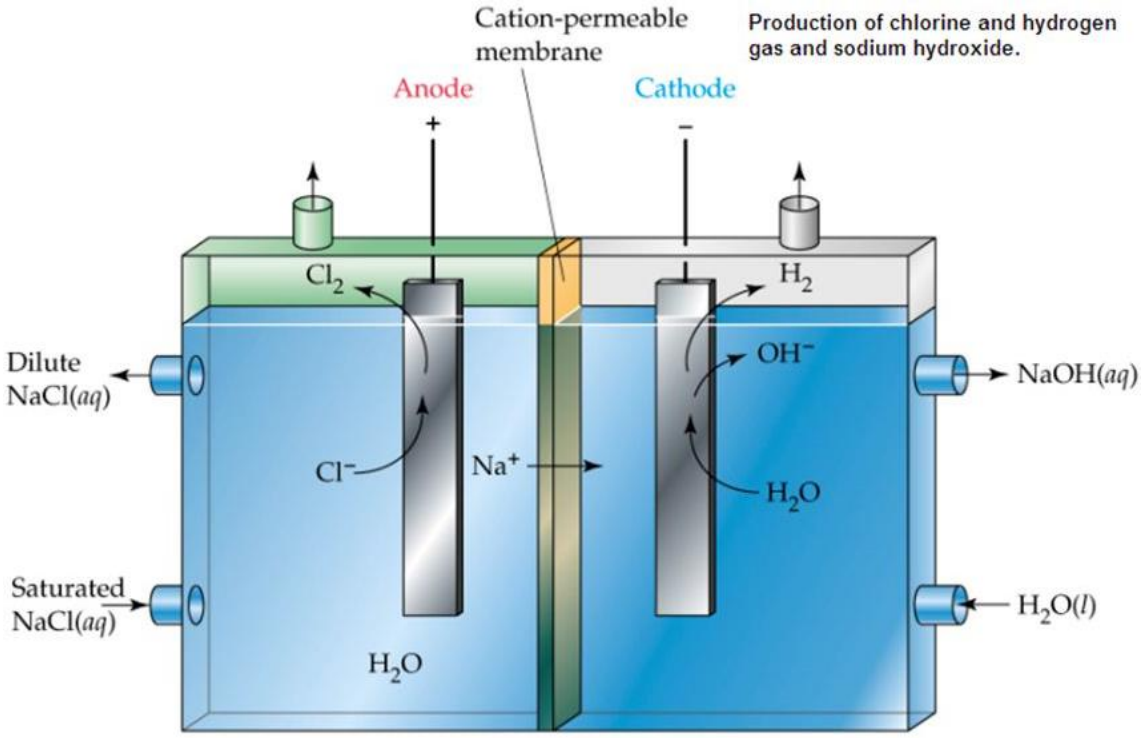
_____

_____

2 + 2 + 1 = 5 marks

Question 8 (9 marks)

The cell below is used to produce a number of important chemicals. Sodium chloride is used as the raw material.



a. Determine the reaction occurring at the:

i. anode

_____

ii. cathode

_____

1+ 1 = 2 marks

SECTION B - Question 8- continued

TURN OVER

b. Why is it important to remove dilute NaCl from the cell and replace it with saturated NaCl?

_____

_____

_____

2 marks

c. What is the role of the "cation permeable membrane"?

_____

_____

_____

1 mark

d. The cell needs to produce 10.0 m^3 of chlorine gas every hour at SLC. What current would be needed in order to achieve this?

_____

_____

_____

_____

4 marks

SECTION B - continued

Question 9 (9 marks)

A group of Chemistry students plan to go on a 4 day hike after their last VCE exam. The students agree that food high in fats such as nuts and chocolate would be ideal for the trip. However there is a disagreement about the types of carbohydrates that the students should take. One student believes that low GI foods are more important and another argues that high GI foods are important. They also decide to take a portable stove to heat up their food. These stoves use a liquid fuel such as methylated spirits (which is mainly ethanol) or butane.

a. A 50 g chocolate bar contains 28% fat, 8% protein and 55% carbohydrates. How much energy would be present in the chocolate bar?

_____

_____

_____

2 marks

b. **i.** What is meant by the GI value of a food?

_____

_____

ii. The student arguing to take low GI food, refers the other students to the structures of amylopectin and amylose. Explain how the type of starch relates to the GI value of food.

_____

_____

_____

1 + 2 = 3 marks

SECTION B - Question 9- continued

TURN OVER

c. The students want to limit the weight of fuel carried on the hike.

i. On this criteria, should they take ethanol or butane? Why?

_____

ii. They calculate that they need enough fuel to heat a total of 30 litres of water by 75°C. Assuming that 80.0% of the heat produced by the fuel is lost, determine the mass of fuel they would need to take.

_____

_____

_____

_____

1 +3 = 4 marks

SECTION B - continued

Question 10 (6 marks)

A student decides to test the effectiveness of an enzyme at different temperatures. She made up four solutions each containing 1.0 g of maltose dissolved in 40 mL of water and heated them up to a range of temperatures from 20°C to 50°C. 1.0 mL of amylase was added to each solution and the time taken for each reaction mixture to change colour when Benedict's solution was added was recorded in the table below;

Temperature	Time (sec)
20°C	No colour change observed
30°C	50
40°C	20
50°C	75

The student's conclusion was:

"This experiment shows that the optimum temperature for the function of enzymes is just below 40°C. This roughly corresponds to the temperature of the human body."

a. For this experiment, indicate what the following variables would be the:

i. dependent variable

_____

ii. independent variable

_____

iii. controlled variable

_____

3 x 1 = 3 marks

b. Describe two ways in which the design of the experiment could be improved.

_____

_____

_____

2 marks

SECTION B - Question 10- continued

TURN OVER

c. Describe one limitation of the student's conclusion.

_____

_____

_____

1 mark

END OF QUESTION AND ANSWER BOOK