TSSM
Creating VCE Success

THIS BOX IS FOR ILLUSTRATIVE PURPOSES ONLY

2022 Trial Examination

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

CHEMISTRY

Units 3&4 – Written examination

Reading time: 15 minutes
Writing time: 120 minutes

QUESTION & ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions be answered*	*Number of to marks*
A	30	30	30
B	7	7	90
			Total 120

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners and rulers
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.
- Scientific calculators are permitted in this examination.

Materials supplied

- Question and answer book of 32 pages.

Instructions

- Print your name in the space provided on the top of this page.
- All written responses 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 marks 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.

Use the following information to answer Questions 1–3.

Natural gas found in Victoria can be used to generate electricity. A Gas power plant will often burn methane and other small alkanes to release energy. The combustion of the natural gas, methane, is shown below.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \qquad \Delta H < 0$$

Question 1

The energy, in kJ, released from the combustion of 1.00 g of methane will be:

A. 18.2

B. 49.8

C. 55.6

D. 890

Question 2

When methane undergoes complete combustion, calculate the mass of oxygen gas burnt when 4.16 g of methane is burnt.

A. 7.39

B. 0.46

C. 8.32

D. 16.64

Question 3

What volume of water will be produced when 4.26 g of methane is burnt at 450^{o}C and 200 kPa?

A. 15.9 L

B. 7.99 L

C. 9.90 L

D. 4.31L

SECTION A- continued

Question 4

Which of the following shows the correct sequence of energy changes for the burning of coal to be released from a coal power station?

A. Chemical energy → thermal energy → mechanical energy → electrical energy

B. Electrical energy → thermal energy → mechanical energy → chemical energy

C. Chemical energy → electrical energy → thermal energy → mechanical energy

D. Electrical energy → mechanical energy → thermal energy → chemical energy

Question 5

Which of the following fuel sources can be considered the most sustainable?

A. Ethanol produced from methane in natural gas

B. Coal from under the ground

C. Petrodiesel from offshore oil rigs

D. Bioethanol from sugar cane

Question 6

When comparing petrodiesel to biodiesel which of the following is not true?

A. Biodiesel has a higher viscosity then petrodiesel

B. Petrodiesel releases more energy biodiesel

C. Petrodiesel is a longer chain of atoms

D. Biodiesel contain more oxygen atoms

Question 7

Common fuels, like methane, are substances that, under the right conditions can be described as which of the following?

A. An exothermic oxidation process

B. An endothermic oxidation process

C. An exothermic reduction process

D. An endothermic process

Question 8

Lead can be a useful addition as an alloy to act as reducing agent. Which metals is lead able to reduce in a spontaneous reaction?

A. Cu^{2+} and Fe^{2+}

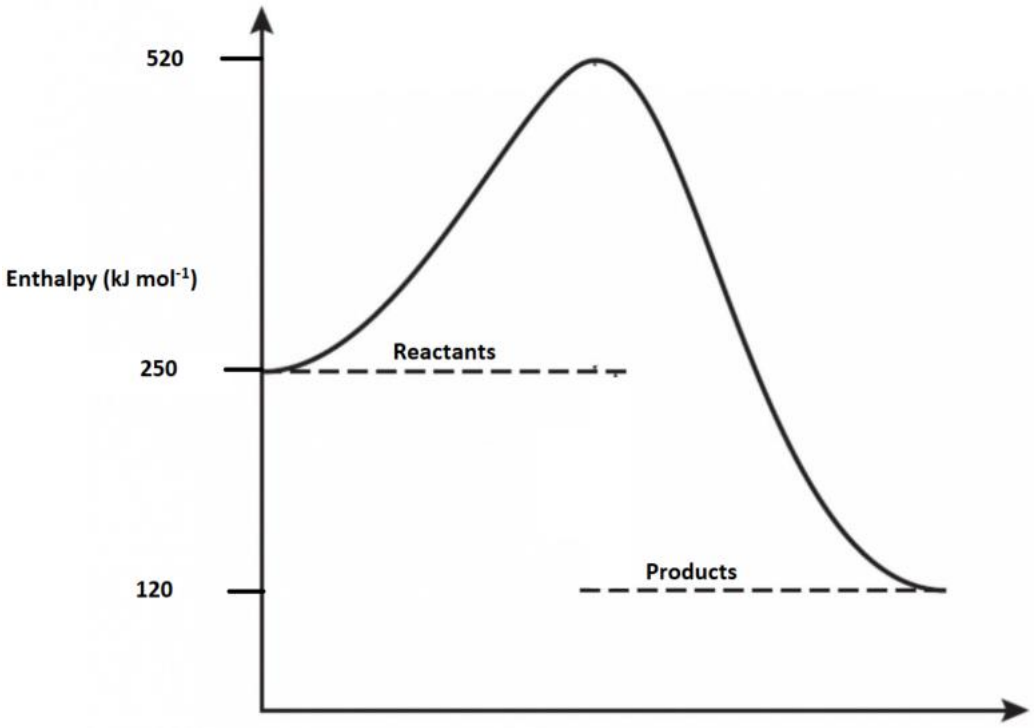
B. Ag^{+} and Cu^{2+}

C. Al^{3+} and Fe^{2+}

D. All of the above

Use the following information to answer Questions 9–10.

Consider the energy profile diagram below to answer this question. The enthalpies of the reactants and the products are shown on the vertical axis.



Question 9

The enthalpy of the reversed catalysed reaction for this energy profile diagram would be:

A. - 130 kJ mol^{-1}

B. + 270 kJ mol^{-1}

C. + 130 kJ mol^{-1}

D. - 400 kJ mol^{-1}

Question 10

The reaction shown above is a combustion reaction of ethane. What would be units of K_c for this equilibrium constant?

A. M

B. M^2

C. M^{-1}

D. No units

SECTION A- continued

(Modern Lithium cells are becoming more in high demand due to the fast-growing market for traction and stationary batteries. Moreover, many lithium sources are not available without compromising environmental aspects. Therefore, there is a growing focus on alternative technologies such as Na-ion and Zn-ion batteries. On a view of Na-ion batteries, especially the combination with carbons derived from food waste.

Use the following information to answer Questions 11-12.

One example of a sodium-ion battery is to use food waste derived carbons to generate electricity, which can be seen by the $Na\text{-}CO_2$ battery below using the two half equations:

$$4Na^+ + CO_2 + 4e^- \rightarrow 2Na_2CO_3 + C$$
$$Na \rightarrow Na^+ + e^-$$

Question 11

What is the overall equation of this reaction?

A. $4Na^+ + CO_2 + 4e^- + Na \rightarrow Na^+ + 2Na_2CO_3 + C$

B. $4Na^+ + CO_2 + 4Na \rightarrow 4Na^+ + 2Na_2CO_3 + C$

C. $2Na_2CO_3 + C \rightarrow 4Na + 3CO_2$

D. $2Na_2CO_3 + C \rightarrow Na + 3CO_2$

Question 12

During the reaction process of discharging sodium carbonate, the electrode is worn away. Which of the following is likely to have an effect on the performance of the battery due to this discharge?

A. Increase battery life

B. Overall performance of the battery will increase

C. The amount of charge being held will increase

D. Reduces the number of recharges

Question 13

Which of the following is a primary alcohol?

A. 1-propanol

B. 2-methyl-2-propanol

C. 2-butanol

D. Pentan-3-ol

SECTION A- continued

TURN OVER

Question 14

Which of the molecules listed below has the molecular formula of $C_4H_8O_2$?

A. Methyl propanoate

B. Ethyl ethanoate

C. Butanoic acid

D. All of the above

Question 15

Pentanol is heated with $KMnO_4$ in acidic conditions to form pentanoic acid. To determine when the reaction was completed, the most notable change according to infra-red spectroscopy data would be:

A. the new absorption band at $3000cm^{-1}$

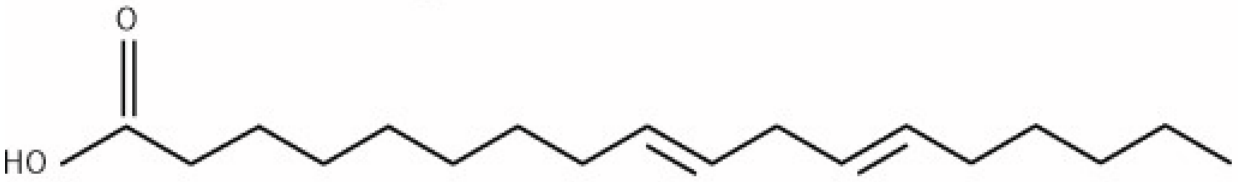
B. the disappearance of a short absorption band at $3300cm^{-1}$

C. the new absorption band at $1700cm^{-1}$

D. the broad absorption band at $3000cm^{-1}$ relocated to $3400cm^{-1}$

Use the following information to answer Questions 16–17.

The following compound is a fatty acid, known as linolelaidic acid, and is often a source of dietary lipids.



Question 16

What is the molecular formula of this fatty acid?

A. $C_{18}H_{30}O_2$

B. $C_{17}H_{36}O_2$

C. $C_{18}H_{34}O_2$

D. $C_{18}H_{32}O_2$

Question 17

In terms of linolelaidic acid's bonding it could be described as having:

A. Cis and trans double bonds

B. Two cis double bonds

C. Two trans double bonds

D. No cis or trans double bonds present

SECTION A- continued

Question 18

How many hydrogen environments does ethyl butanoate have?

A. 4

B. 5

C. 6

D. 7

Use the following information to answer Questions 19–21.

Calcium hypochlorite, $Ca(OCl)_2$, is an inorganic compound that is a main ingredient in various bleaches. These include chlorine powder, chlorinated lime, and has a distinct strong smell of chlorine. A chemist wishes to conduct a titration to determine the percentage by mass of calcium hypochlorite in a sample of bleaching powder. They prepare a solution of calcium hypochlorite by weighing the sample and then adding to a 250ml beaker. The beaker is filled with de-ionised water to the 250ml level mark and titrated against an acidic 0.5 M HCl solution. The results and reaction are shown below:

$$Ca(OCl)_2 + 4HCl \rightarrow \quad CaCl_2 + 2Cl_2 + 2H_2O$$

Mass of bleaching power:	3.45 g
HCl aliquots:	25.0 mL
Titres:	20.1 mL, 20.0 mL, 21.4 mL, 20.1 mL
Indicator used:	Phenolphthalein

Question 19

What would be the likely colour change of the solution as the end point was reached for this reaction?

A. Pink to colourless

B. Red to pink

C. Colourless to pink

D. Pink to yellow

Question 20

Determine the mass of calcium hypochlorite in the beaker using the concordant titres provided.

A. 22.3 g

B. 5.52 g

C. 3.86×10^{-2} g

D. 5.43 g

Question 21

Between each titration, the chemist rinsed all of the equipment. Which of the following procedures is encouraged to ensure correct techniques are used when conducting a volumetric analysis?

A. Rinse the 250 mL beaker with a solution of calcium hypochlorite to avoid diluting the sample

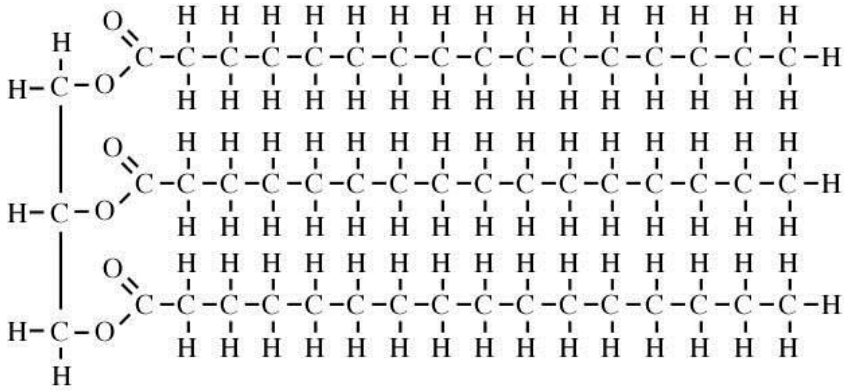
B. Rinse the burette with deionised water to avoid unmeasured amounts of acid or base

C. Rinse the 250 mL beaker with deionised water to avoid unmeasured amounts of acid or base

D. Rinse the burette with a solution of calcium hypochlorite to avoid diluting the sample

Question 22

Reviewing the triglyceride below, identify which two products would result from the hydrolysis of this molecule.



A. Water and a fatty acid

B. Glycerol and a fatty acid

C. Water and a protein

D. Glycerol and an amino acid

Question 23

Which of the following molecules would not be soluble in water?

A. Glucose

B. Biodiesel

C. Glutamate

D. Vitamin D

Question 24

Which of the following foods is likely to have a low-GI content?

A. Potatoes due to high amount of starch

B. Milk due to high amount of lactose

C. Fruit due to the high amount of fructose

D. Nuts due to the high amount of sucrose

SECTION A- continued

Question 25

Using your understanding of endothermic reactions select which answer best describes how a catalyst will impact an energy profile.

A. The activation energy will be lowered for the endothermic reaction but not the reverse exothermic reaction

B. The energy diagram will remain unaffected

C. The activation energy will be lower for both the endothermic and exothermic reactions

D. The activation energy for the endothermic reaction will be reduced at lower temperatures

Use the following information to answer Questions 26–27.

A chemist wished to find out the heat of combustion of an almond which was calculated to be 7.2 kJ g^{-1}. Prior to this experiment, the calibration factor of a bomb calorimeter was calibrated to be 678 J^oC^{-1}.

Question 26

A 1.80 g sample of an almond is burnt in excess air in this calorimeter. What is the expected rise in temperature in degrees Celsius?

A. 19.12

B. 28.24

C. 9.56

D. 18.82

Question 27

The calibration factor was calculated with a significant amount of water in the calorimeter prior to 50mls being added as part of the calibration. Identify what type of error this is example of and how the additional water impact the value of the calorimeter constant.

A.	Random error	The value of the calibration constant will be higher
B.	Random error	The value of the calibration constant will be unchanged
C.	Systematic error	The value of the calibration constant will be lower
D.	Systemic error	The value of the calibration constant will be higher

Question 28

A student is making various esters as part of class experiment. In order to release the natural smells that come as result, a water bath is needed to keep the test tubes at the same temperature. The student is trying to identify if the molecular size of the carboxylic acid used has any impact on the strength of the smell. For this experiment it is evident the temperature of the water bath can be referred to as the:

A. independent variable

B. dependent variable

C. controlled variable

D. systematic variable

Question 29

Which one of the following molecules can be referred to as an omega-3 fatty acid?

A. Myristic

B. Linolenic

C. Oleic

D. Linoleic

Question 30

All fuel cells can be described as:

A. converting chemical energy into electrical energy with the reactants continually supplied

B. rechargeable that have electrodes that are separated

C. rechargeable that store the reactants in the cells

D. converting electrical energy into chemical energy with the reactants continually supplied.

END OF SECTION A

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 (17 marks)

Bio-E10 is short for the biofuel made up of 90% gasoline in volume and 10% bio-ethanol, which is the ethanol made from commercially-grown crops such as corn and wheat by the sugar fermentation process. In China, bio-E10 will be supplied nationwide from 2020 as an alternative to conventional gasoline, aiming at ensuring greater energy security and lowering the greenhouse gas emissions.

Source: https://www.sciencedirect.com/science/article/pii/S2352484719308248

E10 fuel is becoming the way forward as an alternate source to power our transport instead of burning other fuels. Butane is another source of energy referred to as LPG gas which can be used for cooking, heating, and of course powering our vehicles. LPG can be a mixture of propane and butane, or just propane. The below table shows various properties of the fuel sources.

Commercial name of fuel	**Type of fuel**	**Mass of CO_2 emitted per gram of fuel**	**Density (g mL^{-1})**	**Melting point (^oC)**
LPG	Propane	3.0	0.493	-188
E10	Ethanol	1.9	0.79	-114.1
LPG	Butane	3.0	0.573	-138

SECTION B- continued
TURN OVER

a. Discuss how the bonding in propane and ethanol has influenced the melting point. 2 marks

b. Propane is sometimes mixed with butane to produce LPG gas. The mixture for this fuel is 60% propane and 40% butane. Calculate the volume and mass of each fuel for a car that has a 50 L tank of fuel. 2 marks

c. As the car is driving LPG gas it undergoes complete combustion. Calculate the energy released from the 50 L sample of LPG. 2 marks

SECTION B- continued

d. E10 can be produced in a few ways.

i. Draw and name a molecule in the box provided to complete the production of E10 for the below reaction. (2 marks)

Name: _____	+ Glucose	→	Ethanol

ii. Explain why E10 produced from sugar cane is considered biofuel but E10 produced from coal is not considered a biofuel. 2 marks

_____

_____

_____

_____

e. Write out a balanced thermochemical equation for the complete combustion of propane at SLC. 3 marks

_____

_____

SECTION B- continued

TURN OVER

f. Calculate the volume of water that will be produced at 350^{o}C and 102 kPa from the complete combustion of the 50 L sample of LPG (60% propane:40% butane). 4 marks

_____

_____

_____

_____

_____

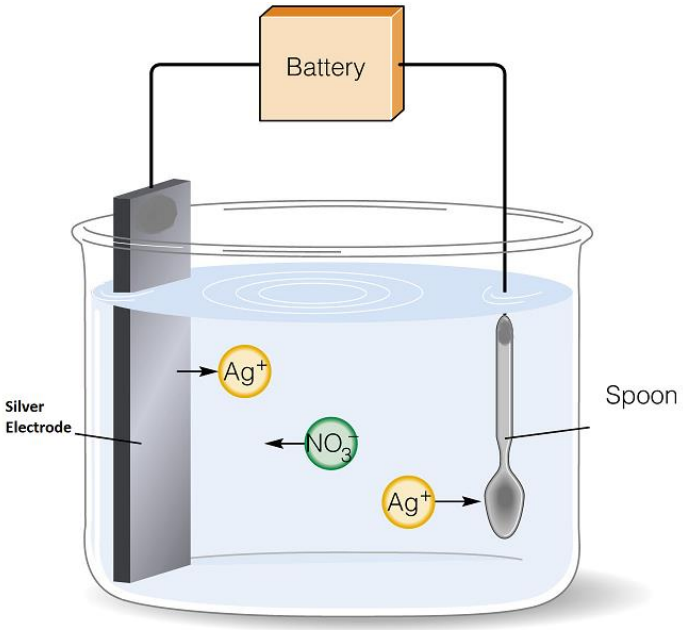
_____

_____

SECTION B- continued

Question 2 (9 marks)

Electroplating is a major use of electrolysis. A thin layer of a desired metal can be coated onto another metal which can be useful for adding new properties or preventing corrosion for example. The electrolytic cell below shows how a spoon is being electroplated with silver to which will create a thin layer and give the spoon a desired metallic 'silver' appearance.



a. The spoon and silver electrode are identified as the two terminals for this electrolytic cell. Use the names of these terminals to fill in the below information. (2 marks)

Cathode: _____ Polarity of the cathode electrode: _____

Anode: _____ Polarity of the anode electrode: _____

b. Write out the half equation for the reductant. 1 mark

_____

_____

SECTION B- continued

TURN OVER

c. Discuss the evidence that shows why this is not a galvanic cell. 2 marks

_____

_____

_____

_____

d. If this cell operated for a time of 70 minutes at a steady current of 50.0 A, what mass of silver would be plated onto the spoon? 3 marks

_____

_____

_____

_____

_____

SECTION B- continued

Question 3 (11 marks)

Pentanoic acid, otherwise known as valeric acid, is used for various flavours and perfumes. Pentanoic acid can be manufactured following the reaction flow chart below.

Pent-1-ene

Structural formula:

Reagent (s)

Compound A

Name:

Pentanoic acid

Structural formula:

Semi- structural formula: _____

SECTION B- continued

TURN OVER

a. Draw the structural formula of pent-1-ene in the box provided. 1 mark

b. Draw two structural isomers of pent-1-ene in the space below. 2 marks

c. State the reagent(s) needed to manufacture pent-1-ene to Compound A in the box provided. (1 mark)
d. Write the systematic name of compound A in the box provided. (1 mark)
e. Draw the structural formula and write the semi-structural formula of pentanoic acid in the box provided. (2 marks)
f. Dichromate is a useful catalyst for allowing the synthesis of pentanoic acid. Write a balanced half equation for $Cr_2O_7^{2-}$ to Cr^{3+}. (2 marks)
g. Pentanoic acid is combined with another compound to produce the following new compound:

$$CH_3CH_2CH_2CH_2COOCH_2CH_3$$

What is the IUPAC name of this new compound and the class of compounds it belongs to? (2 marks)

Name:

Class of compounds:

SECTION B- continued

Question 4 (15 marks)

When nitrogen monoxide, NO, and chlorine, Cl_2, react they produce an orange-red gas known as nitrosyl chloride. This gas whilst toxic to humans, can be used in various industries as an oxidising agent.

$$2NO(g) + Cl_2(g) \rightleftarrows 2NOCl\ (g) \qquad \Delta H > 0$$

a. Write out the expression for the equilibrium constant, K_c, for this reaction. 1 mark

b. Justify whether this is an exothermic or endothermic reaction. 2 marks

c. What effect will increasing the temperature have on the rate of nitrosyl chloride production. Reference collision theory to explain your answer. 3 marks

SECTION B- continued

TURN OVER

d. Explain two strategies that a chemist could use to improve the yield of nitrosyl chloride.

4 marks

e. Within a reactor at pressure of 1 atm and 35^{o}C, nitrogen dioxide and chlorine react. Prior to equilibrium, nitrosyl chlorine was added to an empty reactor tank. At equilibrium the concentration of nitrosyl chlorine is 0.72 M. The K_c value at this temperature is 3.2 x10^{2}.
Calculate the concentration of chlorine. 3 marks

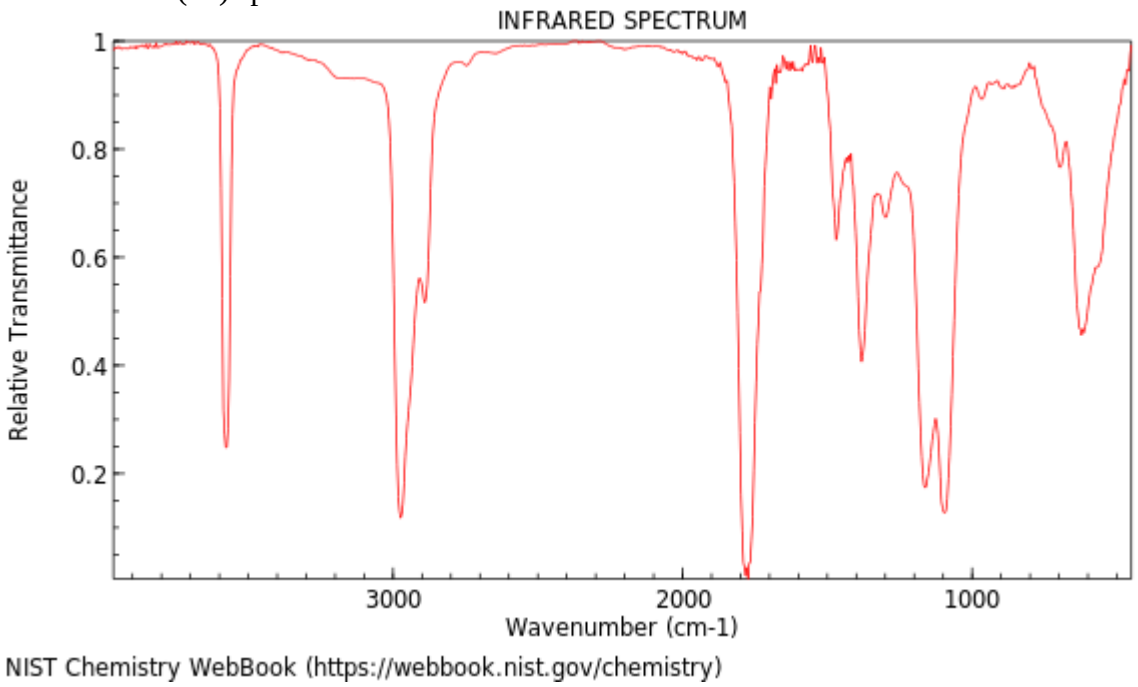
f. Helium, an inert gas, is injected into the reactor. With the temperature remaining at 35^{o}C and pressure of 1 atm, explain what effect the helium will have on the rate of production of nitrosyl chloride in the reactor. 2 marks

SECTION B- continued

Question 5 (12 marks)

A sample of a hydrocarbon is found in a beaker within a science laboratory. Given the title of "hydrocarbon X", it is known that the compound contains at least carbon, hydrogen, with the other possible element being oxygen. A series of tests were conducted to identify the IPUAC name of 'hydrocarbon X".

a. The infra-red (IR) spectrum of substance A is shown below.



Source: https://webbook.nist.gov/cgi/cbook.cgi?ID=C503742&Mask=80, National Institute of Advanced Industrial Science and Technology

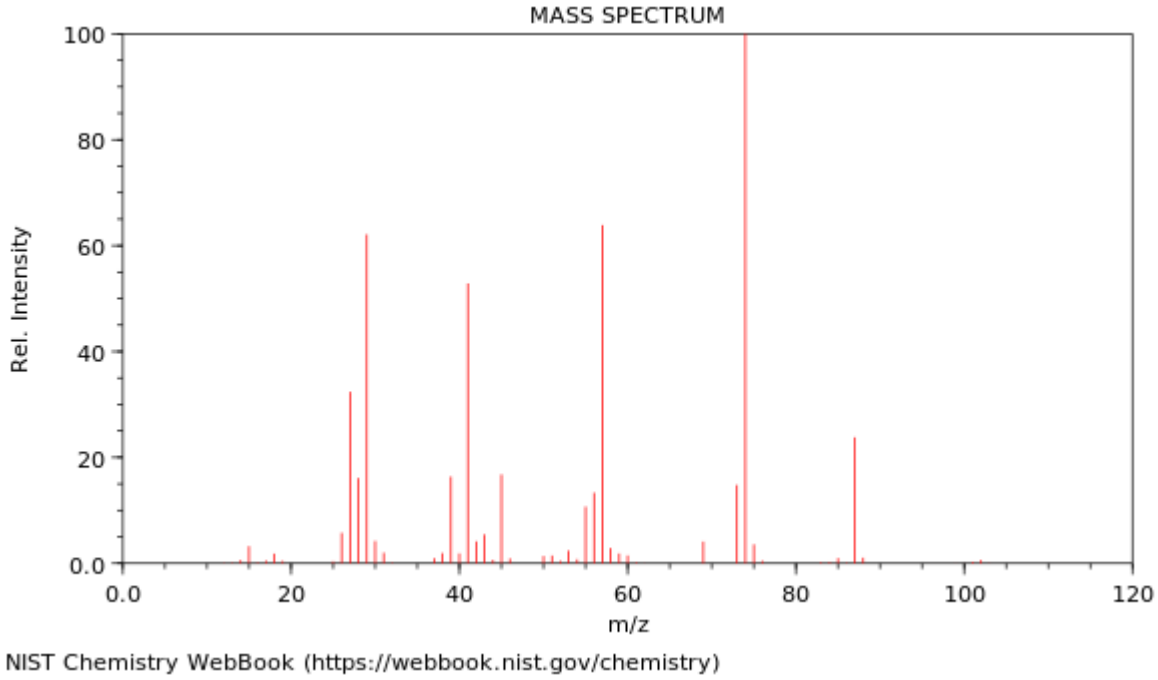
i. Explain two conclusions that can be deduced about "hydrocarbon X" based on the IR spectrum above. 2 marks

SECTION B- continued

TURN OVER

ii. Outline one of the principles of IR spectroscopy. 1 mark

b. The mass spectrum of "hydrocarbon X" is shown below.

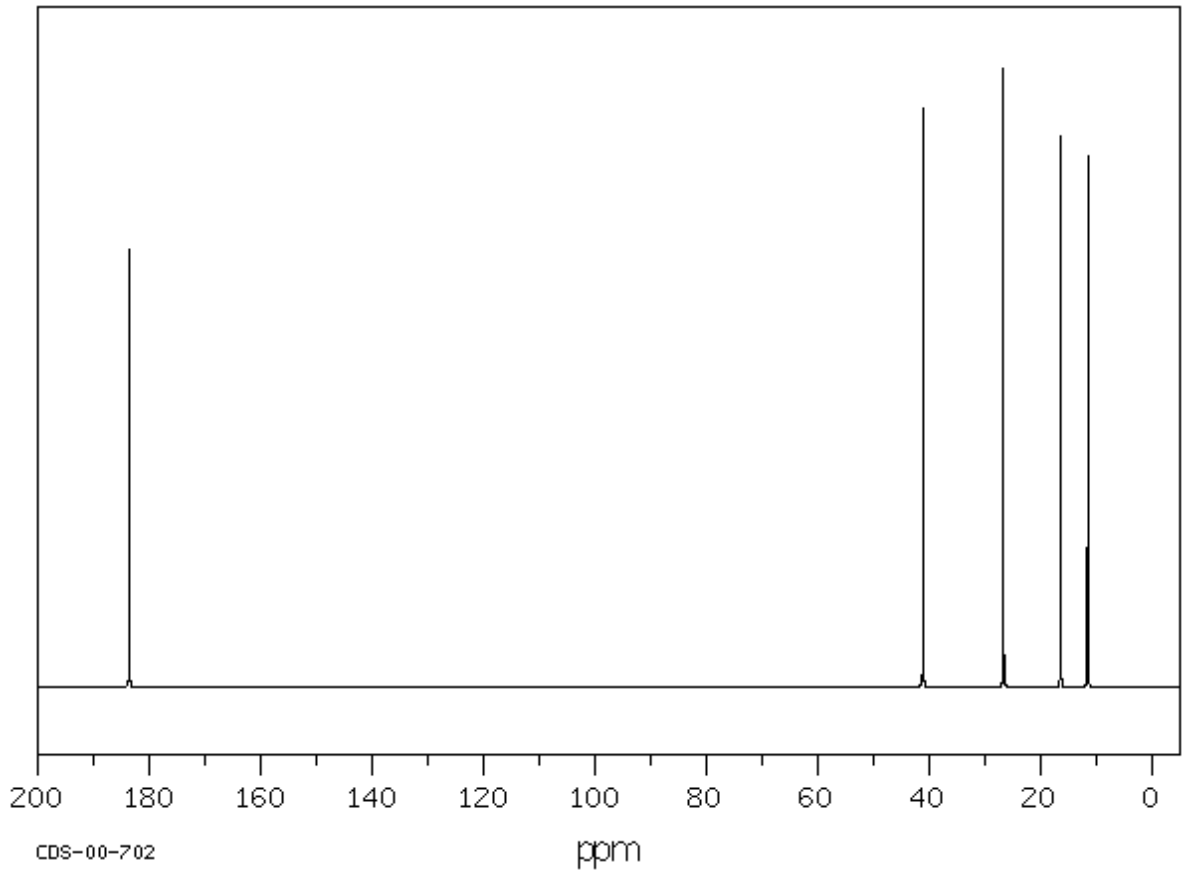


Source: https://webbook.nist.gov/cgi/cbook.cgi?ID=C116530&Mask=200, National Institute of Advanced Industrial Science and Technology

There is a significant peak with a mass-to-charge ratio (m/z) of 57 and 43. Suggest which fragments could produce these two peaks. 2 marks

SECTION B- continued

c. The ^{13}C NMR spectrum of "hydrocarbon X" is shown below. Whilst the ^{1}H-NMR spectrum data is not present, it was noted that five sets of peaks would be included.



Source: https://www.chemicalbook.com/SpectrumEN_116-53-0_13CNMR.htm

Commenting on the information from the ^{1}H NMR, ^{13}C NMR spectrum, IR spectrum, and mass spectrum. Determine the name of "hydrocarbon X". 5 marks

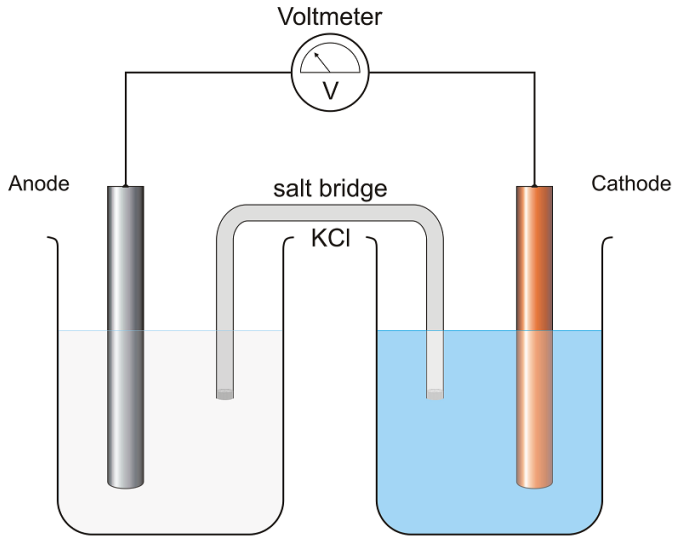
SECTION B- continued

TURN OVER

d. Draw "hydrocarbon X" in the space below that includes a labelled chiral centre. 2 marks

Question 6 (13 marks)

The following diagram is an example of a galvanic cell used as a demonstration in a laboratory to show how electricity can be generated using a spontaneous reaction. The demonstration has neglected to label which metals are located at each electrode, but it is known that lead and silver are the two metals.



a. Write out the suitable half equations that would allow for a spontaneous reaction to occur between these two metals. 2 marks

SECTION B- continued

b. Using oxidation numbers as evidence, identify the oxidant and reductant for this galvanic cell. 4 marks

c. Write out the overall reaction including the potential difference of this cell. 2 marks

d. Identify direction of electron flow to the suitable metal electrode. 1 mark

e. Identifying which ion would move towards each electrode, explain the requirement of a salt bridge for this galvanic cell. 2 marks

SECTION B- continued

TURN OVER

f. Use your understanding of redox to explain whether a spontaneous reaction would occur if the reductant for this reaction was substituted instead for solid gold. 2 marks

_____

_____

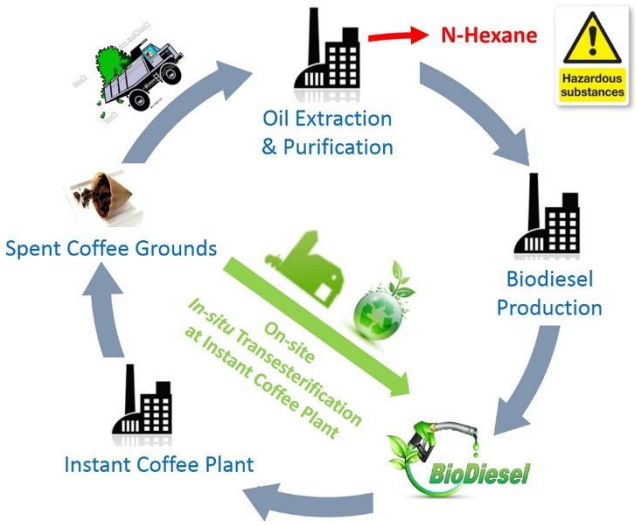
_____

_____

SECTION B- continued

Question 7 (13 marks)

Spent coffee grounds (SCG) waste has been drawing attention in the biodiesel industry due to the promise of oil content. However, SCG sources are very dispersed and require a transportation system. Moreover, a complexity of oil extraction steps using hazardous n-hexane can hinder the SCG biodiesel promotion.
Life cycle assessment was performed to compare the energy usage and environmental impacts between a conventional process, which requires transportation and n-hexane…..which is believed that the process requires 43% less energy and produces fewer environmental impacts.



Source: https://www.sciencedirect.com/science/article/pii/S0973082616311048

With communities and the chemical industry becoming more environmentally conscious about recycling and materials being used in the industry, one company is comparing two alternate ways of using Spent coffee grounds (SCG), which are the remainder coffee beans left over after use. The two different methods of using SCG are:

1. Extracting the oil at a petroleum refinery that burns fossil fuels to generate the energy needed. The SCG oil once extracted can be used for biodiesel production to then be used as an energy source. As summarised by the equation below.

SCG + energy → biodiesel

2. Alternatively the spent coffee ground (SCG) can be burnt to reduce waste and land refill. SCG undergoes complete combustion as summarised below.

SCG + oxygen gas → water + carbon dioxide

SECTION B- continued
TURN OVER

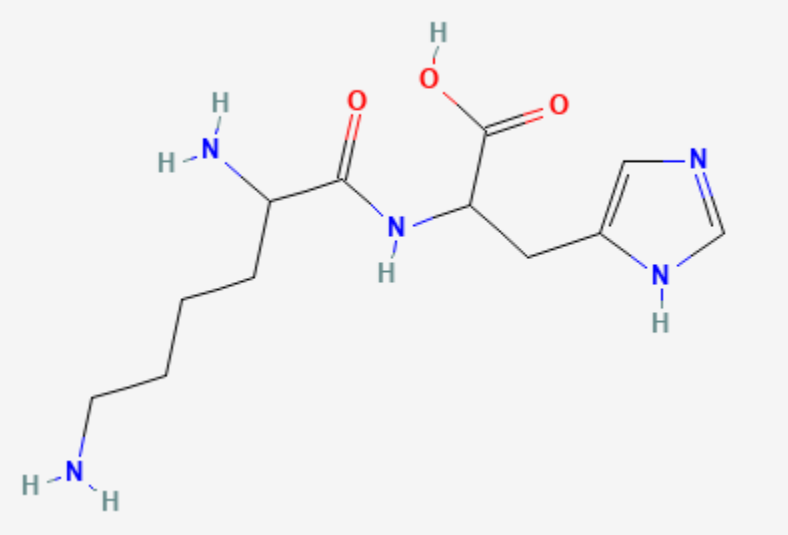
a. Comparing the two processes for processing spent coffee grounds. Discuss and compare the environmental impact and associated risks or hazards of both processes, and how one process could be improved to be considered a more renewable carbon neutral process. 5 marks

b. A scientist was curious to understand the amount of energy burnt by spent coffee grounds. A 20.67g sample of spent coffee grounds was burned under a steel can containing 600 ml of water. Once burnt out and the flame extinguished, the mass of the SCG was 8.67g and the temperature of the water had risen by 31^{o}C. Calculate the energy content of the SCG in kilojoules per gram. 3 marks

SECTION B- continued

c. When drinking coffee it is very common for raw sugar to be added to sweeten up the bitter taste of coffee. Sucrose is the major component of raw sugar making up approximately 98%. Identify what two sugar units synthesise this disaccharide. 2 marks

d. Other people prefer to add milk to their coffee as commonly referred to as latte. Two common amino acids in milk are shown in the image below. Identify which two amino acids are present and the name of the link that binds them together. 2 marks



Source: https://pubchem.ncbi.nlm.nih.gov/compound/ National Library of Medicine

e. Describe the difference between hydrolysis of protein and the denaturation of a protein referencing the type of bonding present in primary, secondary or tertiary protein structure. 2 marks

SECTION B- continued

TURN OVER

f. Lactase is very effective at breaking down the sugars found in milk. Justify whether lactase would be effective at breaking down the raw sugar also found in coffee. 1 mark

END OF QUESTION AND ANSWER BOOK