Neap:

Trial Examination 2015

VCE Chemistry Units 3&4

Written Examination

Question and Answer Booklet

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

Student's Name: _____

Teacher's Name: _____

Structure of Booklet

Section	*Number of questions*	*Number of questions to be answered*	*Marks*	*Suggested time (minutes)*
A	30	30	30	40
B	12	12	90	110
			Total 120	Total 150

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 white out liquid/tape.

Materials supplied

Question and answer booklet of 24 pages.

Data booklet of 11 pages.

Answer sheet for multiple-choice questions.

Instructions

Write your **name** and your **teacher's name** in the space provided above on this page, and on the 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 booklet.

You may keep the data booklet.

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

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2015 VCE Chemistry Units 3&4 Written Examination.

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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

Some reasons suggested for not using sodium hydroxide as a primary standard in volumetric analysis are as follows:

I Solid sodium hydroxide absorbs water and reacts with carbon dioxide from the atmosphere.

II Dissolving sodium hydroxide in water produces a clear solution.

III Weighing a particular mass of sodium hydroxide pellets does not allow the number of mole to be determined accurately.

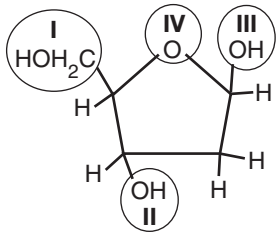
IV Sodium carbonate has a higher molar mass and can be used in place of sodium hydroxide in all titrations.

Which of the above reasons for not using sodium hydroxide as a primary standard are valid?

A. I and II only
B. II and III only
C. I and III only
D. III and IV only

Question 2

Deoxyribose is the sugar component of deoxyribonucleic acid (DNA). The diagram below shows the structure of the sugar deoxyribose, with the oxygen atoms circled and labelled with the numerals I to IV.

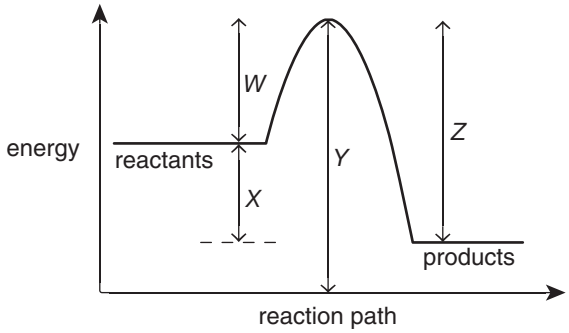


Which of the oxygen atoms labelled is not involved in the formation of covalent bonds between the sugar molecule and the other components of a DNA molecule?

A. I
B. II
C. III
D. IV

Use the following information to answer Questions 3–5.

An energy profile for a particular uncatalysed reaction is shown below.



Question 3

Which one of the following statements about this profile is correct?

A. The activation energy of the forward reaction is $Y - X$.
B. The energy profile is for an endothermic reaction.
C. During the reaction, the temperature of the surroundings increases.
D. No chemical species in the reaction has greater energy than the value of *Z*.

Question 4

If a catalyst was used in the reaction, which values would change?

A. *W*, *X* and *Z* only
B. *W*, *Y* and *Z* only
C. *W* and *Z* only
D. *X* and *Y* only

Question 5

The enthalpy change of the reverse reaction is equal to

A. $Y - X$
B. $W + X$
C. $Y - W$
D. $Z - W$

Question 6

The optimum temperature of a particular enzyme is 55°C. This is the temperature at which the enzyme generates the highest rate of reaction. At 85°C the rate of reaction decreases to almost zero.

Which one of the following is **not** a valid explanation for this decrease in rate of reaction?

A. At higher temperatures enzyme molecules often become denatured.
B. At higher temperatures some bonds holding the enzyme in a certain shape have been disrupted.
C. At higher temperatures the active site of the enzyme has changed and will not bond to the substrate.
D. At higher temperatures the bonds linking the amino acids in the protein chain have been broken.

Question 7

The volume of a fixed mass of gas will be

A. higher at SLC than at STP for all gases.

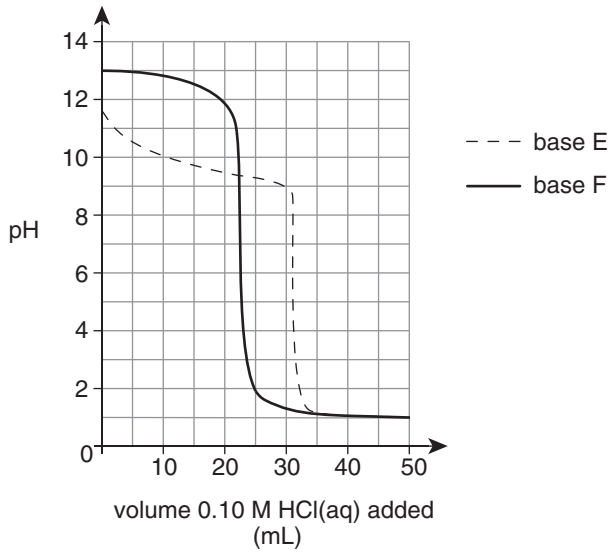
B. higher at STP than at SLC for all gases.

C. identical at STP and SLC for gases with very small molar masses.

D. identical at STP and SLC for gases with very large molar masses.

Use the following information to answer Questions 8 and 9.

Equal volumes of two bases, E and F, were titrated separately with 0.10 M hydrochloric acid. The pH changes during the titrations were recorded and graphed as shown below.



Question 8

Which one of the following is correct?

A. The bases are at the same concentration but base F is weaker than base E.

B. The bases are at the same concentration but base E is weaker than base F.

C. The bases are at different concentrations and base F is weaker than base E.

D. The bases are at different concentrations and base E is weaker than base F.

Question 9

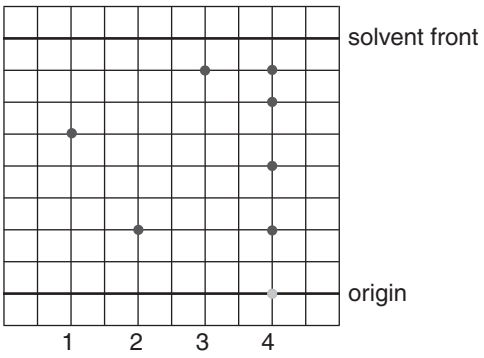
In another experiment, the volume of base F used in the original titration was diluted with pure water and then all of the diluted solution was titrated with 0.10 M hydrochloric acid.

Which one of the following is correct?

	pH of diluted base F solution compared to original base F solution	**Titre of HCl(aq) required to reach endpoint in the second titration compared to the original titration**
A.	same pH	same volume
B.	same pH	different volume
C.	different pH	same volume
D.	different pH	different volume

Use the following information to answer Questions 10–12.

Standard compounds 1, 2 and 3 and a mixture (labelled 4) were analysed by thin-layer chromatography (TLC) using a non-polar solvent and a polar stationary phase. The resulting TLC plate is shown below.



Question 10

For the standard compounds, the order of increasing polarity is

A. 1 < 2 < 3

B. 2 < 3 < 1

C. 2 < 1 < 3

D. 3 < 1 < 2

Question 11

Of the standard compounds tested, the mixture contains compounds

A. 1 and 2 only.

B. 2 and 3 only.

C. 1 and 3 only.

D. 1, 2 and 3.

Question 12

The TLC analysis was repeated under identical conditions, except that a longer plate was used and the solvent front travelled further.

Which one of the following statements is correct?

A. The R_f values of compounds 1, 2 and 3 would not change.

B. The top spot of the mixture would remain the same distance from the solvent front.

C. The distance between the spots of the mixture would decrease in size.

D. The R_f values of all of the spots of the mixture would increase.

Question 13

The $HC_2O_4^-(aq)$ ion could possibly react with water in the two different reactions shown by equations:

I $\quad HC_2O_4^-(aq) + H_2O(l) \rightleftharpoons C_2O_4^{2-}(aq) + H_3O^+(aq)$

II $\quad HC_2O_4^-(aq) + H_2O(l) \rightleftharpoons H_2C_2O_4(aq) + OH^-(aq)$

A 0.1 M solution is made by dissolving $NaHC_2O_4$ in water. When reaction is complete, the pH of the solution is less than 7 at 25°C.

It can be deduced that the value of the equilibrium constant

A. is higher for reaction I than for reaction II.
B. is higher for reaction II than for reaction I.
C. is identical for reaction I and reaction II.
D. cannot be compared for reactions I and II from the information provided.

Use the following information to answer Questions 14 and 15.

An experiment was conducted using the following system at equilibrium in a sealed vessel:

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \quad \Delta H = -920 \text{ kJ mol}^{-1}$$

Question 14

Some changes which could be made to the system include:

I doubling the volume of the vessel

II injecting $N_2(g)$ into the vessel at constant volume

III adding water vapour to the vessel at constant volume

Which of the above changes, made separately, would increase the total pressure in the vessel when the system again reached equilibrium?

A. I and II only
B. II and III only
C. I and III only
D. I, II and III

Question 15

Which one of the following statements about the forward reaction is **incorrect**?

A. The oxidation number of hydrogen increases and so NH_3 is the reducing agent.
B. The oxidation number of oxygen changes from 0 to –2.
C. Nitrogen undergoes oxidation as its oxidation number increases.
D. Oxygen is reduced and so it must be the oxidant.

Question 16

Which of the following amino acids would be expected to exist as a doubly charged ion when found in a solution of pH 2?

A. lysine
B. serine
C. valine
D. glutamic acid

Question 17

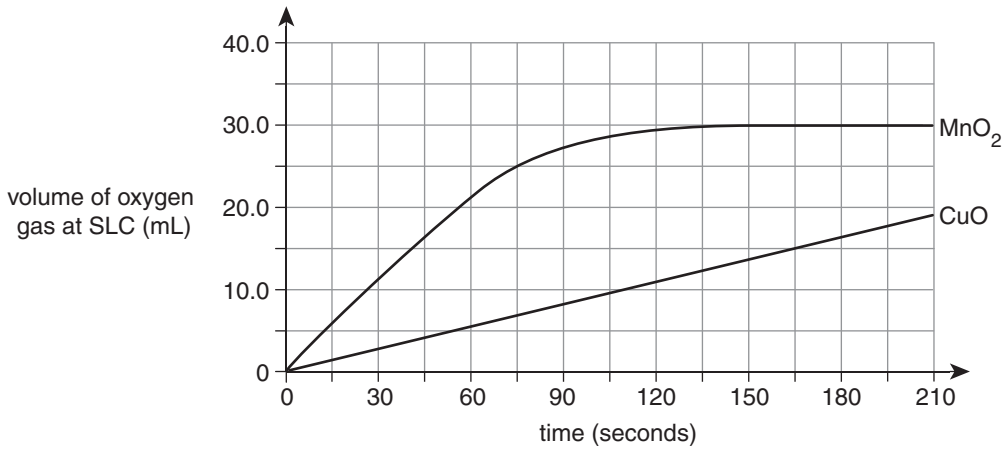
A segment of double-stranded DNA has 500 bases and 29% are guanine.

Which one of the following statements is correct?

A. In a single strand of the DNA, 29% of the bases must be guanine.
B. The total number of thymine bases is 105.
C. The number of cytosine and adenine bases must be 42% of the total.
D. 71% of the bases are either adenine or thymine.

Question 18

The effectiveness of two catalysts, MnO_2 and CuO, in catalysing the decomposition of hydrogen peroxide was tested by measuring the volume of oxygen gas released over time. The results of the experiment are shown below.



Some variables of the decomposition reaction which can be measured in the laboratory include:

I enthalpy change
II rate of reaction
III activation energy
IV equilibrium constant

Which of the above variables are changed by using CuO as a catalyst rather than MnO_2?

A. I and II only
B. II and III only
C. I, III and IV only
D. I, II, III and IV

Question 19

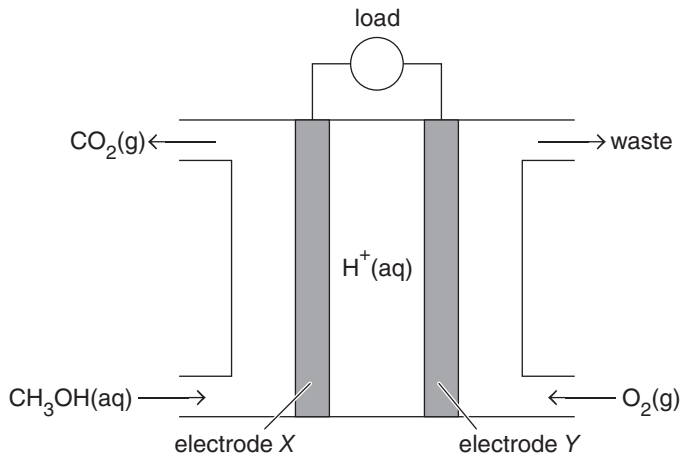
The carboxyl functional group can be described as consisting of a carbonyl group (C=O) and a hydroxyl group (O–H).

When salicylic acid is reacted with ethanoic acid to produce aspirin, which group of atoms of the salicylic acid molecule is involved in the reaction?

A. the carbonyl group of the carboxyl functional group
B. the hydroxyl group within the carboxyl functional group
C. the hydroxyl group outside the carboxyl functional group
D. the benzene ring within the salicylic acid molecule

Use the following information to answer Questions 20 and 21.

A fuel cell which uses methanol as the energy source has been developed by chemists. The simplified diagram below shows its structure.



Question 20

The fuel cell is different to a secondary cell because in a fuel cell

A. a spontaneous redox reaction is used.

B. reactants are continuously replenished.

C. the polarity of the electrodes is reversed.

D. cations travel towards the cathode.

Question 21

Methanol could also be used to generate electricity by combustion to produce hot gases which are then used in turning the turbine in an electrical generator.

For a set mass of methanol, which device would produce the greater amount of electrical energy?

A. fuel cell

B. generator

C. Both devices will be equivalent, as the number of mole of methanol used is equal.

D. No prediction can be made without knowing the exact mass of methanol used.

Question 22

Methanol can be produced from a number of sources.

Which one of the following sources is least sustainable?

A. methane extracted from natural gas being converted to methanol in a two-step process

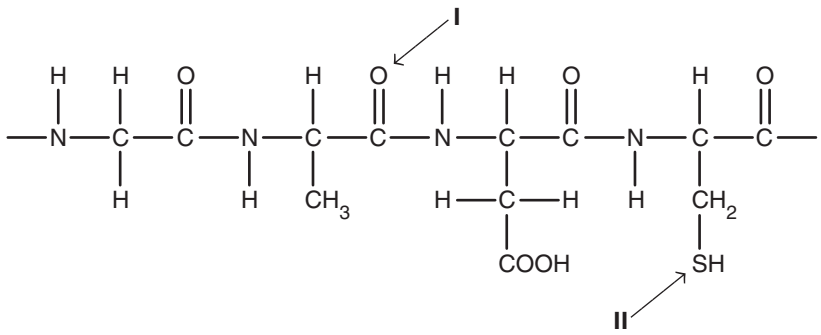
B. decomposition of organic waste producing methane from which methanol is generated

C. fermentation of carbohydrates producing a mixture of alkanols, including methanol

D. modified bacteria using plant structural material in special digesters to produce methanol

Use the following information to answer Questions 23 and 24.

The structure of a section of a protein molecule is shown below. Two atoms in the structure are labelled.



Question 23

If all of the peptide bonds in the protein were cleaved, the amino acids produced would include

A. methionine and asparagine.

B. glycine and valine.

C. glutamic acid and cysteine.

D. alanine and aspartic acid.

Question 24

In which levels of protein structure could the labelled atoms be directly involved?

	I	II
A.	primary	secondary
B.	secondary	tertiary
C.	tertiary	primary
D.	tertiary	secondary

Question 25

In the industrial production of chemicals by electrolysis, cells are designed to prevent products of the reaction from mixing.

What is the main reason for this design feature?

A. The production of the chemical will occur at a much faster rate.

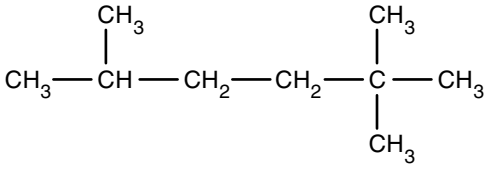
B. The products will be pure and later separation will not be required.

C. It prevents reactants of the process reforming spontaneously.

D. It enhances energy efficiency and conservation.

Question 26

A compound is shown below.



What is the systematic name of the compound shown?

A. 1,2,3-trimethyl-4-methylpentane

B. nonane

C. 2,2,5-trimethylhexane

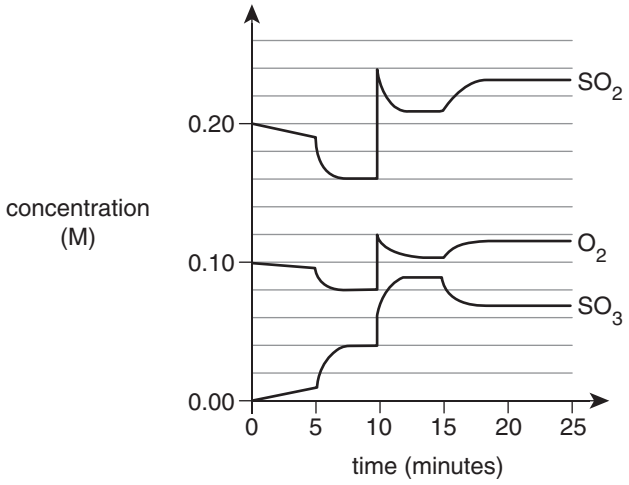
D. 2-methyl-5,5-dimethylhexane

Use the following information to answer Questions 27 and 28.

Sulfur dioxide gas and oxygen gas were placed in a sealed container and reaction occurred according to the equation:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H \text{ is negative}$$

Various changes were made to the system at different times during the experiment and the results were plotted as shown in the diagram below.



Question 27

What change was made to the system at $t = 5$ minutes?

A. The volume of the container was decreased.

B. Heat was added to the system.

C. Some sulfur trioxide gas was removed.

D. A suitable catalyst was introduced.

Question 28

Between the times 0 and 25 minutes, the equilibrium constant has

A. only one value.

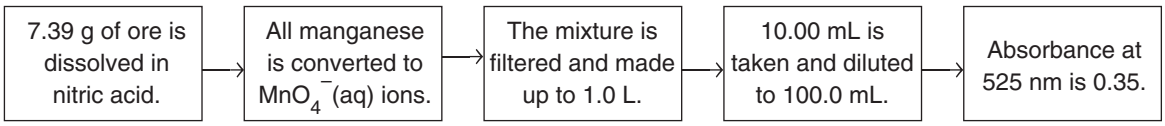
B. only two different values.

C. only three different values.

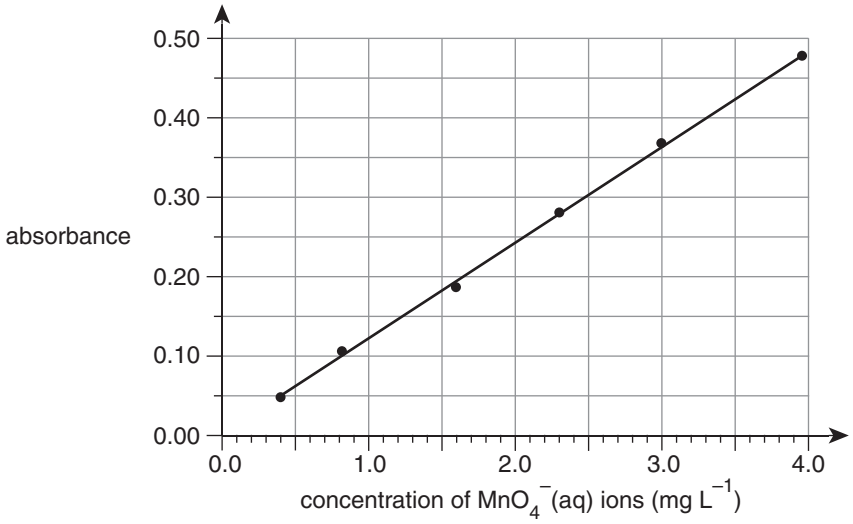
D. more than three different values.

Use the following information to answer Questions 29 and 30.

The manganese content of a sample of ore was determined by UV-visible spectroscopy using the following method:



The absorbances of a series of solutions of MnO_4^-(aq) of known concentrations were read at 525 nm to produce the calibration graph below.



Question 29

The mass of manganese in the original ore sample (in mg) is closest to

A. 1.3

B. 2.9

C. 13

D. 29

Question 30

One reason that the wavelength of 525 nm was chosen is that

A. there is minimum absorbance of radiation by MnO_4^- ions at this wavelength.

B. this is the only wavelength at which MnO_4^- ions absorb any radiation.

C. this wavelength is set by the manufacturer of the UV-visible spectrometer.

D. other substances in the solution do not absorb radiation at this wavelength.

SECTION B: SHORT-ANSWER QUESTIONS

Instructions for Section B

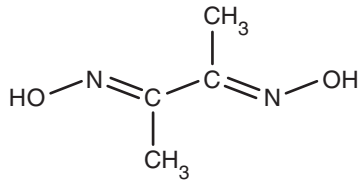
Answer **all** questions in the spaces provided. Write using black or blue pen.

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 answers to numerical questions; no marks 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).

Question 1 (9 marks)

The compound dimethylglyoxime can be used to determine the nickel content of ores. The structure and other information about the compound are shown below.



Formula	Molar mass	Solubility in water	Hazard
$C_4H_8N_2O_2$	116.0 g mol^{-1}	low	toxic skin and eye irritant

a. **i.** Give a specific safety precaution which should be taken when weighing an amount of dimethylglyoxime in the laboratory. 1 mark

_____

_____

ii. In qualitative analysis, dimethylglyoxime is often used as a solution in ethanol.

Explain why the solubility of the compound is much higher in ethanol than in water. 2 marks

_____

_____

_____

_____

_____

_____

b. A sample of nickel alloy was analysed using the following procedure:

Step 1 The alloy sample of mass 5.17 g was dissolved in acid and filtered. An excess of dimethylglyoxime solution was added to the filtrate and stirred.

Step 2 An excess of ammonia solution was added and the mixture was heated. A red precipitate formed according to the equation:

$$Ni^{2+}(aq) + 2C_4H_8N_2O_2(aq) + 2NH_3(aq) \rightarrow Ni(C_4H_7N_2O_2)_2(s) + 2NH_4^+(aq)$$

Step 3 After isolation and washing, the precipitate was weighed to a constant mass of 5.68 g.

i. It is the conjugate base of dimethylglyoxime that reacts with nickel ions to form the precipitate.

Explain why ammonia solution was added in step 2. 1 mark

_____

_____

_____

ii. Calculate the percentage by mass of nickel in the alloy.
($M(Ni(C_4H_7N_2O_2)_2) = 288.7$ g mol^{-1}) 4 marks

_____

_____

_____

_____

_____

c. This analysis could have been completed more rapidly and with greater accuracy using instrumental analysis.

Name the most appropriate instrumental technique for analysis of the nickel content of the alloy. 1 mark

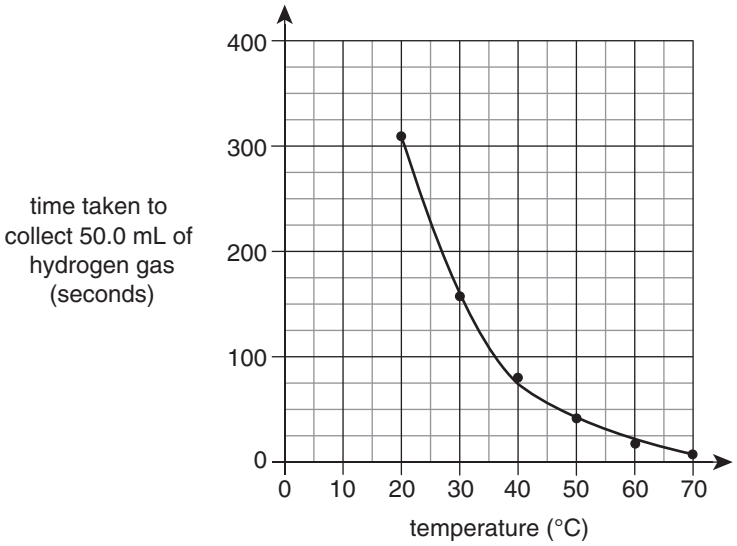
_____

Question 2 (7 marks)

Experiments were conducted to determine the effect of temperature on the rate of the following reaction:

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

A set mass of zinc powder was added to each flask containing excess dilute hydrochloric acid at different temperatures, and the hydrogen gas evolved was collected. The time taken for 50.0 mL of hydrogen gas to be produced was recorded. The results of the experiments were graphed as shown below.



a. Apart from the temperature, all conditions used in the experiments were identical.

Without referring to the zinc, state one condition which would need to be identical for each of the experiments. 1 mark

_____

b. **i.** Assuming that the hydrogen gas is collected at SLC, calculate the minimum mass of zinc which could be used in each experiment. 3 marks

_____

_____

_____

_____

c. The experiment was repeated under identical conditions except that zinc granules were used.

On the set of axes above, draw in the graph of results which could be expected. 1 mark

d. For many reactions, chemists have estimated that increasing the temperature by 10°C will cause the rate of reaction to double.

In terms of collision theory, what is the **major reason** that increasing temperature increases the rate of a chemical reaction? 2 marks

_____

_____

_____

_____

_____

Question 3 (5 marks)

To determine the nitrogen content of 8.47 g of grain, the sample was ground to a powder and the nitrogen present was chemically converted to ammonia (NH_3). All of the ammonia was neutralised by adding 100.0 mL of 0.250 M hydrochloric acid:

$$NH_3(aq) + HCl(aq) \rightleftharpoons NH_4Cl(aq)$$

The unreacted hydrochloric acid was then titrated with 0.375 M sodium hydroxide solution. The endpoint was reached using a titre of 17.80 mL.

a. Calculate the amount, in mol, of hydrochloric acid which reacted with the ammonia. 3 marks

_____

_____

_____

_____

b. Using this analysis, the percentage by mass of nitrogen in the grain sample was found to be 3.0%. This was higher than the manufacturer's specification.

Suggest one possible reason for the higher-than-expected result. 1 mark

_____

_____

_____

c. Suggest why an indirect (back) titration was used in this analysis, rather than directly titrating the ammonia solution with hydrochloric acid. 1 mark

_____

Question 4 (12 marks)

A particular compound is composed of 41.4% carbon, 3.4% hydrogen and oxygen.

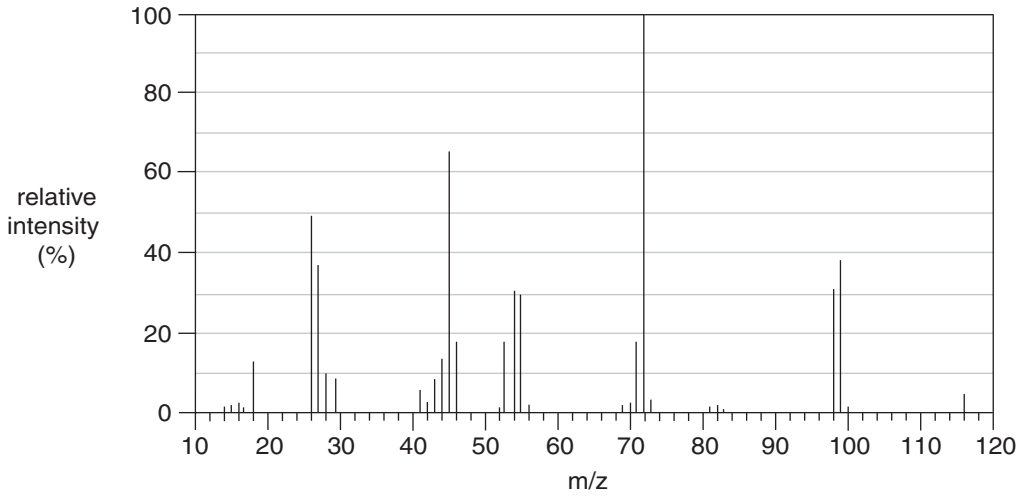
a. Show that the empirical formula of the compound is CHO. 2 marks

_____

_____

_____

b. The mass spectrum of the compound is shown below.

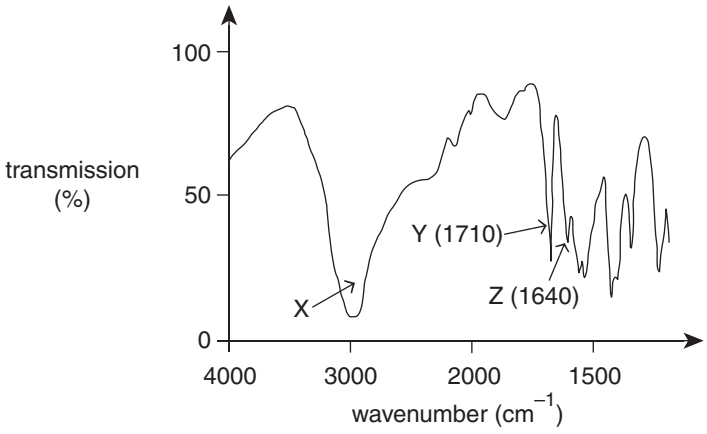


Determine the molecular formula of the compound. 2 marks

_____

_____

c. The infrared spectrum of the compound is shown below.



Identify the atoms and bonds between them that are associated with the absorptions labelled:

i. X 1 mark

_____

ii. Z 1 mark

_____

d. To neutralise 0.045 mol of the compound, 5.05 g of KOH is required.
What does this information reveal about the compound? 2 marks

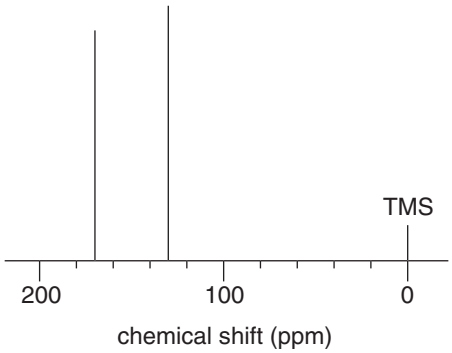
_____

_____

_____

e. Draw the structural formula of the compound, showing all bonds. 2 marks

f. The ^{13}C NMR spectrum of the compound is shown below.



Explain how the ^{13}C NMR spectrum is consistent with the structure of the compound drawn in part **e.** 2 marks

_____

_____

_____

Question 5 (11 marks)

Linoleic acid is a long-chain carboxylic acid with the molecular formula $C_{17}H_{31}COOH$.

a. Linoleic acid can be converted to stearic acid by reaction with hydrogen gas using suitable conditions.

Calculate the volume of hydrogen gas at 50°C and 1.2 atm which would react completely with 15.89 g of linoleic acid. 4 marks

_____

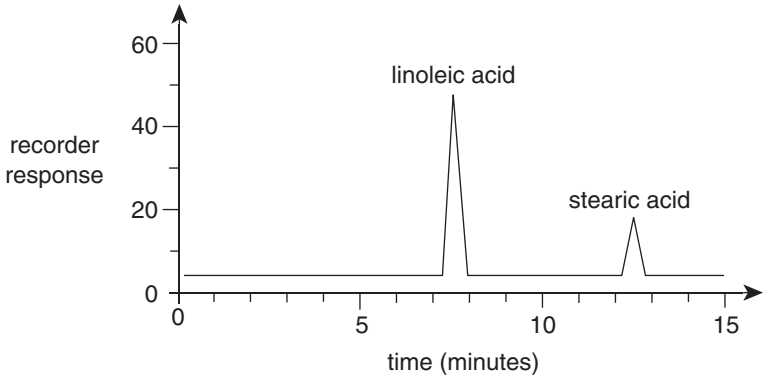
_____

_____

_____

_____

b. A mixture of linoleic acid and stearic acid was analysed by high-performance liquid chromatography (HPLC), using a non-polar stationary phase. The resulting chromatogram is shown below.



i. Which fatty acid, linoleic or stearic, has the higher concentration in the mixture analysed? Explain your choice. 2 marks

_____

_____

_____

ii. Based on the results of the HPLC, which fatty acid, linoleic or stearic, is likely to have the higher melting point? Explain your choice. 3 marks

_____

_____

_____

_____

_____

_____

c. The mixture of linoleic acid and stearic acid could also be analysed by gas chromatography (GC). The components are converted to methyl esters before analysis by GC.

i. Stearic acid is converted to a methyl ester by reaction with methanol.

Write a balanced chemical equation for this reaction. State symbols are **not** required. 1 mark

_____

ii. Suggest a reason why the conversion of long-chain carboxylic acids to methyl esters is the usual practice before GC analysis. 1 mark

_____

_____

Question 6 (7 marks)

a. Ethanol and ethyl ethanoate were analysed by ^{1}H NMR.

Tick one box in each row of the table below to indicate whether each spectral feature applies to ethanol only, or to ethyl ethanoate only, or to both compounds. 4 marks

Proton NMR spectral feature	Ethanol only	Ethyl ethanoate only	Both ethanol and ethyl ethanoate
Apart from the TMS peak, there are three peaks on the low resolution NMR.			
The peak at 3.7 ppm is split into four fine peaks (a quartet).			
One of the peaks is split into three fine peaks (a triplet).			
The area under the low-resolution NMR peaks is in the ratio of 2 : 3 : 3.			

b. Using a sample of ethanol as the only available organic reagent, outline how a quantity of ethyl ethanoate can be synthesised. Include in your answer any inorganic reagents required and suggest how the product could be isolated from the reaction mixture. 3 marks

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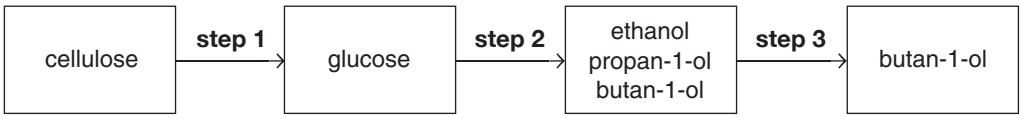
Question 7 (7 marks)

The biochemical fuel biobutanol (butan-1-ol) is formed by the breaking down of plant waste material by microbes. The process is shown in the flowchart below.



a. Cellulose is a structural polysaccharide in plants and is a condensation polymer of glucose.

i. Name the type of linkage in cellulose which is broken when glucose molecules are produced in step 1. 1 mark

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ii. Name the type of reaction occurring in step 1. 1 mark

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b. Explain why step 2 occurs in the absence of oxygen. 1 mark

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c. A 0.498 g sample of biobutanol (M = 74.0 g mol^{-1}) was burned completely in a bomb calorimeter which has a calibration factor of 3.49 kJ °C^{-1}. The temperature increased by 5.16°C.

i. Calculate the amount of energy released, in kJ, by the combustion of 1.00 mol of the biobutanol. 2 marks

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ii. Write the thermochemical equation for the combustion of biobutanol. 2 marks

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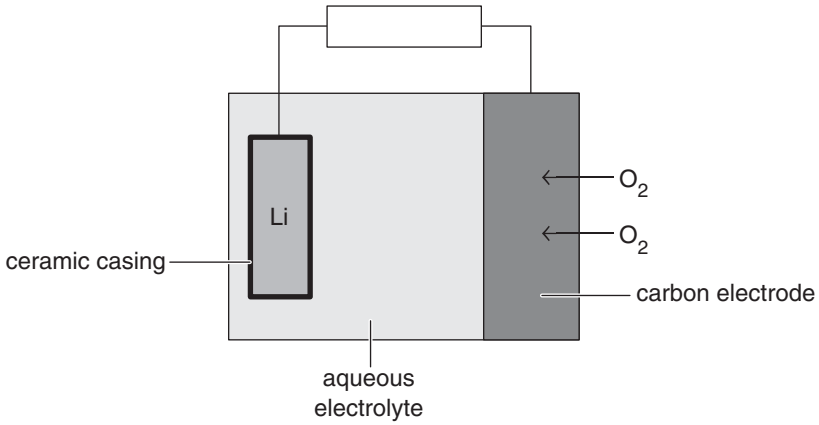
Question 8 (8 marks)

The lithium–air battery is a secondary cell which could be used as the energy source for electrical vehicles. One design of the cell is shown in the simplified diagram below.



When the cell is producing energy, the following reaction occurs using an acidic electrolyte:

$$4Li(s) + O_2(g) + 4H^+(aq) \rightarrow 4Li^+(aq) + 2H_2O(l)$$

a. Lithium reacts with water, and so it is covered by a ceramic casing.

i. With the aid of the electrochemical series, write the equation for the reaction between lithium and water. 2 marks

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ii. As well as preventing the passage of water molecules, what other property must the ceramic casing exhibit to allow the cell to function? 1 mark

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b. The carbon electrode is embedded with fine particles of cobalt and manganese.

i. What is the likely role of these metal particles? 1 mark

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ii. In addition to being unreactive and electrically conductive, what other property must the carbon electrode exhibit? 1 mark

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c. **i.** Write the half-equation for the reaction which occurs at the carbon electrode. 1 mark

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ii. What is the expected cell voltage under standard conditions? 1 mark

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iii. Tick **one** box in the table below to show the identity and polarity of the carbon electrode. 1 mark

	Positive	**Negative**
Anode		
Cathode		

Question 9 (8 marks)

The pH values of acid solutions of the same concentration at 25°C are shown in the table below.

Ethanoic acid	Citric acid	Hydrochloric acid
pH = 3.38	pH = 2.56	pH = 2.00

a. **i.** Write an expression for the acidity constant, K_a, of ethanoic acid. 1 mark

ii. Calculate the percentage ionisation of the ethanoic acid solution. 3 marks

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b. Calculate the hydroxide ion concentration in the citric acid solution. 2 marks

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c. Determine the volume of water which must be added to 10.0 mL of the hydrochloric acid solution to produce a solution of pH = 2.37. 2 marks

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Question 10 (4 marks)

When a solution of a metal chloride is electrolysed for 30 minutes using a constant current of 0.541 amperes, 0.151 grams of the metal is deposited. The charge on the metal ion is +3.

Determine the identity of the metal.

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Question 11 (5 marks)

In a problem-solving exercise, a student was provided with four half-cells under standard conditions. The objective was to place the half-reactions in the correct order in an electrochemical series. The half-cell reduction reactions, in random order, are shown in the table below.

Half-cells	Reduction half-equations
A	$Cr^{2+}(aq) + 2e^- \rightleftharpoons Cr(s)$
B	$NO_3^-(aq) + 4H^+(aq) + 3e^- \rightleftharpoons NO(g) + 2H_2O(l)$
C	$Au^{3+}(aq) + 3e^- \rightleftharpoons Au(s)$
D	$MnO_4^-(aq) + e^- \rightleftharpoons MnO_4^{2-}(aq)$

In a series of experiments, two half-cells were connected at a time and experimental observations were made as follows:

Half-cells	Experimental observations
A and B	Gas bubbles are produced at one electrode.
C and D	The gold electrode increases in mass.
B and C	The pH near one electrode decreases.

a. **i.** Give the formula of an oxidant from the experiment which is known to be stronger than acidified $NO_3^-(aq)$. 1 mark

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ii. Give the formula of a reductant from the experiment which is known to be a stronger reductant than NO(g). 1 mark

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b. Write the balanced equation for the cell reaction produced by connecting half-cells A and B. 1 mark

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c. The standard hydrogen half-cell was not used in the problem-solving exercise.

Explain how the standard hydrogen half-cell could have been used in this exercise to gain further information about the correct order of the half-reactions in an electrochemical series. 2 marks

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Question 12 (7 marks)

Ethanol is made by the petrochemical industry by reacting ethene with steam as shown below:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \quad \Delta H = -45 \text{ kJ mol}^{-1}$$

a. **i.** The maximum yield of ethanol is achieved at temperatures lower than 300°C.

Explain why low temperatures would produce maximum yield in this reaction. 2 marks

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ii. Temperatures above 350°C are used in the manufacture of ethanol.

Suggest one reason why higher temperatures than those which produce maximum yield might be used. 1 mark

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iii. State one condition, other than temperature, which could be used to maximise the yield of ethanol in industrial production. Explain your choice. 2 marks

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b. At a set temperature using suitable reaction conditions, 0.736 mol of ethene and 0.985 mol of steam were introduced into a sealed 5.00 L container. When equilibrium was established at the set temperature, the concentration of ethanol was found to be 0.130 M.

Calculate the concentration of ethene in the equilibrium mixture. 2 marks

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END OF QUESTION AND ANSWER BOOKLET

