

External Assessment 2022

# CHEMISTRY

CHM415115

Section **A**

Pages	12
Questions	5
Information Sheet	1

**Preparation time for this exam:** 15 minutes

**Suggested working time:** 45 minutes

**Instructions:**

- Answer **all** questions and **all** items within each question.
- Write your answers in the spaces provided in this exam paper.
  - Spare diagrams have been provided at the end of each section. Indicate in the box provided if you have used the spare diagrams.
- A TASC approved scientific calculator can be used throughout the exam.
  - Show your workings in answers to numerical questions. No marks can be given for incorrect answers unless they are accompanied by details of the working.
  - The appropriate units must be included.
- The exam is **three (3)** hours in length. It is suggested that you spend **approximately 45 minutes** in total answering the questions in this section.
- The Chemistry Information Sheet can be used throughout this exam.
- All answers must be written in **English**.
- You **must** make sure your answers address:
  - Criterion 5 identify and apply fundamental principles and theories of electrochemistry.

Marker Use	
C5	/ 45

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# Additional Instructions

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- Note: When you are asked to “**show that**”:
  - You should calculate your own answer to the appropriate number of significant figures and then use this value to answer the following item(s) of the question.
  - If you are unable to determine the required value, you should use the value given in the following items of the question.

## Guide to Exam Structure

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	Questions available	Questions to answer	Suggested working time	Marks available
<b>Section A</b>	5	5	45 minutes	45 marks
Section B	5	5	45 minutes	45 marks
Section C	7	7	45 minutes	45 marks
Section D	7	7	45 minutes	45 marks
<b>Totals</b>	<b>24</b>	<b>24</b>	<b>180 minutes (3 hours)</b>	<b>180</b>

**Question 1**

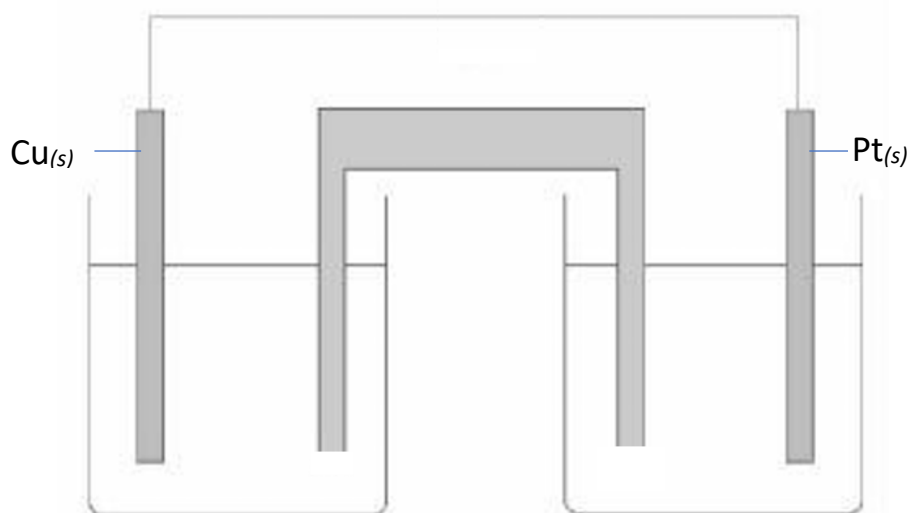
Marker use

An electrochemical cell is constructed using:

- a half-cell with a platinum rod in a solution containing  $1.00 \text{ mol L}^{-1} \text{ FeCl}_{2(aq)}$  and  $1.00 \text{ mol L}^{-1} \text{ FeCl}_{3(aq)}$
- a half cell with a copper rod in  $1.00 \text{ mol L}^{-1} \text{ CuCl}_{2(aq)}$
- connecting wires, a voltmeter and a sodium nitrate salt bridge.

a) Complete the diagram below, showing:

- the anode and the cathode and their polarities
- the ions present in each half-cell
- the direction of electron flow
- the direction of ion flow through the salt bridge
- the placement of the voltmeter.



Spare diagram used (✓)

5

b) Write the anode, cathode and overall equations that describe this electrochemical cell.

Anode equation: .....

Cathode equation: .....

Overall equation: .....

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c) Calculate the maximum voltage expected on the voltmeter as the cell operates.

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**Question 1 continues**

**Question 1 continued**

Marker use

d) Explain what will happen to the cell if the  $\text{Fe}^{2+}, \text{Fe}^{3+} | \text{Pt}$  half-cell is replaced with an  $\text{Fe}^{2+} | \text{Fe}$  half-cell.

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**Total Q1**

12

## Question 2

In some reactions, one species can be both oxidised *and* reduced. These reactions are called “disproportionation reactions”. **When melted (molten)**, potassium chlorate  $\text{KClO}_3$  undergoes a disproportionation reaction in which the chlorate ion ( $\text{ClO}_3^-$ ) produces both the perchlorate ion ( $\text{ClO}_4^-$ ) and the chloride ion.

a) Complete the table below to show the oxidation state of **chlorine** in the species shown.

Species	Oxidation state of chlorine
Chlorate ion, $\text{ClO}_3^-$	
Perchlorate ion, $\text{ClO}_4^-$	

b)

i. Write the redox half-equation for the reaction of chlorate ions to give chloride ions.

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ii. Identify this reaction as oxidation or reduction.

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c) Write the redox half-equation for the reaction of chlorate ions to give perchlorate ions.

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d) Write a balanced **net ionic equation** for the disproportionation of the chlorate ion.

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e) Explain how this reaction can occur even though the species involved are not aqueous.

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Marker use

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Total Q2

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### Question 3

The discovery of electricity revolutionised chemistry because it allowed reactive metals such as aluminium to be extracted from their salts.

- a) Identify the key difference between electrolytic cells and galvanic cells in terms of energy.

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- b) Every year, a huge amount of energy is used to melt an aluminium salt so that electrolysis of  $\text{Al}^{3+}_{(l)}$  can occur. Explain why aluminium cannot be obtained by electrolysis of  $\text{Al}^{3+}_{(aq)}$ . Include relevant half-equation(s).

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- c) Identify a salt which would give the same products regardless of whether electrolysis were carried out on its molten salt or aqueous solution using inert electrodes.

Explain your answer.

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**Total Q3**

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**Question 4**

Sodium chloride solution is an extremely abundant resource (think: seawater!). Apart from a supply of solid NaCl, concentrated NaCl<sub>(aq)</sub> (known as “brine”) is used to produce over 50 million tonnes of sodium hydroxide annually.

a) Complete the following table about the electrolysis of sodium chloride using inert electrodes.

Substance electrolysed	Anode product(s)	Cathode product(s)
Molten NaCl		
Dilute aqueous NaCl		

b) Write the anode and cathode half-equations for the electrolysis of **concentrated NaCl<sub>(aq)</sub>** (using inert electrodes). Use these to write the **net ionic equation** and **balanced chemical equation** for the reaction.

Anode half-equation:.....  
 .....

Cathode half-equation: .....  
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Net ionic equation:.....  
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Balanced chemical equation: .....  
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Marker use

4

3

**Total Q4**

7

### Question 5

Marker use

An important application of electrolysis is electroplating. For example, an iron object could be coated with zinc by electroplating, to help prevent corrosion.

a) What is the term used for an iron object covered with a layer of zinc?

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b) In the space below, draw a **labelled** diagram to show how an iron object could be electroplated with zinc. Include relevant half-equations.

4

Question 5 continues

**Question 5 continued**

- c) An iron nail was used to attach a sign to a wooden fence post (the sign has since fallen off).



Marker use

4

Explain how the nail corrodes over time. Include relevant half-equation(s) in your response.

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- d) Explain how the zinc coating protects the iron object from corrosion, even if the zinc coating is damaged. Equations are not required.

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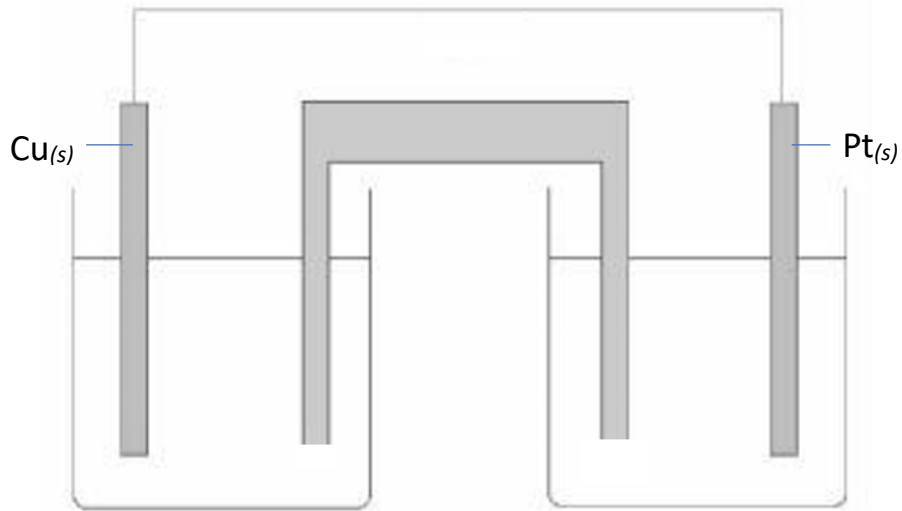
**Total Q5**

11

# Spare Diagrams

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Question 1 a)



End of Section A



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External Assessment 2022

# CHEMISTRY

CHM415115

Section **B**

Pages	16
Questions	5
Information Sheet	1

**Suggested working time:** 45 minutes

**Instructions:**

- Answer **all** questions and **all** items within each question.
- Write your answers in the spaces provided in this exam paper.
  - Spare diagrams have been provided at the end of each section. Indicate in the box provided if you have used the spare diagrams.
- A TASC approved scientific calculator can be used throughout the exam.
  - Show your workings in answers to numerical questions. No marks can be given for incorrect answers unless they are accompanied by details of the working.
  - The appropriate units must be included.
- The exam is **three (3)** hours in length. It is suggested that you spend **approximately 45 minutes** in total answering the questions in this section.
- The Chemistry Information Sheet can be used throughout this exam.
- All answers must be written in **English**.
- You **must** make sure your answers address:
  - Criterion 6 identify and apply principles and theories of thermochemistry, kinetics and equilibrium.

Marker Use	
C6	/ 45

# Additional Instructions

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- Note: When you are asked to “**show that**”:
  - You should calculate your own answer to the appropriate number of significant figures and then use this value to answer the following item(s) of the question.
  - If you are unable to determine the required value, you should use the value given in the following items of the question.

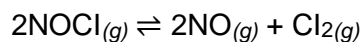
## Guide to Exam Structure

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	Questions available	Questions to answer	Suggested working time	Marks available
Section A	5	5	45 minutes	45 marks
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<b>Totals</b>	<b>24</b>	<b>24</b>	<b>180 minutes (3 hours)</b>	<b>180</b>

**Question 6**

Consider the equilibrium reaction



a) Write the equilibrium constant expression for this reaction.

Marker use

/ 2

b) Predict which reaction (forward or reverse) favours maximum entropy. Explain your answer.

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c) Predict whether the forward reaction is exothermic or endothermic. Explain your answer.

/ 2

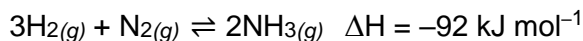
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**Total Q6**

/ 6

**Question 7**

Ammonia is a very important industrial and agricultural chemical; about 176 million tonnes of it are produced annually. The majority is produced by the Haber-Bosch process, which can be summarised by the following equation:



a) Explain the effect of increased temperature on:

i. the rate of reaction.

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ii. the yield of ammonia.

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b) Identify how these **two (2)** effects are taken into account in an industrial process, such as this one.

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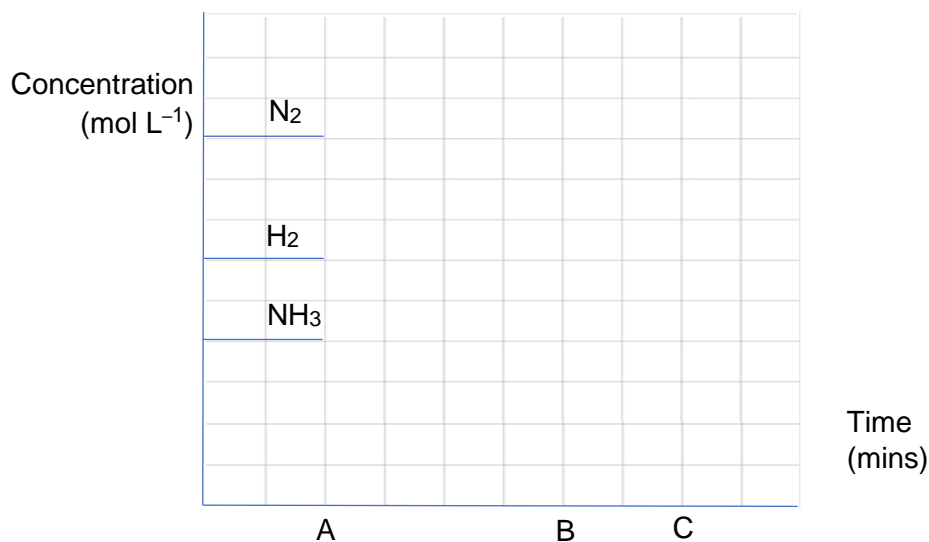
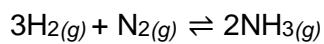
**Question 7 continues**

**Question 7 continued**

c) The graph below shows an equilibrium mixture of nitrogen, hydrogen and ammonia.

- At time "A" there is a rapid addition of nitrogen gas.
- A new equilibrium is established by time "B".

Show this on the graph below, continuing your lines until time "C".



Marker use

4

Spare diagram used (✓)



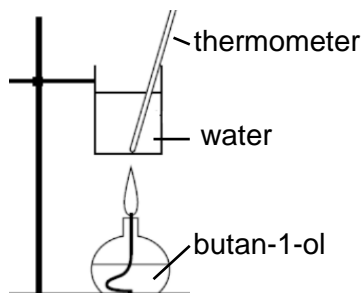
Total Q7

9

### Question 8

Marker use

A class was given the task of determining the enthalpy of combustion of butan-1-ol:



Half of the students chose to use calorimetry, and they set up the equipment as shown. These students collected the following data:

Mass of water used: 100.0 g  
Initial temperature of water: 25.0°C  
Final temperature of water: 31.5°C  
Mass of butan-1-ol burned: 0.152 g  
M (butan-1-ol): 74.12 g mol<sup>-1</sup>

- a) Calculate the heat of combustion of butan-1-ol using these students' results. Express your answer in kJ mol<sup>-1</sup>.

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Question 8 continues

Question 8 continued

Marker use

- b) The other half of the students chose to use bond energies to calculate the enthalpy of combustion. They found the following average bond energy values in a chemistry textbook.

Bond type	Bond energy (kJ)	Bond type	Bond energy (kJ)
C – H	413	C = O	745
C – C	347	O – H	467
C = C	614	O = O	495
C – O	358	O – O	146

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Use bond energies to calculate the enthalpy of combustion of butan-1-ol.

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- c) Identify **one (1)** limitation of each method.

Calorimetry method: .....

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Using bond energies: .....

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Total Q8

9

### Question 9

Marker use

More sulfuric acid is produced industrially worldwide every year than any other chemical. The reaction of sulfur dioxide gas with oxygen gas to produce sulfur trioxide gas is the key step in the process. The reaction is very slow without a catalyst and **releases 99 kJ of energy per mole of SO<sub>2</sub> consumed**.

a) Write a balanced chemical equation for this reaction, including the  $\Delta H$  term.

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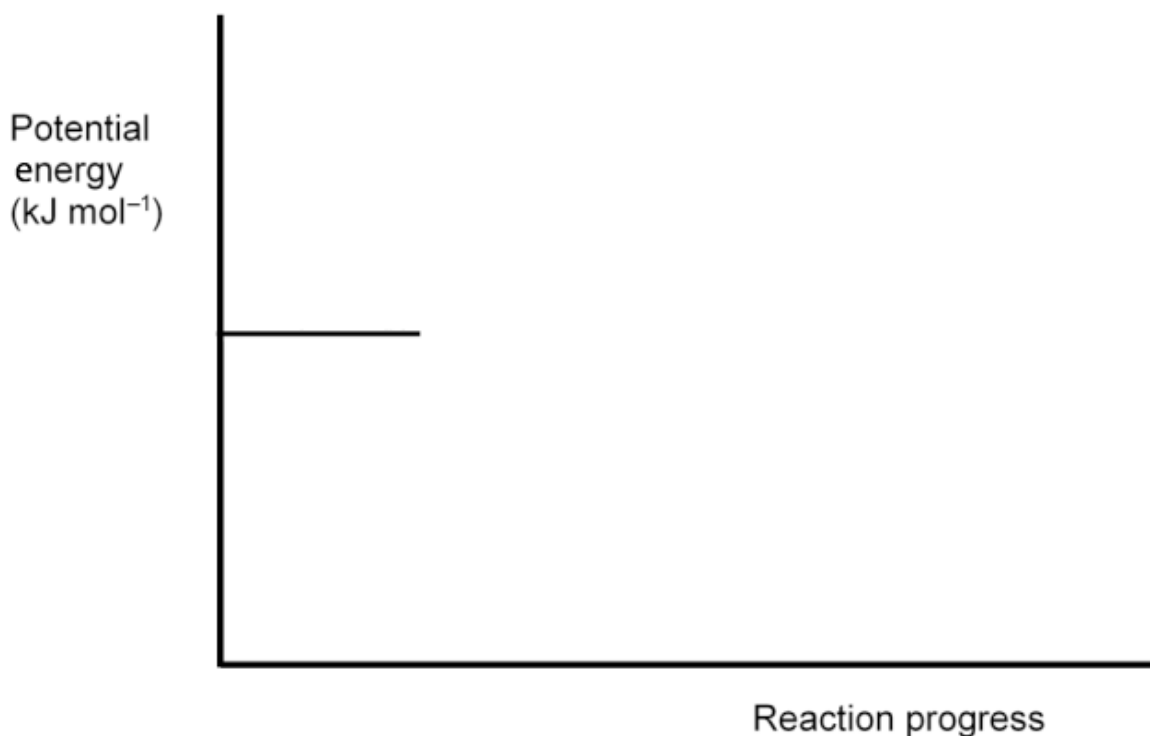
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b) Use the axes below to draw an energy profile diagram for the uncatalysed conversion of SO<sub>2</sub> to SO<sub>3</sub>.

4

Label your diagram with the following:

- specific reactants and products
- enthalpy change ( $\Delta H$ )
- activation energy ( $E_A$ )



Spare diagram used  
(✓)

c) Industrially, a vanadium-based catalyst is used to increase the rate of this reaction. Use a dashed line (- - -) on the diagram to show how the energy profile diagram changes with the addition of a catalyst.

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Question 9 continues

**Question 9 continued**

Marker use

d) Does  $\Delta H$  change with the addition of a catalyst? Explain.

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e) Outline how a catalyst changes the rate of a chemical reaction.

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**Total Q9**

/ 11

### Question 10

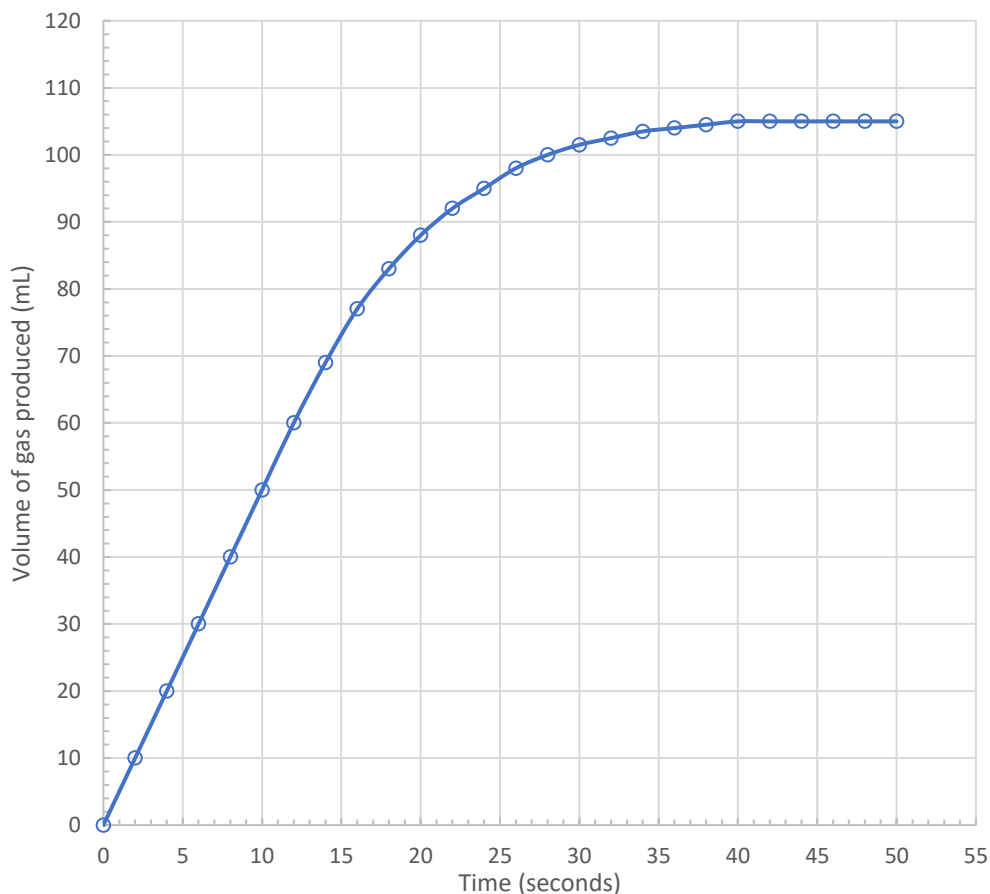
Marker use

In an investigation into rate of reaction, a group of students reacted solid calcium carbonate with  $0.1 \text{ mol L}^{-1}$  ethanoic acid (acetic acid). They collected the gas as it was produced in a graduated gas syringe.

In the first part of their investigation they reacted large pieces of  $\text{CaCO}_3$  with excess  $0.1 \text{ mol L}^{-1}$  ethanoic acid at **25°C**.

The results of this part of their experiment are shown in the graph below.

**Volume of gas produced when  $\text{CaCO}_3$  reacts with ethanoic acid at 25°C**



Spare  
diagram  
used  
(✓)



a) At what time was the limiting reagent completely consumed?

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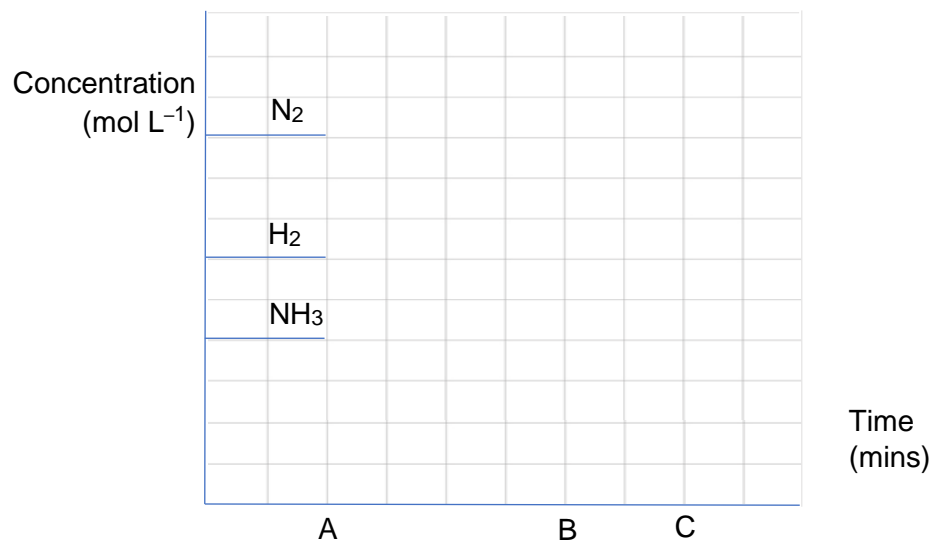
Question 10 continues



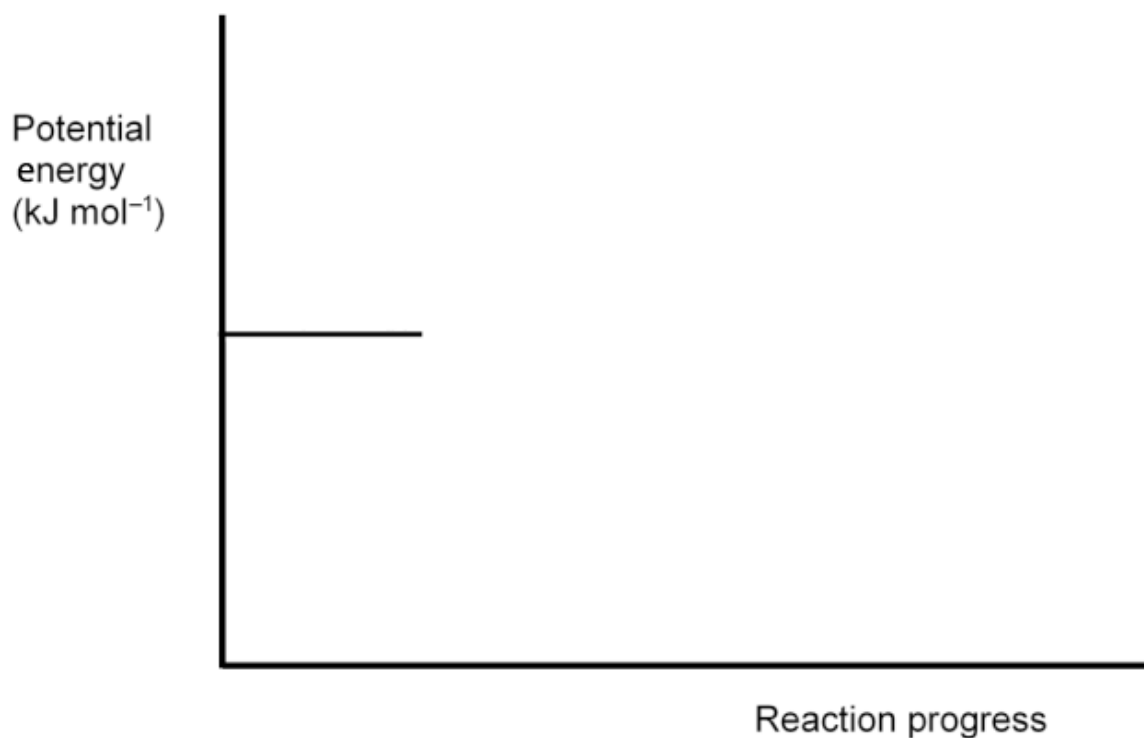
# Spare Diagrams

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Question 7 c)



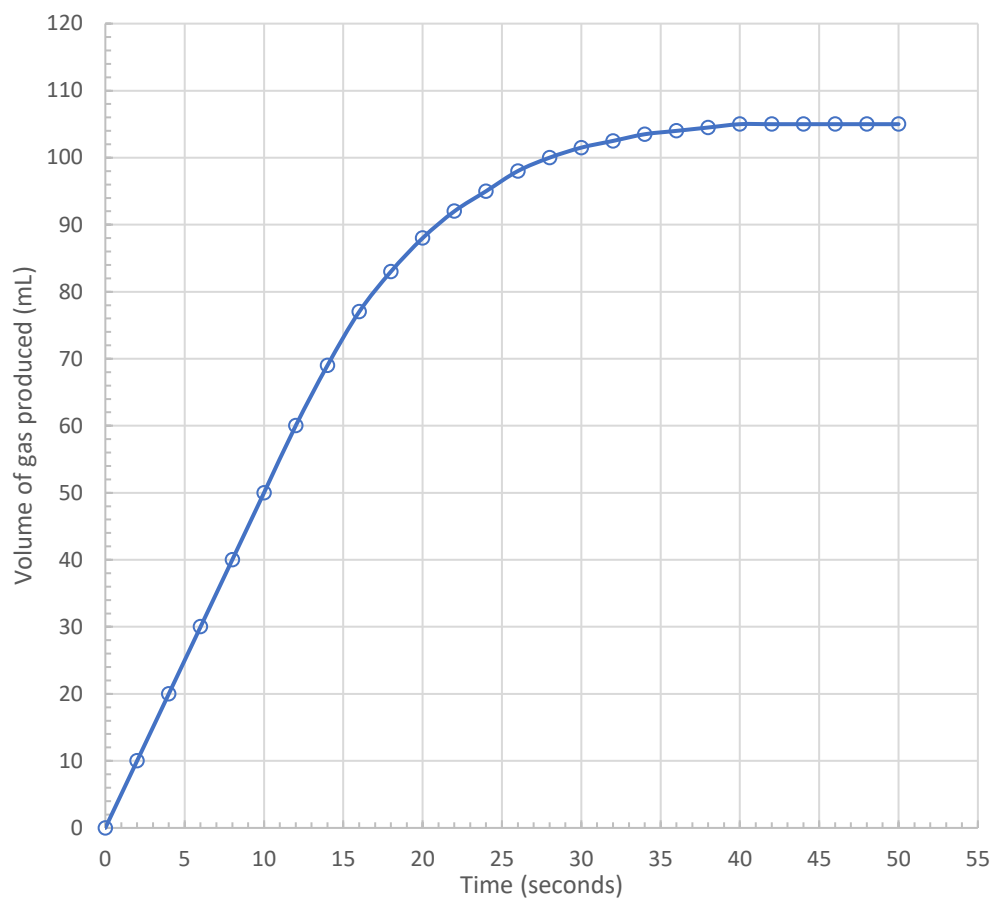
Question 9 b) & c)



# Spare Diagrams

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## Question 10 d)



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End of Section B

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External Assessment 2022

# CHEMISTRY

CHM415115

Section **C**

Pages	16
Questions	7
Information Sheet	1

**Suggested working time:** 45 minutes

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- The Chemistry Information Sheet can be used throughout this exam.
- All answers must be written in **English**.
- You **must** make sure your answers address:
  - Criterion 7 demonstrate knowledge and understanding of properties and reactions of organic and inorganic matter.

Marker Use	
C7	/ 45

# Additional Instructions

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- Note: When you are asked to “**show that**”:
  - You should calculate your own answer to the appropriate number of significant figures and then use this value to answer the following item(s) of the question.
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## Guide to Exam Structure

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Section B	5	5	45 minutes	45 marks
Section C	7	7	45 minutes	45 marks
Section D	7	7	45 minutes	45 marks
<b>Totals</b>	<b>24</b>	<b>24</b>	<b>180 minutes (3 hours)</b>	<b>180</b>

### Question 11

Atoms can exist in the ground state or they can become excited by the absorption of energy.

- a) An excited atom has the electron configuration  $1s^2 2s^2 2p^6 3s^2 3p^4 4s^1$ . Write the ground state electron configuration of this atom.

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- b) Another atom, in the ground state, has the electron configuration  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$ .

- i. Identify the element.

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- ii. What is the electron configuration of the  $2+$  ion of this element?

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- c) Arrange the ions  $Ca^{2+}$ ,  $S^{2-}$ ,  $Cl^-$  and  $K^+$  in order of **increasing ionic radius**, explaining your choice.

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**largest**

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Marker use

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Total Q11

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Question 12

Marker use



A 12.2 L tank of air, which divers use to breathe underwater, has a pressure of 210 atm at 30.0°C.

a) Calculate the volume that this air would occupy if it were released from the tank at 1.0 atm.

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b) In the water, the tank and the air in it cool to 16.0°C. Calculate the pressure inside the full tank at 16.0°C.

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c) Air contains 21% oxygen gas by volume. Breathing oxygen at a partial pressure greater than 1.6 atm can cause convulsions and death due to oxygen toxicity.

A diver at a depth of 45 m breathes air at a pressure of 5.5 atm. Would they be at risk of oxygen toxicity? Explain.

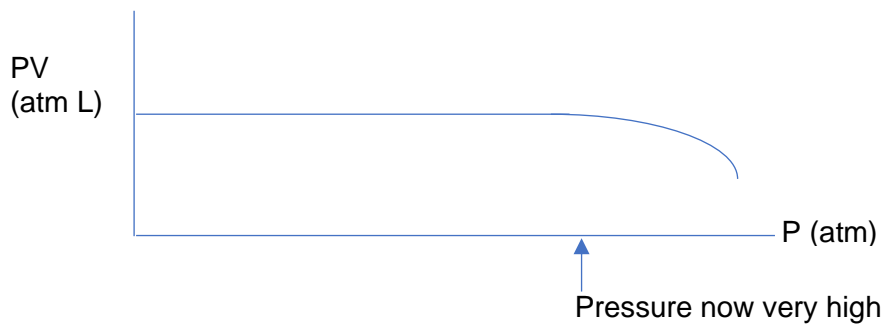
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Question 12 continues

**Question 12 continued**

d) A particular gas has the P vs PV relationship shown below. Is this gas an ideal gas? Explain.



Marker use

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**Total Q12**

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### Question 13

Marker use

The table below shows first ionisation energy ( $1^{\text{st}}$  IE,  $\text{kJ mol}^{-1}$ ) and atomic radius (pm) for elements in Period 3, sodium to chlorine. One picometre (pm) is  $10^{-12}$  m.

	Na	Mg	Al	Si	P	S	Cl
$1^{\text{st}}$ IE ( $\text{kJ mol}^{-1}$ )	490	730	580	780	1060	1000	1250
Atomic radius (pm)	190	145	118	111	98	88	79

a) Explain the trend in atomic radius moving **across Period 3**, from sodium to chlorine.

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b) Define the term: first ionisation energy.

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c) Explain why the first ionisation energy of aluminium is less than that of magnesium.

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Question 13 continues

**Question 13 continued**

d) Explain the trend in first ionisation energy moving down Group I.

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Marker use

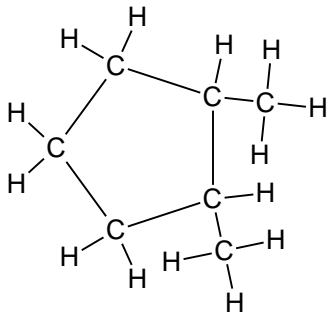
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**Total Q13**

/ 7

**Question 14**Complete the following tables about **two (2)** organic compounds.

<b>Name</b>  hexanal
<b>Structural formula</b>  

<b>Name</b>  .....
<b>Structural formula</b>  
<b>Empirical formula</b>  .....

Spare  
diagram  
used  
(✓)

Marker use

3

Total Q14

3

**Question 15**

Two isomers of C<sub>4</sub>H<sub>8</sub> (Isomer A and Isomer B) react as follows.

Isomer A – reactions	Product(s) and notes	Isomer B – reactions	Product(s) and notes
Br <sub>2</sub> added	Immediate decolouration	Br <sub>2</sub> added	Immediate decolouration
H <sub>2</sub> O(g) added (with H <sup>+</sup> catalyst)	Two products form. When these are reacted with Cr <sub>2</sub> O <sub>7</sub> <sup>2-</sup> /H <sup>+</sup> , one produces an aldehyde and the other a ketone.	H <sub>2</sub> O(g) added (with H <sup>+</sup> catalyst)	One product forms - Compound C.  Compound C reacts with Cr <sub>2</sub> O <sub>7</sub> <sup>2-</sup> /H <sup>+</sup> to produce Compound D.

a) What information about isomers A and B is provided by the reaction with Br<sub>2</sub>?

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b) What additional information about isomers A and B is provided by the results of the reaction with steam?

Isomer A: .....

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Isomer B: .....

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c) Draw and name Isomer A and Compound D.

Isomer A	Compound D
Structural formula:	Structural formula:
Name:	Name:

4

Spare diagram used (✓)

**Total Q15**

7

## Question 16

Marker use

Esters are extremely important chemicals in the food, flavouring and perfume industries.

- a) Ethyl ethanoate can be prepared by heating ethanol and ethanoic acid (with a catalyst) in an equilibrium reaction. **After the reaction, unreacted ethanoic acid (and the catalyst) is removed from the product mixture by reacting with sodium carbonate solution.**

Using molecular formulas, write a balanced chemical equation for the reaction between sodium carbonate and ethanoic acid.

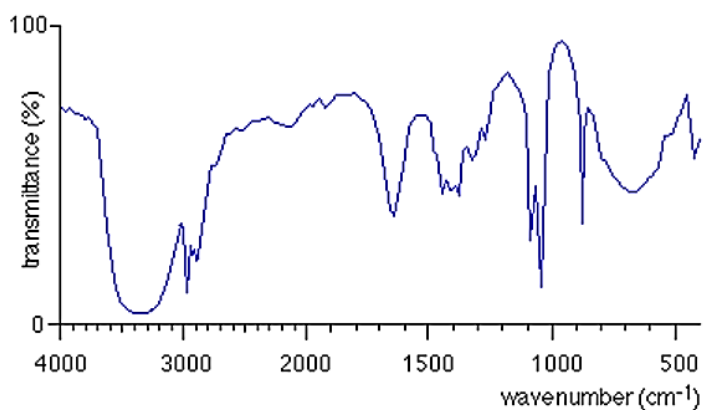
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- b) Ethyl ethanoate was prepared as outlined above, and the product mixture was separated into its components. As expected, it was found to contain **two (2)** organic compounds. The IR spectrum of each of these is shown below.

Identify the compound that produces each spectrum, giving **one (1)** reason for each choice.

i.

**Spectrum A**



Identity of compound:

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Reason:

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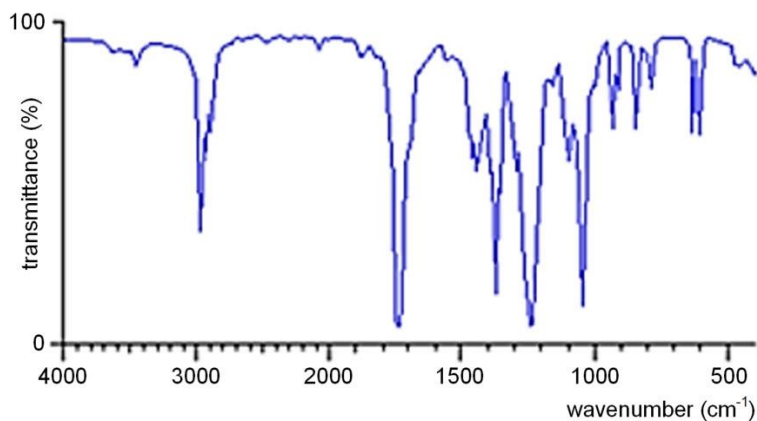
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Question 16 continues

Question 16 continued

ii.

Spectrum B



Marker use

2

Identity of compound:

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Reason:

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c) Using structural formulas for all organic compounds, write a chemical equation to show the preparation of a different ester, propyl methanoate.

3

Question 16 continues

**Question 16 continued**

Alkanes and alcohols with the same number of carbon atoms have very different boiling points, as shown in the table below.

Compound	Boiling point (°C)
Ethane	-89
Ethanol	78

d) Explain why ethane and ethanol have such different boiling points.

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Marker use

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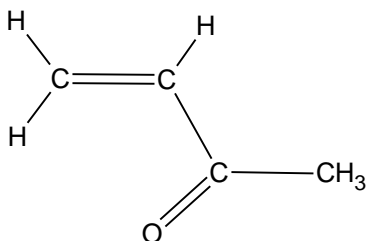
**Total Q16**

/ 11

### Question 17

Marker use

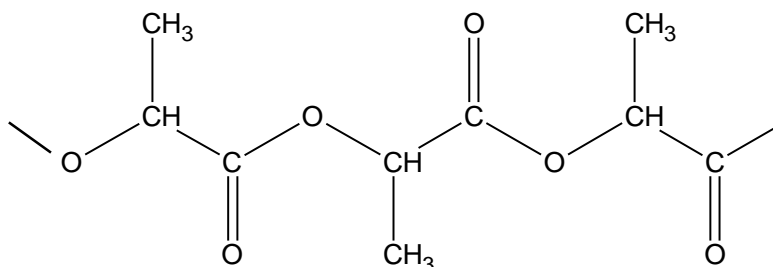
The compound shown below can be used in an **addition polymerisation** reaction.



a) Draw a segment of the addition polymer produced, showing **three (3)** monomer units.

2

Another important polymer (because it is biodegradable) is known as polylactic acid, or PLA. PLA is made from the monomer lactic acid, and a segment of PLA is shown below.



b) Deduce the **structure and systematic name** of the monomer, lactic acid.

Structure:

2

Systematic Name:.....

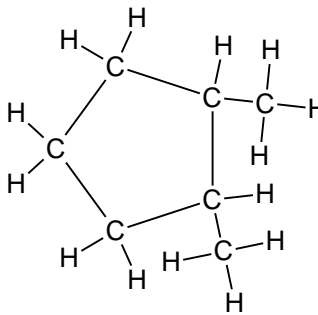
Total Q17

4

# Spare Diagrams

## Question 14

<b>Name</b>  hexanal
<b>Structural formula</b>  

<b>Name</b>  .....
<b>Structural formula</b>  
<b>Empirical formula</b>  .....

## Question 15 c)

<b>Isomer A</b>	<b>Compound D</b>
Structural formula:  	Structural formula:  
Name:	Name:

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End of Section C



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External Assessment 2022

# CHEMISTRY

CHM415115

Section **D**

Pages	12
Questions	7
Information Sheet	1

**Suggested working time:** 45 minutes

**Instructions:**

- Answer **all** questions and **all** items within each question.
- Write your answers in the spaces provided in this exam paper.
  - Spare diagrams have been provided at the end of each section. Indicate in the box provided if you have used the spare diagrams.
- A TASC approved scientific calculator can be used throughout the exam.
  - Show your workings in answers to numerical questions. No marks can be given for incorrect answers unless they are accompanied by details of the working.
  - The appropriate units must be included.
- The exam is **three (3)** hours in length. It is suggested that you spend **approximately 45 minutes** in total answering the questions in this section.
- The Chemistry Information Sheet can be used throughout this exam.
- All answers must be written in **English**.
- You **must** make sure your answers address:
  - Criterion 8 apply logical processes to solve quantitative chemical problems.

Marker Use	
C8	/ 45

# Additional Instructions

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- Note: When you are asked to “**show that**”:
  - You should calculate your own answer to the appropriate number of significant figures and then use this value to answer the following item(s) of the question.
  - If you are unable to determine the required value, you should use the value given in the following items of the question.

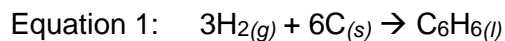
## Guide to Exam Structure

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	Questions available	Questions to answer	Suggested working time	Marks available
Section A	5	5	45 minutes	45 marks
Section B	5	5	45 minutes	45 marks
Section C	7	7	45 minutes	45 marks
Section D	7	7	45 minutes	45 marks
<b>Totals</b>	<b>24</b>	<b>24</b>	<b>180 minutes (3 hours)</b>	<b>180</b>

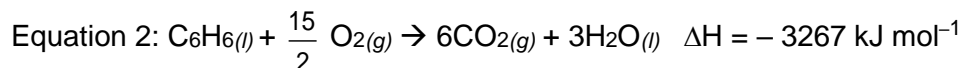
### Question 18

The equation for the formation of benzene from its elements is shown below (Equation 1). It is not possible to measure the enthalpy change for this reaction because hydrogen and carbon will not react to make benzene.



The enthalpy of formation of benzene (Equation 1 above) can be **calculated** using Hess's Law and the combustion reactions shown below.

- a) Use the combustion reactions shown below, and their enthalpy changes, to calculate  $\Delta H$  for Equation 1 above.



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- b) How much energy would be released if 39.00 g of benzene ( $M = 78.11 \text{ g mol}^{-1}$ ) were completely combusted?

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Marker use

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Total Q18

5

**Question 19**

Marker use

A team of chemists with different areas of interest collaborated in the analysis of iron in their local environment.

A geochemist analysed a sample of “hydrated iron carbonate” to determine the empirical formula of the mineral, including the degree of hydration.

The geochemist took a sample of mass 100.0 g and found that the sample contained:

- 24.94% Fe
- 5.36% C
- 5.40 % H
- 64.30% O

a) Use the information above to calculate the empirical formula (including degree of hydration) of the hydrated iron carbonate.

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**Question 19 continues**

**Question 19 continued**

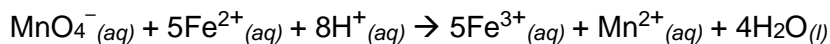
b) An analytical chemist measured the concentration of  $\text{Fe}^{2+}$  in an underground river.

Marker use

The chemist took a 10.0 mL sample of the river water, and analysed it as follows:

- the 10.0 mL of river water was diluted to 100.0 mL.
- three 20.00 mL samples of the diluted river water were titrated with 0.01053 mol L<sup>-1</sup> acidified potassium permanganate solution.

The analysis was based on the following chemical reaction:



Some of the titration data is shown in the table below.

	Titration 1	Titration 2	Titration 3
Titre $\text{MnO}_4^-$ (mL)	24.44	24.40	24.42

i. Show that the average number of moles of  $\text{MnO}_4^-$  delivered from the burette was about  $2.6 \times 10^{-4}$  moles.

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ii. Calculate the concentration of iron(II) ions in the original water sample in mol L<sup>-1</sup> to the correct number of significant figures.

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Total Q19

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**Question 20**

Marker use

In order to produce a sample of silver sulfate, a laboratory technician added 25.0 mL of 0.255 mol L<sup>-1</sup> H<sub>2</sub>SO<sub>4</sub> to 50.0 mL of a 3.26 g/100 mL solution of silver nitrate.

Useful information:

$$M(\text{AgNO}_3) = 169.9 \text{ g mol}^{-1}$$

$$M(\text{Ag}_2\text{SO}_4) = 311.9 \text{ g mol}^{-1}$$

- a) Show that the concentration of the silver nitrate solution was approximately 0.2 mol L<sup>-1</sup>.

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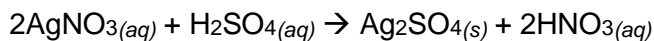
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- b) Show that approximately 6 x 10<sup>-3</sup> moles of sulfuric acid were added.

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- c) Calculate the mass of silver sulfate that would be produced in this reaction:



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Question 20 continues

**Question 20 continued**

d) Calculate the mass of sodium hydroxide needed to neutralise the remaining solution.

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Marker use

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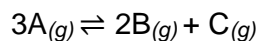
**Total Q20**

9

**Question 21**

Marker use

Compound A dissociates as shown below:



- a) At a particular temperature, a closed 2.0 L container initially contains 1.2 moles of A. At equilibrium 0.75 moles of A remain. Determine the value of the equilibrium constant at the temperature used.

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- b) When a similar mixture of the three gases is analysed (at the same temperature), the following concentrations (in mol L<sup>-1</sup>) are determined:

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[A] = 0.600

[B] = 0.126

[C] = 0.153

Is this mixture at equilibrium? Justify your answer with a calculation and if the mixture is not at equilibrium, predict whether the forward or reverse reaction is favoured.

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**Total Q21**

7

**Question 22**

**Two (2)** electrolytic cells were connected in series, with a current of 1.55 A flowing through each cell. The first cell contained a solution of copper(II) ions, and the second contained a solution of gold(III) ions (as nitrates in both cases).

a) Calculate the time the current was flowing if 1.87 g of copper was deposited in the first cell.

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b) Calculate the mass of gold produced in the second cell.

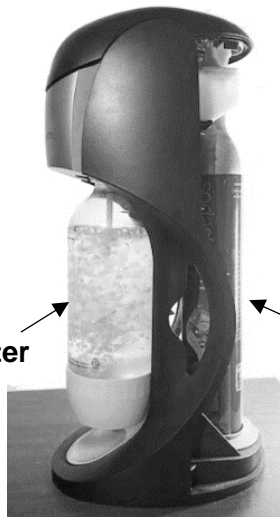
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**Total Q22**

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Question 23



Soda water (carbonated water) can be made by forcing carbon dioxide gas to dissolve in a bottle of water (visible on the left of the photo).

The carbon dioxide cylinder shown on the right of the photo has a capacity of 0.605 L, and when full contains 400.0 g of CO<sub>2</sub> gas.

Soda water

CO<sub>2</sub> gas cylinder

- a) Show that there are approximately **nine (9)** moles of CO<sub>2</sub> in the cylinder.

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- b) Calculate the pressure (in kPa) inside a full carbon dioxide cylinder at 25°C.

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- c) Calculate the number of CO<sub>2</sub> molecules inside the full cylinder.

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Total Q23

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