

91164



Draw a cross through the box (☒)
if you have NOT written in this booklet

☐

+



Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Chemistry 2023

91164 Demonstrate understanding of bonding, structure, properties and energy changes

Credits: Five

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of bonding, structure, properties and energy changes.	Demonstrate in-depth understanding of bonding, structure, properties and energy changes.	Demonstrate comprehensive understanding of bonding, structure, properties and energy changes.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

A periodic table and other reference material are provided in the Resource Booklet L2–CHEMR.

If you need more room for any answer, use the extra space provided at the back of this booklet.

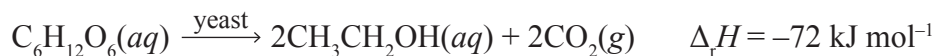
Check that this booklet has pages 2–12 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area (DO NOT WRITE). This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

QUESTION ONE

- (a) Ethanol, $\text{CH}_3\text{CH}_2\text{OH}$, can be used as a biofuel. Biofuels are formed from materials made by living organisms. The production of ethanol and carbon dioxide, $\text{CO}_2(\text{g})$, from glucose, $\text{C}_6\text{H}_{12}\text{O}_6$, is shown in the equation below.

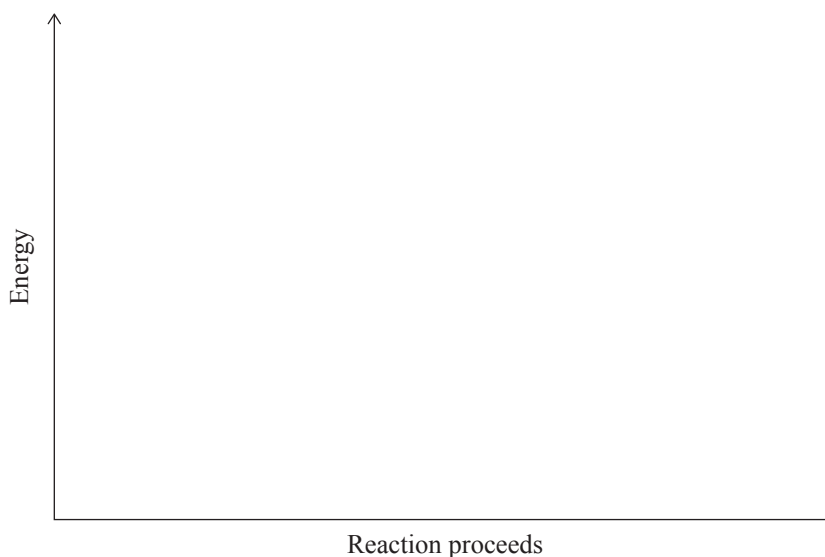


- (i) Is this process endothermic or exothermic?

Provide a reason with your answer.

- (ii) Draw a labelled energy diagram for this reaction, showing reactants, products, and the change in enthalpy, $\Delta_r H$.

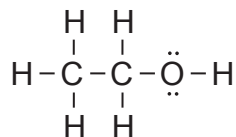
Note that yeast is a catalyst in this process and should not be included in the diagram.



- (iii) Calculate the energy change when 161 g of ethanol is formed.

$$M(\text{CH}_3\text{CH}_2\text{OH}) = 46.0 \text{ g mol}^{-1}$$

(b) The Lewis diagram for ethanol is shown below.

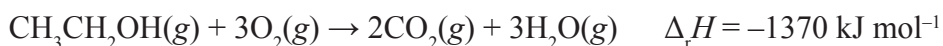


Atom	Bond angles around atom
Carbon	109.5°
Oxygen	109.5°

Compare and contrast the shape and bond angles around the carbon and oxygen atoms in ethanol, with reference to VSEPR theory.

QUESTION TWO

Ethanol is used as a fuel by reacting it with oxygen gas, $\text{O}_2(\text{g})$, in a process called combustion. The combustion of gaseous ethanol, $\text{CH}_3\text{CH}_2\text{OH}(\text{g})$ is shown below.



$ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \\ \text{CH}_3\text{CH}_2\text{OH} \end{array} $	$ \begin{array}{c} \text{O}=\text{O} \\ \text{O}_2 \end{array} $	$ \begin{array}{c} \text{O}=\text{C}=\text{O} \\ \text{CO}_2 \end{array} $	$ \begin{array}{c} \text{O} \\ / \quad \backslash \\ \text{H} \quad \text{H} \\ \text{H}_2\text{O} \end{array} $
---	---	---	---

- (a) Use the change in enthalpy ($\Delta_r H$) for the reaction above and the bond energies listed in the table below to calculate the average bond energy of the $\text{O}=\text{O}$ bond.

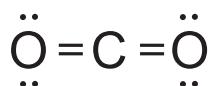
Bond	Bond energy (kJ mol^{-1})
C–C	348
C–H	413
C–O	358
C=O	805
O–H	463

- (b) The products of the combustion of ethanol are carbon dioxide, CO_2 , and water, H_2O .



- (i) Carbon dioxide contains carbon and oxygen atoms. Oxygen is more electronegative than carbon.

Draw two arrows (\rightarrow) OR add δ^+ and δ^- symbols onto the carbon dioxide molecule shown below to represent the bond dipoles present in the carbon dioxide molecule.



- (ii) Circle the word that describes the polarity of each molecule below:

Carbon dioxide (CO ₂)	Polar	Non-polar
Water (H ₂ O)	Polar	Non-polar

- (iii) Compare and contrast the factors that influence the polarity of these two molecules.

- (c) The combustion of fuels can result in toxic by-products, such as carbon monoxide, CO. A catalytic converter can be used to convert these compounds to less harmful substances. Catalytic converters often contain the element palladium, Pd.

- (i) Complete the table below for each of these substances in their solid states.

Substance	Type of solid	Type of particle	Attractive forces
Carbon monoxide, CO(<i>s</i>)			
Palladium, Pd(<i>s</i>)			

- (ii) When exposed to exhaust gases greater than 300 °C, palladium remains in its solid state.

Use your knowledge of structure and bonding to explain the high melting point of palladium.

(a) Draw the Lewis diagram (electron dot diagram) for each of the following molecules, and give their shapes.

(b) The formation of carbonic dibromide, $\text{COBr}_2(\ell)$ is shown in the equation below.

$$2\text{C}(\text{s}) + \text{O}_2(\text{g}) + 2\text{Br}_2(\ell) \rightarrow 2\text{COBr}_2(\ell) \quad \Delta_{\text{r}}H = -145 \text{ kJ mol}^{-1}$$

(i) Calculate the mass of carbonic dibromide formed when 1150 kJ of energy is released.

$$M(\text{COBr}_2) = 187.8 \text{ g mol}^{-1}$$

- If 1 mL of carbonic dibromide liquid has a mass of 2.52 g, will they be able to contain it within the flask?

- (c) Carbonic dibromide, COBr_2 , does not conduct electricity in either the solid or liquid state. However, another bromine-containing compound, lithium bromide, LiBr , conducts electricity when molten, but not when solid.

Elaborate on the electrical conductivity of both carbonic dibromide and lithium bromide, with reference to the structure and bonding in each compound.

Question Three continues
on the next page.

Extra space if required.
Write the question number(s) if applicable.

QUESTION
NUMBER

Extra space if required.
Write the question number(s) if applicable.

QUESTION
NUMBER

91164