SUPERVISOR'S USE ONLY

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91164



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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 (). 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, CH_3CH_2OH , can be used as a biofuel. Biofuels are formed from materials made by living organisms. The production of ethanol and carbon dioxide, $CO_2(g)$, from glucose, $C_6H_{12}O_6$, is shown in the equation below.

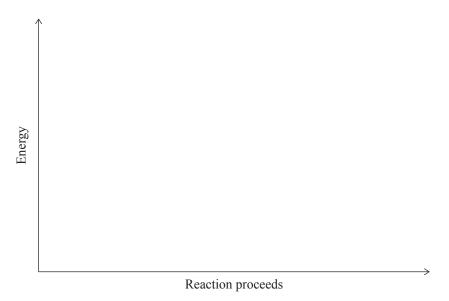
$$C_6H_{12}O_6(aq) \xrightarrow{\text{yeast}} 2CH_3CH_2OH(aq) + 2CO_2(g) \qquad \Delta_r H = -72 \text{ kJ mol}^{-1}$$

(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.

 $M(CH_3CH_2OH) = 46.0 \text{ g mol}^{-1}$

(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.				

(c)	Ethanol is the major component in alcohol-based hand sanitisers. A student noticed that after
	rubbing the hand sanitiser on their hands, it readily evaporated, leaving their hands feeling cool.
	The equation for the evaporation of ethanol is shown below.

$$\mathrm{CH_3CH_2OH}(\ell) \to \mathrm{CH_3CH_2OH}(g)$$

(i) Circle the word that describes the change in enthalpy $\Delta_r H$, for the evaporation of ethanol.

Positive $\Delta_r H$ Negative $\Delta_r H$

(ii) Explain why ethanol readily evaporates, and why the evaporation of ethanol results in the student's hands feeling cool.

In your answer you should:

- consider the transfer of energy occurring during the evaporation process
- refer to the structure and bonding present in ethanol.

QUESTION TWO

Ethanol is used as a fuel by reacting it with oxygen gas, $O_2(g)$, in a process called combustion. The combustion of gaseous ethanol, $CH_3CH_2OH(g)$ is shown below.

$$\text{CH}_3\text{CH}_2\text{OH}(g) + 3\text{O}_2(g) \rightarrow 2\text{CO}_2(g) + 3\text{H}_2\text{O}(g)$$
 $\Delta_r H = -1370 \text{ kJ mol}^{-1}$

H H H-C-C-O-H I I H H	O=O	O = C = O	O H
CH ₃ CH ₂ OH	O ₂	CO ₂	H ₂ O

(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 O=O bond.

Bond	Bond energy (kJ mol ⁻¹)
C–C	348
С–Н	413
С-О	358
C=O	805
О–Н	463

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(b)							[2O.
			$\ddot{\mathbf{C}} = \mathbf{C} = \ddot{\mathbf{C}}$ \mathbf{CO}_2		ГО Н Н		
			CO_2		H_2O		
	(i)	Carbon dioxide contains carbon.	carbon and ox	xygen ator	ns. Oxygen	is more electro	onegative than
		Draw two arrows (\rightarrow) Of below to represent the bo					
			 O =	= C = Ö)		
	(ii)	Circle the word that descri	ribes the pola	rity of eac	h molecule	below:	
		Carbon dioxide (CC	O_2)	Polar		Non-polar	
		Water (H ₂ O)		Polar		Non-polar	
	(iii)	Compare and contrast the	e factors that i	influence t	he polarity o	of these two m	olecules.

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- (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(s)			
Palladium, Pd(s)			

Use your kno palladium.	owledge of stru	cture and bor	iding to expla	in the high mo	elting point of	f

QUESTION THREE

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

Molecule	PH_3	BCl ₃	COBr ₂
Lewis diagram			
Name of shape			

(b)	The formation	of carbonic	dibromide,	COBr₂(ℓ)	is shown in	the equation	below
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$$2C(s) + O_2(g) + 2Br_2(\ell) \rightarrow 2COBr_2(\ell)$$
 $\Delta_r H = -145 \text{ kJ mol}^{-1}$

(i)	Calculate the mass of carbonic dibromide formed when 1150 kJ of energy is released.
	$M(COBr_2) = 187.8 \text{ g mol}^{-1}$

(ii) A chemist wishes to store this mass of carbonic dibromide in a 1 L flask.

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

)	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.

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solvents such a	s water, $H_2O(\ell)$.		

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