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NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Chemistry 2024

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.

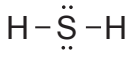
Check that this booklet has pages 2–16 in the correct order and that none of these pages is blank.

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

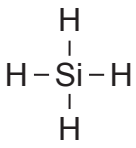
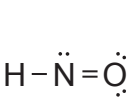
YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

QUESTION ONE

(a) Draw the Lewis structure for each of the two blank molecules, and name their shapes.

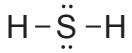
Molecule	**NI_3** (nitrogen triiodide)	**H_2S** (hydrogen sulfide)	**CS_2** (carbon disulfide)
Lewis structure			
Name of shape		bent	
Approximate bond angle around central atom	109.5°	109.5°	180°

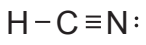
(b) Compare and contrast the shapes and bond angles of silicon tetrahydride, SiH_4, and azanone, HNO.

Molecule	**SIH_4** (silicon tetrahydride)	**HNO** (azanone)
Lewis structure		

(c) Hydrogen sulfide, H_2S, and hydrogen cyanide, HCN, molecules have a different shape, but they both have the same polarity.

The Lewis structure of both of these molecules are shown below:

hydrogen sulfide 

hydrogen cyanide 

(i) Circle the word below which identifies the polarity of both H_2S and HCN.

Polar **Non-polar**

(ii) Justify your choice of polarity by:

- explaining the links between the bonding and structure of each substance, and
- relating this to how the polarity of a molecule is determined.

(d) Methanamine, CH_3NH_2, is used widely in the production of pharmaceuticals, fungicides, insecticides, cleaning agents, and in the fabric industry.

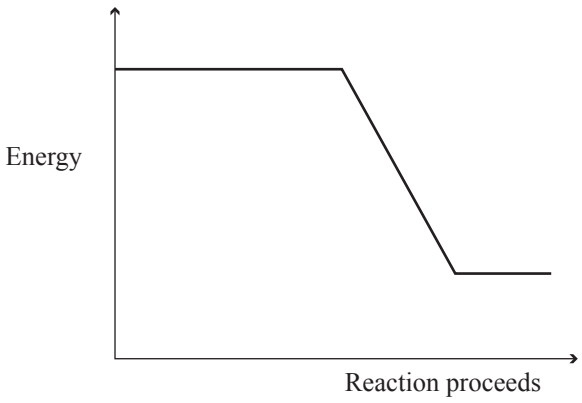
Although hydrogen cyanide, HCN, is highly poisonous, it can be used to produce methanamine, as shown in the reaction below.

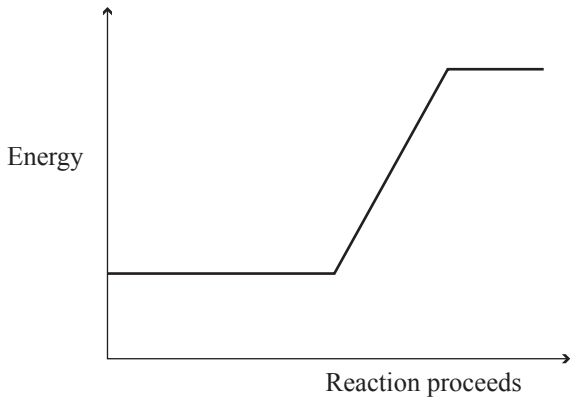
$$HCN(g) + 2H_2(g) \rightarrow CH_3NH_2(g) \quad \Delta_r H = -158 \text{ kJ mol}^{-1}$$

(i) Calculate the mass of methanamine formed when 1890 kJ of energy is released.

$M(CH_3NH_2) = 31.0 \text{ g mol}^{-1}$

(ii) Choose the correct energy diagram that represents the reaction above and label it with the information provided in the equation.





QUESTION TWO

(a) Complete the table below for each substance in their solid state.

Solid	Melting point (°C)	Type of solid	Type of particle	Attractive forces between particles
$SiO_2(s)$ (silicon dioxide)	1700			
$SiCl_4(s)$ (silicon tetrachloride)	–69			
$CuCl_2(s)$ (copper (II) chloride)	620			
Al(*s*) (aluminium)	660			

(b) Both SiO_2 and $SiCl_4$ contain silicon, but $SiCl_4$ has a considerably lower melting point.

Explain why there is a difference in melting point for these substances.

(c) Explain why silicon tetrachloride, $SiCl_4$, does not dissolve in water, but copper(II) chloride, $CuCl_2$, does.

In your answer:

- link to their structure and bonding
- include the type of solvent that $SiCl_4$ will dissolve in, and why
- include a diagram to support your answer for $CuCl_2$.

Diagram to show $CuCl_2$ dissolving in water.

QUESTION THREE

Bottled gas supply in New Zealand is a 60% propane, C_3H_8, and 40% butane, C_4H_{10}, mix.

The combustion reactions for both propane and butane fuels are given below.

(a) Show by calculation how much more energy is released per 1.00 kg of propane compared to 1.00 kg of butane.

(i) Energy released by 1.00 kg of propane combustion

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$ $\quad \Delta_r H = -2044 \text{ kJ mol}^{-1}$

$M(C_3H_8) = 44.1 \text{ g mol}^{-1}$

(ii) Energy released by 1.00 kg of butane combustion

$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$ $\quad \Delta_r H = -2877 \text{ kJ mol}^{-1}$

$M(C_4H_{10}) = 58.1 \text{ g mol}^{-1}$

(iii) Calculate how much more energy is released by 1.00 kg of propane than 1.00 kg of butane.

(b) The reaction of a hydrogen fuel cell is shown below. Hydrogen reacts with oxygen to produce water.

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ $\Delta_r H = -484$ kJ mol^{-1}

H – H	O = O	H – O – H
H_2	O_2	H_2O

Use the bond energies listed in the table, and the change in enthalpy (–484 kJ mol^{-1}) provided for the reaction, to calculate the average bond energy of the O–H bond.

Bond	**Bond energy (kJ mol^{-1})**
H – H	436
O = O	498

Question Three continues on the next page.

(c) ‘Galvorn’ is a newly developed form of carbon that is strong, light, and has good conductivity. With its clean manufacturing process and wide range of applications, it is anticipated that Galvorn could reduce the reliance on standard metals that are energy intensive to produce.

(i) As with graphite, Galvorn conducts electricity.

What requirement must Galvorn have to allow it to conduct electricity?

(ii) Aluminium, Al, is also a good conductor of electricity, and it is malleable (can be pressed into shapes). These properties enable it to be used extensively in overhead power lines and for components and shells in smartphones and laptops.

Explain why aluminium, Al, has these properties, and link it to the uses stated.

Refer to its structure and bonding.

Conducts electricity:

Malleable:

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Write the question number(s) if applicable.

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