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NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Chemistry 2026

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 the margins (▨). This area will be cut off when the booklet is marked.

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QUESTION ONE

(a) Complete the table below.

Solid	Type of solid	Type of particle	Attractive forces between particles
C(*s*) (diamond)			
Fe(*s*) (iron)			
$Fe(OH)_3(s)$ (iron(III) hydroxide)			

(b) A student investigated the physical properties of the solids iron, Fe(*s*), and iron(III) hydroxide, $Fe(OH)_3(s)$. They hit a sample of each solid with a hammer.

(i) Which is more likely to shatter under force? *Circle your answer:*

Iron, Fe(*s*) **Iron(III) hydroxide, $Fe(OH)_3(s)$**

(ii) Justify your choice of solid.

In your answer:

- describe any observations made when a force is applied to each solid
- link the observations made to each solid's properties
- link the observations to the structure, bonding, and forces of attraction between particles in each solid.

(c) Compare the ability of iron, Fe(s), and iron(III) hydroxide, $Fe(OH)_3$(s), to conduct electricity in both the solid(s) AND molten(ℓ) states.

Refer to structure, bonding, and particles in your answer.

You may include a diagram to support your answer.

Optional diagram:

(d) Discuss the melting point of diamond, C(*s*), and iron(III) hydroxide, $Fe(OH)_3(s)$.
In your answer, refer to the structure and bonding of each substance.

QUESTION TWO

(a) Magnesium, Mg(s), reacts with oxygen, $O_2(g)$, according to the following equation:

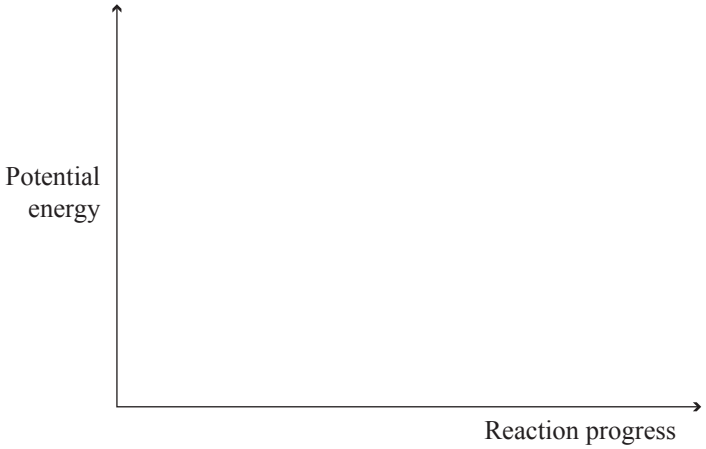
$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$ $\Delta_r H = -1200$ kJ mol^{-1}

(i) **Circle** the term that best describes this reaction.

Exothermic **Endothermic**

Give a reason for your answer.

(ii) Draw a **labelled** enthalpy diagram for the combustion of magnesium, showing the relative energies of the reactants and products.



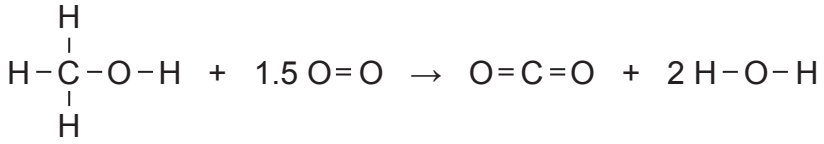
(b) Calculate the heat energy released when 3.32 g of magnesium is completely burnt in oxygen.

M(Mg) = 24.3 g mol^{-1}

(c) Methanol, $CH_3OH(g)$, also reacts with oxygen. The equation for this reaction is shown below:

$$CH_3OH(g) + 1.5\,O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

This equation can be represented as:



Calculate the enthalpy change, $\Delta_r H$, for the complete combustion of **methanol,** $CH_3OH(g)$, using the equation above and the bond enthalpies from the table below.

Bond	Bond enthalpy in kJ mol^{-1}
C–H	414
C–O	358
O–H	463
O=O	498
C=O	804

(d) Propane gas, $C_3H_8(g)$, is commonly used as a fuel in gas heaters and BBQs. An equation for its combustion is:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell) \qquad \Delta_r H = -2220 \text{ kJ mol}^{-1}$$

Calculate the **mass** of **propane**, $C_3H_8(g)$, that must react with oxygen to produce 1350 kJ of heat energy.

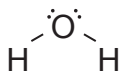
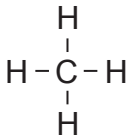
$M(C_3H_8) = 44.0 \text{ g mol}^{-1}$

QUESTION THREE

(a) Complete the table below by drawing the Lewis structure (electron dot diagram) of each of the molecules.

Molecule	CO_2	N_2	NF_3
Lewis structure			

(b) Information about two molecules is shown in the table below.

Molecule	Water, $H_2O(g)$	Methane, $CH_4(g)$
Lewis structure		
Shape	Bent/V-shaped	Tetrahedral

Compare the **shapes** of water, $H_2O(g)$, and methane, $CH_4(g)$.

Your answer should include:

- factors that determine the shape of each molecule
- the approximate bond angle for each molecule.

(c) Chlorofluorocarbons (CFCs) are synthetic compounds found in the atmosphere that consist of carbon, chlorine, and fluorine atoms.

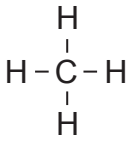
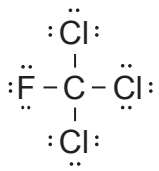
(i) **Circle** the term that describes the polarity of the following **covalent bonds.**

C-Cl bond: **polar** **non-polar**

C-F bond: **polar** **non-polar**

(ii) Give reasons for your answer.

(iii) Methane, $CH_4(g)$, and trichlorofluoromethane, $CCl_3F(g)$, have the same shape, but methane is non-polar and trichlorofluoromethane is polar.

Molecule	Methane, $CH_4(g)$	Trichlorofluoromethane, $CCl_3F(g)$
Lewis structure		
Polarity	Non-polar	Polar

Explain the difference in the polarity of the two molecules.

Question Three continues on the following page.

(d) Solid potassium chloride, KCl(*s*), is soluble in water, whereas methane gas, $CH_4(g)$ is not.

Use your knowledge of structure and bonding to explain the differences in solubility of these two substances.

Include a diagram to illustrate the dissolving of potassium chloride, KCl(*s*).

Diagram:

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

QUESTION NUMBER

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QUESTION NUMBER