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NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Chemistry 2025

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 margins (⁘). 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

Sodium chloride, NaCl, is used as an antiseptic and antimicrobial agent. In analytical chemistry, it is often reacted with silver nitrate, $AgNO_3$, shown below.

$$NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

(a) When silver nitrate, $AgNO_3$, is added to 73.0 g of sodium chloride, NaCl, 81.8 kJ of energy is released.

Calculate the $\Delta_r H$ for the above reaction.

M(NaCl) = 58.4 g mol^{-1}

(b) (i) Identify which substance below matches the information provided in the table by placing it into the correct row.

Zinc (Zn) **Ammonia (NH_3)** **Diamond (C)** **Sodium chloride (NaCl)**

Solid type	Melting point (°C)	Substance selected
3D Covalent Network	3550	
Ionic	801	
Metallic	420	
Molecular	–78	

(ii) Relate the bonding and structure in ionic and molecular solids to their relative melting points.

In your answer:

- describe the bonding and structure in ionic and molecular solids
- explain what the melting point of a solid indicates about the strength of forces between its particles
- link the strength of forces between the particles to their relative melting points.

(c) Diamond, C, and gold, Au, are both used frequently in jewellery making, but their properties are very different.

Diamond is very hard and can only be scratched by a substance equally as hard as itself. Gold, however, is malleable and ductile, and is used to craft intricate shapes and patterns.

Explain how the structure and bonding of each substance results in these properties.

Diamond, C, hardness:

Gold, Au, malleable and ductile:

(d) The development of the Haber-Bosch process, shown in the reaction below, is historically significant.

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ $\Delta_r H = -93.0$ kJ mol^{-1}

Calculate the average bond energy of the N≡N bond in N_2, using the average bond energies listed in the table below for this reaction between nitrogen, N_2, and hydrogen, H_2, that produces ammonia, NH_3.

Bond	Bond energy (kJ mol^{-1})
H–H	436
N–H	391

N≡N	H−H	H−N−H | H

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QUESTION TWO

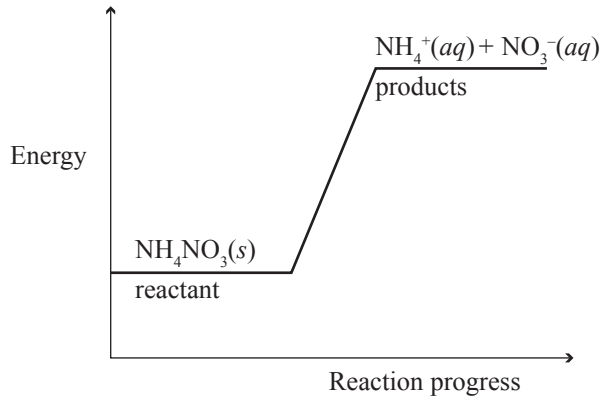
(a) (i) Identify whether each of the statements apply to endothermic (Endo) or exothermic (Exo) reactions by circling the correct term only.

- The products have more energy than the reactants. **Endo / Exo**
- Energy is released to the surroundings. **Endo / Exo**
- The change in enthalpy (ΔH) for the reaction is positive. **Endo / Exo**

(ii) State whether the following process is endothermic or exothermic, and give a reason for your choice.

$H_2O(g) \rightarrow H_2O(\ell)$

Ammonium nitrate, NH_4NO_3, is used in first aid to treat injuries. The energy change in the reaction is shown in the diagram below.

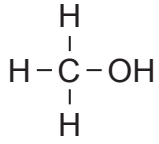
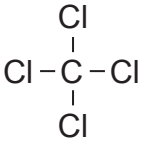


(iii) Is the reaction in the graph above absorbing energy from the surroundings or releasing energy to the surroundings?

(iv) Circle the correct option for identification of the enthalpy change of this reaction ($\Delta_r H$):

$\Delta_r H < 0$, negative **$\Delta_r H > 0$, positive**

(b) All three of the compounds given in the table below contain polar bonds, but only two of them are polar molecules.

Methanol	Tetrachloromethane	Water
		

(i) Define what makes a chemical bond polar, and give an example from one of the above compounds.

(ii) Circle the compound in the table above that is the **non-polar** molecule.

(iii) Use your understanding of structure and bonding to justify your choice of the molecule you circled above.

(c) Predict the solubility of the following combinations of solutes and solvents by adding a tick (✓) to the correct column for each combination.

Solute and solvent combination	**Soluble?**	**Insoluble?**
Tetrachloromethane, CCl_4, in water, H_2O		
Magnesium bromide, $MgBr_2$ in hexane, C_6H_{14}		
Bromine, Br_2, in hexane, C_6H_{14}		

(d) What makes sodium chloride, NaCl, soluble in water, but iodine, I_2, insoluble in water.

In your answer:

- refer to the structure and bonding of each substance
- explain how the substance interacts with water molecules
- include a diagram showing the dissolving of NaCl in water.

Diagram to show NaCl dissolving in water:

QUESTION THREE

(a) Different forms (allotropes) of carbon have different electrical conductivities. Diamond does not conduct electricity, but graphite is a very good electrical conductor.

Compare and contrast the structure and bonding of these two carbon compounds.

In your answer:

- explain the structure and bonding of diamond and graphite
- define electrical conductivity in solids
- justify the difference in electrical conductivity between diamond and graphite.

You may include a diagram to support your answer.

(b) Combustion is a chemical reaction in which a substance combines with oxygen and produces heat.

When ethanol, C_2H_5OH, is combusted with oxygen, O_2, carbon dioxide, CO_2, and water, H_2O, are produced.

$C_2H_5OH(\ell) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O\ (\ell)$ $\Delta_r H = -1370$ kJ mol^{-1}

(i) Calculate the mass of ethanol, C_2H_5OH, that must react to release 17 500 kJ of energy.

$M(C_2H_5OH) = 46.7$ g mol^{-1}

(ii) Calculate the energy change when 187 g of zinc oxide, ZnO, is produced in the reaction below between zinc, Zn, and oxygen, O_2.

$2Zn(s) + O_2(g) \rightarrow 2ZnO(s)$ $\Delta_r H = -696$ kJ mol^{-1}

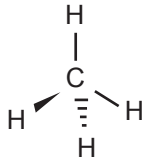
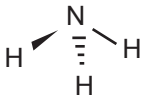
$M(ZnO) = 81.4$ g mol^{-1}

Question Three continues on the next page.

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

Molecule	**CO_2**	**Cl_2O**	**BF_3**
Lewis structure			
Name of shape			

(d) The table gives information relating to the shape of each molecular substance.

Solid name	**Methane**	**Ammonia**
Shape diagram		
Bond angle	109.5°	109.5°
Molecular shape	Tetrahedral	Trigonal pyramid

Compare the two shapes and explain the factors that contribute to:

- arrangement around the central atom
- molecular shape.

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

QUESTION NUMBER

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