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91164



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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.

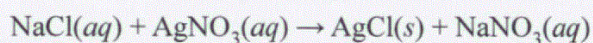
**YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.**

**Achievement**

**TOTAL 11**

## QUESTION ONE

Sodium chloride, NaCl, is used as an antiseptic and antimicrobial agent. In analytical chemistry, it is often reacted with silver nitrate, AgNO<sub>3</sub>, shown below.



- (a) When silver nitrate, AgNO<sub>3</sub>, 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.

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

$$M(\text{NaCl}) = 58.4 \text{ g mol}^{-1} \quad \frac{73.0}{58.4} = 1.25 \text{ mol}$$

$$n = \frac{m}{M}$$

$$81.8 \text{ (kJ)} \times 1.25 \text{ mol} = 102.25 \text{ kJ mol}^{-1}$$

$$\Delta_r H = 102.25$$

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

Zinc (Zn)      Ammonia (NH<sub>3</sub>)      Diamond (C)      Sodium chloride (NaCl)

Solid type	Melting point (°C)	Substance selected
3D Covalent Network	3550	Diamond
Ionic	801	Sodium chloride <del>Ammonia</del>
Metallic	420	Zinc
Molecular	-78	Ammonia

- (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.

In ionic solids, the metallic and molecular forces of the molecule attract each other to be tightly packed,

resulting in very strong inter-molecular forces in the solid, ~~or~~ resulting in extreme amounts of energy to be absorbed to break these bonds <sup>between particles</sup>, ~~and~~ the energy is heat, so it needs high amounts of heat to melt (bonds broken), also <sup>indicated</sup> ~~shown~~ through melting point of  $801^{\circ}\text{C}$ .

Molecular solids have very weak structure made up of weak inter-molecular forces between the particles, as the melting point shows to be very low ( $-78^{\circ}\text{C}$ ), ~~for~~ this indicates that very little heat energy is needed to be absorbed to break the weak-intermolecular forces and melt it.

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

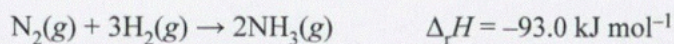
Diamond is very hard and can only be scratched by a substance equally as hard as itself. Gold, however, is malleable and ductile, and is used to craft intricate shapes and patterns.

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

Diamond, C, hardness: Diamond's solid type is a 3D covalent network, the structure of covalent networks means the particles are extremely packed together in a rigid structure, the intermolecular forces are so strong the solid requires extreme energy to break these bonds, as the structure lattice is 3D, the covalent network and amount of bonds between particles is ~~very~~ much larger than any other solid, resulting in very rigid and solid properties.

Gold, Au, malleable and ductile: The Au gold's solid type is metallic, the <sup>particles</sup> ~~particles~~ <sup>can</sup> ~~are~~ move past each other in the <sup>solid</sup> ~~solid~~ molecule, which not only allows for conductivity, but because their bonds can be moved without breaking, gold is ~~not~~ malleable and ductile (able to be moulded and shaped), without the ~~inter~~ metallic bonds completely breaking.

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

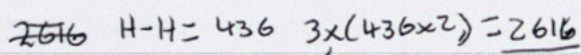
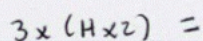
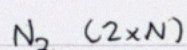


Calculate the average bond energy of the  $\text{N}\equiv\text{N}$  bond in  $\text{N}_2$ , using the average bond energies listed in the table below for this reaction between nitrogen,  $\text{N}_2$ , and hydrogen,  $\text{H}_2$ , that produces ammonia,  $\text{NH}_3$ .

Bond	Bond energy ( $\text{kJ mol}^{-1}$ )
H-H	436
N-H	391

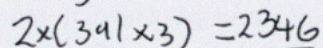
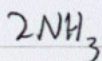
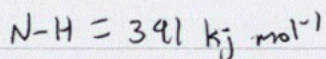
$\text{N}\equiv\text{N}$	H-H	$\begin{array}{c} \text{H}-\text{N}-\text{H} \\   \\ \text{H} \end{array}$
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products



$$\Delta_r H = 93.0 \text{ kJ mol}^{-1}$$

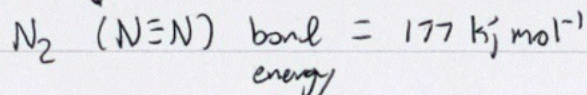
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$$2616 - 2346 = 270$$

$$270 - 93 = \underline{177}$$

$$177 \text{ kJ mol}^{-1}$$



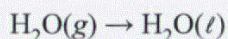
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## QUESTION TWO

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

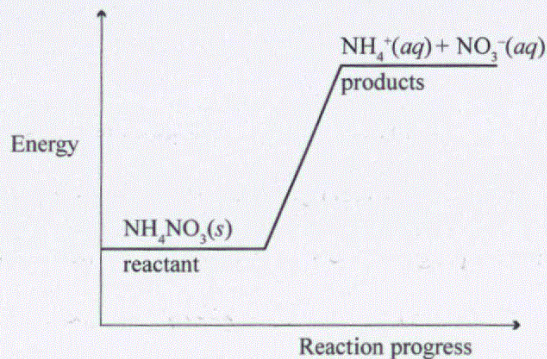
- The products have more energy than the reactants. **Endo** / Exo
- Energy is released to the surroundings. Endo / **Exo**
- The change in enthalpy ( $\Delta H$ ) for the reaction is positive. Endo / **Exo**

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



~~Endothermic~~  
 Exothermic  
 as the gaseous  $\text{H}_2\text{O}$  requires  
 to ~~absorb~~ <sup>release</sup> energy to create liquid  $\text{H}_2\text{O}$  as  
 bonds are formed not broken

Ammonium nitrate,  $\text{NH}_4\text{NO}_3$ , is used in first aid to treat injuries. The energy change in the reaction is shown in the diagram below.



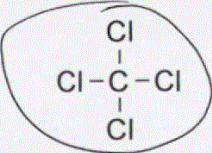
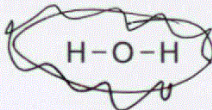
- (iii) Is the reaction in the graph above absorbing energy from the surroundings or releasing energy to the surroundings?

Ab Absorbing

- (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
$\begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}-\text{OH} \\   \\ \text{H} \end{array}$	 $\begin{array}{c} \text{Cl} \\   \\ \text{Cl}-\text{C}-\text{Cl} \\   \\ \text{Cl} \end{array}$	 $\text{H}-\text{O}-\text{H}$

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

A chemical bond's polarity is determined based on the Electronegativity of the each atom in the molecule, when there are uneven <sup>amounts</sup> EN atoms of EN in a molecule, it creates a bond dipole, e.g. in Methanol, Carbon and Oxygen are all more EN than H, this creates a bond dipole, as the dipole can not be balanced out, the molecule is a symmetrical, resulting in a chemical bond being polar, and the molecule being polar.

- (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.

In  $\text{H}_2\text{O}$ , H atoms are less electronegative than in tetrachloromethane, Cl atoms are slightly more Electronegative than Carbon, as they are spread around the carbon atom, the electronegativity of the Cl balances out, creating a bond dipole that is symmetrical, which determines the overall molecules polarity, as being non-polar.

- (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, $\text{CCl}_4$ , in water, $\text{H}_2\text{O}$	✓	
Magnesium bromide, $\text{MgBr}_2$ in hexane, $\text{C}_6\text{H}_{14}$		✓
Bromine, $\text{Br}_2$ , in hexane, $\text{C}_6\text{H}_{14}$	✓	

- (d) What makes sodium chloride,  $\text{NaCl}$ , soluble in water, but iodine,  $\text{I}_2$ , 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  $\text{NaCl}$  in water.

Although  $\text{NaCl}$  is a ionic solid, the ~~also the electronegativity~~ electronegativity of the  $\text{Cl}$  atom attracts to the less EN of H in  $\text{H}_2\text{O}$ . The O gets attracted to Na in  $\text{NaCl}$  as both O is more EN than Na, this results in  $\delta^-$  and  $\delta^+$  charges particles attracting each other, resulting in  $\text{NaCl}$  being able to dissolve in water as particles can separate and ~~will~~ dissolve easily.

Iodine is a singular molecule and holds similar EN to O, this ~~means~~ <sup>means</sup> ~~it~~ <sup>the</sup> bonds in  $\text{H}_2\text{O}$  can not easily be moved to attract the iodine particle together, meaning it can't dissolve.

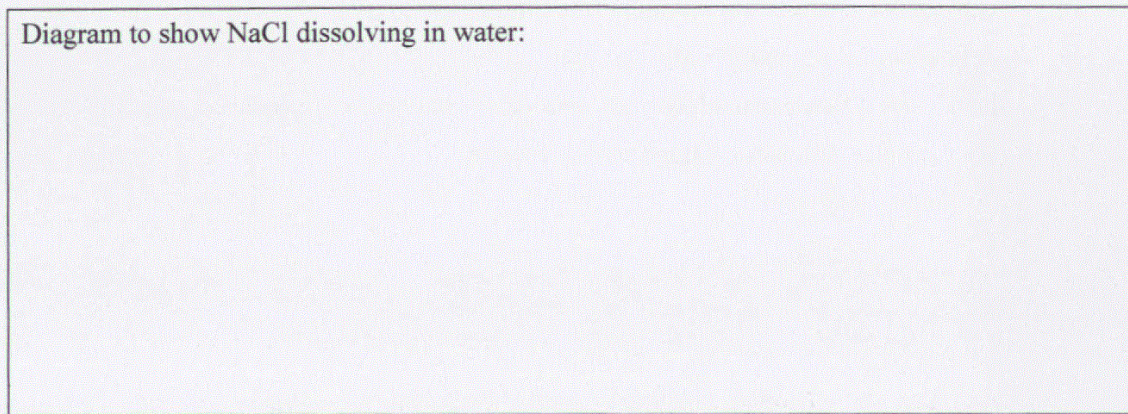
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Diagram to show NaCl dissolving in water:



**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:

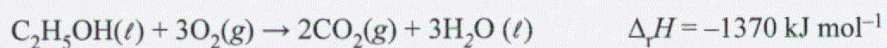
- explain the structure and bonding of diamond and graphite
- define electrical conductivity in solids
- justify the difference in electrical conductivity between diamond and graphite.

You may include a diagram to support your answer.

As diamond is a 3D covalent network, the ~~intermolecular~~ inter-molecular forces/bonds between particles in the solid are extremely rigid and strong, requiring significant energy to break these bonds. Although graphite is similar to diamond, its more metallic-like structure means the particles in the solid can move back and forth between each other, which allows for conductivity. electrical conductivity in solids requires movement of particles in the solid, which graphite can do, but because of the 3D lattice that makes up diamond solid, diamond bonds are extremely rigid and can not move around meaning it can not conduct electricity.

- (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.

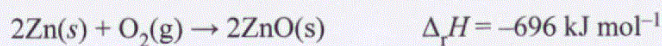


- (i) Calculate the mass of ethanol,  $C_2H_5OH$ , that must react to release 17 500 kJ of energy.

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

$$n = m/M$$

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



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

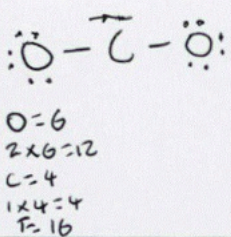
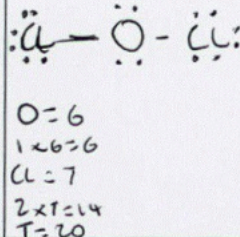
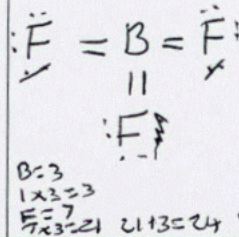
$$\cancel{187 \text{ g}} \quad 187 \text{ g} / 81.4 \text{ g mol}^{-1} = 2.29 \text{ mol}^{-1}$$

$$2.29 \times -696 = -1593.84 \text{ kJ mol}^{-1}$$

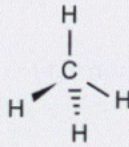
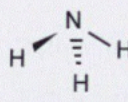
$$\underline{-1593.84 \text{ kJ mol}^{-1}}$$

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 <sub>2</sub>	Cl <sub>2</sub> O	BF <sub>3</sub>
Lewis structure	 <p>O=6 2x6=12 C=4 1x4=4 T=16</p>	 <p>O=6 1x6=6 Cl=7 2x7=14 T=20</p>	 <p>B=3 1x3=3 F=7 2x7=14 T=20</p>
Name of shape	Bent <del>Linear</del> Linear	Trigonal pyramidal	Trigonal pyramidal

- (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.

In methane, there are four regions of electron density around the central C atom, <sup>4</sup> these of the regions are bonding with H atoms, ~~0~~ we non-bonding, which means the ~~ED~~ shape is tetrahedral. These H atoms are arranged for maximum separation with minimum repulsion around the C atom, creating a bond angle of 109.5°, and an overall Lewis shape of tetrahedral.

In Ammonia, there are 3 regions of electron density around the central N atom, 3 H atoms

are arranged with maximum separation for minimum repulsion around the N atom, this creates a bond angle of  $109.5^\circ$ , as these 3 H atoms are all bonded, meaning there is 3 bonded regions of ED around the N atom, and 0 non-bonding, creating a ED shape of Trigonal pyramidal. The overall molecular Lewis structure is Trigonal pyramidal.







## Achievement

**Subject:** L2 Chemistry

**Standard:** 91164

**Total score:** 11

Q	Grade score	Marker commentary
One	A4	The candidate was awarded A4 as they calculated moles from a given mass and identified types of solids when given data. They recognised the relationship between melting point and forces between particles, but were unable to describe particle types and lacked detail when describing the hardness of diamond or malleability of gold. Two incorrect calculations in bonds broken and a subtraction led to an achieved grade being awarded for part (d).
Two	A4	The candidate was awarded A4 as they were able to identify most exothermic and endothermic statements, correctly identified that bonds were made, and that condensation is an exothermic reaction with energy is released. They were awarded a merit point for part (a). In part (b), tetrachloromethane is correctly identified as a non-polar molecule and electronegativity is explained appropriately. However, the discussion in part (b)(iii) lacked any mention of bond dipole cancellation. Two of three solubility options were selected correctly in part (c), and in part (d) they recognised that attractions (or lack of them) were required for a solute to dissolve in water and failed to draw a diagram.
Three	A3	The candidate was awarded A3. There was no achievement for part (a) as they failed to describe the basic structure of either allotrope or identify that mobile charged particles are needed for conductivity. An achieved point was awarded for part (b) as they correctly calculated moles from the second calculation. One Lewis diagram was correct in part (c), and the shapes were incorrect, so no point was awarded here. In part (d), the shape and bond angle of methane is correctly discussed using VSEPR theory. Ammonia lacks the parent shape; a merit point was awarded here.