

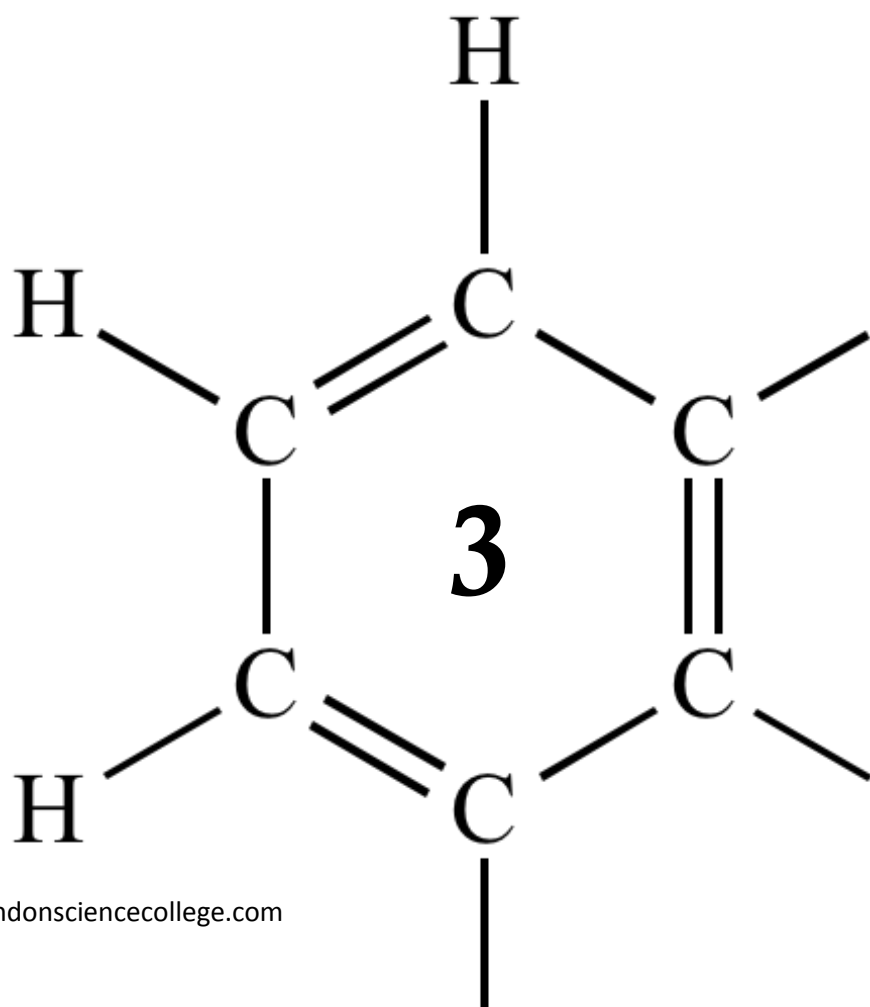
OCR AS CHEMISTRY

# MODULE 2

BONDING

SHAPES OF MOLECULES

INTERMOLECULAR FORCES



**1**

(a) Nickel is a metal with a high melting point.

(i) State the block in the Periodic Table that contains nickel.

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**(1)**

(ii) Explain, in terms of its structure and bonding, why nickel has a high melting point.

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**(2)**

(iii) Draw a labelled diagram to show the arrangement of particles in a crystal of nickel. In your answer, include at least six particles of each type.

**(2)**

(iv) Explain why nickel is ductile (can be stretched into wires).

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**(1)**

(b) Nickel forms the compound nickel(II) chloride ( $\text{NiCl}_2$ ).

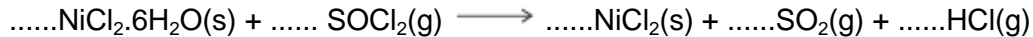
(i) Give the full electron configuration of the  $\text{Ni}^{2+}$  ion.

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**(1)**

- (ii) Balance the following equation to show how anhydrous nickel(II) chloride can be obtained from the hydrated salt using  $\text{SOCl}_2$

Identify **one** substance that could react with both gaseous products.



Substance .....

(2)

(Total 9 marks)

2

- (a) Ammonia gas readily condenses to form a liquid when cooled.

- (i) Name the strongest attractive force between two ammonia molecules.

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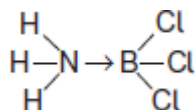
(1)

- (ii) Draw a diagram to show how two ammonia molecules interact with each other in the liquid phase.

Include all partial charges and all lone pairs of electrons in your diagram.

(3)

- (b) Ammonia reacts with boron trichloride to form a molecule with the following structure.



State how the bond between ammonia and boron trichloride is formed.

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(1)

(c) The following table shows the electronegativity values of some elements.

	H	Li	B	C	O	F
Electronegativity	2.1	1.0	2.0	2.5	3.5	4.0

(i) Give the meaning of the term **electronegativity**.

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(2)

(ii) Suggest the formula of an ionic compound that is formed by the chemical combination of two different elements from the table.

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(1)

(iii) Suggest the formula of the compound that has the least polar bond and is formed by chemical combination of two of the elements from the table.

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(1)

(Total 9 marks)

**3**

Thallium is in Group 3 of the Periodic Table.

Thallium reacts with halogens to form many compounds and ions.

(a) Draw the shape of the  $\text{TlBr}_3^{2-}$  ion and the shape of the  $\text{TlCl}_4^{3-}$  ion.  
Include any lone pairs of electrons that influence the shapes.

Name the shape made by the atoms in  $\text{TlBr}_3^{2-}$  and suggest a value for the bond angle.

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(4)

(b) Thallium(I) bromide (TlBr) is a crystalline solid with a melting point of 480 °C.

Suggest the type of bonding present in thallium(I) bromide and state why the melting point is high.

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(3)

(c) Write an equation to show the formation of thallium(I) bromide from its elements.

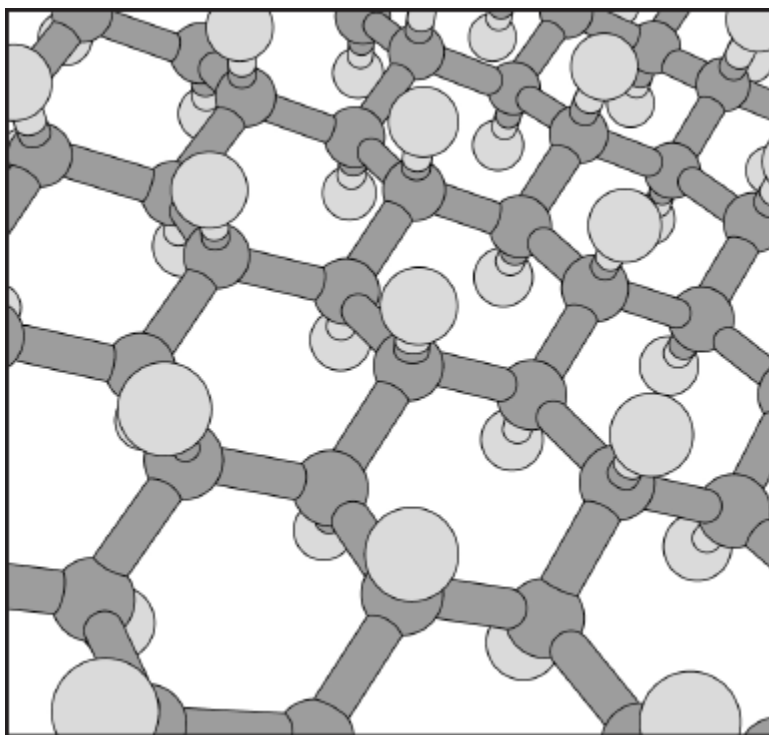
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(1)

(Total 8 marks)

4

In 2009 a new material called graphane was discovered. The diagram shows part of a model of the structure of graphane. Each carbon atom is bonded to three other carbon atoms and to one hydrogen atom.



(a) Deduce the type of crystal structure shown by graphane.

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(1)

(b) State how two carbon atoms form a carbon–carbon bond in graphane.

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(1)

(c) Suggest why graphane does **not** conduct electricity.

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(1)

(d) Deduce the empirical formula of graphane.

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(1)

(Total 4 marks)

**5**

Fritz Haber, a German chemist, first manufactured ammonia in 1909.  
Ammonia is very soluble in water.

(a) State the strongest type of intermolecular force between one molecule of ammonia and one molecule of water.

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(1)

(b) Draw a diagram to show how one molecule of ammonia is attracted to one molecule of water. Include all partial charges and all lone pairs of electrons in your diagram.

(3)

(c) Phosphine ( $\text{PH}_3$ ) has a structure similar to ammonia.

In terms of intermolecular forces, suggest the main reason why phosphine is almost insoluble in water.

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(1)  
(Total 5 marks)

6

Aluminium and thallium are elements in Group 3 of the Periodic Table. Both elements form compounds and ions containing chlorine and bromine.

(a) Write an equation for the formation of aluminium chloride from its elements.

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(1)

(b) An aluminium chloride molecule reacts with a chloride ion to form the  $\text{AlCl}_4^-$  ion.

Name the type of bond formed in this reaction. Explain how this type of bond is formed in the  $\text{AlCl}_4^-$  ion.

Type of bond .....

Explanation .....

.....  
.....

(2)

(c) Aluminium chloride has a relative molecular mass of 267 in the gas phase.

Deduce the formula of the aluminium compound that has a relative molecular mass of 267

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(1)

(d) Deduce the name or formula of a compound that has the same number of atoms, the same number of electrons and the same shape as the  $\text{AlCl}_4^-$  ion.

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(1)

(e) Draw and name the shape of the  $\text{TlBr}_5^{2-}$  ion.

Shape of the  $\text{TlBr}_5^{2-}$  ion.

Name of shape .....

(2)

(f) (i) Draw the shape of the  $\text{TlCl}_2^+$  ion.

(1)

(ii) Explain why the  $\text{TlCl}_2^+$  ion has the shape that you have drawn in part (f)(i).

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(1)

(g) Which **one** of the first, second or third ionisations of thallium produces an ion with the electron configuration  $[\text{Xe}] 5d^{10}6s^1$ ?

Tick (✓) one box.

First

Second

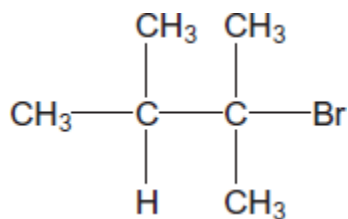
Third

(1)  
(Total 10 marks)



7

(a) The structure of the bromoalkane **Z** is



Give the IUPAC name for **Z**.

Give the general formula of the homologous series of straight-chain bromoalkanes that contains one bromine atom per molecule.

Suggest **one** reason why 1-bromohexane has a higher boiling point than **Z**.

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(Extra space) .....

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(3)

(b) Draw the displayed formula of 1,2-dichloro-2-methylpropane.

State its empirical formula.

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(2)  
(Total 5 marks)

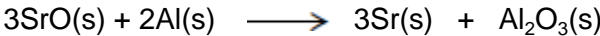
8

Group 2 metals and their compounds are used commercially in a variety of processes.

- (a) Strontium is extracted from strontium oxide (SrO) by heating a mixture of powdered strontium oxide and powdered aluminium.

Consider these standard enthalpies of formation.

	SrO(s)	Al <sub>2</sub> O <sub>3</sub> (s)
$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	- 590	- 1669



Use these data and the equation to calculate the standard enthalpy change for this extraction of strontium.

The use of powdered strontium oxide and powdered aluminium increases the surface area of the reactants.

Suggest **one** reason why this increases the reaction rate.

Suggest **one** major reason why this method of extracting strontium is expensive.

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(5)

(b) Explain why calcium has a higher melting point than strontium.

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**(2)**

(c) Magnesium is used in fireworks. It reacts rapidly with oxygen, burning with a bright white light. Magnesium reacts slowly with cold water.

Write an equation for the reaction of magnesium with oxygen.

Write an equation for the reaction of magnesium with cold water.

Give a medical use for the magnesium compound formed in the reaction of magnesium with cold water.

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**(3)**  
**(Total 10 marks)**

9

The following table shows the electronegativity values of the elements from lithium to fluorine.

	Li	Be	B	C	N	O	F
Electronegativity	1.0	1.5	2.0	2.5	3.0	3.5	4.0

(a) (i) State the meaning of the term *electronegativity*.

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(Extra space) .....  
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(2)

(ii) Suggest why the electronegativity of the elements increases from lithium to fluorine.

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(Extra space) .....  
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(2)

(b) State the type of bonding in lithium fluoride.  
Explain why a lot of energy is needed to melt a sample of solid lithium fluoride.

Bonding .....  
Explanation .....  
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(Extra space) .....  
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(3)

(c) Deduce why the bonding in nitrogen oxide is covalent rather than ionic.

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(Extra space) .....  
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(1)

(d) Oxygen forms several different compounds with fluorine.

(i) Suggest the type of crystal shown by  $\text{OF}_2$

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(1)

(ii) Write an equation to show how  $\text{OF}_2$  reacts with steam to form oxygen and hydrogen fluoride.

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(1)

(iii) One of these compounds of oxygen and fluorine has a relative molecular mass of 70.0 and contains 54.3% by mass of fluorine.

Calculate the empirical formula and the molecular formula of this compound.  
Show your working.

Empirical formula .....

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Molecular formula .....

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(4)  
(Total 14 marks)

**10**

Chlorine can form molecules and ions that contain only chlorine, or that contain chlorine combined with another element.

- (a) Use your understanding of the electron pair repulsion theory to draw the shape of the  $\text{AsCl}_3$  molecule and the shape of the  $\text{Cl}_3^+$  ion. Include any lone pairs of electrons that influence the shape.

Name the shape made by the atoms in the  $\text{AsCl}_3$  molecule and in the  $\text{Cl}_3^+$  ion.

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(Extra space) .....

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**(4)**

- (b) Explain why the  $\text{AsCl}_4^+$  ion has a bond angle of  $109.5^\circ$ .

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(Extra space).....

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**(2)**

**(Total 6 marks)**

11

The following equation shows the reaction of a phosphine molecule (PH<sub>3</sub>) with an H<sup>+</sup> ion.



- (a) Draw the shape of the PH<sub>3</sub> molecule. Include any lone pairs of electrons that influence the shape.

(1)

- (b) State the type of bond that is formed between the PH<sub>3</sub> molecule and the H<sup>+</sup> ion. Explain how this bond is formed.

Name of bond .....

How bond is formed .....

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(2)

- (c) Predict the bond angle in the PH<sub>4</sub><sup>+</sup> ion.

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(1)

- (d) Although phosphine molecules contain hydrogen atoms, there is no hydrogen bonding between phosphine molecules. Suggest an explanation for this.

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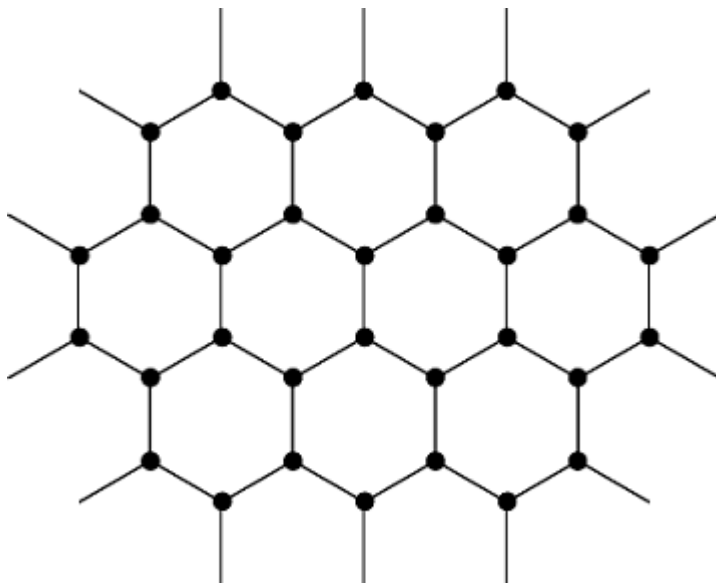
(1)

(Total 5 marks)

12

(a) Graphene is a new material made from carbon atoms. It is the thinnest and strongest material known. Graphene has a very high melting point and is an excellent conductor of electricity.

Part of the structure of graphene is illustrated in the diagram.



(i) Deduce the type of crystal structure shown by graphene.

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(1)

(ii) Suggest why graphene is an excellent conductor of electricity.

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(2)

(iii) Explain, in terms of its structure and bonding, why graphene has a high melting point.

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(2)



(b) Titanium is also a strong material that has a high melting point. It has a structure similar to that of magnesium.

(i) State the type of crystal structure shown by titanium.

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**(1)**

(ii) Explain, in terms of its structure and bonding, why titanium has a high melting point.

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**(2)**

(c) Titanium can be hammered into objects with different shapes that have similar strengths.

(i) Suggest why titanium can be hammered into different shapes.

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**(1)**

(ii) Suggest why these objects with different shapes have similar strengths.

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**(1)**

(d) Magnesium oxide (MgO) has a melting point of 3125 K.  
Predict the type of crystal structure in magnesium oxide and suggest why its melting point is high.

Type of crystal structure .....

Explanation .....

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**(3)**

**(Total 13 marks)**