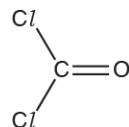


# Bonding and Structure

1. Phosgene,  $\text{COCl}_2$ , exists as simple molecules.

The displayed formula of a phosgene molecule is shown below.



- i. Draw a 'dot-and-cross' diagram of a phosgene molecule.

Show outer electrons only.

[1]

- ii. Name the shape of a phosgene molecule and explain why it has this shape.

Name of shape

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Explanation

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[3]

- 2(a). Sodium sulfide,  $\text{Na}_2\text{S}$ , is an ionic compound of sodium, Na, and sulfur, S.

Draw a 'dot-and-cross' diagram to show the bonding in sodium sulfide.

Show outer electrons only.

[2]

- (b). The table below compares the properties of sodium sulfide, sodium and sulfur.

Complete the table.

		Sodium sulfide	Sodium	Sulfur
Melting point / °C		1180	98	113
Type of structure ( <b>giant</b> or <b>simple</b> )				
Electrical conductivity ( <b>good</b> or <b>poor</b> )	solid			
	liquid			

[3]

3. Solid barium chloride has a high melting point. Barium chloride dissolves in water to form a solution that can be used to test for sulfate ions.

- i. Draw a 'dot-and-cross' diagram to show the bonding in solid barium chloride. Show outer electrons only.

[2]

- ii. A solution of barium chloride can be made in the laboratory using dilute hydrochloric acid.

Suggest a compound that can be reacted with hydrochloric acid to make barium chloride.

----- [1]

4. Bromine is a reactive element. It combines with other non-metals to form covalent compounds. Phosphorus tribromide,  $\text{PBr}_3$ , and iodine monobromide,  $\text{IBr}$ , are examples of covalent compounds used in organic synthesis.

$\text{PBr}_3$  can be prepared by heating bromine with phosphorus,  $\text{P}_4$ .

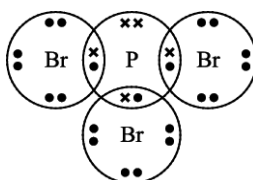
- i. Write an equation for this reaction.

..... [1]

- ii. How many molecules are present in 1.3535 g of  $\text{PBr}_3$ ?

number of molecules = ..... [3]

- iii. The 'dot-and-cross' diagram of a molecule of  $\text{PBr}_3$  is given below.



Name the shape of this molecule and explain why the molecule has this shape.

name: .....

explanation: .....

.....  
 .....

[3]

5. The hydroxyl group,  $\text{-OH}$ , is responsible for many properties of alcohols.

Methanol,  $\text{CH}_3\text{OH}$ , is soluble in water because it has polar bonds.

Pauling electronegativity values for carbon, oxygen and hydrogen are shown below.

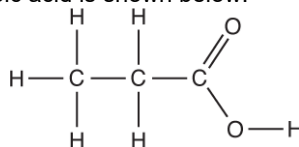
Element	Electronegativity
Carbon	2.5
Oxygen	3.5
Hydrogen	2.1

Use a labelled diagram to explain why methanol is soluble in water.

- Use displayed formulae showing one molecule of methanol and one molecule of water.
- Add partial charges  $\delta^+$  and  $\delta^-$  to show the **two** most polar bonds in a methanol molecule and the polar bonds in a water molecule.
- Show all lone pairs.
- Label the most important intermolecular bond between the molecules.

[2]

6. The displayed formula for propanoic acid is shown below.



- i. State the shape and bond angle around a carbon atom in the alkyl group of propanoic acid. Explain the shape.

Shape

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Bond angle

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Explanation

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[2]

- ii. Suggest a value for the C–O–H bond angle in propanoic acid.

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[1]

7. Barium combines with oxygen, chlorine and nitrogen to form ionic compounds.

Barium oxide, BaO, has a giant ionic lattice structure.

- i. State what is meant by the term *ionic bond*.

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[1]

- ii. Draw a 'dot-and-cross' diagram to show the bonding in barium oxide.

Show outer electrons only.

- iii. Calculate the number of barium ions in 1.50 g of barium oxide.

Give your answer in standard form and to **three** significant figures.

number of barium ions = .....

- 8(a).** At room temperature and pressure, the first four members of the alkanes are all gases but the first four alcohols are all liquids.

Explain this difference in terms of intermolecular forces.

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**[2]**

- (b).** The boiling points of 2-methylpropan-1-ol and butan-1-ol are shown below.

Alcohol	Boiling point / °C
2-methylpropan-1-ol	108
butan-1-ol	117

Explain why the boiling points are different.

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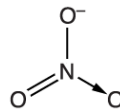
**[2]**

- 9.** Nickel(II) nitrate,  $\text{Ni}(\text{NO}_3)_2$ , can be prepared by reacting nickel(II) oxide with dilute nitric acid.

i. Write the equation for this reaction.

**[1]**

- ii.  $\text{Ni}(\text{NO}_3)_2$  contains the  $\text{NO}_3^-$  ion. The nitrogen atom bonds to the oxygen atoms with a single covalent bond, a double covalent bond and a dative covalent bond, as shown below.



Draw the '*dot-and-cross*' diagram for the  $\text{NO}_3^-$  ion, showing outer shell electrons only. Use a different symbol for the extra electron.

[2]

10. Compounds of calcium have many uses.

- i. Identify a compound of calcium that could be used to convert a soil pH from 5.8 to 7.5.

[1]

- ii. Calcium phosphide,  $\text{Ca}_3\text{P}_2$ , is an ionic compound used in rat poison.

Calcium phosphide can be prepared by reacting calcium metal with phosphorus,  $\text{P}_4$ .

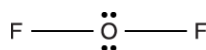
Write the equation for the reaction of calcium with phosphorus to form calcium phosphide.

[1]

- iii. Draw a '*dot-and-cross*' diagram to show the bonding in calcium phosphide,  $\text{Ca}_3\text{P}_2$ . Show **outer** electrons only.

[2]

11. i. Fluorine is the most electronegative element. Indicate any dipoles on the molecule of  $\text{F}_2\text{O}$  below using partial charges.



[1]

- ii. Suggest the **shape** of the  $\text{F}_2\text{O}$  molecule and the **F-O-F bond angle**.

Shape .....

Bond angle .....

[1]

iii. What is the oxidation number of oxygen in  $F_2O$ ?

Include the sign in your answer.

----- [1]

12. This question is about halogens.

Solid chlorine and solid bromine have a similar structure.

Name this structure.

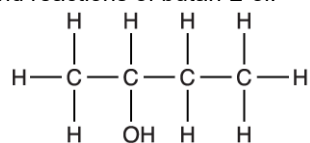
----- [1]

13. Draw a 'dot-and-cross' diagram to show the bonding in a nitrogen molecule.

Show **outer** electrons only.

[1]

14 This question is about the properties and reactions of butan-2-ol.



Some properties of butan-2-ol are listed in the table.

<b>Melting point</b>	-115 °C
<b>Boiling point</b>	99.5 °C

The shape around the oxygen atom in butan-2-ol is non-linear.

Predict the C-O-H bond angle and explain this shape.



bond angle .....

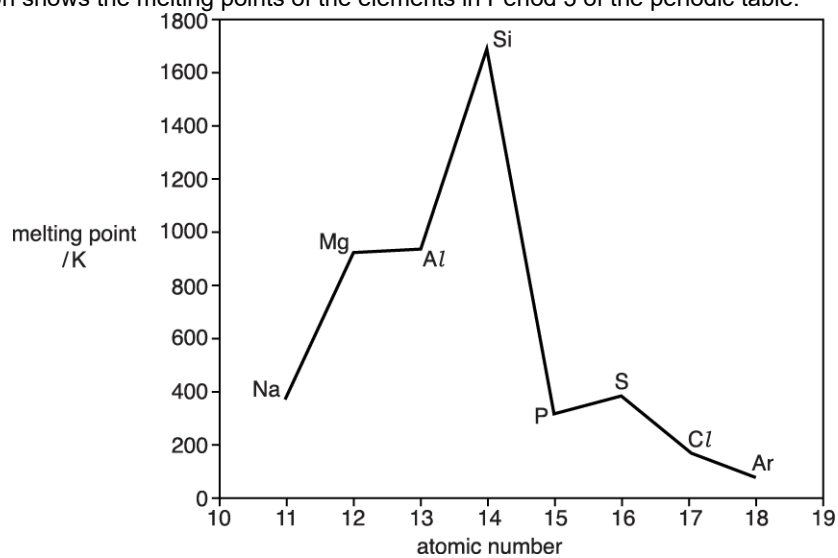
explanation

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 .....

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[4]

15. The graph shows the melting points of the elements in Period 3 of the periodic table.



Phosphorus and chlorine have simple molecular structures.  
 More information about phosphorus and chlorine is given in the table below.

Element	Molecular formula
phosphorus	P <sub>4</sub>
chlorine	Cl <sub>2</sub>

Explain the differences in the melting points of phosphorus and chlorine.

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----- [3]

16. The table shows the boiling points of ammonia, fluorine and bromine.

	Boiling point / °C
ammonia, NH <sub>3</sub>	- 33
fluorine, F <sub>2</sub>	- 188
bromine, Br <sub>2</sub>	59

Explain the different boiling points of NH<sub>3</sub>, F<sub>2</sub> and Br<sub>2</sub>.

Include the names of any relevant forces and particles.

*In your answer you should use appropriate technical terms, spelled correctly.*

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----- [5]

17. Chlorine gas reacts with methane. One of the products is dichloromethane,  $\text{CH}_2\text{Cl}_2$ .

- i. Chlorine is more electronegative than carbon and hydrogen, which have approximately equal electronegativity values.

Explain what is meant by the term *electronegativity*.

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----- [2]

- ii. Draw a 3-D diagram of a molecule of  $\text{CH}_2\text{Cl}_2$ .

Use partial charges to indicate polar bonds.

[2]

- iii. Explain why a  $\text{CH}_2\text{Cl}_2$  molecule is polar.

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----- [1]

18(a). Solid aluminium fluoride has a giant ionic lattice structure.

- i. Describe what is meant by the term *ionic lattice*, in terms of the type and arrangement of particles present.

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----- [2]

- ii. Draw a '*dot-and-cross*' diagram for aluminium fluoride.

Show outer electrons only.

[2]

- (b). Solid boron tribromide has a simple molecular lattice structure. The atoms are held together by covalent bonds.

- i. What is meant by the term *covalent bond*?

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----- [1]

- ii. Draw a '*dot-and-cross*' diagram to show the bonding in a boron tribromide molecule.

Show outer electrons only.

[1]

19 A chemist carries out reactions of barium and barium nitride,  $\text{Ba}_3\text{N}_2$ .

**Reaction 1** Barium is reacted with water.

**Reaction 2** Barium nitride is reacted with water, forming an alkaline solution and an alkaline gas.

**Reaction 3** Barium is reacted with an excess of oxygen at  $500^\circ\text{C}$ , forming barium peroxide,  $\text{BaO}_2$ .

- i. Write equations for **Reaction 1** and **Reaction 2**.

Ignore state symbols.

Reaction 1:

.....  
.....

Reaction 2:

.....  
 .....

[3]

- ii. Predict the structure and bonding of  $\text{Ba}_3\text{N}_2$ .

[1]

- iii.  $\text{BaO}_2$  formed in **Reaction 3** contains barium and peroxide ions.  
 The peroxide ion has the structure  $[\text{O}-\text{O}]^{2-}$ .

Suggest a 'dot-and-cross' diagram for  $\text{BaO}_2$ .

Show outer shell electrons only.

[1]

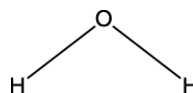
- 20(a).** Oxides can have different types of bonding.

$\text{H}_2\text{O}$  has hydrogen bonding.

- i. Complete the diagram below to show hydrogen bonding between the  $\text{H}_2\text{O}$  molecule shown and **one** other  $\text{H}_2\text{O}$  molecule.

Include relevant dipoles and lone pairs.

Label the hydrogen bond.



[2]

- ii. State and explain **two** anomalous properties of ice caused by hydrogen bonding.

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2

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[4]

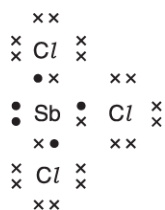
(b). Draw a 'dot-and-cross' diagram to show the bonding in  $\text{CO}_2$ .

Show outer electrons only.

[1]

21 Antimony chloride,  $\text{SbCl}_3$ , exists as simple covalent molecules.

A 'dot-and-cross' diagram of  $\text{SbCl}_3$  is shown below.



i. Predict the shape of a molecule of  $\text{SbCl}_3$ .

Explain your answer.

name of shape:

.....

.....

explanation:

.....

.....

[3]



- ii. Polonium, Po, is at the bottom of Group 16. Its hydride has the formula  $\text{H}_2\text{Po}$ . Estimate from the graph the boiling point of  $\text{H}_2\text{Po}$ . The relative molecular mass of  $\text{H}_2\text{Po}$  is 211.

----- [1]

- (b). The compounds  $\text{SO}_2$  and  $\text{MgO}$  both contain oxygen.

The table below shows the melting point of both compounds:

Compound	Melting point / K
$\text{SO}_2$	200
$\text{MgO}$	3125

Predict the type of structure and bonding of  $\text{SO}_2$  and  $\text{MgO}$  and explain the difference in their melting points.

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----- [4]

23. Carbon monoxide contains a triple bond, and includes a dative covalent bond.

Construct a 'dot-and-cross' diagram to show the outer electron pairs in a molecule of carbon monoxide.

[2]

END OF QUESTION PAPER