Covalent Bonding & Shapes of Molecules

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Chemical Bonding
Sub-Topic	Covalent Bonding & Shapes of Molecules
Paper Type	Theory
Booklet	Question Paper 1

Time Allowed: **74 minutes**

Score: **/61**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)** Complete the electronic configurations of the following atoms.

oxygen: $1s^2$.....

fluorine: $1s^2$.....

[1]

(b) A compound of fluorine and oxygen contains three atoms in each molecule.

(i) Predict its formula.

..... [1]

(ii) Draw a 'dot-and-cross' diagram to show its bonding.

[1]

(iii) Suggest the shape of this molecule.

..... [1]

(c) Use $E^{\ominus}$ values from the *Data Booklet* to predict the relative oxidising abilities of fluorine and chlorine.

.....

.....

..... [2]

(ii) Predict the *type of reaction* that would occur between the interhalogen compound chlorine fluoride, C*l*F, and potassium bromide solution.

..... [1]

(iii) Construct an equation for this reaction.

..... [1]

[Total: 8]

2 **(a)** Explain what is meant by the term *ionisation energy*.

.....

.....

..... [3]

(b) The first seven ionisation energies of an element, **A**, in kJ mol^{-1}, are

1012 1903 2912 4957 6274 21 269 25 398.

(i) State the group of the Periodic Table to which **A** is most likely to belong. Explain your answer.

.....

.....

.....

..... [2]

(ii) Complete the electronic configuration of the element in Period 2 that is in the same group as **A**.

1s^2 ..... [1]

(c) Another element, **Z**, in the same period of the Periodic Table as **A**, reacts with chlorine to form a compound with empirical formula **Z**Cl_2. The percentage composition by mass of **Z**Cl_2 is **Z**, 31.13; Cl, 68.87.

(i) Define the term *relative atomic mass*.

.....

.....

..... [2]

(ii) Calculate the relative atomic mass, A_r, of **Z**.
Give your answer to **three** significant figures.

A_r of **Z** = ... [2]

(d) The chlorides of elements in Period 3 of the Periodic Table show different behaviours on addition to water, depending on their structure and bonding.

(i) Write equations to show the behaviour of sodium chloride, $NaCl$, and silicon chloride, $SiCl_4$, when separately added to an excess of water.

$NaCl$ .....

$SiCl_4$ .....
[2]

(ii) State and explain the differences in behaviour of these two chlorides when added to water, in terms of their structure and the bonding found in the compounds.

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.....

.....

..... [4]

(e) Sulfur reacts with fluorine to form SF_6. State the shape and bond angle of SF_6.

shape of SF_6 .....

bond angle of SF_6 .....
[2]

[Total: 18]

3 Carbon disulfide,CS_2, is a volatile, flammableliquidwhichisproducedinsmall quantities in volcanoes.

(a) The sequence of atoms in the CS_2 molecule is sulfur to carbon to sulfur.

(i) Draw a 'dot-and-cross' diagram of the carbon disulfide molecule.
Show outer electrons only.

(ii) Suggest the shape of the molecule and state the bond angle.

shape .....

bond angle .....
[3]

(b) Carbon disulfide is readily combusted to give CO_2 and SO_2.

(i) Construct a balanced equation for the complete combustion of CS_2.

.....

(ii) Define the term *standard enthalpy change of combustion*, $\Delta H_c^{\ominus}$.

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.....
[3]

(c) Calculate the standard enthalpy change of formation of CS_2 from the following data. Include a sign in your answer.

standard enthalpy change of combustion of CS_2 = –1110 kJ mol^{-1}

standard enthalpy change of formation of CO_2 = –395 kJ mol^{-1}

standard enthalpy change of formation of SO_2 = –298 kJ mol^{-1}

[3]

(d) Carbon disulfide reacts with nitrogen monoxide, NO, in a 1:2 molar ratio.
A yellow solid and two colourless gases are produced.

(i) Construct a balanced equation for the reaction.

.....

(ii) What is the change in the oxidation number of sulfur in this reaction?

from ..... to .....

[3]

[Total: 12]

4 Ammonia, NH_3, and methane, CH_4, are the hydrides of elements which are next to one another in the Periodic Table.

(a) In the boxes below, draw the 'dot-and-cross' diagram of a molecule of **each** of these compounds. Show outer electrons only.
State the shape of **each** molecule.

NH_3	CH_4
shape	shape

[3]

(b) Ammonia is polar whereas methane is non-polar. The physical properties of the two compounds are different.

(i) Explain, using ammonia as the example, the meaning of the term *bond polarity*.

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(ii) Explain why the ammonia molecule is polar.

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(iii) State **one** physical property of ammonia which is caused by its polarity.

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.....

[4]

(c) When ammonia gas is mixed with hydrogen chloride, white, solid ammonium chloride is formed.

State **each type** of bond that is present in one formula unit of ammonium chloride and how many of each type are present.
You may draw diagrams.

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.....

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.....

..... [3]

[Total: 10]

5 Elements and compounds which have small molecules usually exist as gases or liquids.

(a) Chlorine, Cl_2, is a gas at room temperature whereas bromine, Br_2, is a liquid under the same conditions.

Explain these observations.

.....

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..... [2]

(b) The gases nitrogen, N_2, and carbon monoxide, CO, are isoelectronic, that is they have the same number of electrons in their molecules.

Suggest why N_2 has a lower boiling point than CO.

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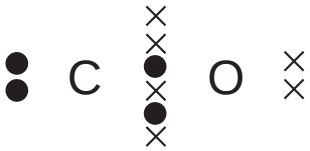
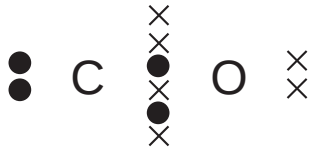
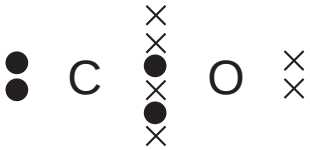
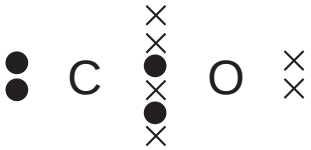
..... [2]

(c) A 'dot-and-cross' diagram of a CO molecule is shown below. Only electrons from outer shells are represented.



In the table below, there are three copies of this structure.
On the structures, draw a circle round a pair of electrons that is associated with **each** of the following.

(i) a co-ordinate bond	**(ii)** a covalent bond	**(iii)** a lone pair
		

[3]

(d) Hydrogen cyanide, HCN, is a gas which is also isoelectronic with N_2 and with CO. Each molecule contains a strong triple bond with the following bond energies.

bond	bond energy / kJ mol^{-1}
–C≡N in HCN	890
N≡N	994
C≡O	1078

Although each compound contains the same number of electrons and a strong triple bond in its molecule, CO and HCN are both very reactive whereas N_2 is not.

Suggest a reason for this.

.....

..... [1]

(e) HCN reacts with ethanal, CH_3CHO.

(i) Give the **displayed formula** of the organic product formed.

(ii) What type of reaction is this?

.....

(iii) Draw the mechanism of this reaction. You should show all full and partial charges and represent the movement of electron pairs by curly arrows.

[5]

[Total: 13]