

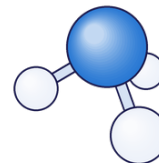
GCSE CHEMISTRY

Covalent Bonding

OCR-style Topic Practice

For OCR Chemistry A (Gateway Science) J248 and OCR Chemistry B (Twenty First Century Science) J258

Tier: Mixed demand



Name _____

Date _____

INSTRUCTIONS

- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Answer all the questions.
- Write your answer to each question in the space provided.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.
- A scientific calculator may be used.

INFORMATION

- The total mark for this paper is **52**.
- The marks for each question are shown in brackets [].
- Quality of extended response will be assessed in questions marked with an asterisk (*).

ADVICE

- Read each question carefully before you start your answer.

These are original, independent practice questions written in the style of OCR GCSE Chemistry. They are not official OCR examination questions and are not endorsed by OCR.

SECTION A

Answer **all** the questions. You should spend approximately 10 minutes on this section. Write your answer to each question in the box provided.

1 Which substance consists of small covalent molecules?

- A** calcium chloride, CaCl_2
- B** carbon monoxide, CO
- C** iron, Fe
- D** lithium oxide, Li_2O

Your answer

[1]

2 Methane has a low boiling point.

Which statement explains why?

- A** The covalent bonds in methane are weak.
- B** The forces between methane molecules are weak.
- C** The ions in methane are free to move.
- D** Methane molecules have no overall charge.

Your answer

[1]

3 How many electrons are shared between the two atoms in an oxygen molecule, O_2 ?

- A** 2
- B** 4
- C** 6
- D** 8

Your answer

[1]

4 What is the typical size (order of magnitude) of an atom?

- A** 10^{-6} m
- B** 10^{-8} m
- C** 10^{-10} m
- D** 10^{-14} m

Your answer

[1]

- 5 Which row is correct for a molecule of ammonia, NH_3 ?

	Covalent bonds	Lone pairs on the nitrogen atom
A	3	1
B	3	0
C	4	0
D	3	2

Your answer

[1]

- 6 Which representation shows the three-dimensional shape of a molecule?

- A dot and cross diagram
B displayed formula
C ball and stick model
D molecular formula

Your answer

[1]

- 7 Which molecule contains a triple covalent bond?

- A chlorine, Cl_2
B hydrogen, H_2
C nitrogen, N_2
D oxygen, O_2

Your answer

[1]

- 8 Which substance is a gas at 20°C ?

	Melting point ($^\circ\text{C}$)	Boiling point ($^\circ\text{C}$)
A	-7	59
B	114	184
C	-101	-34
D	801	1413

Your answer

[1]

SECTION B

Answer **all** the questions.

- 9 Chlorine is a gas made of Cl_2 molecules. A chlorine atom has seven electrons in its outer shell.

(a) Fig. 9.1 shows the outer shells of the two atoms in a chlorine molecule.

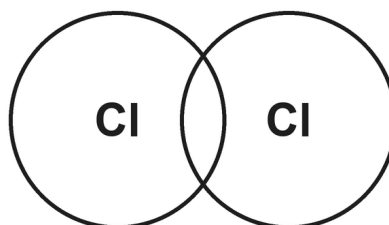


Fig. 9.1

Complete Fig. 9.1 to show the covalent bond in a chlorine molecule. Show the outer shell electrons only.

[2]

(b) Explain how the covalent bond holds the two chlorine atoms together.

.....

.....

[2]

(c) Complete the sentences about chlorine.

Use words from the list.

charge	covalent	intermolecular forces	ions
molecules	move	strong	weak

Chlorine has a low boiling point because the between chlorine molecules are

When chlorine boils, the bonds inside the molecules do not break.

Liquid chlorine does not conduct electricity because there are no charged particles free to

[2]

- (d) Chlorine is a green-yellow gas.

A student writes:

'Each chlorine molecule is green-yellow.'

Explain why the student is wrong.

[1]

- 10 Fig. 10.1 shows two representations, A and B, of a methane molecule, CH₄.

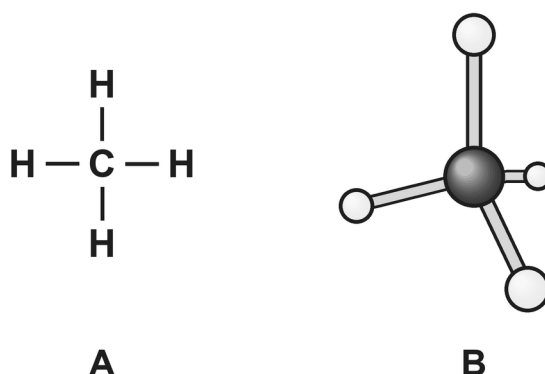


Fig. 10.1

- (a) Name the type of representation shown by A and by B.

A

B

[2]

- (b) Give **one** thing that representation B shows about a methane molecule that representation A does not show.

[1]

- (c) In a methane molecule, the angle between any two covalent bonds is 109.5°. Explain why representation A gives a misleading impression of the bond angles.

[2]

- (d) Give **one** limitation of representation B.

[1]

- 11** Titan is the largest moon of Saturn. Its surface temperature is about $-179\text{ }^{\circ}\text{C}$. Titan has lakes of liquid hydrocarbons.

Table 11.1 shows information about three hydrocarbons. Each consists of small molecules.

Table 11.1

Hydrocarbon	Formula	Relative formula mass	Melting point ($^{\circ}\text{C}$)	Boiling point ($^{\circ}\text{C}$)
Methane	CH_4	16	-182	-162
Ethane	C_2H_6	30	-183	-89
Propane	C_3H_8	44	-188	-42

- (a) Explain why methane is a liquid on the surface of Titan.

Use Table 11.1.

.....
 [2]

- (b) On Earth, at $20\text{ }^{\circ}\text{C}$, methane is a gas.

What is the bonding and structure of methane?

.....
 [2]

- (c) Describe and explain the trend in the boiling points in Table 11.1.

.....

 [3]

- (d) Butane, C_4H_{10} , melts at $-138\text{ }^{\circ}\text{C}$.

Predict the state of butane on the surface of Titan.

Give a reason for your answer.

.....
 [2]

- (e) A student writes:

'Each time the relative formula mass increases by 14, the boiling point increases by the same amount.'

Evaluate this statement. Use Table 11.1.

.....

[2]

- 12** A water molecule is about 3×10^{-10} m across. A raindrop is about 2 mm across.

- (a) Give the width of the raindrop in metres, in standard form.

Width = m

[1]

- (b) Estimate how many water molecules, side by side, would fit across the raindrop.

.....

Number of molecules =

[2]

- 13** Lauric acid is a simple molecular substance found in coconut oil. A student measured its melting point four times.

Table 13.1 shows the results.

Table 13.1

Trial	1	2	3	4
Melting point (°C)	43.6	44.2	46.9	43.9

- (a) Identify the anomalous result in Table 13.1.

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[1]

- (b) Calculate the mean melting point of lauric acid.

Do **not** include the anomalous result.

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Mean melting point = °C

[2]

- (c) Lauric acid has a relative formula mass of 200. Methane has a relative formula mass of 16 and melts at $-182\text{ }^{\circ}\text{C}$.

Explain why lauric acid has a much higher melting point than methane.

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[2]

- (d) Suggest **one** reason why the student measured the melting point four times.

.....

[1]

- 14** Carbon dioxide, CO_2 , consists of small molecules. A carbon atom has four electrons in its outer shell. An oxygen atom has six.

- (a) Fig. 14.1 shows the outer shells of the atoms in a carbon dioxide molecule.

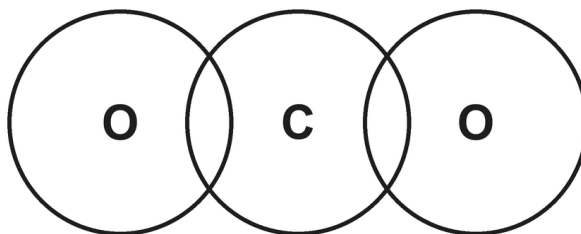


Fig. 14.1

Complete Fig. 14.1 to show the covalent bonding in a carbon dioxide molecule. Show the outer shell electrons only.

[3]

- (b) The bonds in a carbon dioxide molecule are strong double bonds. Even so, solid carbon dioxide turns into a gas at $-78\text{ }^{\circ}\text{C}$.

Explain why.

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.....

[2]

- 15*** Nitrogen, N_2 , and hydrogen chloride, HCl , both consist of small molecules.

A nitrogen atom has five electrons in its outer shell. A hydrogen atom has one electron. A chlorine atom has seven electrons in its outer shell.

Table 15.1 shows some properties of the two substances.

Table 15.1

Substance	Relative formula mass	Boiling point ($^{\circ}C$)	Conducts electricity when liquid?
Nitrogen, N_2	28	-196	no
Hydrogen chloride, HCl	36.5	-85	no

Describe the covalent bonding in a molecule of nitrogen and in a molecule of hydrogen chloride.

Use Table 15.1 to explain the properties of the two substances.

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[6]

END OF QUESTION PAPER

Mark scheme

Annotations: ✓ = one mark. / separates alternatives. () words not needed for the mark. ALLOW = an acceptable alternative. IGNORE = neither gains nor loses the mark. DO NOT ACCEPT = does not gain the mark. ECF = error carried forward.

Question	Answer	Marks	AO element	Guidance
1	B ✓	1	2.1	A, C and D each contain a metal, so are ionic or metallic
2	B ✓	1	1.1	A: the covalent bonds are strong and are not broken on boiling D: true, but it explains poor conduction, not the low boiling point
3	B ✓	1	2.1	a double bond is two shared pairs, which is four electrons
4	C ✓	1	1.1	D is about the size of a nucleus
5	A ✓	1	2.1	
6	C ✓	1	1.1	
7	C ✓	1	1.1	D contains a double bond; A and B contain single bonds
8	C ✓	1	3.1a	20 °C is above both its melting point and its boiling point
9(a)	one pair of electrons (one dot and one cross) in the overlap ✓ three lone pairs on each chlorine atom ✓	2	1.1 ×2	ALLOW any symbols for electrons if the two atoms' electrons are distinguished each chlorine atom must have 8 electrons in its outer shell for the second mark IGNORE inner electrons if drawn
9(b)	the two atoms share a pair of electrons ✓ both (positive) nuclei are attracted to the shared (negative) pair of electrons ✓	2	1.1 ×2	ALLOW electrostatic attraction between the nuclei and the shared electrons for the second mark DO NOT ACCEPT attraction between ions
9(c)	intermolecular forces, weak, covalent, move all four correct ✓✓	2	1.1 ×2	2–3 correct = 1 mark the words must be in this order
9(d)	colour is a property of the bulk substance / of very many molecules, not of a single molecule ✓	1	2.1	ALLOW individual molecules / atoms do not have the bulk properties of the substance

Question	Answer	Marks	AO element	Guidance
10(a)	A: displayed formula ✓ B: ball and stick model ✓	2	1.1 ×2	ALLOW structural formula for A ALLOW 3D model / molecular model for B
10(b)	the three-dimensional shape / the angles between the bonds / the arrangement of the atoms in space ✓	1	1.1	IGNORE which atoms are joined together (A shows this too)
10(c)	A is drawn flat / in two dimensions, so the bonds appear to be at 90° (and 180°) ✓ the real molecule is three-dimensional (tetrahedral), so every bond angle is 109.5° ✓	2	2.1 ×2	ALLOW the hydrogen atoms point in three dimensions, as far apart as possible
10(d)	one from: • does not show the electrons / which electrons are shared ✓ • the bonds are not really sticks ✓ • the atoms are much closer together than shown ✓ • the sizes of the atoms are not to scale ✓	1	1.1	IGNORE it is not the real colour
11(a)	–179 °C is above the melting point of methane (–182 °C) ✓ and below its boiling point (–162 °C) ✓	2	3.1a ×2	a clear statement that –179 °C lies between methane's melting point and boiling point = 2 marks a statement that refers only to being above the melting point = 1 mark a statement that refers only to being below the boiling point = 1 mark ALLOW scientifically equivalent wording
11(b)	covalent (bonding) ✓ simple molecules / small molecules / simple molecular (structure) ✓	2	1.1 ×2	DO NOT ACCEPT giant for the second mark IGNORE ionic if clearly crossed out
11(c)	the boiling point increases as the relative formula mass increases ✓ the intermolecular forces are stronger between larger molecules ✓ so more energy is needed to overcome them ✓	3	1.1 ×2 3.1a	ALLOW forces between molecules for intermolecular forces if the answer states that covalent bonds break on boiling, award a maximum of 2 marks
11(d)	solid ✓ because –179 °C is below its melting point (of –138 °C) ✓	2	2.1 3.2a	the second mark needs a comparison with the melting point do not award the second mark without the first

Question	Answer	Marks	AO element	Guidance
11(e)	the statement is not supported / is wrong ✓ the boiling point increases by 73 °C and then by 47 °C / the increases get smaller ✓	2	3.2a ×2	the second mark needs the two differences, or a clear comparison using data from Table 11.1 ALLOW the boiling point does increase with relative formula mass, but not by equal amounts, for the first mark
12(a)	2×10^{-3} (m) ✓	1	2.2	ALLOW 2.0×10^{-3} DO NOT ACCEPT 0.002, which is not in standard form
12(b)	$(2 \times 10^{-3}) \div (3 \times 10^{-10})$ ✓ $= 6.7 \times 10^6$ (molecules) ✓	2	2.2 ×2	award 2 marks for the correct answer with no working ALLOW 7×10^6 or 6 666 667 ECF from (a)
13(a)	46.9 (°C) ✓	1	3.1a	ALLOW trial 3
13(b)	$(43.6 + 44.2 + 43.9) \div 3$ ✓ $= 43.9$ (°C) ✓	2	2.2 ×2	award 2 marks for the correct answer with no working award 1 mark for 44.65, where the anomalous result has been included
13(c)	lauric acid molecules are (much) larger than methane molecules, so the intermolecular forces are stronger ✓ so more energy is needed to overcome them ✓	2	2.1 ×2	ALLOW higher relative formula mass for larger molecules if the answer states that covalent bonds break on melting, award a maximum of 1 mark
13(d)	one from: • to identify anomalous results ✓ • to check that the results are repeatable ✓ • so that a mean can be calculated ✓	1	3.3a	IGNORE to make it a fair test IGNORE to make it accurate, unless linked to a mean or to anomalies
14(a)	two pairs of electrons (two dots and two crosses) in each overlap ✓ two lone pairs on each oxygen atom ✓ no lone pairs on the carbon atom / every atom has 8 electrons in its outer shell ✓	3	2.1 ×3	ALLOW any symbols for electrons if the atoms' electrons are distinguished the carbon atom's electrons must all be shown in the overlaps for the third mark
14(b)	the intermolecular forces (between carbon dioxide molecules) are weak ✓ so little energy is needed to overcome them; the (double) covalent bonds are not broken ✓	2	1.1 2.1	DO NOT ACCEPT the double bonds break

Question	Answer	Marks	AO element	Guidance
15*	Level 3 (5–6 marks) A detailed description of the bonding in both molecules in terms of shared pairs of electrons, including the triple bond in nitrogen, and a clear explanation of the low boiling points, the difference between them, and the lack of conduction. There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated. Level 2 (3–4 marks) A description of the bonding in at least one molecule in terms of shared electrons, and an explanation of at least one property. There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence. Level 1 (1–2 marks) Simple statements about covalent bonds, molecules or the properties in Table 15.1, with little explanation. The information is basic and communicated in an unstructured way. 0 marks No response or no response worthy of credit.	6	1.1 ×3 2.1 ×3	Indicative scientific points may include: AO1.1 knowledge - a covalent bond is a shared pair of electrons - both substances consist of small molecules with strong covalent bonds - the intermolecular forces between the molecules are weak - the molecules have no overall charge AO2.1 application - each nitrogen atom needs 3 more electrons, so the two atoms share three pairs: a triple bond, with one lone pair on each nitrogen - hydrogen and chlorine share one pair of electrons: a single bond, with three lone pairs on the chlorine - little energy is needed to overcome the weak intermolecular forces, so both boiling points are low; the covalent bonds do not break - hydrogen chloride molecules are larger (higher relative formula mass), so the intermolecular forces are stronger and its boiling point is higher - there are no charged particles free to move, so neither conducts electricity The indicative points are not a checklist. Credit other relevant, correct points. An answer that states that covalent bonds break on boiling cannot reach Level 3.

Specification coverage

The questions in this paper have been mapped to relevant content and/or assessment skills in both OCR Chemistry A (Gateway Science) J248 and OCR Chemistry B (Twenty First Century Science) J258. For teachers; not part of the student paper.

Question	Gateway J248	Twenty First Century J258	AO	Marks
1	C2.2d	C3.4.8	AO2.1	1
Question 1 total				1
2	C2.3d, C2.3f	C3.4.14	AO1.1	1
Question 2 total				1
3	C2.2f	C3.4.10	AO2.1	1
Question 3 total				1
4	C1.2c	C2.1.5	AO1.1	1
Question 4 total				1
5	C2.2f	C3.4.10	AO2.1	1
Question 5 total				1
6	C2.2g	C3.4.11, C3.4.12	AO1.1	1
Question 6 total				1
7	C2.2f	C3.4.10	AO1.1	1
Question 7 total				1
8	C2.3e	C1.1.4	AO3.1a	1
Question 8 total				1
9(a)	C2.2f	C3.4.10	AO1.1 ×2	2
9(b)	C2.2e	C3.4.9	AO1.1 ×2	2
9(c)	C2.3d, C2.3f	C3.4.14	AO1.1 ×2	2
9(d)	C2.3f	C1.1.1	AO2.1	1
Question 9 total				7
10(a)	C2.2g	C3.4.11	AO1.1 ×2	2
10(b)	C2.2g, CM2.2ii	C3.4.11	AO1.1	1
10(c)	C2.2g, CM2.2ii	C3.4.11, C3.4.12	AO2.1 ×2	2
10(d)	C2.2g	C3.4.12	AO1.1	1
Question 10 total				6
11(a)	C2.3e	C1.1.4	AO3.1a ×2	2
11(b)	C2.2d	C3.4.8	AO1.1 ×2	2
11(c)	C2.3d, C2.3f, WS1.3e	C3.4.5, C3.4.14, laS2.8	AO1.1 ×2, AO3.1a	3
11(d)	C2.3e	C1.1.4	AO2.1, AO3.2a	2
11(e)	WS1.3e, WS1.3f	C3.4.13, laS2.11	AO3.2a ×2	2

Question	Gateway J248	Twenty First Century J258	AO	Marks
Question 11 total				11
12(a)	C1.2c, CM1.2i, WS1.4d	C2.1.6, IaS2.3	AO2.2	1
12(b)	C1.2c, CM1.2i, WS1.4d	C2.1.6, IaS2.3	AO2.2 ×2	2
Question 12 total				3
13(a)	WS1.3f	IaS2.9	AO3.1a	1
13(b)	WS1.3c	IaS2.8	AO2.2 ×2	2
13(c)	C2.3d, C2.3f	C1.1.3, C3.4.14	AO2.1 ×2	2
13(d)	WS1.3g	IaS2.9	AO3.3a	1
Question 13 total				6
14(a)	C2.2f, C2.3a	C3.4.10	AO2.1 ×3	3
14(b)	C2.3d, C2.3f	C1.1.3, C3.4.14	AO1.1, AO2.1	2
Question 14 total				5
15	C2.2e, C2.2f, C2.3d, C2.3f	C3.4.9, C3.4.10, C3.4.14	AO1.1 ×3, AO2.1 ×3	6
Question 15 total				6
Paper total				52

Assessment objectives in this paper

Assessment objective	Marks
AO1 knowledge and understanding	22 (42%)
AO2 applying knowledge and understanding	21 (40%)
AO3 analysing, interpreting and evaluating	9 (17%)
Total	52