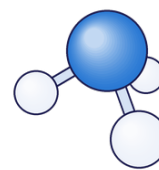


GCSE (9–1) CHEMISTRY

Covalent Bonding

Pearson Edexcel-style Topic Practice

Based on Pearson Edexcel GCSE Chemistry (1CH0)



Name _____

Date _____

Instructions

- Answer all questions.
- Write your answers in the spaces provided.
- Show all working in calculations. A calculator may be used.
- For multiple-choice questions, put a cross in the box next to your answer.

Information

- The marks for each question are shown in brackets.
- Questions marked with an asterisk (*) require a structured extended response. Organise your answer clearly and make logical links between your points.
- The total mark for this paper is 50.

These are original practice questions written in the style of Pearson Edexcel GCSE Chemistry. They are not official Pearson examination questions.

Total marks

50

1 Atoms of non-metals can join together by forming covalent bonds.

(a) Which of these substances contains covalent bonds?

- A ☐ calcium oxide, CaO
B ☐ lithium chloride, LiCl
C ☐ potassium bromide, KBr
D ☐ sulfur dioxide, SO₂

(1)

(b) Which statement describes a covalent bond?

- A ☐ a shared pair of electrons between two atoms
B ☐ the attraction between two oppositely charged ions
C ☐ an electron transferred from one atom to another
D ☐ a weak force of attraction between two molecules

(1)

(c) What is the typical diameter of an atom?

- A ☐ 1×10^{-4} m
B ☐ 1×10^{-7} m
C ☐ 1×10^{-10} m
D ☐ 1×10^{-13} m

(1)

(d) Which row shows the number of shared pairs of electrons and the total number of lone pairs in one molecule of carbon dioxide, CO₂?

		Shared pairs of electrons	Lone pairs
A	☐	2	4
B	☐	4	4
C	☐	4	2
D	☐	2	2

(1)

(Total for Question 1 = 4 marks)

2 Hydrogen chloride, HCl, and water, H₂O, are both made of molecules.

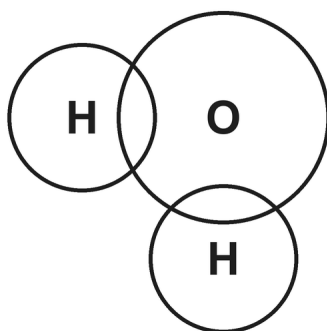
- (a) Explain how a covalent bond holds the hydrogen atom and the chlorine atom together in a molecule of hydrogen chloride.

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(2)

- (b) The diagram shows the outer shells of the atoms in a molecule of water.



The outer shells of the atoms in a molecule of water.

Complete the dot and cross diagram to show the covalent bonding in a molecule of water.
Show outer electrons only.

(2)

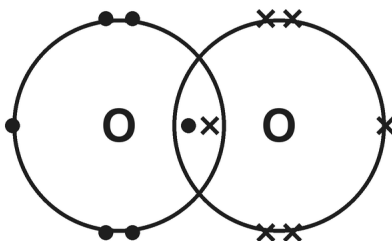
- (c) State the total number of electrons in the outer shell of the oxygen atom in a molecule of water.

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(1)

(Total for Question 2 = 5 marks)

- 3 Oxygen, O_2 , and carbon dioxide, CO_2 , both contain double bonds.
- (a) A student drew this dot and cross diagram for a molecule of oxygen.



A student's dot and cross diagram for oxygen.

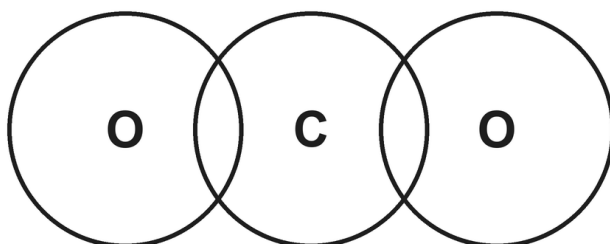
Explain what is wrong with the student's diagram.

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(2)

- (b) The diagram shows the outer shells of the atoms in a molecule of carbon dioxide.



The outer shells of the atoms in a molecule of carbon dioxide.

Complete the dot and cross diagram to show the covalent bonding in a molecule of carbon dioxide. Show outer electrons only.

(2)

- (c) Draw the displayed formula of a molecule of carbon dioxide.

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(1)

- (d) The double bond between the two atoms in an oxygen molecule is strong. However, oxygen boils at $-183\text{ }^{\circ}\text{C}$.

Explain why oxygen has a low boiling point.

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(2)

(Total for Question 3 = 7 marks)

- 4 The number of covalent bonds an atom usually forms can be related to the number of electrons in its outer shell.

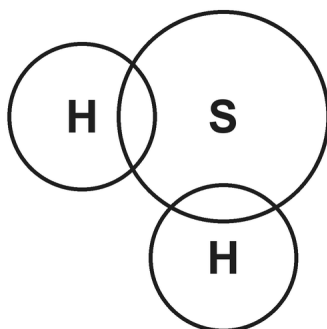
(a) Complete the table to show the number of covalent bonds each atom usually forms.

Atom	Group	Electrons in outer shell	Number of covalent bonds
carbon	4	4	
nitrogen	5	5	
sulfur	6	6	
chlorine	7	7	

(2)

- (b) Hydrogen sulfide, H_2S , is a poisonous gas. Sulfur is in group 6 of the periodic table.

The diagram shows the outer shells of the atoms in a molecule of hydrogen sulfide.



The outer shells of the atoms in a molecule of hydrogen sulfide.

Complete the dot and cross diagram to show the covalent bonding in a molecule of hydrogen sulfide. Show outer electrons only.

(2)

- (c) Phosphorus has five electrons in its outer shell. Hydrogen has one electron in its outer shell. Predict the formula of the molecule formed when phosphorus bonds with hydrogen and state the number of lone pairs on the phosphorus atom in one molecule.

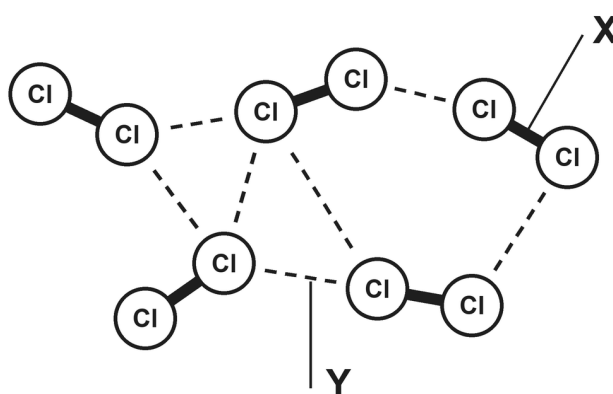
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(2)

(Total for Question 4 = 6 marks)

- 5 Chlorine, Cl_2 , has a simple molecular structure. The diagram shows some molecules of chlorine.



Some molecules of chlorine.

- (a) Name the type of bond or force labelled X and the type of force labelled Y.

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(2)

- (b) Chlorine boils at $-34\text{ }^{\circ}\text{C}$. Explain why chlorine has a low boiling point.

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(2)

- (c) Explain why liquid chlorine does not conduct electricity.

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(2)

(Total for Question 5 = 6 marks)

- 6 The table shows the relative formula mass and the boiling point of four substances. Each substance has a simple molecular structure.

Substance	Formula	Relative formula mass	Boiling point (°C)
methane	CH ₄	16	−162
ethane	C ₂ H ₆	30	−89
propane	C ₃ H ₈	44	−42
butane	C ₄ H ₁₀	58	−1

- (a) Describe the trend in boiling point shown in the table.

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(1)

- (b) Suggest a reason for this trend.

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(2)

- (c) State whether propane is a solid, a liquid or a gas at room temperature (20 °C). Give a reason for your answer.

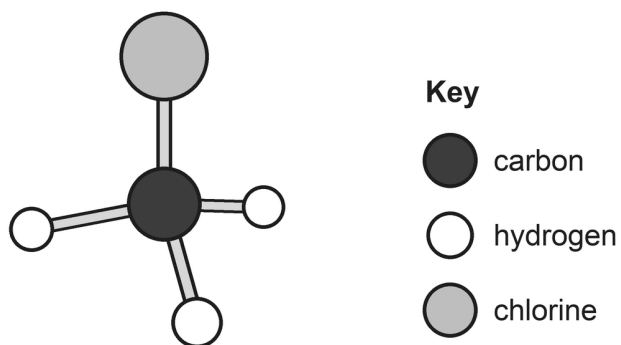
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(2)

- (d) Pentane has a relative formula mass of 72. Estimate the boiling point of pentane.

Answer °C
(1)

(Total for Question 6 = 6 marks)

- 7 The diagram shows a ball and stick model of a molecule.



A ball and stick model of a molecule.

- (a) Give the molecular formula of this molecule.

(1)

- (b) Give one thing the ball and stick model shows about the molecule that a dot and cross diagram does not show.

(1)

- (c) Give two limitations of the ball and stick model.

(2)

(Total for Question 7 = 4 marks)

- 8 Atoms are very small. The diameter of a chlorine atom is about 2×10^{-10} m.

- (a) A chlorine molecule is about 0.3 nm long. $1 \text{ nm} = 1 \times 10^{-9}$ m.

Give the length of a chlorine molecule in metres, in standard form.

Answer m

(1)

- (b) Calculate how many chlorine atoms, side by side, would make a line 1 mm long. $1 \text{ mm} = 1 \times 10^{-3} \text{ m}$.

Answer atoms

(2)

(Total for Question 8 = 3 marks)

- 9** Nitrogen gas makes up about 78% of the air. A nitrogen molecule, N_2 , contains a triple bond.

- (a) Nitrogen is in group 5 of the periodic table.

Use this information to explain why the bond between the two nitrogen atoms in an N_2 molecule consists of three shared pairs of electrons.

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(2)

- (b) Nitrogen gas is very unreactive. Suggest why.

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(1)

(Total for Question 9 = 3 marks)

- *10** Methane, CH_4 , is the main compound in natural gas. Carbon is in group 4 and hydrogen has one electron.

Methane boils at $-162\text{ }^\circ\text{C}$ and does not conduct electricity.

Explain how the atoms in methane are bonded together, and why methane has these properties.

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(6)

(Total for Question 10 = 6 marks)

TOTAL FOR PAPER = 50 MARKS

Mark scheme

General marking guidance: credit any answer that is scientifically correct and conveys the same meaning as the answer given, unless the additional guidance says otherwise. Words in brackets are not needed to gain the mark.

Question number	Answer	Additional guidance	Mark
1(a)	D sulfur dioxide, SO ₂	The only correct answer is D. A, B and C are not correct because each is a compound of a metal and a non-metal, so it is ionic.	(1)
1(b)	A a shared pair of electrons between two atoms	The only correct answer is A. B is not correct because it describes ionic bonding. C is not correct because transferring electrons forms ions, not a covalent bond. D is not correct because it describes an intermolecular force.	(1)
1(c)	C 1×10^{-10} m	The only correct answer is C. A and B are not correct because they are far too large: 1×10^{-4} m is about the width of a human hair. D is not correct because it is closer to the size of a nucleus.	(1)
1(d)	B (4 shared pairs, 4 lone pairs)	The only correct answer is B. A is not correct because each double bond is two shared pairs, so there are four. C is not correct because each oxygen atom has two lone pairs. D is not correct because it treats each double bond as one pair and counts only one oxygen's lone pairs.	(1)

(Total for Question 1 = 4 marks)

Question number	Answer	Additional guidance	Mark
2(a)	An explanation linking: - the atoms share a pair of electrons (1) (the positive) nuclei of both atoms are attracted to the shared (negative) pair of electrons (1)	Accept electrostatic attraction between the nuclei and the shared electrons for the second marking point. Do not accept attraction between ions or between oppositely charged atoms.	(2)

Question number	Answer	Additional guidance	Mark
2(b)	- one dot and one cross in each overlap (1) - two lone pairs (four further electrons) on the oxygen atom, in its shell but not in an overlap (1)	Accept any symbols for electrons if the two atoms' electrons are distinguished. Do not award the second marking point if the oxygen atom has more or fewer than 8 outer electrons in total. Ignore inner electrons if drawn.	(2)
2(c)	8	Accept eight.	(1)

(Total for Question 2 = 5 marks)

Question number	Answer	Additional guidance	Mark
3(a)	An explanation linking: - each oxygen atom has only 7 electrons in its outer shell / does not have a full outer shell (1) - there should be two shared pairs / a double bond between the atoms (1)	Accept the student has shown one shared pair but oxygen needs to share two pairs. Allow each oxygen atom needs 2 more electrons, so it must share 2 of its own. Accept the student has drawn an unpaired electron on each atom for the first marking point.	(2)
3(b)	- two shared pairs (two dots and two crosses) in each overlap (1) - two lone pairs on each oxygen atom and none on the carbon atom (1)	Each oxygen atom must have 8 outer electrons and the carbon atom 8. Accept any symbols for electrons if the atoms' electrons are distinguished.	(2)
3(c)	O=C=O	Two lines must be drawn between the carbon atom and each oxygen atom. Ignore lone pairs if shown.	(1)
3(d)	An explanation linking: - the intermolecular forces (between oxygen molecules) are weak (1) - so little energy is needed to overcome them; the double bond / covalent bonds are not broken when oxygen boils (1)	Do not award either marking point for an answer stating that covalent bonds break on boiling. Accept "forces between molecules" for intermolecular forces.	(2)

(Total for Question 3 = 7 marks)

Question number	Answer	Additional guidance	Mark
4(a)	carbon 4, nitrogen 3, sulfur 2, chlorine 1	Award 2 marks for all four correct. Award 1 mark for two or three correct.	(2)

Question number	Answer	Additional guidance	Mark
4(b)	- one dot and one cross in each overlap (1) - two lone pairs on the sulfur atom, giving 8 outer electrons in total (1)	Accept any symbols for electrons if the atoms' electrons are distinguished. Credit the same diagram as water, with S in place of O.	(2)
4(c)	- formula: PH_3 (1) - number of lone pairs on the phosphorus atom: one (1)	Accept H_3P for the formula. ECF: award the second marking point for the lone pairs consistent with an incorrect formula, provided phosphorus has 8 outer electrons.	(2)

(Total for Question 4 = 6 marks)

Question number	Answer	Additional guidance	Mark
5(a)	- X: covalent bond (1) - Y: intermolecular force (1)	Accept "force between molecules" for Y. Do not accept "intermolecular bond" for Y. Do not accept "ionic bond" for X.	(2)
5(b)	An explanation linking: - the intermolecular forces (between chlorine molecules) are weak (1) - so little energy is needed to overcome them / to separate the molecules (1)	Do not award either marking point for an answer stating that covalent bonds break when chlorine boils. Ignore "chlorine molecules are small".	(2)
5(c)	An explanation linking: - there are no mobile charged particles (1) (because) chlorine consists of neutral molecules / there are no mobile ions or delocalised electrons to carry the current (1)	Accept scientifically equivalent wording. The answer does not need to mention both ions and electrons if it clearly explains that there are no mobile charged particles. Do not accept "because chlorine is covalent" alone.	(2)

(Total for Question 5 = 6 marks)

Question number	Answer	Additional guidance	Mark
6(a)	The boiling point increases as the relative formula mass increases	Accept the bigger the molecule, the higher the boiling point. Accept the converse.	(1)

Question number	Answer	Additional guidance	Mark
6(b)	A suggestion linking: - the intermolecular forces are stronger between larger molecules / molecules with a higher relative formula mass (1) - so more energy is needed to overcome them (1)	Do not award either marking point for an answer stating that covalent bonds break when the substance boils.	(2)
6(c)	- gas (1) - because 20 °C is above its boiling point (of –42 °C) (1)	The reason must refer to the boiling point. Do not award the second marking point without the first.	(2)
6(d)	any value from 20 to 50 (°C)	The pentane boiling point is 36 °C. Accept any value in the range that continues the pattern of smaller increases. Do not accept a value of 0 °C or below.	(1)

(Total for Question 6 = 6 marks)

Question number	Answer	Additional guidance	Mark
7(a)	CH ₃ Cl	Accept the atoms in any order, for example CClH₃ or CH₃Cl. Do not accept a formula with a number in the wrong place, for example C₃HCl.	(1)
7(b)	One from: - the three-dimensional shape of the molecule - the angles between the bonds - the arrangement of the atoms in space	Accept the relative size of the atoms. Ignore "which atoms are joined together", as a dot and cross diagram also shows this.	(1)
7(c)	Two from: - it does not show the electrons / which electrons are shared / lone pairs (1) - bonds are not really sticks / the bonds are shown as solid objects (1) - the atoms are much closer together than shown / the gaps between atoms are too large (1) - the sizes of the atoms are not to scale (1)	Ignore "it is not the real colour".	(2)

(Total for Question 7 = 4 marks)

Question number	Answer	Additional guidance	Mark
8(a)	3×10^{-10} (m)	Accept 3.0×10^{-10}. Do not accept 0.3×10^{-9}, which is not in standard form.	(1)

Question number	Answer	Additional guidance	Mark
8(b)	$(1 \times 10^{-3}) \div (2 \times 10^{-10})$ (1) 5×10^6 (atoms) (1)	Award full marks for a correct answer with no working. Accept 5 000 000. Award 1 mark for 5×10^n with the wrong power of ten.	(2)

(Total for Question 8 = 3 marks)

Question number	Answer	Additional guidance	Mark
9(a)	An explanation linking: - each nitrogen atom has 5 electrons in its outer shell and needs 3 more for a full outer shell (1) - therefore each nitrogen atom shares 3 electrons / the atoms share 3 pairs of electrons (1)	Accept "needs 8 electrons in its outer shell" in place of "needs 3 more", if 5 outer electrons is stated.	(2)
9(b)	The triple bond is very strong / needs a lot of energy to break	Accept "it is hard to break the bond between the atoms". Ignore "nitrogen is stable" alone.	(1)

(Total for Question 9 = 3 marks)

Question 10 is marked using levels of response. Decide which level descriptor best matches the answer, then award a mark within that level.

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	Demonstrates isolated elements of chemical understanding. Some relevant points about the bonding or properties are identified, but links between structure, bonding and properties are limited. The response may lack clarity or logical organisation.
Level 2	3–4	Demonstrates mostly relevant chemical understanding. The bonding is described and some properties are explained in terms of structure, although some reasoning may be incomplete. The response has some logical structure.
Level 3	5–6	Demonstrates accurate and relevant chemical understanding throughout. The bonding is explained in terms of electrons, and both properties are explained in terms of structure and bonding. The response is clear, coherent and logically structured.

Question number	Answer	Additional guidance	Mark
*10	Indicative content: - carbon has 4 outer electrons and needs 4 more for a full outer shell - each hydrogen atom has 1 electron and needs 1 more - carbon shares one pair of electrons with each of four hydrogen atoms - so there are four (single) covalent bonds - each covalent bond is a shared pair of electrons - both nuclei are attracted to the shared pair, so the covalent bonds are strong - methane is made of separate small molecules (a simple molecular structure) - the intermolecular forces between methane molecules are weak - little energy is needed to overcome them, so methane has a low boiling point / is a gas at room temperature - the covalent bonds are not broken when methane boils - methane molecules have no overall charge - there are no ions or free electrons that can move, so methane does not conduct electricity	The indicative content is not a checklist. Other scientifically correct points can receive credit. To reach Level 3, the answer must explain both properties in terms of structure and bonding, not simply state them. Do not credit statements that covalent bonds break when methane boils.	(6)

(Total for Question 10 = 6 marks)