

GCE AS / A LEVEL – CHEMISTRY UNIT 1 SUPPLEMENTARY QUESTION PACK

Sourced from legacy 1092-02 (CH2) papers · New spec Unit 1 Topic 11 · AS unit, 80 marks, 1h 30min paper

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CHEMISTRY – UNIT 1 · SHAPES OF MOLECULES (VSEPR)

Topic 1.4 – Valence shell electron pair repulsion theory and molecular geometry

Predicting molecular shape from bonding pair / lone pair counts: linear, trigonal planar, tetrahedral, trigonal pyramidal, bent, trigonal bipyramidal, octahedral. Bond angles and how lone pairs distort them.

Legacy 2008 specification · CH2 source

Estimated time for entire question pack: ~1 h 58 min*Derived from the legacy CH2 paper's pace of ~1.1 min/mark, padded for long-prose answers (74 marks over 9 questions).**You are advised to **not** attempt to complete all of this in one sitting.*

ABOUT THIS QUESTION PACK

This is a **supplementary practice question pack** for new-spec Unit 1. It contains every legacy WJEC CH2 question (2008 modular spec, Jun 2009 – Jun 2016) that maps onto 2015 AS Unit 1 Topic 1.4 – bonding, intermolecular forces, solid structures and periodicity were assessed in the old CH2 module but now belong in Unit 1 under the 2015 specification.

Questions are ordered by source paper date.

INSTRUCTIONS

Use black ink or black ball-point pen. Show all working – quality of written communication will affect marks. A calculator is allowed. You may need the WJEC Periodic Table / Data Booklet.

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Q	Source	Max	Mark
1	Jun 09 Q9	14	
2	Jan 10 Q3	3	
3	Jun 10 Q1	2	
4	Jun 10 Q7	14	
5	Jan 11 Q3	1	

Q	Source	Max	Mark
6	Jan 11 Q6	12	
7	Jan 13 Q10	14	
8	Jan 14 Q8	12	
9	Jun 14 Q6	2	
Total		74	

Shapes of Molecules (VSEPR) – what the new spec asks

WJEC GCE AS / A Level Chemistry (from 2015) · Unit 1: The Language of Chemistry, Structure of Matter & Simple Reactions · Topic 1.4.

VSEPR principle

- Electron pairs around a central atom repel and adopt positions of max separation.
- Counts bonding pairs *and* lone pairs (multiple bonds count as one pair).
- Lone pair repulsion > lone-bond > bond-bond \Rightarrow bond angles reduced where lone pairs present.

Common shapes & angles

- 2 pairs: linear, 180° (BeCl_2 , CO_2).
- 3 pairs: trigonal planar, 120° (BF_3).
- 4 pairs: tetrahedral, 109.5° (CH_4).
- 5 pairs: trigonal bipyramidal, $90^\circ/120^\circ$ (PCl_5).
- 6 pairs: octahedral, 90° (SF_6).

Lone pairs distort shapes

- NH_3 : 4 pairs, 1 lone \Rightarrow trigonal pyramidal, 107° .
- H_2O : 4 pairs, 2 lone \Rightarrow bent, 104.5° .
- XeF_2 : 5 pairs, 3 lone \Rightarrow linear (lone pairs occupy equatorial positions).
- Trend: each extra lone pair reduces bond angle by $\sim 2.5^\circ$.

Predicting a shape

- Count valence e^- on central atom.
- Add 1 per single-bonded atom; adjust for charge (+ subtract, - add).
- Divide by 2 \Rightarrow total electron pairs.
- Subtract bonded atoms \Rightarrow lone pairs; choose geometry that maximises lone-pair separation.

Shapes of Molecules (VSEPR) in one page

Quick-reference notes – revisit before each question.

Counting pairs

Outer e⁻ on central atom + 1 per single-bonded atom ± charge. /2 = pairs.
Subtract atoms = lone pairs.

Shape table

2 BP / 0 LP: linear (180°)
3/0: trig planar (120°)
4/0: tetrahedral (109.5°)
3/1: pyramidal (107°)
2/2: bent (104.5°)
5/0: TBP
6/0: octahedral (90°)

Lone pair effect

Each lone pair ≈ -2.5° to bond angle.
NH₃ 107° (1 LP); H₂O 104.5° (2 LP).

Multiple bonds

Double / triple bonds count as ONE region of e⁻ density. CO₂: 2 double bonds + 0 LP ⇒ linear.

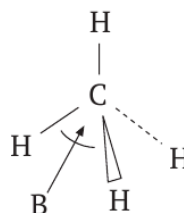
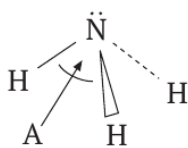
Tricky ones

XeF₂: 3 LP equatorial in TBP ⇒ linear.
SF₄: 1 LP equatorial in TBP ⇒ see-saw.
BrF₃: 2 LP ⇒ T-shaped.

Ions

NH₄⁺: lost 1 e⁻ from N ⇒ 4 BP, 0 LP ⇒ tetrahedral 109.5°.
NO₃⁻: 3 regions ⇒ trig planar 120°.

9. (a) (i) Explain why angle A in an ammonia molecule is less than angle B in a methane molecule. [1]



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(ii) A student wrote that 'the bonds in an ammonia molecule are not purely covalent'. Explain why this statement is correct. [2]

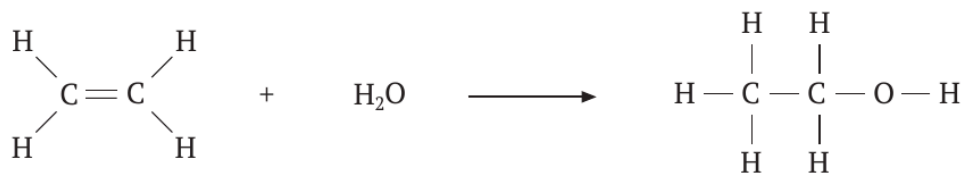
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(b) The d-block element, nickel, has a number of important uses.

- (i) Nickel is used as the catalyst in the hydrogenation of alkenes. Using an alkene of your choice, write an equation, using displayed formulae, for this hydrogenation, naming your product. [2]

- (ii) In recent years, nickel-containing 'smart alloys' have been developed. A particular smart alloy changes shape when a force is applied but returns to its original shape when the force is removed. Suggest a use for this type of smart alloy. [1]

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(iii) Nickel is purified using nickel tetracarbonyl, $\text{Ni}(\text{CO})_4$. This is a tetrahedral molecule with the same shape as methane. State the bond angle in such tetrahedral molecules. [1]

- (c) The industrial preparation of ethanol from ethene is carried out at 300 °C in the presence of a catalyst.



- (i) State the pressure used in this process [1]
- (ii) The reverse process is carried out by passing ethanol vapour over a catalyst.
- I. State a catalyst that can be used [1]
- II. State the type of reaction that is occurring in this reverse process. [1]
-
- (d) (i) 1,1,1-Trifluoro-2-bromo-2-chloroethane (halothane) is used as a general anaesthetic. Write the displayed formula for this compound. [1]

- (ii) State another use for halogenoalkanes. [1]
-

- (iii) One disadvantage of some halogenoalkanes, the CFCs, is that they cause damage to the ozone layer.

The table shows the relative ozone depletion potential (RODP) of some CFCs, taking CCl_3F as having a value of 1.0.

Compound	RODP
CHF_3	0.01
CHClF_2	0.05
CCl_2F_2	0.86
CCl_3F	1.00
CBrClF_2	10.00

The carbon-halogen bond energies are shown below.

Bond	Average bond enthalpy / kJ mol^{-1}
$\text{C}-\text{Br}$	276
$\text{C}-\text{Cl}$	338
$\text{C}-\text{F}$	484

Use both tables to comment on how the C—halogen bond energies, and the number and type of halogen atoms per molecule, are related to their destructive effects on the ozone layer. [2]

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Total [14]

Section B Total [70]

Rough Work

A series of horizontal dotted lines for writing rough work.

SECTION A

Answer **all** questions in the spaces provided.

1. State which **one** of the following bonds is generally the **weakest**. [1]

- A Covalent
B Hydrogen
C Ionic
D Van der Waals

2. State which **one** of the following formulae represents a compound that can show hydrogen bonding. [1]

- A CH_3CH_3
B CH_3OCH_3
C HCl
D HF

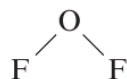
3. Complete the table below by inserting the number of bonding pairs of electrons and name the shapes of the molecules involved. [3]

<i>Molecule</i>	<i>Number of bonding pairs of electrons in outer shell</i>	<i>Number of lone pairs of electrons in outer shell</i>	<i>Shape</i>
BeCl_2		0	Linear
PCl_3	3	1	
CCl_4	4	0	

SECTION A

Answer **all** questions in the spaces provided.

1. The covalent compound difluorine oxide has the formula



- (i) Showing **outer** electrons only, draw a dot and cross diagram for difluorine oxide. [1]

- (ii) Difluorine oxide reacts with magnesium metal to produce magnesium oxide and magnesium fluoride, MgF_2 .
Give the equation for this reaction. [1]
-

2. Potassium chloride can be used by those who need a low-salt diet.
Its solubility in water at two temperatures is shown in the table.

Temperature/ $^{\circ}\text{C}$	Solubility/g per 100 g of water
15	32.7
100	56.5

Calculate the mass of solid potassium chloride produced when a saturated solution containing 500 g of water is cooled from 100°C to 15°C . [2]

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SECTION B

Answer **all** questions in the spaces provided.

7. (a) Sulfur hexafluoride, SF₆, is a colourless gas that is used as an insulator in electrical transformers.

- (i) Complete the table below, giving the number of bonding and lone pairs for the sulfur atom in a molecule of gaseous sulfur hexafluoride.

Use your answers to deduce an F — $\hat{\text{S}}$ — F angle and name the shape of the SF₆ molecule. [4]

Number of bonding pairs	Number of lone pairs	F — $\hat{\text{S}}$ — F	Shape

- (ii) The S — F bond in sulfur hexafluoride is a polar covalent bond. Describe what is meant by bond polarity and how it arises in this bond. [2]

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- (iii) Sulfur hexafluoride reacts with hydrogen sulfide in a redox reaction.



Complete the table below, giving the oxidation states (numbers) of the sulfur atoms present and use these to explain how hydrogen sulfide is the reducing agent in this reaction. [2]

Oxidation state of sulfur in SF ₆	Oxidation state of sulfur in H ₂ S	Oxidation state of sulfur in sulfur, S

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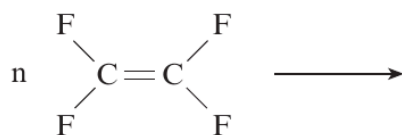
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- (b) Sodium fluoride is a white, ionic solid that has the same crystal structure as sodium chloride.
Give the formula of each ion present and its crystal co-ordination number. [2]

Sodium ion *Crystal co-ordination number*

Fluoride ion *Crystal co-ordination number*

- (c) Tetrafluoroethene, C_2F_4 , can be polymerised to give poly(tetrafluoroethene), PTFE, in a similar way to the polymerisation of ethene.
- (i) Complete and balance the equation below, showing a repeating section of the structural formula of poly(tetrafluoroethene). [1]



- (ii) A stretched form of PTFE is marketed under the name 'Goretex'. This is used to make waterproof materials that can 'breathe'. Gaseous water molecules can escape from tiny 'holes' in the fabric but larger liquid water droplets cannot enter. These liquid water droplets contain water molecules that are hydrogen bonded to each other.

Draw a diagram to show hydrogen bonding between water molecules. [3]

Total [14]

SECTION A

Answer **all** questions in the spaces provided.

1. (a) Ethanol is present in many intoxicating drinks. Give **one** health problem associated with the consumption of excess ethanol. [1]

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- (b) Ethanol can be converted to ethanoic acid in an oxidation reaction. Give suitable reagents for this reaction. [1]

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2. Calcium compounds are important in many biological systems. Give an example of where a calcium compound is used in a living organism. [1]

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3. State which one of the following species has the smallest bond angle. [1]



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4. Write a chemical equation for the displacement reaction that occurs when chlorine gas is bubbled through a solution of sodium bromide, NaBr. [1]

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5. Use the electronegativity values given in the table below to answer the questions that follow.

Atom	B	H	C	O	Cl
Electronegativity value	2.0	2.1	2.5	3.5	3.0

- (a) Identify any dipoles present in the following bonds, marking their polarity clearly.



- (b) State which of the bonds in (a) will have the largest dipole. [1]
-

6. XeF_2 is one of the few noble gas compounds known. It reacts with water in the presence of a base according to the equation below.



Complete the table below to give the initial and final oxidation states of the xenon and oxygen atoms, noting whether oxidation or reduction has occurred. [2]

Element	Initial oxidation state	Final oxidation state	Oxidation or reduction
xenon			
oxygen			

Total Section A [10]

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10. Aluminium, boron and nitrogen all form chlorides containing three chlorine atoms, XCl_3 .

(a) Molecules of boron chloride, BCl_3 , and molecules of nitrogen chloride, NCl_3 , have different shapes.

Use VSEPR (valence shell electron pair repulsion) theory to state and explain the shapes of these molecules.

[6]
QWC [2]

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- (b) The boron atom in boron chloride, BCl_3 , is described as being electron deficient. Draw a dot and cross diagram for BCl_3 and use it to show what is meant by the term *electron deficient*. [2]

- (c) Nitrogen chloride, NCl_3 , is insoluble in cold water whilst the similar compound ammonia, NH_3 , is very soluble. Explain this difference in behaviour. [2]

- (d) Aluminium chloride, AlCl_3 , forms a dimer that contains both covalent bonds and coordinate bonds. Describe what is meant by the terms *covalent bond* and *coordinate bond*. [2]

Total [14]



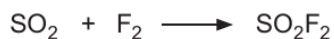
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SECTION B

Answer **all** questions in the spaces provided.

8. Sulfur difluoride dioxide (sulfuryl fluoride), SO_2F_2 , is used as a gaseous insecticide to control termite infestations in wooden houses.

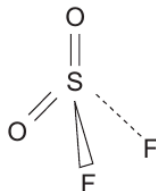
- (a) It can be produced by reacting together sulfur dioxide and fluorine.



Use the oxidation numbers of sulfur to show that sulfur has been oxidised in this reaction. In your answer you should state how changes in oxidation number are related to oxidation.

[2]

- (b) Sulfuryl fluoride is a tetrahedral molecule where the sulfur atom has no lone pairs of electrons.



Use the valence shell electron pair repulsion theory (VSEPR) to state why sulfuryl fluoride has this shape.

[1]

- (c) Ammonia reacts with sulfuryl fluoride to give sulfamide, $\text{SO}_2(\text{NH}_2)_2$. During this reaction ammonia reacts as a nucleophile.

- (i) State the meaning of the term *nucleophile*.

[1]

- (ii) Give the **formula** of another nucleophile.

[1]

- (iii) Organic reaction mechanisms involving nucleophiles (for example the conversion of 1-chlorobutane into butan-1-ol) often use a curly arrow (\curvearrowright).

State what this curly arrow represents.

[1]

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- (d) Sulfuryl fluoride reacts rapidly with calcium hydroxide to give calcium sulfate, calcium fluoride and water as the only products.

Give the equation for this reaction. [2]

- (e) Bromomethane, CH_3Br , was formerly used as a fumigant gas to remove insect infestation but has now been largely replaced by sulfuryl fluoride. One reason for this change is that bromomethane has an adverse effect on the ozone layer.

- (i) Explain how **both** bromomethane and CFCs have an adverse effect on the ozone layer.

The table below should be used to help you in your response. [3]

Bond	Bond enthalpy/ kJ mol^{-1}
C—H	412
C—F	484
C—Cl	338
C—Br	276
S—F	410

- (ii) Use the information in the table in (i) above to state why sulfuryl fluoride is now preferred to bromomethane as a fumigant. [1]

Total [12]

6. Select **all** the molecules from the list below that have bond angles of less than 109° .



..... [2]

Section A Total [10]

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END OF QUESTION PACK

9 questions · 74 marks · ~1 h 58 min

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Curated for WJEC Chemistry 2015 spec AS Unit 1 – Topic 11 (1.4)

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