

GCE AS / A LEVEL – CHEMISTRY UNIT 2 QUESTION PACK

1092-01 (Legacy CH2) · New spec Unit 2 Topic 4 · AS unit, first sat 2016, 80 marks, 1h 30min paper

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# CHEMISTRY – UNIT 2 · HALOGENOALKANES & SUBSTITUTION & ELIMINATION

Topic 2.6 – Halogenoalkanes: nucleophilic substitution, elimination and reaction mechanisms

*Halogenoalkane chemistry: identifying electrophiles, nucleophiles and free radicals, converting halogenoalkanes to alcohols by nucleophilic substitution with aqueous OH<sup>-</sup>, the competing elimination pathway with alcoholic OH<sup>-</sup>, and heterolytic bond fission.*

Legacy 2008 specification

**Estimated time for entire question pack: ~1 h 30 min**

*Derived from the legacy CH2 paper's pace of ~1.1 min/mark, padded for long-prose answers (56 marks over 5 questions).*

*You are advised to **not** attempt to complete all of this in one sitting.*

## ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC CH2 papers (2008 modular spec, Jan 2010 – Jun 2016) that maps onto the new-spec AS Unit 2 Topic 2.6.

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	Jan 10 Q8	13	
2	Jun 10 Q11	15	
3	Jan 12 Q10	15	

Q	Source	Max	Mark
4	Jun 13 Q4	2	
5	Jun 14 Q10	11	
<b>Total</b>		<b>56</b>	

# Halogenoalkanes – Substitution & Elimination – what the new spec asks

WJEC GCE AS / A Level Chemistry (from 2015) · Unit 2: Energy, Rate & Chemistry of Carbon Compounds · Topic 2.6.

## Halogenoalkanes – basics

- C-X bond is polar (X = Cl/Br/I more electronegative).
- Polarity makes  $C^{\delta+}$  susceptible to nucleophilic attack.
- Bond strength: C-I < C-Br < C-Cl – iodoalkanes most reactive.

## Nucleophilic substitution ( $S_N$ )

- $RX + OH^- (aq) \rightarrow ROH + X^-$ .
- Aqueous KOH or NaOH, warmed: gives alcohol.
- Other nucleophiles:  $CN^- \rightarrow$  nitrile;  $NH_3 \rightarrow$  amine.
- Curly arrows from nucleophile lone pair  $\rightarrow$  carbon; X leaves with both electrons.

## Elimination

- $RX + OH^-$  (ethanolic)  $\rightarrow$  alkene +  $H_2O + X^-$ .
- Alcoholic KOH, heated: gives alkene.
- $\beta$ -H removed; X leaves; C=C forms.

## Heterolytic vs homolytic fission

- Heterolytic: both electrons go to one atom  $\Rightarrow$  ions.
- Homolytic: one electron each  $\Rightarrow$  radicals.
- Polar C-X bonds fission heterolytically in  $S_N$  mechanisms.

# Halogenoalkanes – Substitution & Elimination in one page

Quick-reference notes – revisit before each question.

## Bond polarity

$C^{\delta+}-X^{\delta-}$ . Nucleophile attacks the  $C^{\delta+}$ .

## Reactivity order

$C-I$  (240) <  $C-Br$  (276) <  $C-Cl$  (340 kJ  $mol^{-1}$ ). Weakest = most reactive  $\Rightarrow$  iodides fastest.

## $S_N$ arrows

Curly arrow: nucleophile lone pair  $\rightarrow C^{\delta+}$ . Second arrow:  $C-X$  bond  $\rightarrow X$ .  
Product alcohol +  $X^-$ .

## Substitution vs elimination

Aqueous KOH – warmed  $\Rightarrow$  substitution (alcohol). Ethanolic KOH – heated  $\Rightarrow$  elimination (alkene).

## Hydroxide nucleophile

$OH^-$  uses lone pair on O.  $NH_3$ : uses lone pair on N (gives amine + HX salt).

## Test for halides

Hydrolyse with NaOH(aq); acidify with  $HNO_3$ ; add  $AgNO_3$ . Cl: white; Br: cream; I: pale yellow precipitate.

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8. (a) In 1928 an American engineer, Thomas Midgley, developed a CFC as a replacement for chloromethane and sulfur dioxide, which were in common use as refrigerants despite being toxic. He showed that the new compound was both non-flammable and non-toxic by inhaling it and using it to blow out a lighted candle.

(i) State the name of the group of compounds often abbreviated to CFC. [1]

(ii) State another use to which CFCs have been put. [1]

- (iii) In the stratosphere, chloromethane breaks down to give chlorine radicals whereas fluoromethane does not break down.

I. Explain what the term *radical* means. [1]

II. Give a reason why chloromethane breaks down but fluoromethane does not. [1]

- (iv) In the 1960s other halogenoalkanes such as  $\text{CBrF}_3$  were developed as effective fire-fighting materials.

When  $\text{CBrF}_3$  reacts with aqueous sodium hydroxide, bromide ions are produced. To test for the presence of these ions, dilute nitric acid has to be added first, followed by an appropriate reagent.

I. State why nitric acid has to be added. [1]

II. Name the reagent that you would add to test for the bromide ions. [1]

III. State what you would see after the addition of the reagent. [1]

IV. Write an **ionic equation** for the reaction that confirms the presence of bromide ions. [1]

- (b) Draw the mechanism for the reaction of bromoethane and  $\text{OH}^-(\text{aq})$ . [3]

*Assume the mechanism is the same as for the reaction of 1-chlorobutane and  $\text{OH}^-(\text{aq})$ .*

- (c) Bromoethane can also undergo an elimination reaction with  $\text{OH}^-$ .

- (i) Name the organic product of this reaction. [1]

.....

- (ii) State the conditions required. [1]

.....

Total [13]

Examiner  
only

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11. (a) One method for making butan-1-ol is to react sodium hydroxide (used as a source of hydroxide ions) and 1-chlorobutane.

Describe how butan-1-ol can be made in this way.

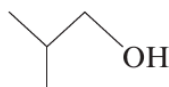
Your answer should

- state any necessary conditions
- show the mechanism for the reaction between hydroxide ions and 1-chlorobutane
- state the type of reaction mechanism

[6]

(QWC) [2]

- (b) Compound **G** is an isomer of butan-1-ol and its skeletal formula is



- (i) Give the **systematic name** of compound **G**. [1]

- (ii) Compound **G**,  $C_4H_{10}O$ , is being developed as a possible replacement for ethanol in fuels. In a new process it is made by reacting genetically modified *E. coli* bacteria with glucose in aqueous solution. One equation for this is



$M_r$  74

In a laboratory experiment, 0.50 mol of glucose reacted in this way to give an 86% yield, by mass, of compound **G**.

Calculate the mass of compound **G** produced. [2]

Examiner  
only

- (iii) Both butan-1-ol and compound **G** are primary alcohols that can be oxidised to carboxylic acids.

Give an oxidising agent that can be used, in acid solution, to oxidise primary alcohols to carboxylic acids and state what is seen as the reaction proceeds. [2]

*Oxidising agent* .....

*Observation(s)* .....

- (c) One method of preparing an alcohol is from an alkene and water/steam.  
State the conditions of temperature and pressure used in the preparation of ethanol from ethene. [2]

*Temperature* .....

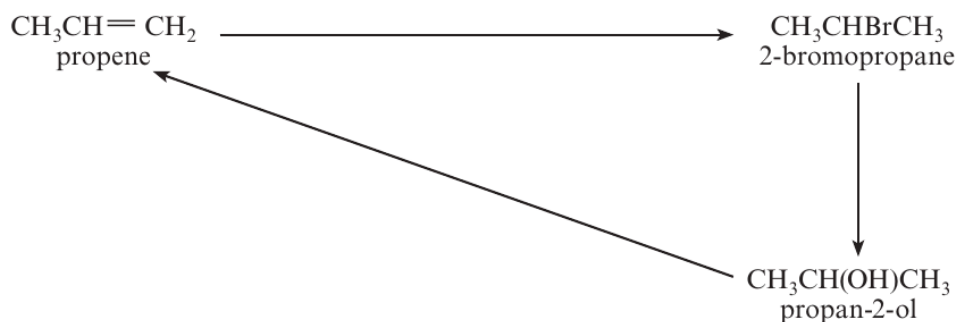
*Pressure* .....

Total [15]

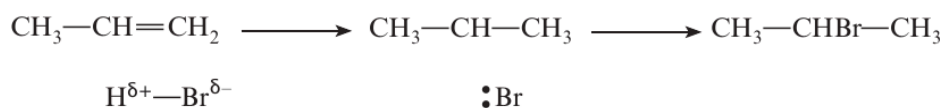
**Total Section B [70]**



10. (a) This question is about the compounds and reactions shown in the diagram below.



- (i) The addition of hydrogen bromide to propene gives 2-bromopropane as the main product. Complete the outline mechanism below, inserting curly arrows and charges where appropriate. [2]



- (ii) The reaction of 2-bromopropane to give propan-2-ol is an example of a nucleophilic substitution reaction. Suggest a nucleophile that can be used for this reaction and give a reason why this is classed as a substitution reaction. [2]

*Nucleophile* .....

*Reason* .....

- (iii) The production of propene from propan-2-ol is an example of an elimination reaction. Another elimination reaction is the reaction of bromoethane with sodium hydroxide.



Complete the equation by giving the formulae of the other products. [1]



Examiner  
only

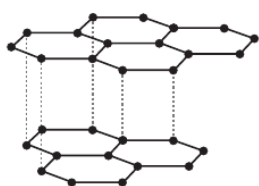
- (b) A primary alcohol was oxidised to a carboxylic acid. The mass spectrum of the acid showed a molecular ion at  $m/z$  88.  
Use the information provided to write a displayed formula for the acid. [3]

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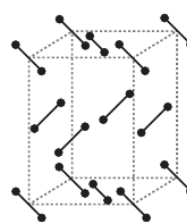
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- (c) Both carbon and iodine are non-metallic elements. The crystalline structures of graphite and iodine are shown below.



graphite



iodine

Solid iodine exists as a molecular crystal,  $I_2$ .

Explain why graphite is able to conduct electricity but iodine is a non-conductor.  
Your answer should focus on the bonding present in each solid element.

[5]  
QWC [2]

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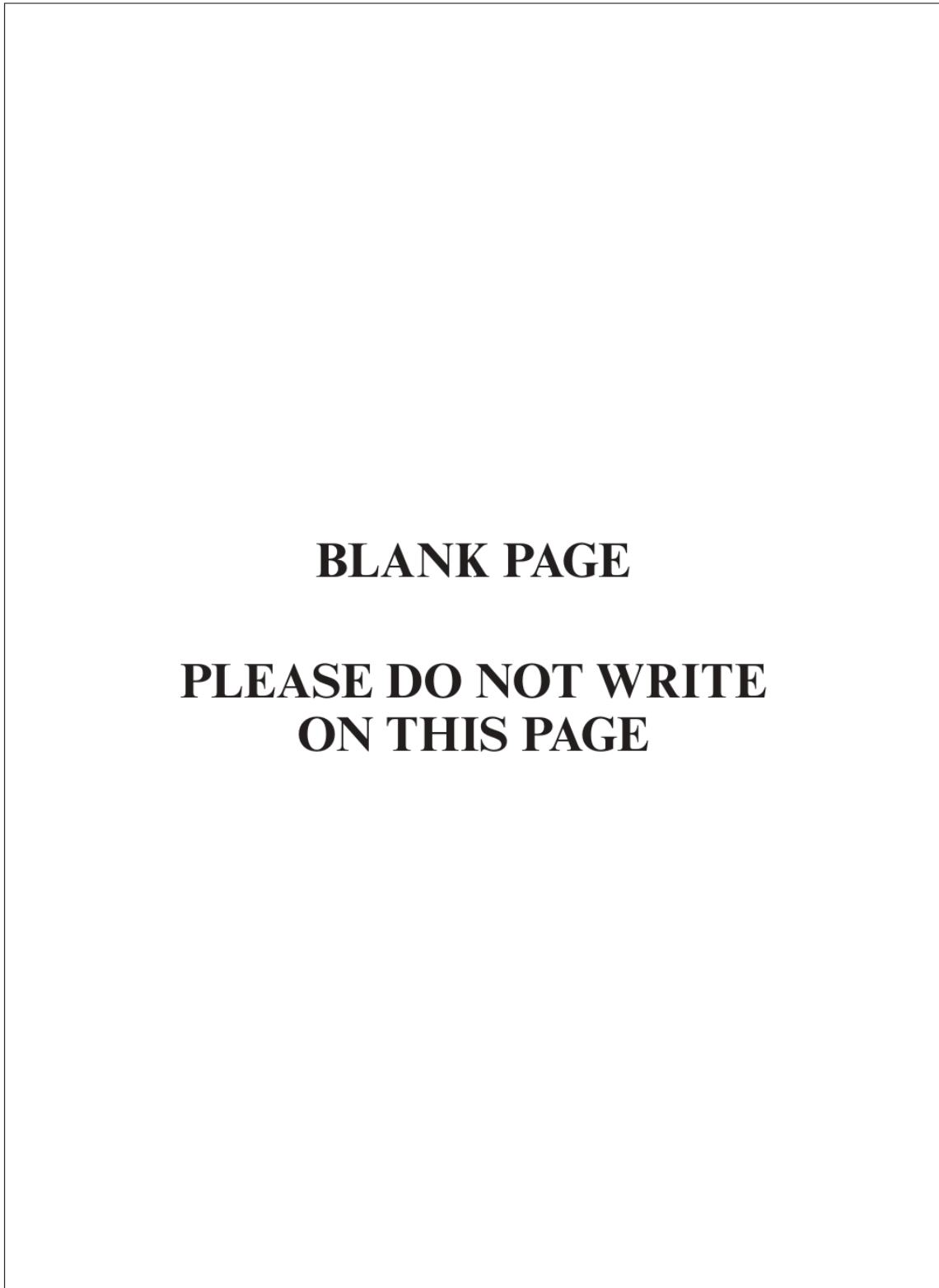
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Total [15]

Section B Total [70]







**GCE AS/A level**

1092/01-A

**CHEMISTRY – DATA SHEET  
FOR USE WITH CH2**

P.M. THURSDAY, 19 January 2012

## Infrared Spectroscopy characteristic absorption values

Bond	Wavenumber /cm <sup>-1</sup>
C—Br	500 to 600
C—Cl	650 to 800
C—O	1000 to 1300
C=C	1620 to 1670
C=O	1650 to 1750
C≡N	2100 to 2250
C—H	2800 to 3100
O—H	2500 to 3550
N—H	3300 to 3500

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4. Classify the following species as electrophile, nucleophile or radical by completing the table below. [2]

Species	Cl•	NH <sub>3</sub>
Classification		

5. Nanoscience involves the study of very small particles. Nano-sized silver particles have antibacterial and antifungal properties. Give **one** use of nano-sized silver particles. [1]

.....

.....

6. State and explain which two of the following elements combine to form the **most** ionic bond. [2]

chlorine                  magnesium                  potassium                  sulfur

.....

.....

**Total Section A [10]**

1092  
010003



0 3





**END OF QUESTION PACK**

5 questions · 56 marks · ~1 h 30 min

Source: WJEC CH2 (2008 modular spec, Jan 2010 – Jun 2016)

Curated for WJEC Chemistry 2015 spec AS Unit 2 – Topic 4 (2.6)

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