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Examiners' report

CHEMISTRY B (SALTERS)

H033

For first teaching in 2015

H033/01 Summer 2023 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers is also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Paper 1 series overview

This synoptic paper targets all three assessment objectives requiring candidates to:

- demonstrate and apply knowledge and understanding of scientific ideas, processes, techniques and procedures in theoretical and practical contexts
- handle qualitative and quantitative data
- analyse, interpret and evaluate scientific information to make judgements and reach conclusions
- show an ability to develop practical procedures.

To do well, candidates needed to demonstrate a broad knowledge and understanding of inorganic, organic and physical chemistry and be able to carry out multi-step calculations.

In general, candidates demonstrated knowledge and understanding of organic and inorganic reactions. Often candidates found describing laboratory practical procedures and questions relating to the graphical representation of data difficult.

There were very few cases where candidates did not reach the end of the paper although some candidates left a small number of questions and question parts unanswered.

The majority of candidates answered within the fixed number of answer lines provided. Where extra answer space was used this was normally clearly linked to the specific answer.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• produced concise, well-structured written responses to multi-mark questions • demonstrated a methodical approach to mathematical elements.	• gave long responses which lacked coherence • had limited recall of specific chemical processes • had difficulty manipulating mathematical formulae • had difficulty describing or explaining laboratory practical procedures.

Section A overview

The majority of MCQs (Questions 1-20) were answered correctly by the majority of candidates. Candidates should be advised that they should not overwrite the letter in the answer box if they change their mind but should cross out the first response and write the new response alongside the box. A very small number of candidates left questions unanswered. It should be noted that, whenever possible, the options are presented in alphabetical order which can lead to clustering of correct responses. Specific questions, particularly those which candidates found challenging, are indicated below

Question 7

7 What is correct about a cracking reaction?

A An alkane can be broken into an alkane and two alkenes.

B An alkane can be converted into two smaller alkanes and an alkene.

C Matter is destroyed in the reaction.

D Unsaturated molecules are converted to saturated molecules.

Your answer ☐ **[1]**

Many candidates chose option B.

Question 9

9 A sample of a gas has a volume of 0.60 m^3 under a pressure of 200 kPa and at 300 K.

How many moles of molecules are in this sample of gas?

A 0.021

B 0.048

C 21

D 48

Your answer ☐ **[1]**

The Gas Equation was generally known but many candidates made mistakes when rearranging or did not convert kPa to Pa.

Question 11

11 Chlorine is made by electrolysing sea water.

The following reaction occurs at the anode.

$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

Which statement is correct?

A Chloride ions are reduced.

B Electrons flow through the solution from the anode to the cathode.

C Sodium forms at the cathode.

D Some of the chlorine formed dissolves in the sea water.

Your answer ☐ **[1]**

Few candidates answered this question correctly. Option C was most commonly given. This is incorrect because hydrogen, not sodium, is formed at the cathode.

Question 12

12 A liquid is insoluble in water. It is purified from an aqueous solution in which it has been prepared.

One stage in the purification is allowing the liquid to stand over anhydrous sodium sulfate.

Which statement is correct?

A In this stage, no other anhydrous salt can be used.

B The next stage involves the use of a separating funnel.

C This stage is done before a final distillation.

D This stage is done to remove acidic impurities.

Your answer ☐ **[1]**

The removal of residual water and the stage where this happens during purification were not well understood by candidates. Anhydrous sodium sulfate (or other anhydrous salts, such as calcium chloride) are used to dry crude organic compounds before the pure product is separated by distillation.

OCR support

Guidance on suggested practical activities (PAG3) which cover these techniques is available in the Practical Skills Handbook

Question 14

14 The calcium ion is Ca^{2+}. The phosphate ion is PO_4^{3-}.

What is the formula of calcium phosphate?

A $CaPO_4$

B $Ca_2(PO_4)_3$

C Ca_3PO_4

D $Ca_3(PO_4)_2$

Your answer [ ] **[1]**

This question was well answered by candidates across the attainment range.

Question 15

15 Which of the following represents the wavelength of radiation in terms of its energy, ΔE, the Planck constant, h, and the speed of light, c?

A $ch/\Delta E$

B $\Delta E/hc$

C $c\Delta E/h$

D $h\Delta E/c$

Your answer [ ] **[1]**

The most successful candidates usually answered correctly but others had difficulty combining and rearranging the relevant expressions.

Question 17

17 What is the Avogadro constant, N_A, the number of?

A Atoms in one mole of carbon dioxide.

B Carbon atoms in one mole of C_2H_5OH.

C Sodium ions in one mole of NaC*l*.

D Molecules in one mole of magnesium.

Your answer ☐ **[1]**

Very few candidates gave the correct response (C). Option D was most common incorrect response.

Question 19

19 The table shows some homologous series and the molecular formulae of compounds that may be members of those series.

Which row is correct?

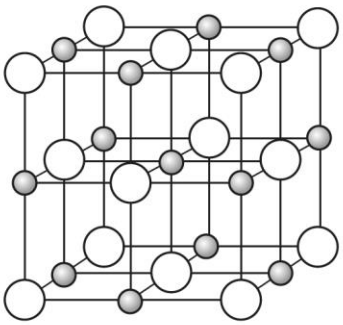
	Homologous series	**Molecular formula of one member of the series**
A	acid anhydride	$C_4H_6O_3$
B	aldehyde	C_4H_7O
C	carboxylic acid	$C_4H_{10}O_2$
D	ester	$C_4H_8O_3$

Your answer ☐ **[1]**

Few candidates answered this question correctly. Candidates should be encouraged to draw out the structures of the molecules either in the space adjacent to the question or in the extra answer space.

Question 20

20 The model shown below represents part of a lattice of sodium chloride.



Which statement is correct about the model shown?

A Each line represents a shared pair of electrons.

B There are unequal numbers of sodium and chloride ions.

C The model represents a molecule of sodium chloride.

D The white circles are sodium ions.

Your answer [ ] **[1]**

Few candidates answered this question correctly. Care needs to be taken to when reading the question which referred to the "model" rather than the formula of NaCl.

Section B overview

The range of questions in Section B allowed candidates to demonstrate their breadth of knowledge and understanding across the specification.

Question 21 (a) (i)

21 Some students investigate plaster of Paris, hydrated calcium sulfate.
This is used for setting fractured bones as it sets into a hard mass when soaked in water.

Groups of students heat samples of plaster of Paris to constant mass to drive off the water of crystallisation.

Their results are shown in **Table 21.1** below.

Table 21.1

Group	Mass of plaster of Paris heated / g	Mass left after heating to constant mass / g
A	5.45	5.11
B	7.09	6.65
C	3.49	3.27
D	4.05	3.80
E	6.59	5.48

(a) (i) Explain the meaning of heating to constant mass.

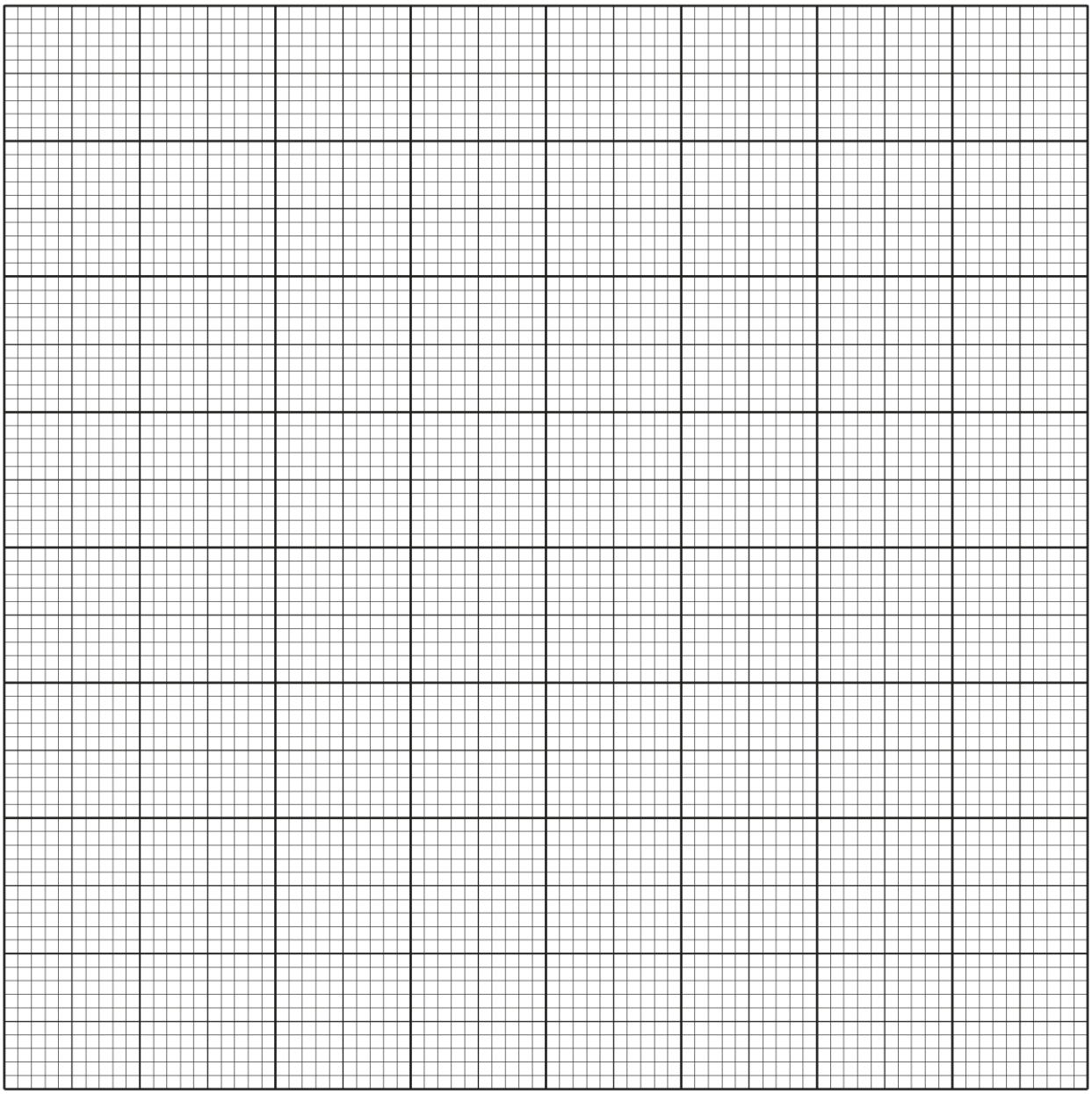
.....

..... **[1]**

Few candidates related their responses to the practical process of repeated heating and weighing. Most responses just rephrased the question.

Question 21 (a) (ii)

(ii) On the grid below, plot a graph of the results in **Table 21.1**. Include the origin. Draw the line of best fit.



[3]

The majority of candidates produced clearly labelled axes (with units) but a small yet significant number had the dependant variable on the x-axis. Some did not include the origin as instructed in the question. A number of candidates produced a bar chart with the group letter on the x-axis which precluded the award of any marks. Candidates are advised to use as much of the grid as possible to make sure that points can be accurately plotted.

OCR support

Guidance on plotting graphs of two variables from experimental or other data is available in the Mathematical Skills Handbook

Question 21 (a) (iii)

(iii) Plaster of Paris has the formula $CaSO_4 \cdot xH_2O$.

Calculate the value of x in this formula.

Give your answer to **1** significant figure.

x = ... **[3]**

While a few candidates read from the line of best fit, the majority either used the values from a single group or produced average values by summing together group values from the table. All of these were acceptable except when the anomalous group (E) was included. The final ratio was often inverted giving the response '2'.

Question 21 (c)

(c) Why do chemists often compare the chemistry of magnesium and calcium?

Refer to electronic configurations in your answer.

.....

.....

..... **[2]**

This question was generally well answered. A reference to both same group and same outer electrons was required.

Question 22 (a) (i)

22 The Antarctic ozone holes of 2020 and 2021 were some of the largest on record, in spite of an overall downwards trend. This was because of unusually cold conditions in the Antarctic in those years.

Chlorine radicals in the stratosphere form other radicals that react together on the cold surface of polar clouds. Chlorine molecules are one of the products.

When the clouds warm up, the chlorine molecules are split by ultraviolet radiation. This causes a sudden release of chlorine radicals.

(a) (i) Draw a mechanism (including 'half curly arrows') to show how a chlorine molecule is split to produce chlorine radicals.

[1]

Most candidates answered correctly although some used double headed arrows. 'Half curly arrows' are required for radical mechanisms to show the movement of a single electron as opposed to two electrons.

Question 22 (b) (i) and (ii)

(b) Chlorine radicals react in the stratosphere as shown in **equations 22.1, 22.2 and 22.3**.

$Cl + O_3 \rightarrow ClO + O_2$ **Equation 22.1**

$ClO + O \rightarrow Cl + O_2$ **Equation 22.2**

$Cl + Cl \rightarrow Cl_2$ **Equation 22.3**

(i) Identify a **termination** reaction from **Equation 22.1**, **Equation 22.2** and **Equation 22.3**.

Explain your answer.

Equation .....

Explanation .....

.....

..... **[1]**

(ii) A student says:

- The reactions shown in **Equation 22.1** and **Equation 22.2** work together to cause the breakdown of ozone by the equation shown below:

  $2O_3 \rightarrow 3O_2$

- This does not break down much ozone, as there are so few chlorine atoms in the stratosphere and any present are rapidly removed by the reaction in **Equation 22.3**.

Comment on these statements.

.....

.....

.....

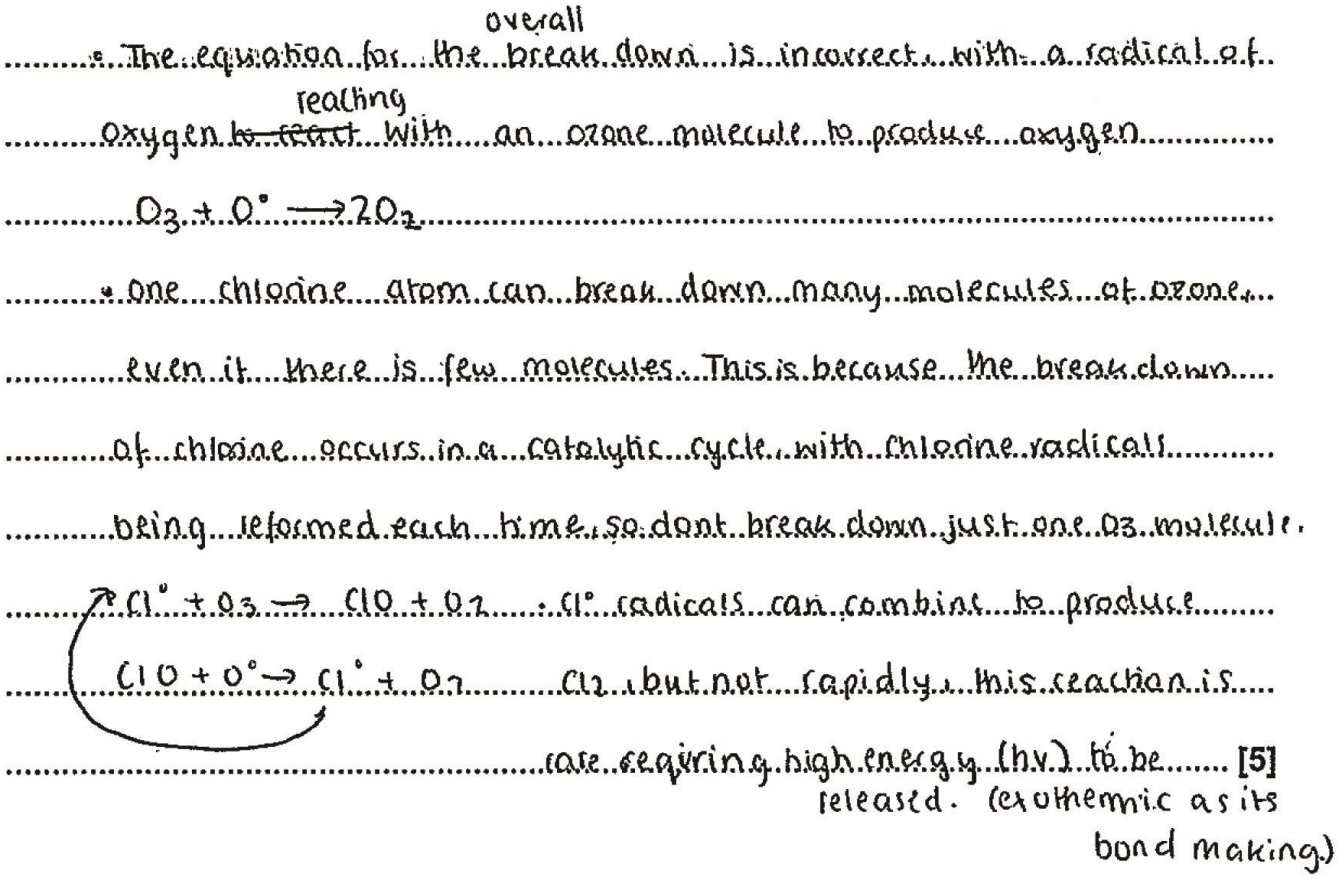
.....

.....

..... **[5]**

Most candidates answered part (i) successfully. Part (ii) required candidates to draw on the stem of Question 22, the equations in Question 22(b)(i), the information in the student's statements and their own knowledge and understanding of radical catalysis. There were some excellent responses which addressed all the points in the student's two statements. A number of candidates did not notice that equations 22.1 and 22.2 did not produce three oxygen molecules. Catalysis was not always mentioned and few gained the fifth mark which required either an understanding of the low chance of Cl radicals meeting or a realisation that they are constantly being regenerated by UV radiation.

Exemplar 1



This response is well structured and correctly comments on the first of the student's statements. It includes reference to the catalytic role of chlorine radicals but does not explain why the termination reaction is rare.

Question 22 (c) (i)

(c) Haloalkanes are the source of the original chlorine radicals in the stratosphere.

CH_3Cl is present in the stratosphere, having been released by natural processes.

(i) Give the systematic name for CH_3Cl.

..... **[1]**

This question was generally answered well with only a small number of candidates either using a one or a dash between chloro and methane.

Question 22 (c) (ii)

(ii) CH_3Cl has a higher boiling point than CH_4. This is because CH_3Cl has permanent dipole-permanent dipole bonding whereas CH_4 does not.

Explain why CH_3Cl has a permanent dipole.

.....

.....

.....

..... **[2]**

The majority of responses for this question mentioned the difference in electronegativity producing a polarised Cl-C bond but they often did not say that Cl was more electronegative. Most candidates did not link the polarity of the bond with the asymmetry of the complete molecule to determine the dipole.

Question 22 (d)

(d) When CH_3Cl is bubbled through a warm solution of silver ions in aqueous ethanol, a precipitate forms slowly.

Write an **ionic** equation for the formation of the precipitate.

Include state symbols.

[2]

Many candidates did not realise that the chloromethane needed to hydrolyse to give chloride ions. The charge on the silver ion was often wrong leading to an incorrect formula for the precipitate. The state symbol for the chloride ion was often given as (g) which shows a fundamental misunderstanding.

Question 23 (a)

23 Cyanogen, N≡C–C≡N, is a gas which gives a very hot flame when it burns.

$N{\equiv}C{-}C{\equiv}N(g) + O_2(g) \rightarrow 2CO(g) + N_2(g)$ $\Delta_r H = -529\,kJ\,mol^{-1}$ **Equation 23.1**

Table 23.1 gives some bond enthalpy data.

Table 23.1

Bond	Enthalpy / kJ mol^{-1}	Bond	Enthalpy / kJ mol^{-1}
C–C (average)	+347	O=O	+498
C≡O (in CO)	+1077	C=O (in CO_2)	+805
N≡N	+945		

(a) The bond enthalpy for C–C in **Table 23.1** is described as an **average** bond enthalpy.

Explain the meaning of average in this context.

.....

..... **[1]**

Many candidates gave an explanation of "average" but few explicitly stated that this average was based on many different compounds containing the C-C bond.

Question 23 (b)

(b) Use **Equation 23.1** and data from **Table 23.1** to calculate the bond enthalpy of C≡N in cyanogen.

bond enthalpy = ... $kJ\,mol^{-1}$ **[3]**

Candidates should show their workings clearly. Common errors included: missing the C-C bond in cyanogen; using the value for carbon dioxide rather than carbon monoxide; omitting or doubling the value for O=O; and putting ΔH on the wrong side of the mathematical equation. Most candidates successfully divided their calculated response by 2 to account for the two C≡N bonds in cyanogen.

Exemplar 2

(b) Use **Equation 23.1** and data from **Table 23.1** to calculate the bond enthalpy of C≡N in cyanogen.

(released) $2(1077) + 945 = 3099\ kJ\,mol^{-1}$

(break) $2C{\equiv}N + 347 + 498 = 845 + 2C{\equiv}N$

$3099 - (845 + 2C{\equiv}N) = -529$

$2254 - 2C{\equiv}N = -529$

$-2C{\equiv}N = -2783$

$C{\equiv}N = 1391.5$

bond enthalpy = 1392 $kJ\,mol^{-1}$ **[3]**

This response has been laid out logically with bonds broken and made correctly identified and calculated. ΔH has been included on the wrong side of the equation leading to an incorrect final response.

Question 23 (c) (i)

(c) (i) Explain why the bond enthalpies in **Table 23.1** are all endothermic.

.....

.....

..... **[2]**

Most candidates scored both marks but a significant number mentioned a balance between bond breaking and bond making rather than just referring to bond breaking.

Question 23 (d) (i)

(d) **Equation 23.1** is repeated below:

$N{\equiv}C{-}C{\equiv}N(g) + O_2(g) \rightarrow 2CO(g) + N_2(g)$ $\Delta_r H = -529\,kJ\,mol^{-1}$ **Equation 23.1**

Scientists do two experiments using a steady flow of cyanogen gas.

Experiment 1

They collect the cyanogen from the flow in a measuring cylinder over water for 5.0 minutes.

They collect $2.4 \times 10^2\,cm^3$ at RTP.

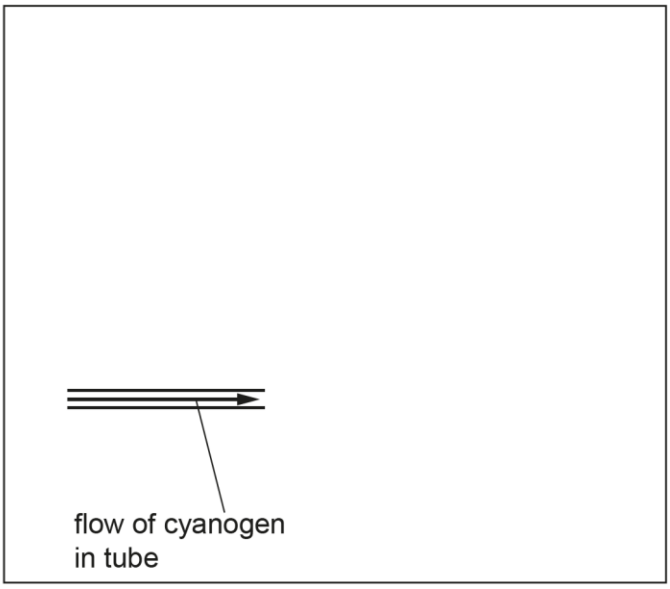
Experiment 2

They ignite the flow of cyanogen and use it to heat $110\,cm^3$ of water for 5.0 minutes.

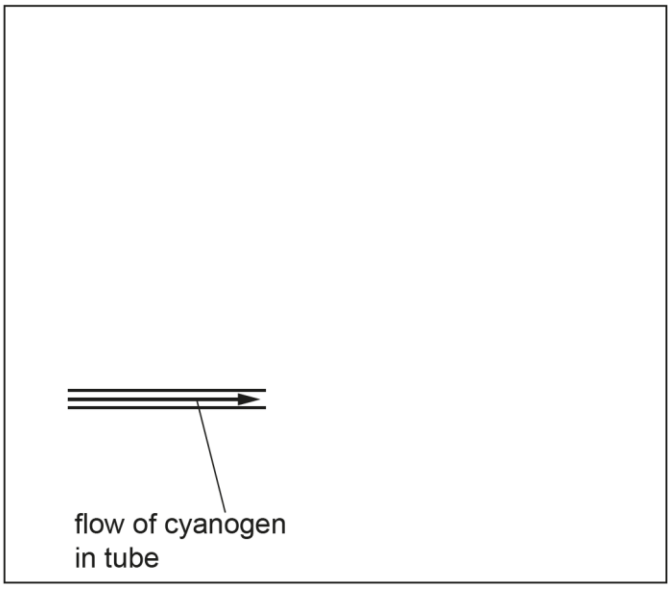
They measure the increase in temperature of the water.

(i) Complete labelled diagrams of simple apparatus that could be used for **Experiment 1** and **Experiment 2**.

Experiment 1



Experiment 2



[3]

The quality of diagrams was frequently inadequate. Experiment 1 was generally well answered. Experiment 2 proved more challenging. Many candidates added extra flames from Bunsen burners or fed the cyanogen into a spirit burner before ignition.

OCR support

Guidance on suggested practical activities (PAG3) which cover these techniques is available in the Practical Skills Handbook

Question 23 (d) (ii)

(ii) Describe **one** improvement that could have been made to **Experiment 2** to improve the accuracy of the result.

.....

..... **[1]**

Many candidates correctly suggested methods to reduce heat loss but some responses were expressed in terms of "precision" rather than "accuracy".

OCR support

Our '[Language of Measurement in context]' support document is a useful resource to help your students understand the definitions of measurement terms like 'accuracy' and 'precision'.

Question 23 (d) (iii)

(iii) Calculate the maximum possible temperature rise of the water.

Use the scientists' result and measurements from **part (d)** and **Equation 23.1**.

Give your answer to an **appropriate** number of significant figures.

maximum possible temperature rise = ... °C **[4]**

Relatively few responses calculated the number of moles of cyanogen with many omitting any reference to it. kJ were often not converted to J. A number of candidates produced temperature rises of over 100 °C but did not notice that this would be impossible.

Question 23 (e)

(e) Cyanogen is toxic.

Name another toxic compound in **Equation 23.1**.

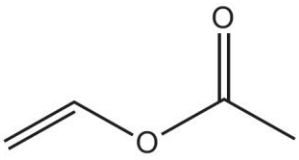
..... **[1]**

Candidates need to be instructed to read questions carefully. The formula CO was insufficient.

Question 24 (a)

24 Polyvinyl acetate, PVAc, is a polymer used as a wood glue.

PVAc is made from the monomer vinyl acetate.



Vinyl acetate

(a) Give the **full structural** formula of a repeating unit of PVAc.

[1]

This question was not well answered. Very few candidates recognised that the C=C needed to be opened out. Candidates should be encouraged to redraw the molecule as ethene with one R group to help when answering this type of question. Few produced a full structural formula as request by the question.

Question 24 (b)

(b) PVAc acts as a glue because of the intermolecular bonds it forms.

Name the **strongest** type of intermolecular bond between chains of PVAc.

..... **[1]**

As in Question 24(a), candidates needed to read the question carefully. Many gave 'hydrogen bonds' as the response.

Question 24 (c)

(c) A student carries out a simple test to show that the liquid vinyl acetate is unsaturated.

Give details of the test and its result.

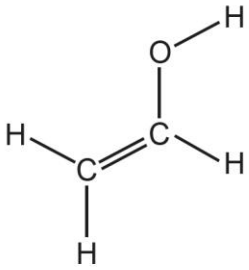
.....

..... **[1]**

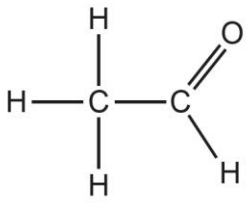
The majority of candidates knew the test for unsaturation.

Question 24 (d)

(d) Polyvinyl alcohol is another useful polymer. However, the monomer, vinyl alcohol, is unstable and forms its isomer ethanal.



Vinyl alcohol



Ethanal

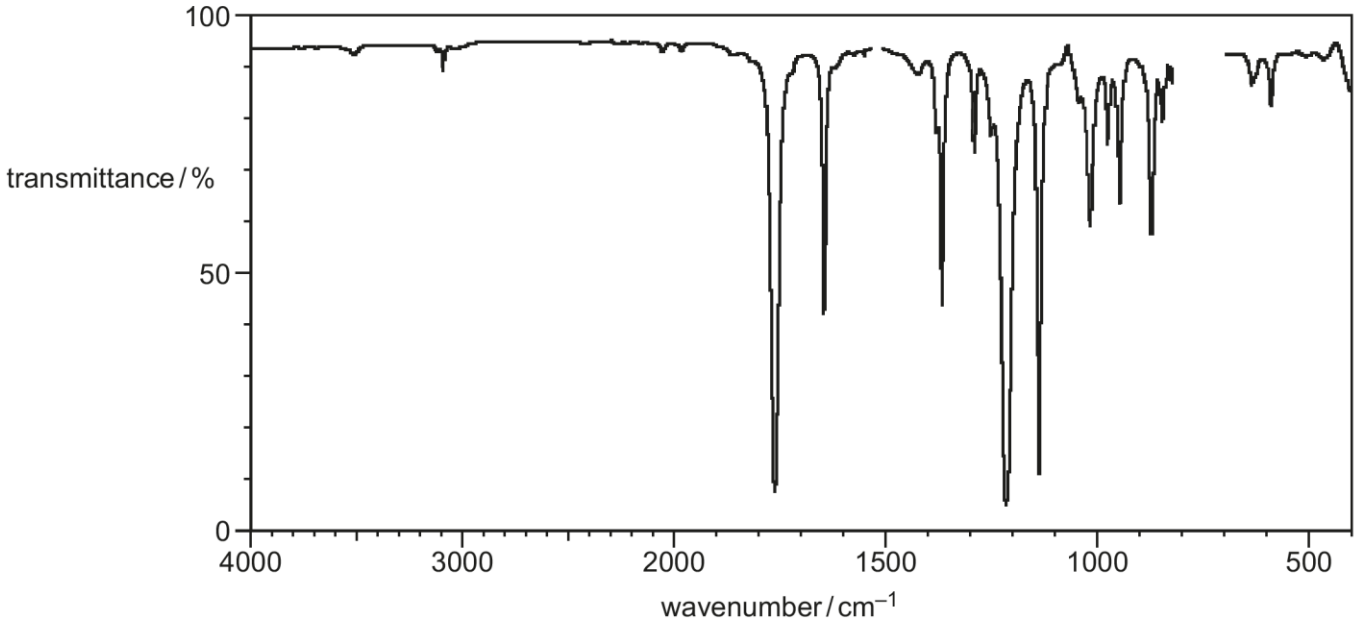
Name the functional group in ethanal.

..... **[1]**

The most common response to this question was "aldehyde". A small number wrote "carbonyl".

Question 24 (e)

(e) The IR spectrum of a compound is shown below.



The compound is **one** of:

- ethanal
- polyvinyl acetate
- polyvinyl alcohol
- vinyl acetate

Identify the compound and give your reasons in terms of wavenumbers and the related bonds.

.....

.....

.....

.....

.....

..... **[4]**

To gain all 4 marks candidates were required to identify at least three regions of the IR spectrum and correctly identify the compound as vinyl acetate.

Copyright information

Question 24 part e: Graph - The IR spectrum of a compound, National Institute of Advanced Industrial Science and Technology: https://sdbs.db.aist.go.jp

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