Examiners' Report
June 2023

International Advanced Level Chemistry WCH15 01

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications come from Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk.

Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

Giving you insight to inform next steps

ResultsPlus is Pearson's free online service giving instant and detailed analysis of your students' exam results.

- See students' scores for every exam question.
- Understand how your students' performance compares with class and national averages.
- Identify potential topics, skills and types of question where students may need to develop their learning further.

For more information on ResultsPlus, or to log in, visit www.edexcel.com/resultsplus. Your exams officer will be able to set up your ResultsPlus account in minutes via Edexcel Online.

Pearson: helping people progress, everywhere

Pearson aspires to be the world’s leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We’ve been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk.

June 2023

Publications Code WCH15_01_2306_ER

All the material in this publication is copyright

© Pearson Education Ltd 2023

Introduction

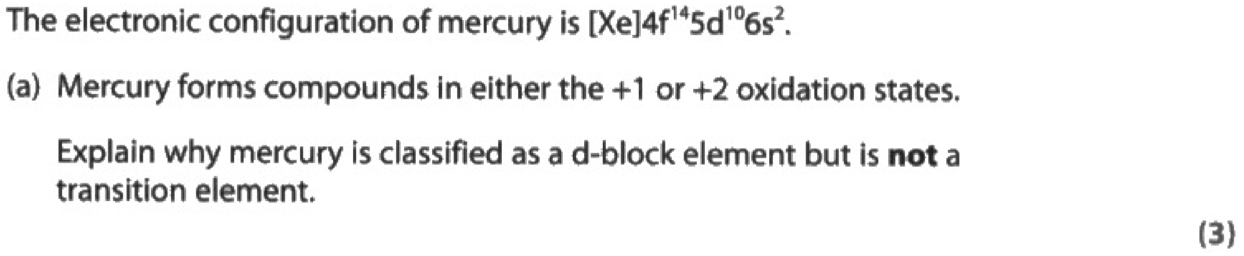
While some excellent responses were seen to all questions, many candidates found it difficult to apply their knowledge and understanding in an unfamiliar context and centres are well advised to provide greater opportunities for candidates to develop their skills in this area as part of the teaching and learning routine. It was also apparent that a significant proportion of the candidates lacked basic skills in chemistry, for example in constructing equations and in representing organic structures using different types of formulae.

Again, more practise is required. While candidates were generally most confident in performing calculations and in recalling basic knowledge, such as organic reagents and conditions, it was clear that many lacked an understanding of the underlying chemistry. Placing a greater emphasis on understanding would help promote deeper learning, avoid misconceptions and make candidates more resilient and adaptable under examination conditions.

Exam technique is another area for development, where candidates should be encouraged to follow instructions more carefully, as well as consider and use the information they are provided more thoughtfully.

Question 21 (a)

This question required candidates to apply their knowledge of definitions to an unfamiliar example. Many candidates did not read the instructions carefully and failed to explain what is meant by a d-block element. While the majority of candidates used the term transition element, many did not use the information provided to relate this to the 1+ and 2+ **ions** of mercury.

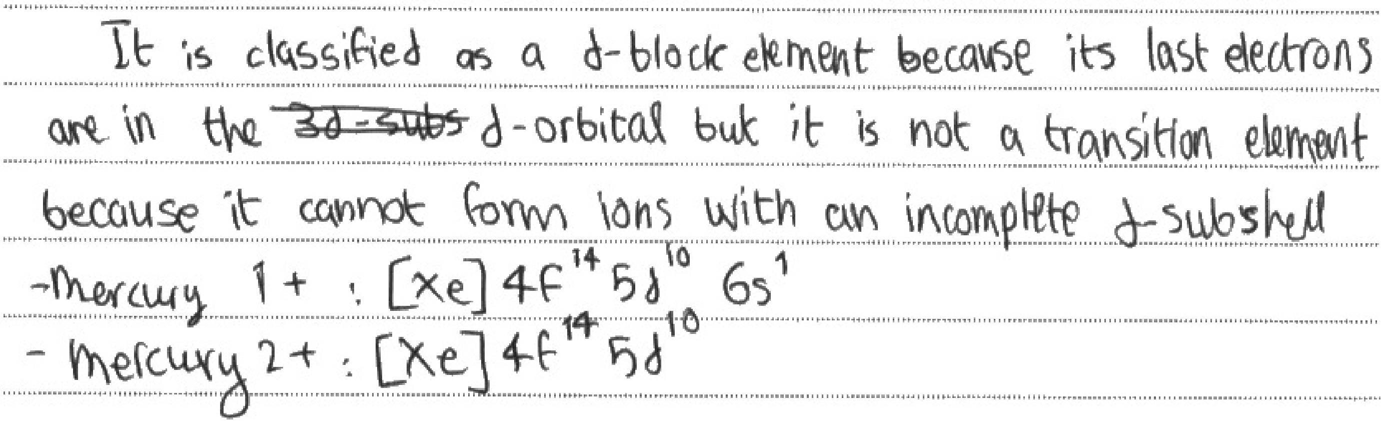


The electronic configuration of mercury is $[Xe]4f^{14}5d^{10}6s^2$.

(a) Mercury forms compounds in either the +1 or +2 oxidation states.

Explain why mercury is classified as a d-block element but is **not** a transition element.

(3)



It is classified as a d-block element because its last electrons are in the ~~3d-subs~~ d-orbital but it is not a transition element because it cannot form ions with an incomplete d-subshell

-Mercury 1+ : $[Xe]4f^{14}5d^{10}6s^1$

- Mercury 2+ : $[Xe]4f^{14}5d^{10}$

ResultsPlus Examiner Comments

A good example of a concise and specific response scoring full marks. The difference between a d-block element and a transition element is explained, with clear reference to the electronic configuration of mercury and its ions.

ResultsPlus Examiner Tip

The highest energy electrons in an atom of a d-block element are in the highest energy s subshell. These electrons are removed first when forming ions.

The electronic configuration of mercury is [Xe]$4f^{14}5d^{10}6s^2$.

(a) Mercury forms compounds in either the +1 or +2 oxidation states.

Explain why mercury is classified as a d-block element but is **not** a transition element.

(3)

H is a d-block element because it is located in the d-block section of periodic table and has d-orbitals. H's not a transition metal because the d-orbitals are full whereas they should be partially filled. Resultantly, the compounds and ~~e~~ its complex ions will not be coloured.

ResultsPlus
Examiner Comments

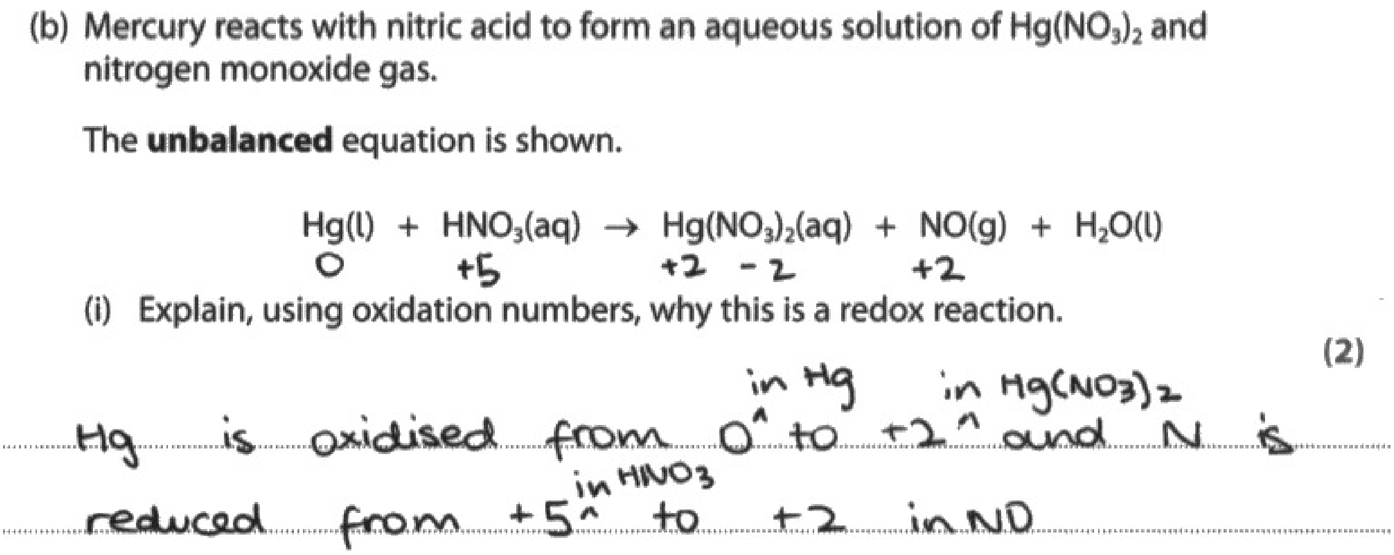
This response, which scored 1 mark, neither explains how blocks of the periodic table relate to electronic structure, nor considers the electronic configurations of the ions of mercury.

ResultsPlus
Examiner Tip

Make sure to use any relevant information provided when answering a question set in an unfamiliar context.

Question 21 (b)(i)

Most candidates correctly deduced the changes in oxidation number for mercury and nitrogen, but many did not link these to oxidation and reduction. Another common mistake was to state that the oxidation number of nitric acid, rather than the element nitrogen, was reduced from +5 to +2.



(b) Mercury reacts with nitric acid to form an aqueous solution of $Hg(NO_3)_2$ and nitrogen monoxide gas.

The **unbalanced** equation is shown.

$$\underset{0}{Hg(l)} + \underset{+5}{HNO_3(aq)} \rightarrow \underset{+2\ \ -2}{Hg(NO_3)_2(aq)} + \underset{+2}{NO(g)} + H_2O(l)$$

(i) Explain, using oxidation numbers, why this is a redox reaction.

(2)

in Hg in $Hg(NO_3)_2$

Hg is oxidised from 0^ to +2^ and N is

in HNO_3

reduced from +5^ to +2 in NO

ResultsPlus
Examiner Comments

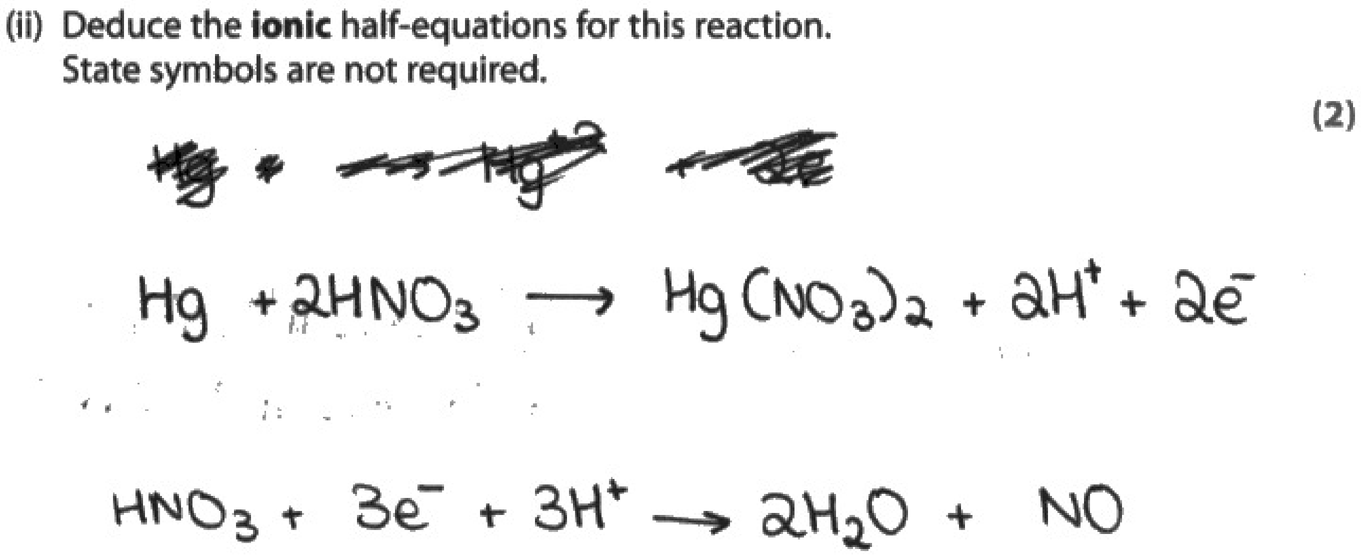
An excellent response scoring both marks. The relevant oxidation numbers are clearly identified, linked to the correct species and the changes in oxidation number connected to oxidation and reduction.

ResultsPlus
Examiner Tip

Annotating equations with oxidation numbers is helpful in identifying redox processes.

Question 21 (b)(ii)

This question was surprisingly poorly answered suggesting that many candidates do not understand how to construct half-equations for redox reactions. The simpler half-equation for the oxidation of mercury was tackled more confidently, but the reduction of nitrate to nitrogen monoxide proved too challenging for most candidates.



(ii) Deduce the **ionic** half-equations for this reaction.
State symbols are not required.

(2)

$$Hg + 2HNO_3 \longrightarrow Hg(NO_3)_2 + 2H^+ + 2e^-$$

$$HNO_3 + 3e^- + 3H^+ \longrightarrow 2H_2O + NO$$

ResultsPlus
Examiner Comments

This candidate has left the nitric acid undissociated so has not produced the **ionic** half-equations. This mistake was penalised once only and 1 mark was awarded for the reduction half-equation.

ResultsPlus
Examiner Tip

Strong acids, such as nitric acid, dissociate completely into their ions.

(ii) Deduce the **ionic** half-equations for this reaction.
State symbols are not required.

(2)

Hg H^+ NO_3^- $\rightarrow$ Hg^{2+} $2NO_3^{2-}$ NO H_2O

oxidation : $Hg \rightarrow Hg^{2+} + 2e^-$

reduction : $3e^- + 4H^+ + NO_3^- \rightarrow NO + 2H_2O$

$8H^+$ NO_3^-

2

$+ 4H_2O$

ResultsPlus Examiner Comments

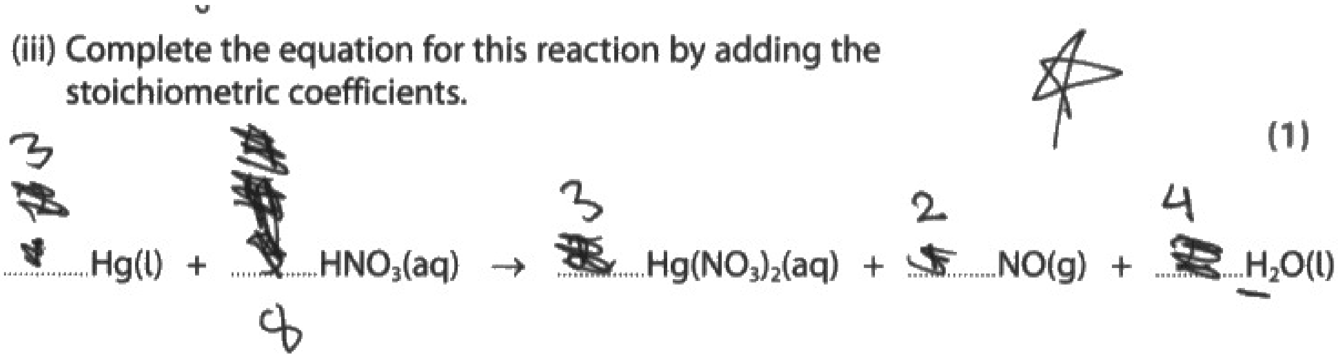
This response is poorly presented with much rough working on display. Both marks were awarded, however, as two correct ionic half-equations are shown with the labelling helping to direct the examiner to the intended answer.

ResultsPlus Examiner Tip

Put a line through any work that you do not want to be marked.

Question 21 (b)(iii)

Again, following on from the half-equations, only a small proportion of candidates were able to tackle this question successfully.



(iii) Complete the equation for this reaction by adding the stoichiometric coefficients.

(1)

$3\,Hg(l) + 8\,HNO_3(aq) \rightarrow 3\,Hg(NO_3)_2(aq) + 2\,NO(g) + 4\,H_2O(l)$

ResultsPlus
Examiner Comments

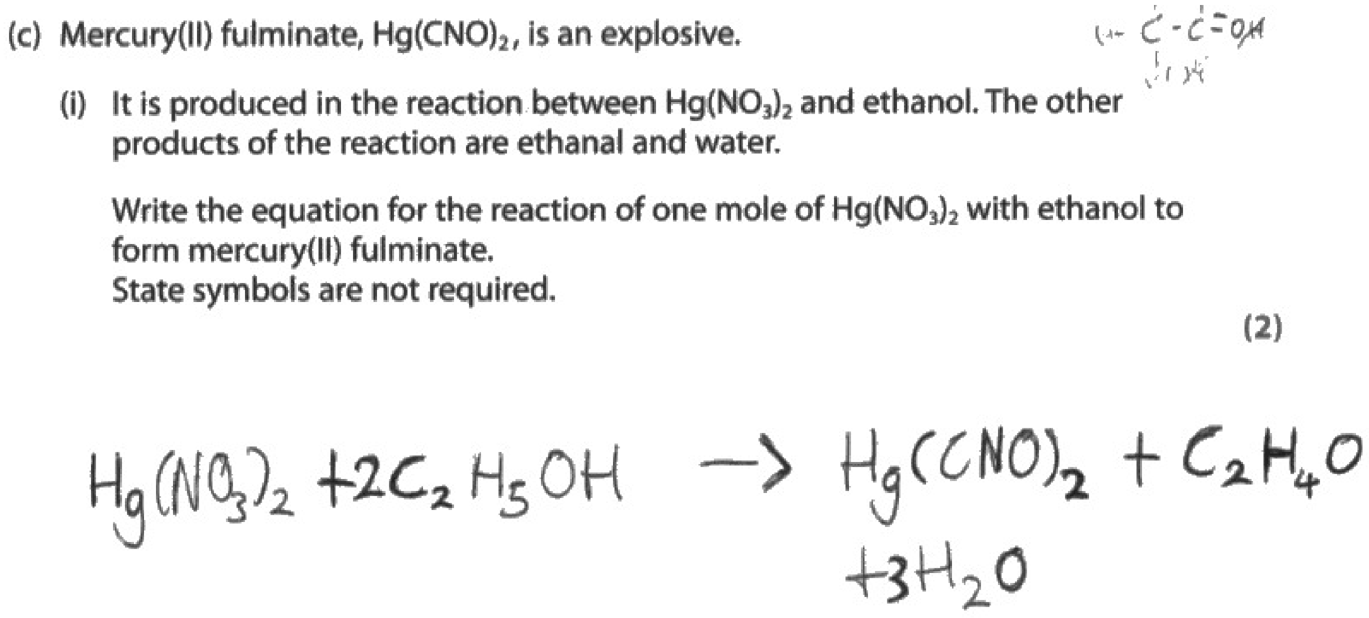
A correctly balanced equation. This candidate has clearly crossed out the work they do not wish to be marked.

ResultsPlus
Examiner Tip

It is best to put a single line through work you do not wish to be marked. Crossed out work is still marked unless it has been replaced with an alternative response.

Question 21 (c)(i)

Although all of the required information was provided in the question, candidates failed to produce an acceptable equation, with many using molecular formulae for the organic species, or representing the aldehyde group as COH. Very few candidates were able to balance the equation.



(c) Mercury(II) fulminate, $Hg(CNO)_2$, is an explosive.

(i) It is produced in the reaction between $Hg(NO_3)_2$ and ethanol. The other products of the reaction are ethanal and water.

Write the equation for the reaction of one mole of $Hg(NO_3)_2$ with ethanol to form mercury(II) fulminate.
State symbols are not required.

(2)

$Hg(NO_3)_2 + 2C_2H_5OH \rightarrow Hg(CNO)_2 + C_2H_4O$
$+ 3H_2O$

ResultsPlus
Examiner Comments

This was a difficult equation to balance; however, 1 mark was available for the correct species. This response did not receive any credit as the molecular formula for ethanal was not accepted.

ResultsPlus
Examiner Tip

Do not use molecular formulae to represent organic structures unless instructed to do so.

(c) Mercury(II) fulminate, $Hg(CNO)_2$, is an explosive.

(i) It is produced in the reaction between $Hg(NO_3)_2$ and ethanol. The other products of the reaction are ethanal and water.

Write the equation for the reaction of one mole of $Hg(NO_3)_2$ with ethanol to form mercury(II) fulminate.
State symbols are not required.

(2)

$$Hg(NO_3)_2 + 3C_2H_5OH \rightarrow Hg(CNO)_2 + 2CH_3COH + 5H_2O$$

ResultsPlus
Examiner Comments

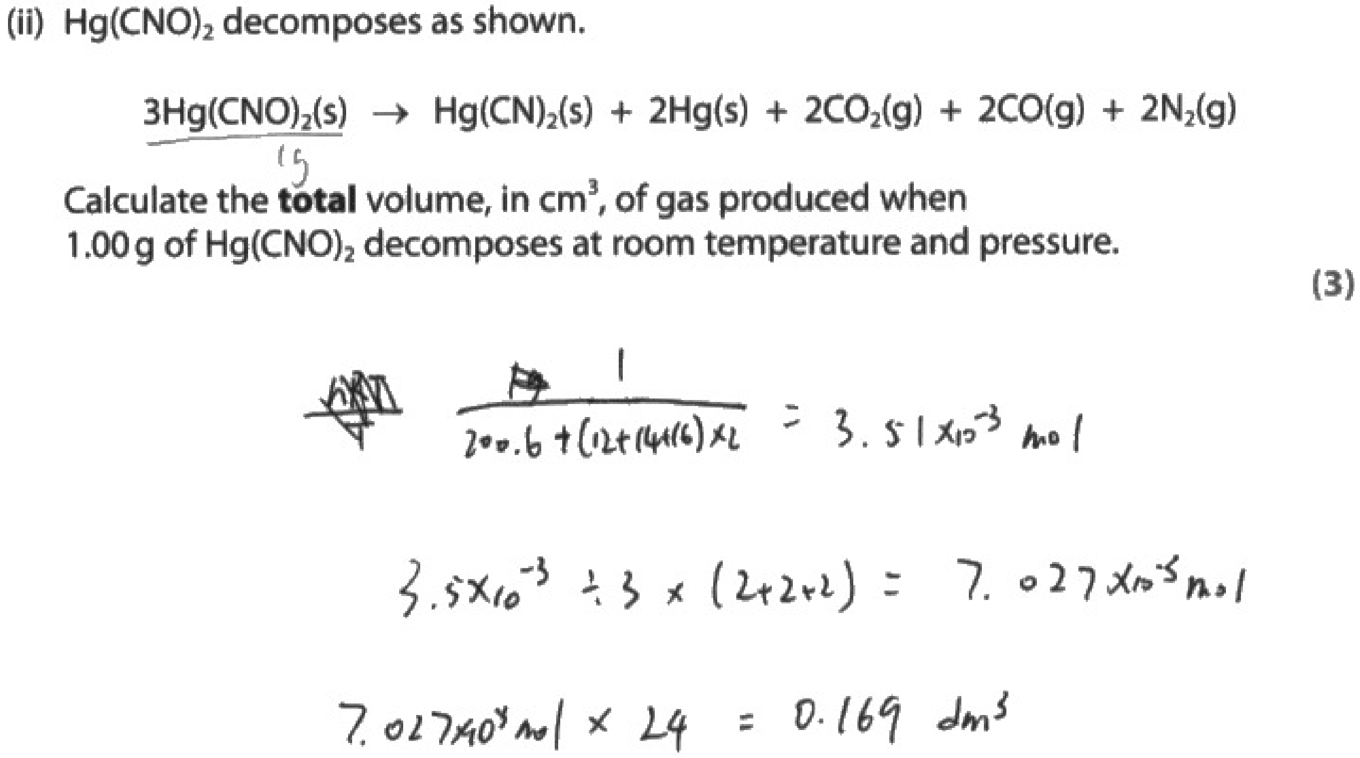
This response scored 1 mark for a correctly balanced equation, but the incorrect representation of ethanal did not receive credit.

ResultsPlus
Examiner Tip

When using structural formulae, aldehydes must be represented as RCHO.

Question 21 (c)(ii)

Generally well answered though candidates often made the calculation more complicated than necessary by using the ideal gas equation, or by treating each gas separately as opposed to the **total** moles of gas. Some candidates ignored the instruction and gave their answer in dm^3.



(ii) $Hg(CNO)_2$ decomposes as shown.

$$3Hg(CNO)_2(s) \rightarrow Hg(CN)_2(s) + 2Hg(s) + 2CO_2(g) + 2CO(g) + 2N_2(g)$$

15

Calculate the **total** volume, in cm^3, of gas produced when 1.00 g of $Hg(CNO)_2$ decomposes at room temperature and pressure.

(3)

$$\frac{1}{200.6+(12+14+16)\times2} = 3.51\times10^{-3}\ \text{mol}$$

$$3.5\times10^{-3} \div 3 \times (2+2+2) = 7.027\times10^{-5}\ \text{mol}$$

$$7.027\times10^{-3}\ \text{mol} \times 24 = 0.169\ \text{dm}^3$$

ResultsPlus
Examiner Comments

Although unlabelled, the working in this response is clearly presented and easy to follow. Full marks were awarded, even though the final answer is given in dm^3 and not cm^3 as instructed.

ResultsPlus
Examiner Tip

Read instructions carefully.

(ii) $Hg(CNO)_2$ decomposes as shown.

$$3Hg(CNO)_2(s) \rightarrow Hg(CN)_2(s) + 2Hg(s) + 2CO_2(\underline{g}) + 2CO(\underline{g}) + 2N_2(\underline{g})$$

Calculate the **total** volume, in cm^3, of gas produced when 1.00 g of $Hg(CNO)_2$ decomposes at room temperature and pressure.

(3)

$$\frac{1}{284.6} = 3.5 \times 10^{-3} \text{ mol}$$

$$3.5 \times 10^{-3} \times 2 = 7 \times 10^{-3} \text{ mol}$$

$$pV = nRT$$

$$1000 \times V = 7 \times 10^{-3} \times 8.31 \times 298$$

$$V = 0.0173 \text{ dm}^3$$

$$= 17.3 \text{ cm}^3$$

ResultsPlus
Examiner Comments

This response scored just 1 mark for the calculation of the moles of $Hg(CNO)_2$.

The correct mole ratio is used in determining the total amount of gas, but the answer is given to 1 significant figure, which has been carried through in the calculation.

The candidate has ignored the reference to **room temperature and pressure** and then made a mistake (with the pressure) in using the ideal gas equation.

ResultsPlus
Examiner Tip

In calculations, never give answers to 1 significant figure, even in intermediate steps, unless the answer is exact or if instructed to do so.

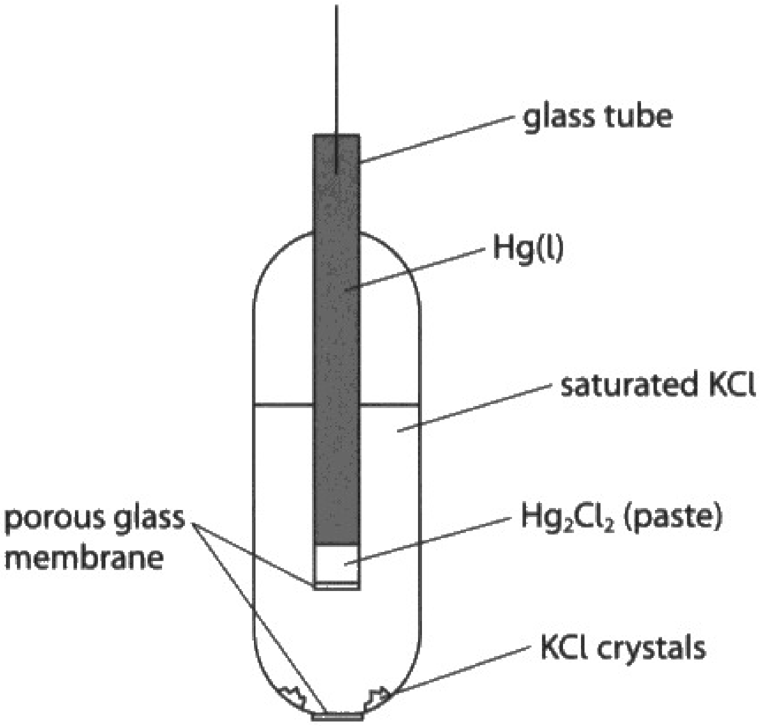
Always use the molar gas volume given in the Data booklet ($24\ dm^3\ mol^{-1}$) when working with gases at room temperature and pressure. Note that "room temperature and pressure" corresponds to a temperature of 20^oC and a pressure of 1 atm.

Question 21 (d)(i)

An example of a question where candidates found it difficult to apply their knowledge and understanding in an unfamiliar context. It was disappointing to see so many candidates jump straight to an improbable answer such as "catalyst", "to increase surface area" or even "anti-bumping granules", without consideration of the chemistry or of the information provided.

(d) Mercury(I) chloride, Hg_2Cl_2, is also known as calomel.

A saturated calomel electrode may be used as an alternative to the standard hydrogen electrode.



The half-equation for the calomel electrode is

$$Hg_2Cl_2(s) + 2e^- \rightleftharpoons 2Hg(l) + 2Cl^-(aq)$$

The standard electrode potential of the calomel electrode is $E^\ominus = +0.24\,V$.

(i) Suggest why KCl crystals are needed in the outer tube of the electrode.

(1)

~~to~~ [illegible]

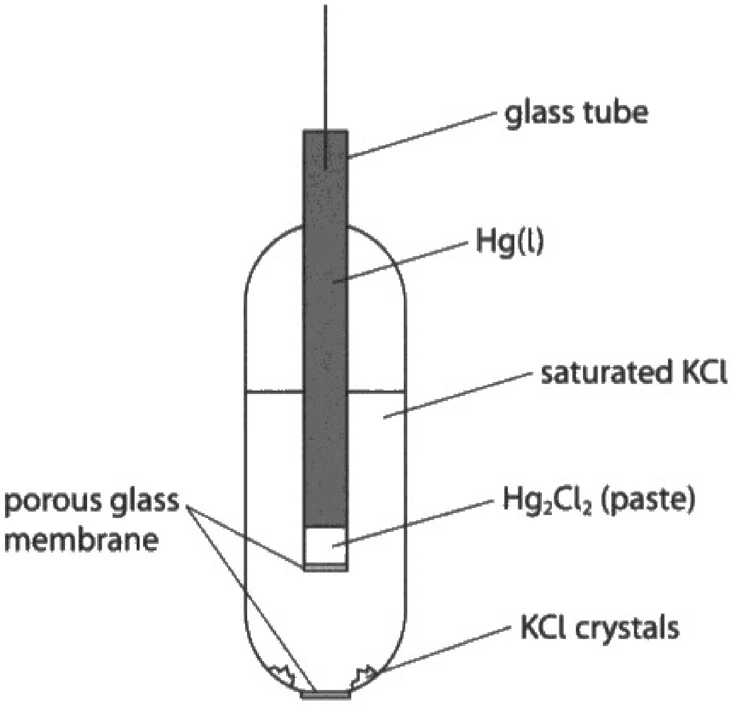
to provide Cl^- when KCl solution becomes unsaturated

ResultsPlus
Examiner Comments

This response clearly conveys the idea of maintaining a constant chloride ion concentration and was awarded the mark.

(d) Mercury(I) chloride, Hg_2Cl_2, is also known as calomel.

A saturated calomel electrode may be used as an alternative to the standard hydrogen electrode.



The half-equation for the calomel electrode is

$$Hg_2Cl_2(s) + 2e^- \rightleftharpoons 2Hg(l) + 2Cl^-(aq)$$

The standard electrode potential of the calomel electrode is $E^\ominus = +0.24\,V$.

(i) Suggest why KCl crystals are needed in the outer tube of the electrode.

(1)

KCl decomposes to K^+ and Cl^-, making up a salt bridge, which completes the electric circuit.

ResultsPlus
Examiner Comments

Salt bridge / to complete the circuit were common incorrect answers to this question.

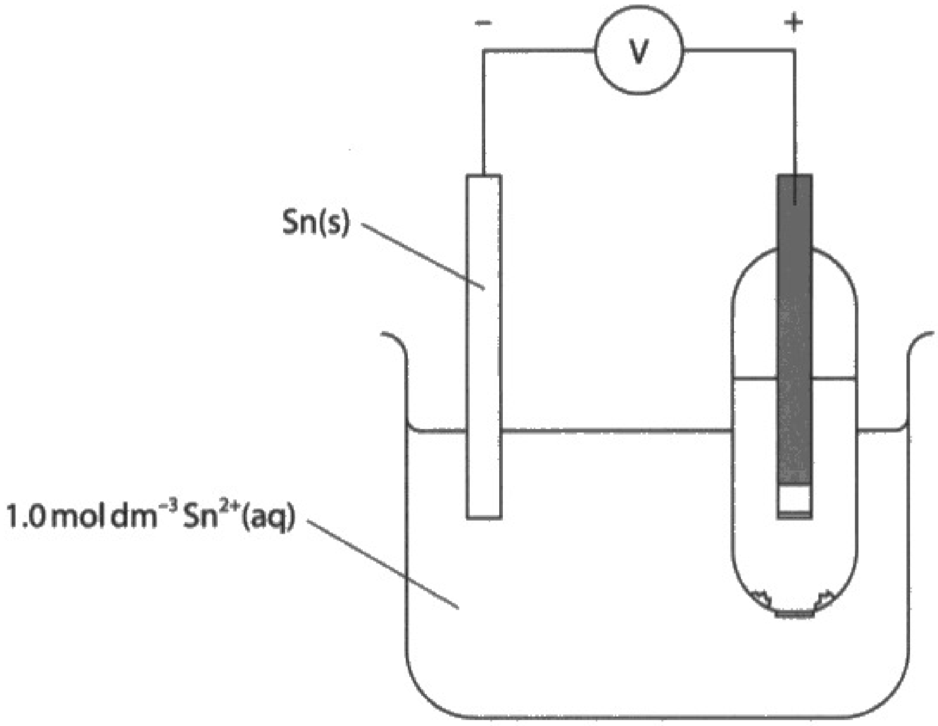
ResultsPlus
Examiner Tip

Always check the stem for useful information when answering questions set in an unfamiliar context: the solution is labelled as **saturated KCl** in this example.

Question 21 (d)(ii-iii)

Many candidates seemingly missed that the diagram displayed the calomel electrode as the positive electrode on the right and the tin as the negative electrode on the left and subsequently confused their calculation. Where the answer to Q21(d)(iii) was incorrect this may have been because candidates did not link the signs of the electrodes to oxidation and reduction. In addition, a significant number of candidates misread the question, offering a cell diagram in place of an overall equation.

(ii) A calomel electrode was used to measure the standard electrode potential of the $Sn^{2+}(aq) \mid Sn(s)$ half-cell.



The reading on the voltmeter in this cell was +0.37 V.

Deduce the standard electrode potential for the $Sn^{2+}(aq) \mid Sn(s)$ half-cell.

(1)

$E^{\ominus}_{cell} = E^{\ominus}_{right} - E^{\ominus}_{left}$

$+0.37 = +0.24 - x$

$E^{\ominus}_{left} = -0.13\ V$

(iii) Write the overall equation for the cell reaction.

(1)

$Hg_2Cl_2(s) + \cancel{2e^-} \rightleftharpoons 2Hg(l) + 2Cl^-(aq)$

$Sn(s) \rightleftharpoons Sn^{2+}(aq) + \cancel{2e^-}$

$Hg_2Cl_2(s) + Sn(s) \rightleftharpoons 2Hg(l) + Sn^{2+}(aq) + 2Cl^-(aq)$

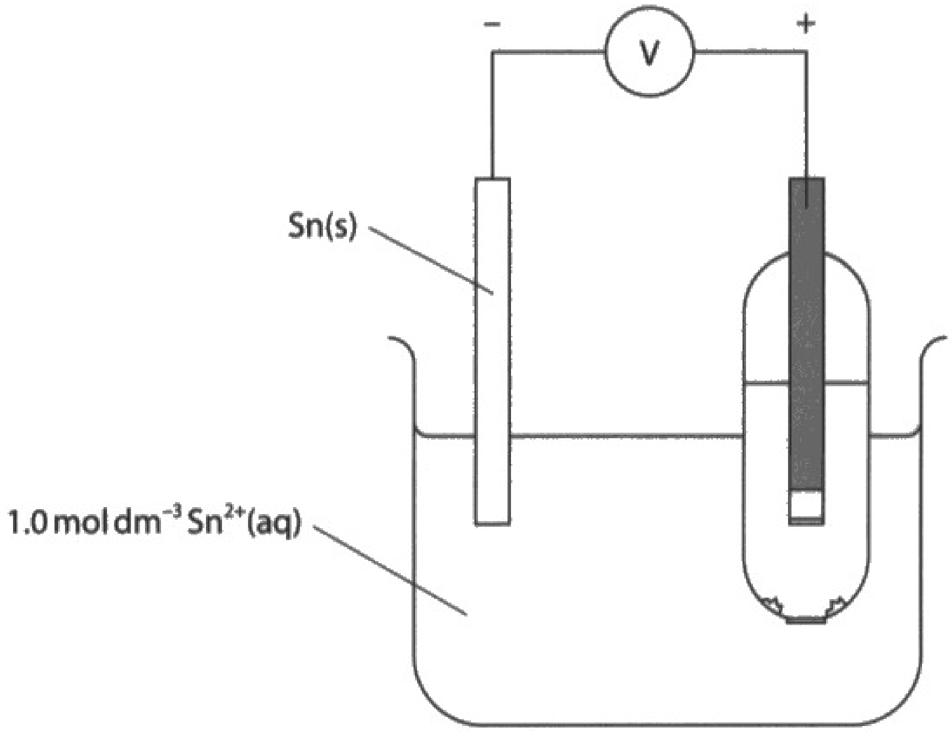
ResultsPlus
Examiner Comments

An excellent response with clearly presented working. The reversible reaction arrow in Q21(d)(iii) was allowed.

ResultsPlus
Examiner Tip

When writing equations it is good practice to include state symbols, but when required this will always be stated in the question.

(ii) A calomel electrode was used to measure the standard electrode potential of the $Sn^{2+}(aq) | Sn(s)$ half-cell.



The reading on the voltmeter in this cell was +0.37 V.

Deduce the standard electrode potential for the $Sn^{2+}(aq) | Sn(s)$ half-cell.

(1)

$x - 0.\overrightarrow{24} = 0.37$

$x = 0.61$

$E^0 = 0.61 \text{ V}$

(iii) Write the overall equation for the cell reaction.

(1)

$Sn^{2+}_{(aq)} + 2Hg_{(c)} + 2Cl^-_{(aq)} \longrightarrow Sn_{(s)} + Hg_2Cl_{2(s)}$

ResultsPlus
Examiner Comments

The calculation in Q21(d)(ii) is incorrect but credit was given in Q21(d)(iii) as the candidate has appreciated that the more positive electrode potential would make Sn^{2+} the oxidising agent for the cell reaction.

ResultsPlus
Examiner Tip

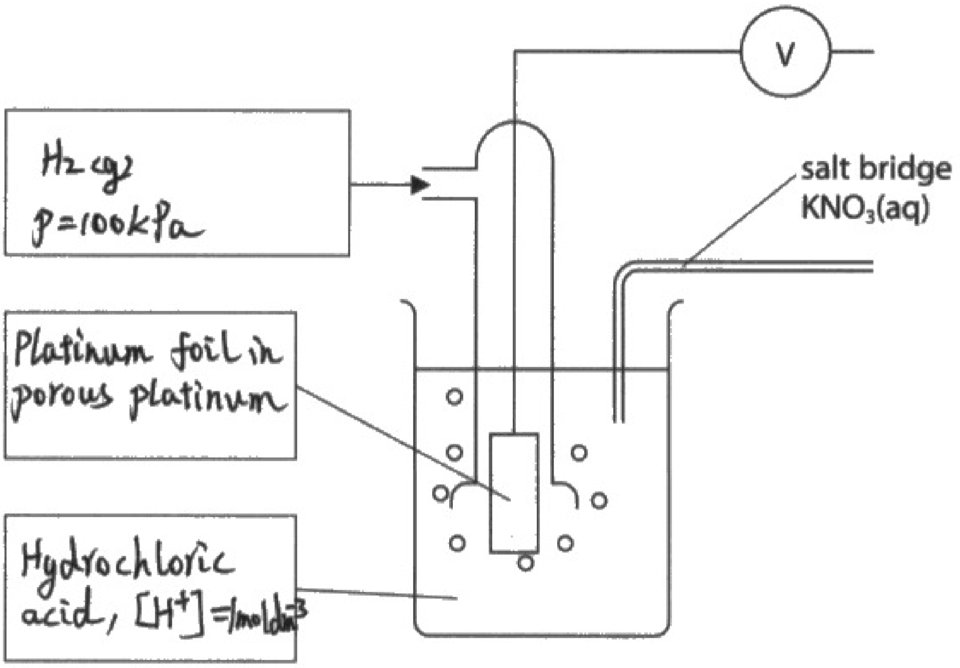
By convention the right hand electrode is connected to the positive input terminal of the voltmeter and the left hand electrode connected to the negative. If the reading on the voltmeter is positive, therefore, this means that the left hand electrode is the negative electrode (and vice versa).

Question 21 (d)(iv)

This was a familiar question to most candidates. A common mistake was to omit the temperature, presumably as it was not associated with any one of the gas, electrode or solution, despite this being an essential condition of the **standard** hydrogen electrode.

(iv) Add labels to complete the diagram of a standard hydrogen electrode. Include details of any essential conditions.

(3)



H_2 has pressure of 100kPa, porous Pt can increase surface area contact with solution, $[HCl(aq)] = 1\ mol\,dm^{-3}$, $T = 298\ K$.

ResultsPlus
Examiner Comments

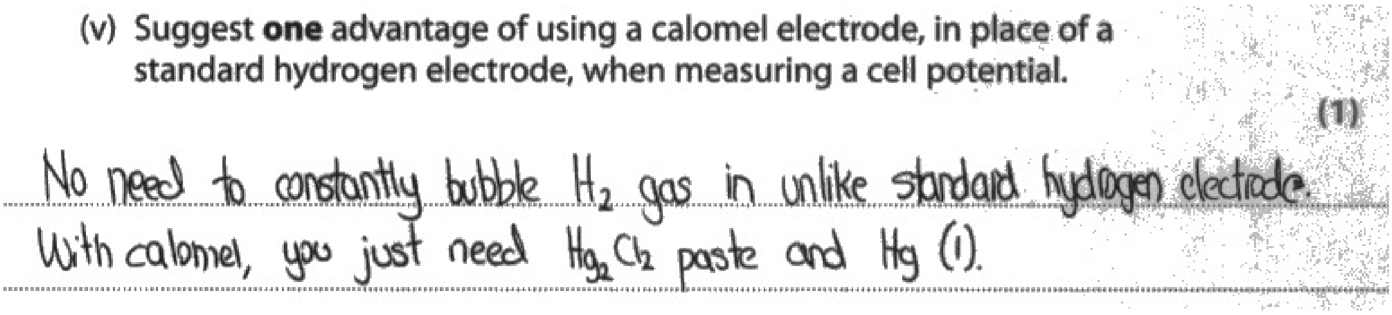
A clearly labelled response correctly identifying the features of a standard hydrogen electrode. As instructed, the essential conditions have been stated. The platinum electrode did not need to be porous in nature, nor was any explanation required.

ResultsPlus
Examiner Tip

Always read instructions carefully. Additional credit will not be given for providing information that is superfluous to the question.

Question 21 (d)(v)

While many candidates recognised an advantage of the calomel electrode is that it does not require hydrogen gas, most candidates simply related this to a hazard of hydrogen, or incorrectly to not needing a high pressure, as opposed to the difficultly in providing a continuous supply of gas. A minority of candidates recognised that the calomel electrode does not require a (separate) salt bridge.



(v) Suggest **one** advantage of using a calomel electrode, in place of a standard hydrogen electrode, when measuring a cell potential.

(1)

No need to constantly bubble H_2 gas in unlike standard hydrogen electrode.

With calomel, you just need Hg_2Cl_2 paste and Hg (l).

ResultsPlus
Examiner Comments

This candidate has recognised that a disadvantage of using a standard hydrogen electrode is that a continuous supply of hydrogen gas is required.

ResultsPlus
Examiner Tip

Using reverse arguments is acceptable in questions of this nature.

(v) Suggest **one** advantage of using a calomel electrode, in place of a standard hydrogen electrode, when measuring a cell potential.

(1)

- Better resuls, more accurate.
- Less uncentarty values.
- Easier to use

ResultsPlus
Examiner Comments

None of these generic responses were worthy of credit without qualification.

ResultsPlus
Examiner Tip

Avoid generic responses and be specific wherever possible.

Question 22

This unstructured titration calculation was handled competently by many candidates. Those who struggled to make progress seemed unfamiliar with the concept of using excess reagent in a back titration. Other common errors arose from ignoring the instructions, for example calculating the mass of ethanedioate ions, as opposed to the calcium salt, or failing to consider an appropriate number of significant figures. It was pleasing to see many well-presented responses where TE could be awarded even where the final answer was incorrect.

22 The amount of calcium ethanedioate, CaC_2O_4, present in a sample of spinach is determined by redox titration.

11.4 g of spinach leaves are stirred in 50.0 cm^3 of a warm acidified solution of 0.0100 mol dm^{-3} potassium manganate(VII), $KMnO_4$, oxidising all the ethanedioate ions, $C_2O_4^{2-}$.

$$16H^+ + 2MnO_4^- + 5C_2O_4^{2-} \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

The excess manganate(VII) ions, MnO_4^-, are then titrated with an acidified solution of 0.0500 mol dm^{-3} iron(II) sulfate, $FeSO_4$.

$$5Fe^{2+} + 8H^+ + MnO_4^- \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

25.95 cm^3 of iron(II) sulfate solution was needed for complete reaction.

Calculate the percentage by mass of CaC_2O_4 present in the spinach leaves.
Give your answer to an appropriate number of significant figures.

Moles of $FeSO_4$ used = $0.05 \times (25.95 \div 1000)$
= 1.2975×10^{-3}

moles of MnO_4^- titrated = $(1.2975 \times 10^{-3}) \div 5$
= 2.595×10^{-4}

original amount of MnO_4^- = $0.01 \times (50 \div 1000)$
= 5×10^{-4}

moles of MnO_4^- used up = $(5 \times 10^{-4}) - (2.595 \times 10^{-4})$
= 2.405×10^{-4}

moles of $C_2O_4^{2-}$ present = $(2.405 \times 10^{-4}) \times 2.5$
= 6.0125×10^{-4}

Mr of CaC_2O_4 = $40.1 + 2(12) + 4(16)$
= 128.1

mass of CaC_2O_4 = $(6.0125 \times 10^{-4}) \times 128.1 = 0.077020125$ g

% mass = $(0.077020125 \div 11.4) \times 100 = 0.6756151316$ %

→ 0.68 %

ResultsPlus
Examiner Comments

A well-presented calculation receiving full marks. Giving the final answer to either 2 or 3 significant figures was acceptable for this question. Note that the "original amount of MnO_4-" is given to 1 significant figure, but this was not penalised as the value is exact.

ResultsPlus
Examiner Tip

Always present your working clearly and logically in unstructured calculations. This makes it easier for the examiner to award transferred errors where the final answer is incorrect.

22 The amount of calcium ethanedioate, CaC_2O_4, present in a sample of spinach is determined by redox titration.

11.4 g of spinach leaves are stirred in 50.0 cm³ of a warm acidified solution of 0.0100 mol dm⁻³ potassium manganate(VII), $KMnO_4$, oxidising all the ethanedioate ions, $C_2O_4^{2-}$.

$$16H^+ + 2MnO_4^- + 5C_2O_4^{2-} \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

The excess manganate(VII) ions, MnO_4^-, are then titrated with an acidified solution of 0.0500 mol dm⁻³ iron(II) sulfate, $FeSO_4$.

$$5Fe^{2+} + 8H^+ + MnO_4^- \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

25.95 cm³ of iron(II) sulfate solution was needed for complete reaction.

Calculate the percentage by mass of CaC_2O_4 present in the spinach leaves. Give your answer to an appropriate number of significant figures.

spinach leaves

mass = 11.4

volume = 50.0 cm^3

mol = $\frac{mass}{mr}$

mr = (40.1) + (12×2) + (16×4)

= 128.1

mol = $\frac{11.4}{128.1}$

mol = 0.08899

conc

n = cv

n / c | v

c = $\frac{n}{v}$ → $\frac{50}{1000}$

conc = 1.7748 mol dm^{-3}

% by mass = 1.163×10^2 %

$\frac{11.5}{}$ ×100

1151.5151 mass = n × mr

= 1151.5% n = $\frac{m}{mr}$

0.20

for 0.19 + 0.79 =

= 1163 %

potassium manganate conc.

0.0100 mol dm^{-3}

↓

mass

=

n = cv

volume = $\frac{50.0}{1000}$

0.0500 mol dm^{-3}

n = 5×10^{-3}

$\boxed{mass = 0.79}$

mr of KMnO4

39.1 + 54.9 + (16×4)

= 158

mass = $\boxed{0.199}$

151.9

55.8 + 32.1 + (16×4)

FeSO4

iron sulfate

conc = 0.0500

volume = 25.95 cm^3

moles = n = cv

v = $\frac{25.95}{1000}$

v = 0.02595

moles = 1.2795 ×10^{-3}

moles = 1.2795×10^{-3}

mass = n × mr

m / n | mr

n = $\frac{m}{mr}$

mr of iron sulfate =

ResultsPlus
Examiner Comments

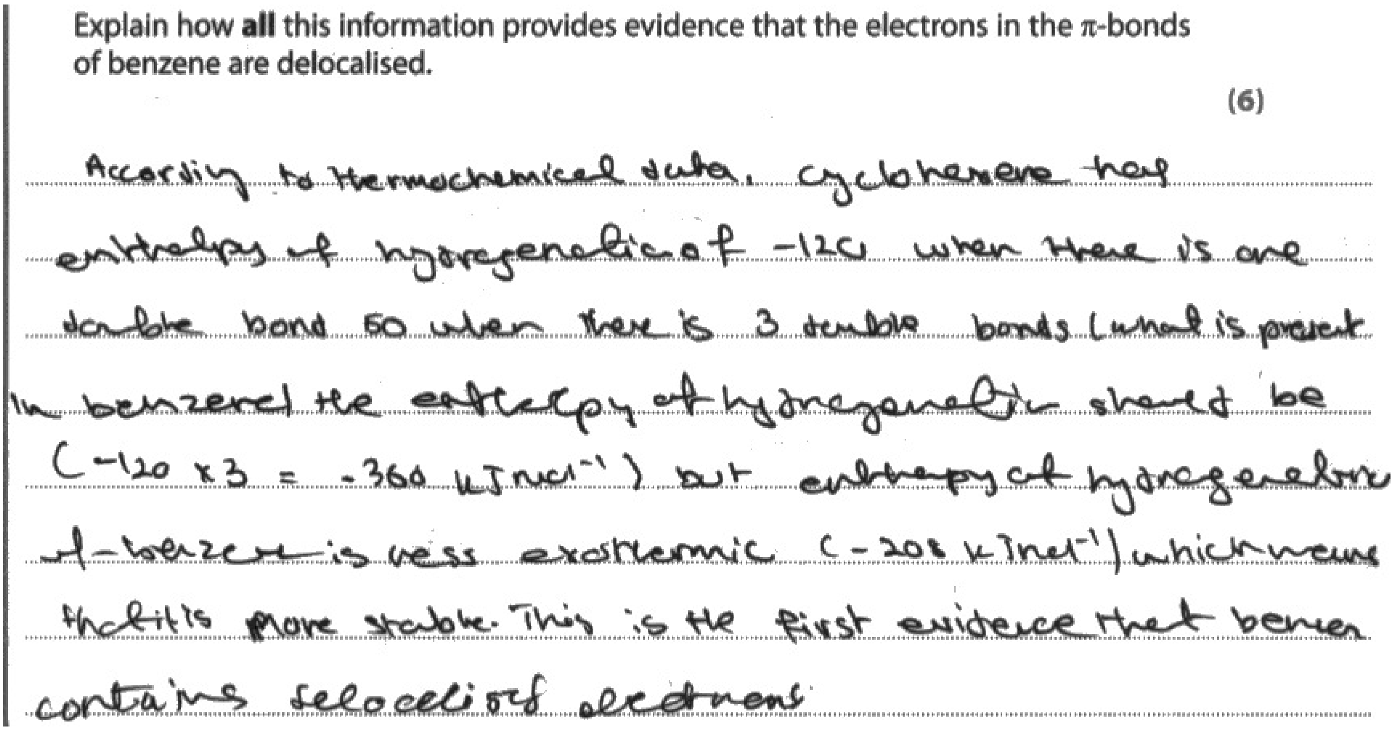
Nothing worthy of credit was found in this poorly presented response.

ResultsPlus
Examiner Tip

You can ask for additional answer sheets for rough working. Cross out any rough work that you do not want to be marked.

Question 23

The majority of candidates found it difficult to **use the information** as evidence for the delocalisation of the pi-bonds in benzene. With the thermochemical data, many candidates simply compared the values for benzene and cyclohexene without thought to the 1,3,5-triene. Vague language such as higher or lower was commonly used. Most candidates used the X-ray diffraction data to show that benzene has only one carbon-carbon bond length but did not explain that this is longer than the localised pi-bond in the C=C of cyclohexene. With regards to the bromination data, many candidates commented on the conditions, but failed to mention the stability arising from the delocalised pi-bonds in benzene means that a **catalyst** is required for bromination and that the reaction is substitution and not addition.



Explain how **all** this information provides evidence that the electrons in the π-bonds of benzene are delocalised.

(6)

According to thermochemical data, cyclohexene has enthalpy of hydrogenation of -120 when there is one double bond so when there is 3 double bonds (what is present in benzene) the enthalpy of hydrogenation should be ($-120 \times 3 = -360\ kJ\,mol^{-1}$) but enthalpy of hydrogenation of benzene is less exothermic ($-208\ kJ\,mol^{-1}$) which means that it's more stable. This is the first evidence that benzen contains delocalised electrons

According to X-ray diffraction, cyclohexene has three different bond types and 3 different bond lengths which also applyes for cyclo hexa-1,3,5-diene but in benzene there is a single type of bond and all bond lengths are equal. The bond length in benzene is shorter than single bond and longer than double bond in cyclohexene which shows that electrons in benzene are delocalised. According to bromination, cyclohexene is able to perform multiple subsitutions of bromine at milder conditions than benzene which only does monosubstitution of bromine with a catalyst and heat because the delocalisation in benzene result in kinetic barrier to intermediate formation. which is not present in cyclorexene- cyclohexene de-colorises bromine while cyclohexene doesnot which also shows that the pi electrons in benzene are delocalised.

ResultsPlus
Examiner Comments

A coherent and logically structured answer, addressing all of the information provided. This response would have scored full marks had the candidate not incorrectly said that cyclohexene reacts by substitution.

ResultsPlus
Examiner Tip

Reread your answers to check for careless mistakes.

Explain how **all** this information provides evidence that the electrons in the π-bonds of benzene are delocalised.

(6)

The Enthalpy of hydrogenation of Benzene is more negative than Cyclohexene by -88 kJ mol⁻¹ meaning its more stable than cyclohexene where the stability is due to delocalised electrons, The bond length & type in benzene is ~~of the sam~~ is the same and is ~~Shorter~~ longer than the C=C bond (d) in cyclohexe which indicates that Benzene doesn't actually have C=C with π bonds, Cyclohexene has different bond lengths and types

In the Bromination reaction Benzene undergoes electrophilic substitution reaction where cyclohexene undergoes addition reaction where the C=C bond bonds and Br_2 bonds to the C atom producing a bromocyclohexane that decolourises bromine water. Benzene ~~have~~ however undergoes substitution reaction to preserve & restore the delocalised ring which provides the stability of Benzene and that's why Bromination of Benzene requires heat energy and a Freidel Craft Catalyst but bromination of Cyclohexane doesn't as activation energy of Bromination of Benzene is higher than Cyclohexene which has C=C bond with π-bond that is shorter in length & can be easily broken or attacked

ResultsPlus
Examiner Comments

An example of a response referring to all of the information that scored 3 marks. As seen here, many candidates unnecessarily or incorrectly compared the hydrogenation enthalpy of benzene with that of cyclohexene instead of that of the theoretical triene. This candidate has used the X-ray diffraction data effectively, comparing the bond length in benzene to that of bond d in cyclohexene. The bromination information could have been used more concisely but the expected points, that benzene reacts by substitution and requires a catalyst, are covered. The incorrect reference to a Friedel-Crafts reaction however was penalised.

Explain how **all** this information provides evidence that the electrons in the π-bonds of benzene are delocalised.

(6)

With the thermochemical data, we can see that the enthalpy of hydrogenation is much higher in benzene compared to cyclohexene. This proves that the electrons in π bonds are delocalised because the only way the enthalpy of hydrogenation can be so high is if the structure is more stable. That would be the case if delocalised e^- were distributed evenly throughout the benzene, making it harder to break the bonds.

With x-ray diffraction data, we can see that the length of every bond around the benzene is the same. This shows that there are ~~the~~ delocalised e^- evenly distributed throughout the structure because if there were normal double bonds in benzene like in cyclohexene, the bond lengths would be varied.

With bromination, we can see benzene requires a catalyst and heat and it is an addition reaction. With cyclohexene, there are no conditions required and it's a substitution reaction. This is because the delocalised electrons in benzene are able to attack the Br^+ ~~and~~ to produce bromobenzene. ~~With cyclohexen~~ There can't be a substitution reaction with benzene because the electrons in π-bonds are holding everything together to keep it very stable. That's why heat is required. With cyclohexene, it's less stable due to no delocalised e^- and so it easily forms the organic product in a substitution reaction.

ResultsPlus
Examiner Comments

This response scored 2 marks.

Again, the hydrogenation enthalpy of benzene has been compared with that of cyclohexene. Even if the candidate had made the comparison with cyclohexa-1,3,5-triene, the vague reference to a "higher" enthalpy change would not have received credit.

The X-ray diffraction data has been used to conclude that benzene has only one (carbon-carbon) bond length, but this has not been compared directly with either the C=C or C-C bonds in cyclohexene as evidence for delocalisation of the pi-bonds.

It is correctly stated that the bromination of benzene requires a catalyst, but substitution has been confused with addition.

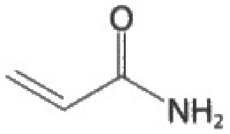
ResultsPlus
Examiner Tip

When comparing enthalpy changes, always use the terms more or less exothermic/endothermic.

Question 24 (a)(i)

Many candidates did not seem to recognise PAM as poly(propenamide) from the specification and did not know how to name the monomer, even though its common name provided includes amide as a suffix. Propanamide was a common incorrect answer, where the alkene functional group had been ignored.

(i) PAM is made from the acrylamide monomer.



acrylamide

Give the IUPAC name for acrylamide.

(1)

~~eth~~ ~~[illegible]~~ ~~pent~~ ~~prop-3-enamide~~ propenamide

ResultsPlus
Examiner Comments

Prop-2-enamide is the preferred IUPAC name of acrylamide but this is an acceptable alternative as "propenamide" is used in the specification.

ResultsPlus
Examiner Tip

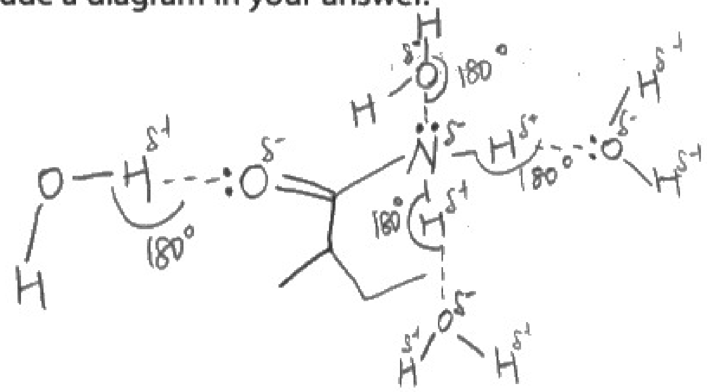
Make sure you are familiar with the content presented in the specification.

Question 24 (a)(ii)

Many candidates did not appear well-practised in drawing hydrogen bonds, with partial charges and lone pairs frequently missing and a range of bond angles seen. While the majority of candidates realised that PAM can H-bond with water, fewer appreciated that these can form to both the O and the NH_2 of the amide group, explaining the **large** amount of water that can be absorbed. Those candidates scoring 0 marks usually thought that PAM would react with water.

(ii) Explain why PAM is able to absorb **large** amounts of water.
Include a diagram in your answer.

(3)



it can form 4 hydrogen bond with water. ~~becaus~~

ResultsPlus
Examiner Comments

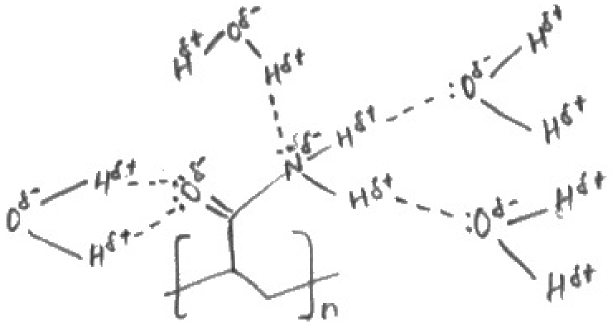
To score full marks on this question it was necessary to indicate that hydrogen bonds with water can form at both the O and NH_2 of PAM. The H-bonds shown in this response are generally well drawn as they contain the relevant partial charges, lone pairs and are linear in shape. Only 2 marks were awarded, however, as one of the H-bonds is incorrectly shown between a nitrogen and an oxygen atom.

ResultsPlus
Examiner Tip

In addition to partial charges and lone pairs, it is good practice to indicate the 180^{o} bond angle about a hydrogen bond.

(ii) Explain why PAM is able to absorb **large** amounts of water.
Include a diagram in your answer.

(3)



This is because of the lone pair of electrons on oxygen and nitrogen atom making both partially negative ; δ^- ~~rel~~ resulting to H in N-H to be δ^+ therefore more hydrogen bonds formed with water.

ResultsPlus
Examiner Comments

A good response showing all the required features of multiple hydrogen bonds between PAM and water. Full marks were awarded; however, the response would be even better if all H-bonds were shown as linear and if the left hand water molecule was forming only one H-bond to the carbonyl oxygen.

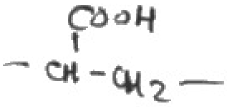
Question 24 (a)(iii)

Another question where candidates found it difficult to apply their knowledge and understanding. Of those candidates scoring 1 mark, many did so for simply guessing that the (intramolecular) hydrogen bonds must break above pH 8, without considering why this would happen. Candidates were expected to notice from the structure that PAA is a carboxylic acid, which would deprotonate in alkaline solution. Only the strongest candidates realised that the negatively charged carboxylate ions would repel.

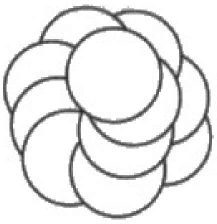
(iii) The structure of PAA in aqueous solution is pH-dependent.

Below pH 4, the structure of PAA is compact due to the formation of intramolecular hydrogen bonds.

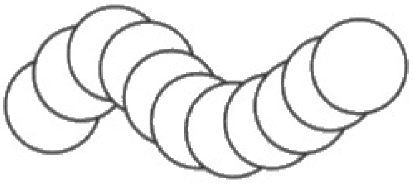
Above pH 8, PAA has an open coil structure.



$-\underset{}{\overset{COOH}{\overset{|}{CH}}}-CH_2-$



compact structure
below pH 4



open coil structure
above pH 8

Suggest why PAA exists as an open coil structure above pH 8.

(2)

Above pH 8 of aqueous solution, PAA acts as an acid, and thus loses H in COOH to form COO^- ions in each repeat unit. COO^- ions on neighbouring repeat units repel each other electrostatically as they have same charge hence it has open structure.

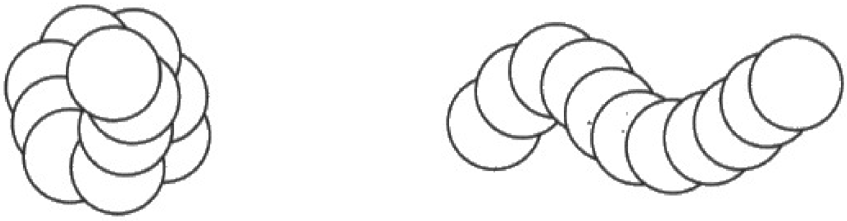
ResultsPlus
Examiner Comments

An excellent response demonstrating a clear understanding of the premise of the question.

(iii) The structure of PAA in aqueous solution is pH-dependent.

Below pH 4, the structure of PAA is compact due to the formation of intramolecular hydrogen bonds.

Above pH 8, PAA has an open coil structure.



compact structure below pH 4

open coil structure above pH 8

Suggest why PAA exists as an open coil structure above pH 8.

(2)

It is because the O atoms in PAA don't form hydrogen bonds with H_2O, [illegible] so it is less able to react with [illegible] H^+ and less H^+ [illegible] left in the solution, so that it has a higher PH.

ResultsPlus
Examiner Comments

Suggest questions require the use of knowledge and understanding in an unfamiliar context. From the information provided in the stem, this candidate has appreciated that the answer relates to hydrogen bonding but they have missed the significance of the **intramolecular** nature of these. Further, they appear to have ignored the structure of PAA and the role of its carboxylic acid functional group: the reference to pH was a prompt to this.

ResultsPlus
Examiner Tip

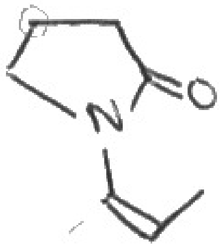
WCH15 involves questions that are both synoptic and unfamiliar in nature.

Question 24 (b)(i-ii)

Despite being told that PVP is an addition polymer, candidates were unable to deduce the structure of the alkene monomer, with many candidates failing to understand the nature of the continuation bonds and including additional carbon atoms. In Q24(b)(ii), most candidates knew what they were supposed to do but often had difficulty in working out the molar mass of the monomer, typically using an incorrect number of hydrogen atoms and a surprising number of candidates were unable to round their answer to the nearest whole number as instructed.

(i) Draw the structure of the vinylpyrrolidone monomer used to make PVP.

(1)



(ii) Calculate the number of monomers needed to make one molecule of PVP polymer with a molar mass of 90 000 g mol^{-1}.

Give your answer to the nearest whole number.

(2)

M_r = monomer = ~~1245~~ ~~135~~ ~~127~~ 125

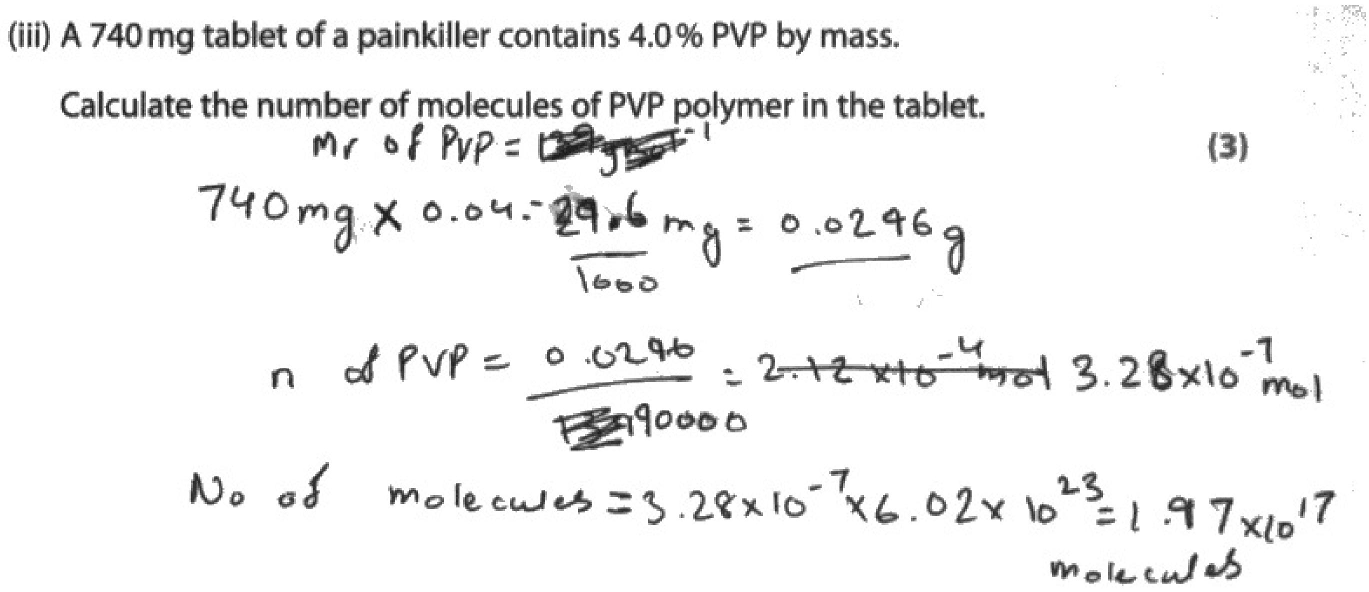
$$\frac{90{,}000}{\cancel{127}\ 125} = 720 \text{ monomers}$$

ResultsPlus
Examiner Comments

The monomer given in Q24(b)(i) is incorrect, however, the molar mass of this $C_7H_{11}NO$ structure is then used correctly, with the final answer given to the nearest whole number, so 2 marks were awarded in Q24(b)(ii).

Question 24 (b)(iii)

A calculation that was competently dealt with by many candidates. Frequent mistakes included using the molar mass of the monomer instead of the polymer and omitting the final step of converting moles to molecules.



(iii) A 740 mg tablet of a painkiller contains 4.0% PVP by mass.

Calculate the number of molecules of PVP polymer in the tablet.

(3)

Mr of PVP = [illegible]

$740 \text{ mg} \times 0.04 = \frac{29.6}{1000} \text{ mg} = \underline{0.0296} \text{ g}$

$n \text{ of PVP} = \frac{0.0296}{90000} = \cancel{2.12 \times 10^{-4} \text{ mol}}\ 3.28 \times 10^{-7} \text{ mol}$

No of molecules $= 3.28 \times 10^{-7} \times 6.02 \times 10^{23} = 1.97 \times 10^{17}$ molecules

ResultsPlus
Examiner Comments

This calculation is presented clearly and is easy to follow. An incorrectly rounded moles of PVP has been carried through to the final answer, however, so this response was awarded 2 marks only.

ResultsPlus
Examiner Tip

Take care to round your answers correctly, even in intermediate calculation steps.

(iii) A 740 mg tablet of a painkiller contains 4.0% PVP by mass.

Calculate the number of molecules of PVP polymer in the tablet.

(3)

$740 \text{ mg} \xrightarrow{\times 1000} 740000 \text{g}$

$740000 \times 4\% = 29600 \text{g}$

$29600 \times 6.02 \times 10^{23}$

$= 1.78192 \times 10^{28}$

ResultsPlus
Examiner Comments

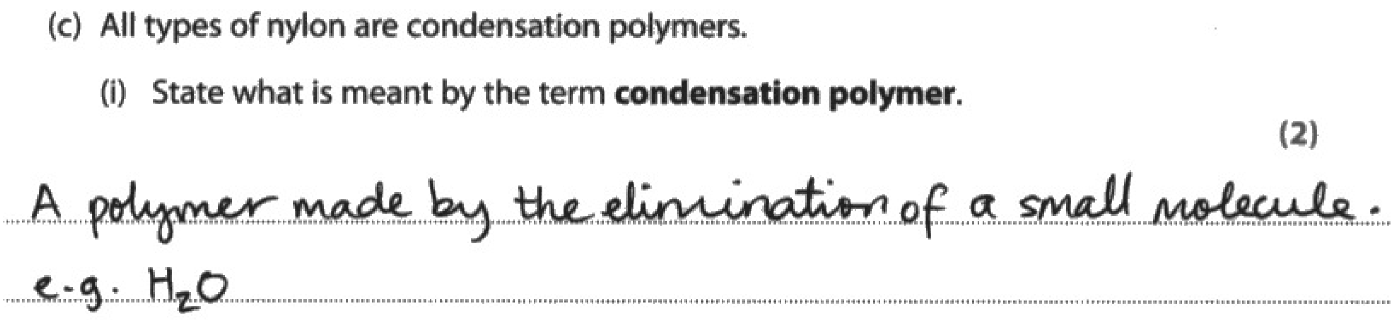
This response scored 0 marks. The conversion of mg to g is incorrect and there is no attempt to calculate an amount in moles.

ResultsPlus
Examiner Tip

Practise unit conversions, particularly for masses, volumes and energies.

Question 24 (c)(i)

An example of a question where candidates did not appear to consider the number of marks on offer. While most understood what is meant by condensation, very few candidates addressed the term **polymer**, either omitting any reference to this whatsoever or simply stating that a polymer is made from two or more monomers. A polymer is a large molecule, of high relative molecular mass, composed of a repeating subunit.



(c) All types of nylon are condensation polymers.

(i) State what is meant by the term **condensation polymer**.

(2)

A polymer made by the elimination of a small molecule.

e.g. H_2O

ResultsPlus
Examiner Comments

A typical response to this question, scoring 1 mark only. Many candidates did not appreciate that the question also required definition of the word **polymer**.

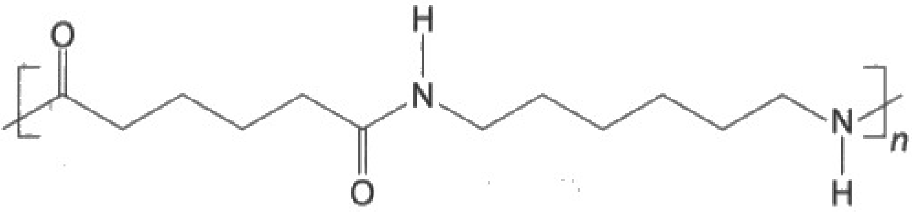
ResultsPlus
Examiner Tip

Pay special attention to all emboldened text and consider the marks available for each question.

Question 24 (c)(ii)

Many candidates were fortunate to score 2 marks on this question as the instruction to use **structural** formulae was often ignored. Careless errors in connectivity, such as OH-C or NH_2-C, in skeletal formulae were subsequently penalised.

(ii) The structure of nylon 6,6 is shown.



nylon 6,6

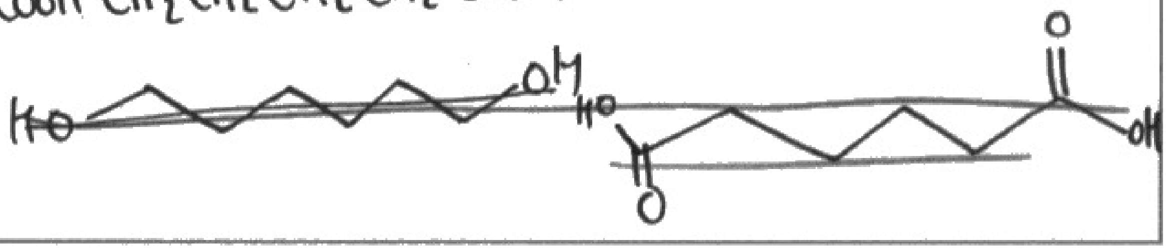
Nylon 6,6 is made from two monomers.

Deduce the **structural** formulae of these two monomers.

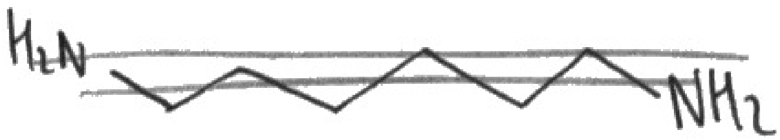
(2)

structural formula of monomer 1

$CooH\ CH_2CH_2CH_2CH_2\ CooH$



structural formula of monomer 2



$NH_2\ CH_2CH_2CH_2CH_2CH_2CH_2\ NH_2$

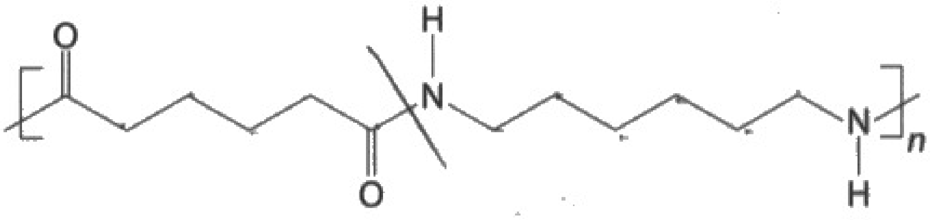
ResultsPlus
Examiner Comments

This candidate has first used skeletal formulae before considering the instructions more carefully. As structural formulae are more difficult to use, the $COOHCH_2$... and NH_2CH_2... connectivities were allowed and both marks awarded.

ResultsPlus
Examiner Tip

This is a good example of how to neatly put a line through any work that you do not want to be marked.

(ii) The structure of nylon 6,6 is shown.

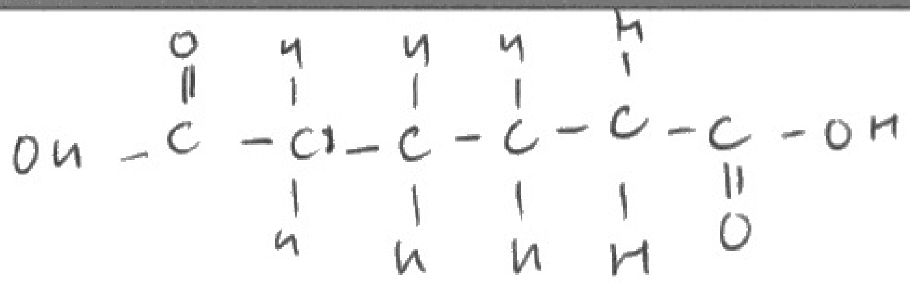


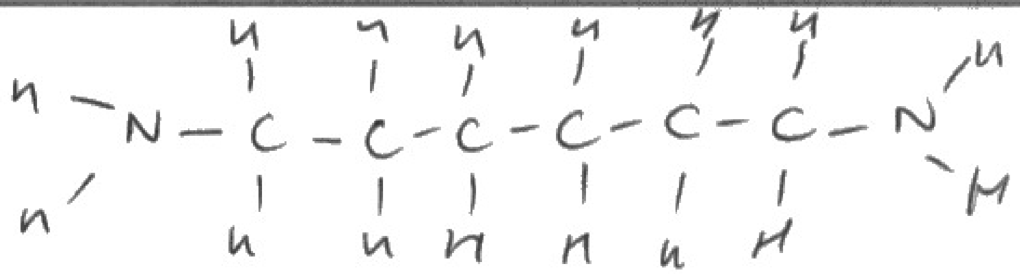
nylon 6,6

Nylon 6,6 is made from two monomers.

Deduce the **structural** formulae of these two monomers.

(2)

structural formula of monomer 1


structural formula of monomer 2


ResultsPlus
Examiner Comments

The correct monomers but this candidate has overlooked the instruction and used displayed formulae. Both marks would have been awarded had both structures been fully correct, however, the OH-C connectivity in the dioic acid was penalised and only 1 mark was given (for monomer 2).

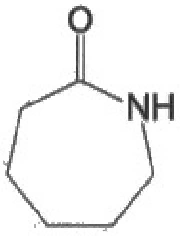
ResultsPlus
Examiner Tip

Take care with atom connectivity in organic structures.

Question 24 (c)(iii)

This unfamiliar question was handled less competently, with many candidates missing the term **ring-opening** and being confused with making a polyamide from a monomer already containing an amide group. As a result, many candidates incorrectly joined two caprolactam rings via the nitrogen atoms. The small proportion of candidates who scored both marks had often deduced the number of carbon atoms in one molecule of caprolactam before proceeding with their answer.

(iii) Caprolactam can be directly converted to give a different polymer, nylon 6, in a ring-opening polymerisation reaction.

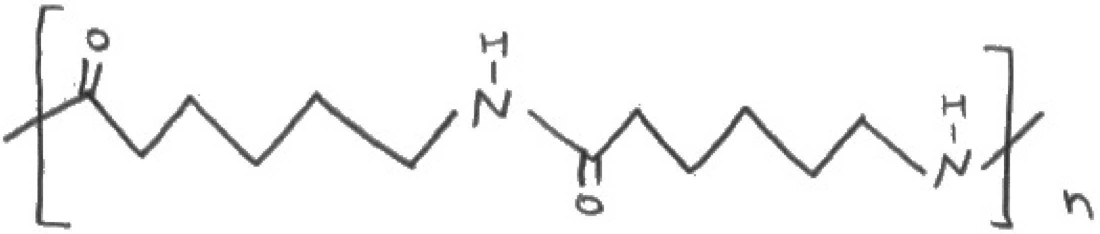


$\overset{O}{\overset{\|}{C}}-C-C-C-C-C-NH-$

caprolactam

Draw **two** repeat units of nylon 6.

(2)



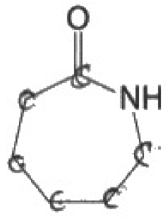
ResultsPlus
Examiner Comments

An excellent response scoring both marks. The candidate has sensibly used rough working to deduce the number of carbon atoms in one molecule of caprolactam.

ResultsPlus
Examiner Tip

Use any available space in the question paper for rough working but remember to put a line through work that you do not wish to be marked.

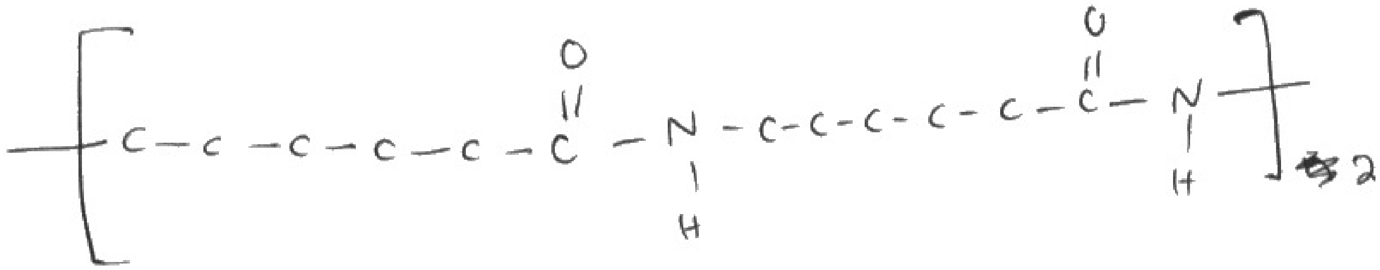
(iii) Caprolactam can be directly converted to give a different polymer, nylon 6, in a ring-opening polymerisation reaction.



caprolactam

Draw **two** repeat units of nylon 6.

(2)



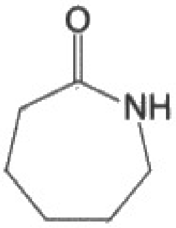
ResultsPlus
Examiner Comments

This candidate has sensibly annotated the structure to deduce the number of carbons in caprolactam. Unfortunately they have gone on to omit the CH_2 hydrogens from the displayed formula so were awarded 1 mark only.

ResultsPlus
Examiner Tip

All bonds and atoms must be shown when using displayed formulae to represent organic structures.

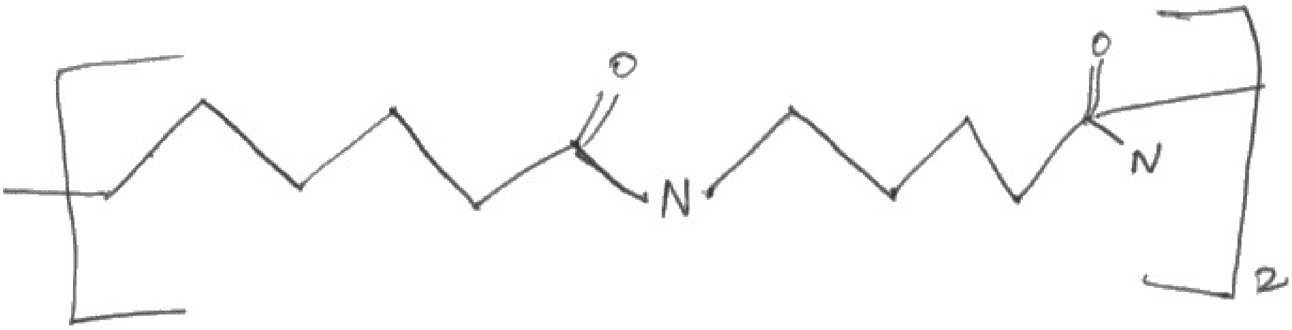
(iii) Caprolactam can be directly converted to give a different polymer, nylon 6, in a ring-opening polymerisation reaction.



caprolactam

Draw **two** repeat units of nylon 6.

(2)



ResultsPlus
Examiner Comments

This response includes several mistakes and was awarded 0 marks, despite being close to the correct answer. Firstly, the right hand repeat unit has one too few carbon atoms. Secondly, the amide linkage on the right is incorrect. Thirdly, the hydrogen attached to each nitrogen atom should be shown.

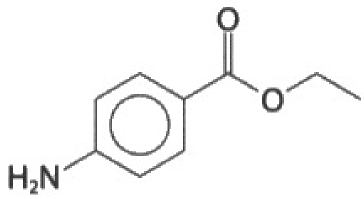
ResultsPlus
Examiner Tip

Hydrogens attached to heteroatoms, such as N and O, must be shown when using skeletal formulae.

Question 25 (a)

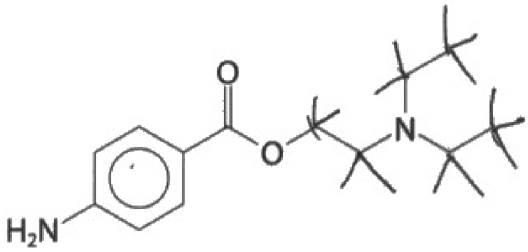
Omitting or incorrectly naming the ester functional group was the most common error on this question, with many candidates giving ketone, carboxylic acid or just carbonyl. Some candidates chose to ignore the instructions, giving more than three functional groups or providing structures instead of names.

25 The synthetic drugs of the 'Caine' family are used as local anaesthetics. Caine drugs prevent nerve activity by binding to sodium channel receptors in the lipid cell membranes of neurons.

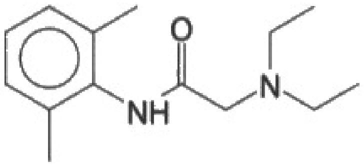


benzocaine

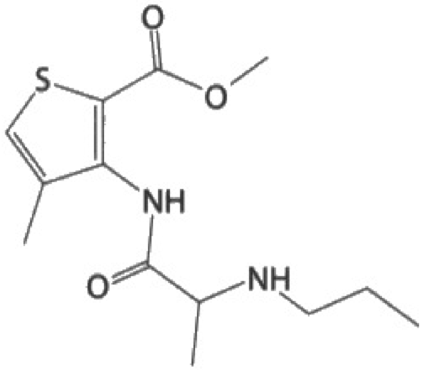
H_2O



procaine



lidocaine



articaine

(a) Name the **three** functional groups present in benzocaine.

(2)

amine group , benzene group , carbonyl group

ResultsPlus
Examiner Comments

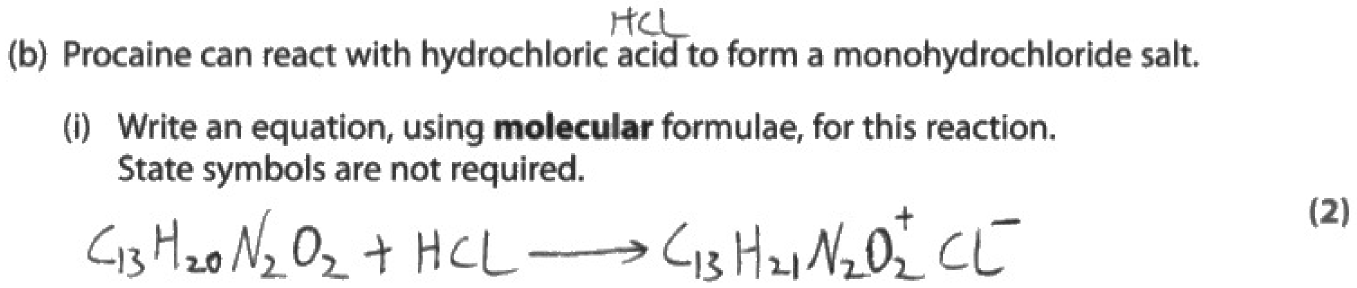
A common response scoring 1 mark. This candidate has focused on the C=O bond as opposed to the ester functional group as a whole.

ResultsPlus
Examiner Tip

At A-Level, the term carbonyl is generally reserved for aldehydes and ketones only.

Question 25 (b)(i)

Ignoring the instruction was common, with many candidates failing to work in **molecular** formulae. Of those candidates who did, many gave an incorrect number of hydrogen atoms or did not understand the reaction, giving an additional product such as water or attempting an equation for the hydrolysis of procaine. The following question clearly indicated the reaction involved protonation of one of the nitrogen atoms: candidates should be encouraged to read all parts of a question before beginning their response.



HCL

(b) Procaine can react with hydrochloric acid to form a monohydrochloride salt.

(i) Write an equation, using **molecular** formulae, for this reaction.
State symbols are not required.

(2)

$C_{13}H_{20}N_2O_2 + HCL \longrightarrow C_{13}H_{21}N_2O_2^{+} CL^{-}$

ResultsPlus
Examiner Comments

A correct response scoring 2 marks. The charges were not required and their positions ignored. There is no ambiguity in the term **molecular** formulae so no other types of formulae were allowed in this question.

ResultsPlus
Examiner Tip

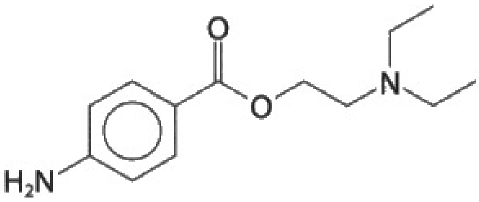
Always follow instructions carefully.

Question 25 (b)(ii)

This question was poorly answered in terms of both chemistry and exam technique. Despite being instructed to refer to **both** nitrogen atoms, many candidates focused on just one and although many knew the lone pair on the NH_2 nitrogen interacted with the benzene ring, many candidates incorrectly thought this made the aromatic amine group more likely to be protonated. Many candidates did not refer to the electron pushing effect of the alkyl groups and instead thought that steric hindrance would make protonation of the tertiary amine group less likely. The specification requires candidates to understand the difference in basicity between ammonia, primary aliphatic amines and primary aromatic amines, so a comparison between a primary aromatic amine and a tertiary aliphatic amine should have been possible.

(ii) Explain by considering **both** nitrogen atoms in procaine which nitrogen is more likely to be protonated in the reaction with hydrochloric acid.

(2)



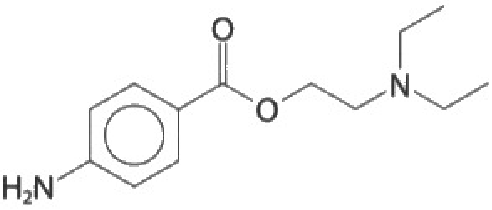
the nitrogen atom on the [redacted] tertiary amine is more easily protonated than the aromatic amine group as the lone pair electrons on N atom are more [redacted]. available.
The 3 alkyl groups [redacted] exert positive inductive effect
In Ar-NH_2, the [redacted] lone pair on N atom delocalized into the benzene ring.

ResultsPlus
Examiner Comments

An excellent response scoring 2 marks. It has clearly indicated the nitrogen more likely to be protonated as well as providing an explanation in terms of **both** nitrogen atoms.

(ii) Explain by considering **both** nitrogen atoms in procaine which nitrogen is more likely to be protonated in the reaction with hydrochloric acid.

(2)



The Nitrogen attached to the benzene ring is more likely to be protonated because [illegible] it adds it electrons to the benzene ring (increasing the electron density) [illegible] hence it will be more attracted to protons.

ResultsPlus
Examiner Comments

This response scored 0 marks. The wrong nitrogen has been identified and the explanation relates to only one of the nitrogen atoms. Further, the explanation is imprecise as it should refer to the **lone pair** of electrons on the nitrogen.

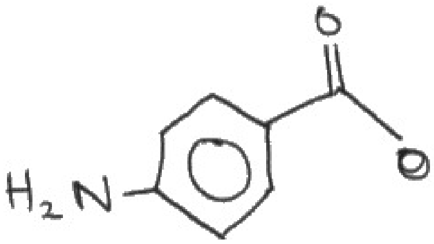
Question 25 (c)

Many candidates scored well on this question, with common incorrect answers being the methyl – or ethyl ester instead of the carboxylic acid.

(c) When benzocaine and procaine are hydrolysed, one of the products formed is the same in both reactions.

Give the structure of this product.

(1)



ResultsPlus
Examiner Comments

As the question did not specify whether the hydrolysis was acid or alkaline, answers with either carboxylic acid or carboxylate groups were allowed. However, this response scored 0 marks as the negative charge on the oxygen is missing.

Question 25 (d)(i)

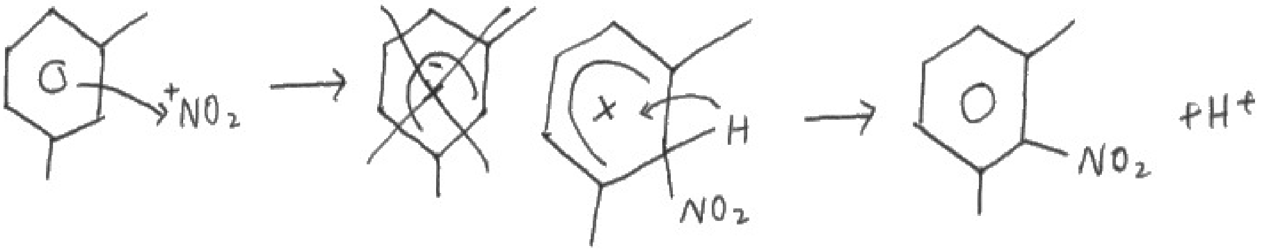
A familiar mechanism that did not require much application and, in general, scored well. Evidence of rote learning was apparent with all the usual mistakes seen: unbalanced equations for the formation of the electrophile; incorrect directions and placements of curly arrows; negatively charged electrophiles; incorrect positioning of the disrupted pi-system and charge on the intermediate. Candidates should be encouraged to understand the equations and mechanisms they learn in organic chemistry as this makes them easier to remember and to identify mistakes under the pressure of an examination.

(i) Give the mechanism for Step **1**.

Include an equation for the formation of the electrophile.

(4)

$HNO_3 + H_2SO_4 \rightarrow {}^{+}NO_2 + HSO_4^- + H_2O$



$H^+ + HSO_4^- \rightarrow H_2SO_4$

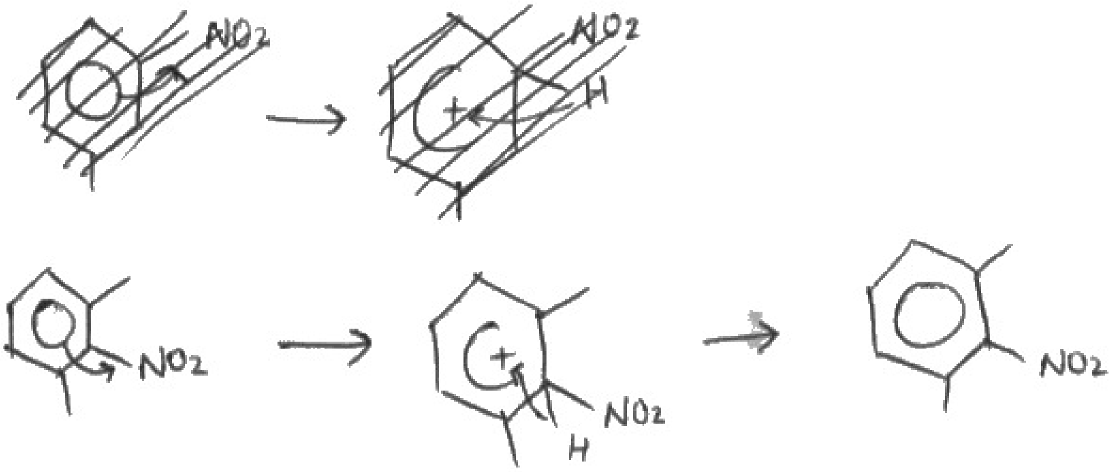
ResultsPlus
Examiner Comments

This response would have scored full marks had the curly arrow shown on the intermediate started at the C-H bond. The equation for the regeneration of the sulfuric acid catalyst was not required and did not need to be included.

(i) Give the mechanism for Step **1**.

Include an equation for the formation of the electrophile.

(4)



ResultsPlus Examiner Comments

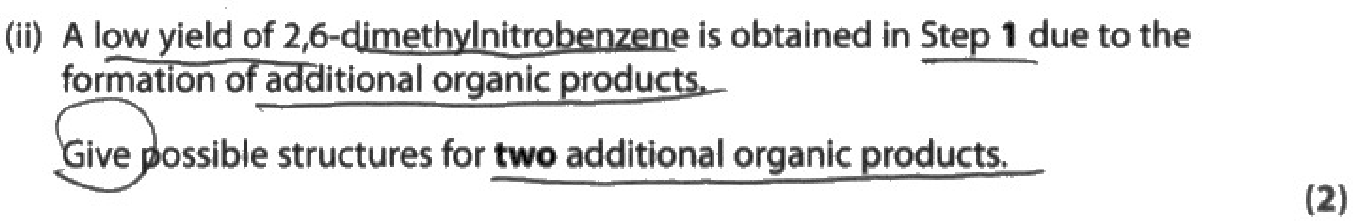
This response scored 1 mark for the intermediate: benefit of doubt was given that some part of the gap in the "horseshoe" was facing the tetrahedral carbon, but mainly because the position of this is correct in the crossed out structure.

ResultsPlus Examiner Tip

When crossing out rough work it is helpful to leave it visible for the examiner.

Question 25 (d)(ii)

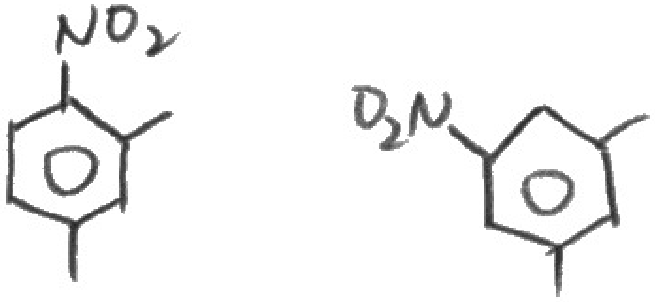
Generally well answered with most candidates understanding that substitution could happen at a different position. Structures showing further substitution were allowed, although it was anticipated that candidates would appreciate the temperature used would make this unlikely. Some candidates did not recognise the symmetry of the molecule and inadvertently gave the structure of 2,4-dimethylnitrobenzene twice.



(ii) A low yield of 2,6-dimethylnitrobenzene is obtained in Step **1** due to the formation of additional organic products.

Give possible structures for **two** additional organic products.

(2)



ResultsPlus
Examiner Comments

A correct answer scoring 2 marks.

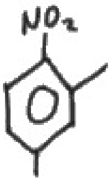
ResultsPlus
Examiner Tip

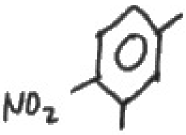
This candidate is demonstrating good practice in highlighting key words, command words and instructions as they read the question.

(ii) A low yield of 2,6-dimethylnitrobenzene is obtained in Step **1** due to the formation of additional organic products.

Give possible structures for **two** additional organic products.

(2)



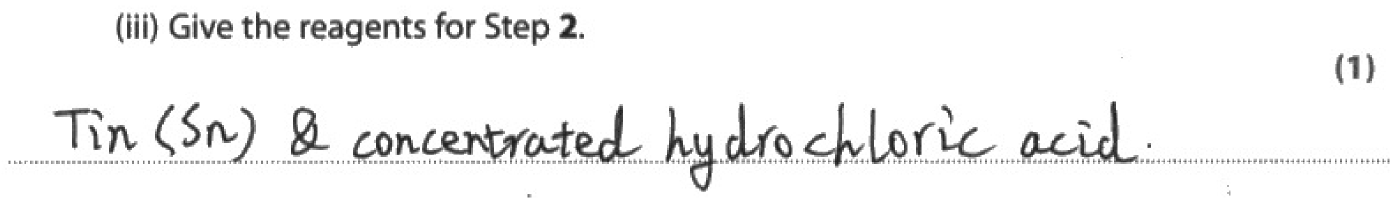


ResultsPlus
Examiner Comments

The same structure is given twice. The atom connectivity of the nitro group is poor on both structures but, fortunately for this candidate, this error was penalised elsewhere on the question paper.

Question 25 (d)(iii)

The reagents for this familiar reaction were generally well known, although some candidates gave other reducing agents such as $LiAlH_4$. Other careless mistakes included classifying the tin as a catalyst or including NaOH in the same step, failing to appreciate that this would neutralise the hydrochloric acid.



(iii) Give the reagents for Step **2**.

(1)

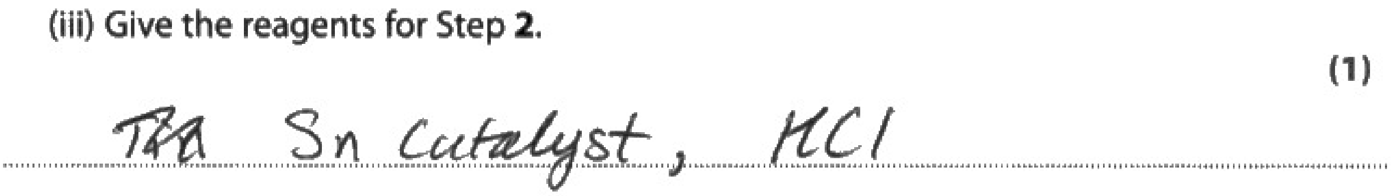
Tin (Sn) & concentrated hydrochloric acid.

ResultsPlus
Examiner Comments

A correct response.

ResultsPlus
Examiner Tip

It is good practice to quote reagents and conditions as they appear in the specification, as they are done here.



(iii) Give the reagents for Step **2**.

(1)

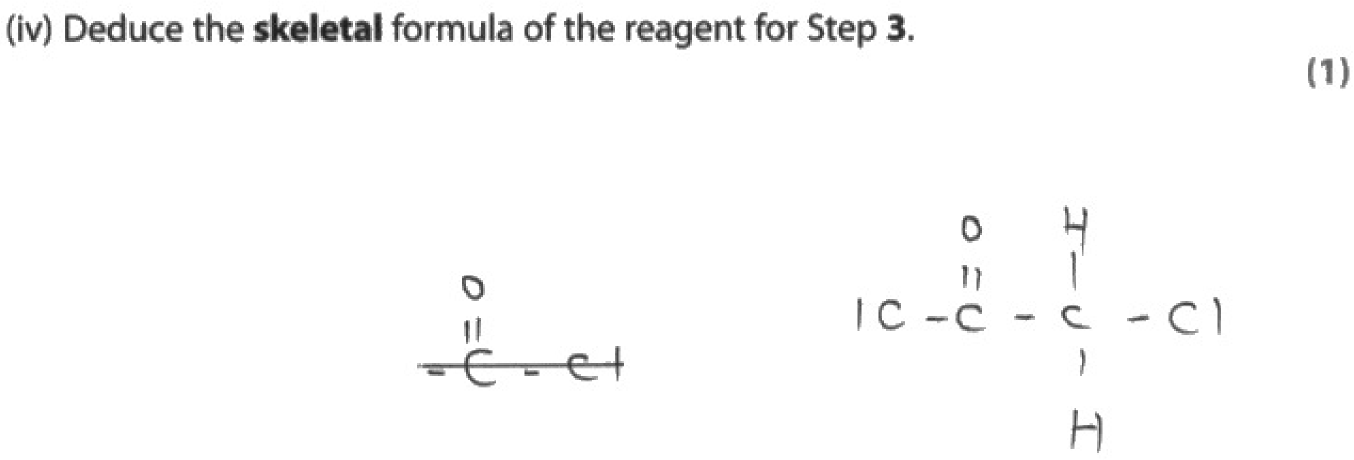
TAa Sn Catalyst , HCl

ResultsPlus
Examiner Comments

This response did not score the mark as tin is a reducing agent and not a catalyst in this reaction.

Question 25 (d)(iv)

Almost all candidates followed instruction, providing a skeletal formula. Around half of the candidates scored the mark, with the carboxylic acid being the most popular answer. Candidates should be aware that carboxylic acids react with amines to form salts, unless heated, and that acyl chloride was a much better answer to this question. Most incorrect responses usually gave the ketone, or just ethanoic acid or ethanoyl chloride.



(iv) Deduce the **skeletal** formula of the reagent for Step **3**.

(1)

ResultsPlus
Examiner Comments

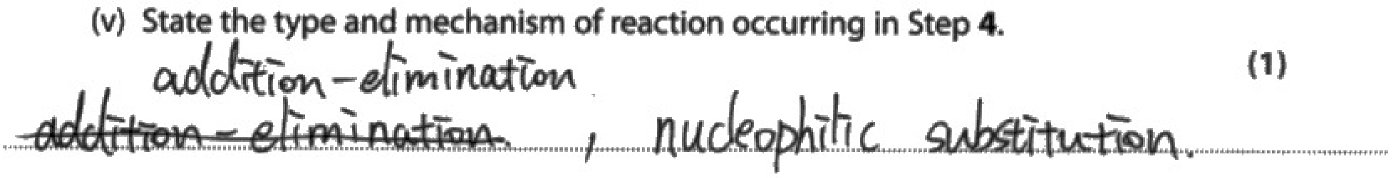
Despite deducing the correct reagent, this candidate did not score the mark as they have not provided the **skeletal** formula.

ResultsPlus
Examiner Tip

As "Cl" is the symbol for an element the atom connectivity on the left should be shown as Cl-C.

Question 25 (d)(v)

Many candidates did not recognise this as a nucleophilic substitution reaction of an amine with a halogenoalkane. When dealing with larger structures in organic synthesis, candidates should be encouraged to focus only on the part, or parts, of the molecule that are changing. Nucleophile was commonly confused with electrophile and substitution with addition.



(v) State the type and mechanism of reaction occurring in Step 4.

(1)

addition-elimination

~~addition-elimination~~ , nucleophilic substitution.

ResultsPlus
Examiner Comments

This response did not score the mark as the nucleophilic substitution reaction of a primary halogenoalkane with an amine is not an addition-elimination process.

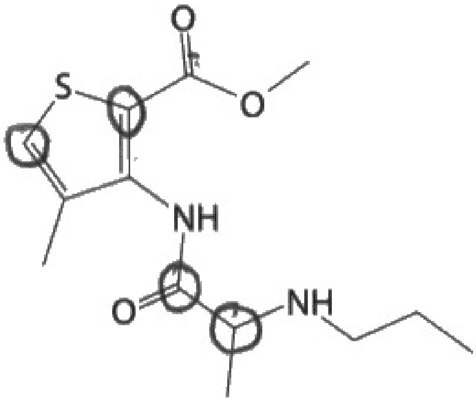
Question 25 (e)

A significant number of candidates left this question blank, suggesting that they had not understood they needed to annotate the structure shown. Many candidates indicated more than one carbon, with double-bonded carbons frequently chosen.

(e) Articaine is a chiral molecule.

Indicate any chiral centres on the structure of articaine.

(1)



articaine

ResultsPlus
Examiner Comments

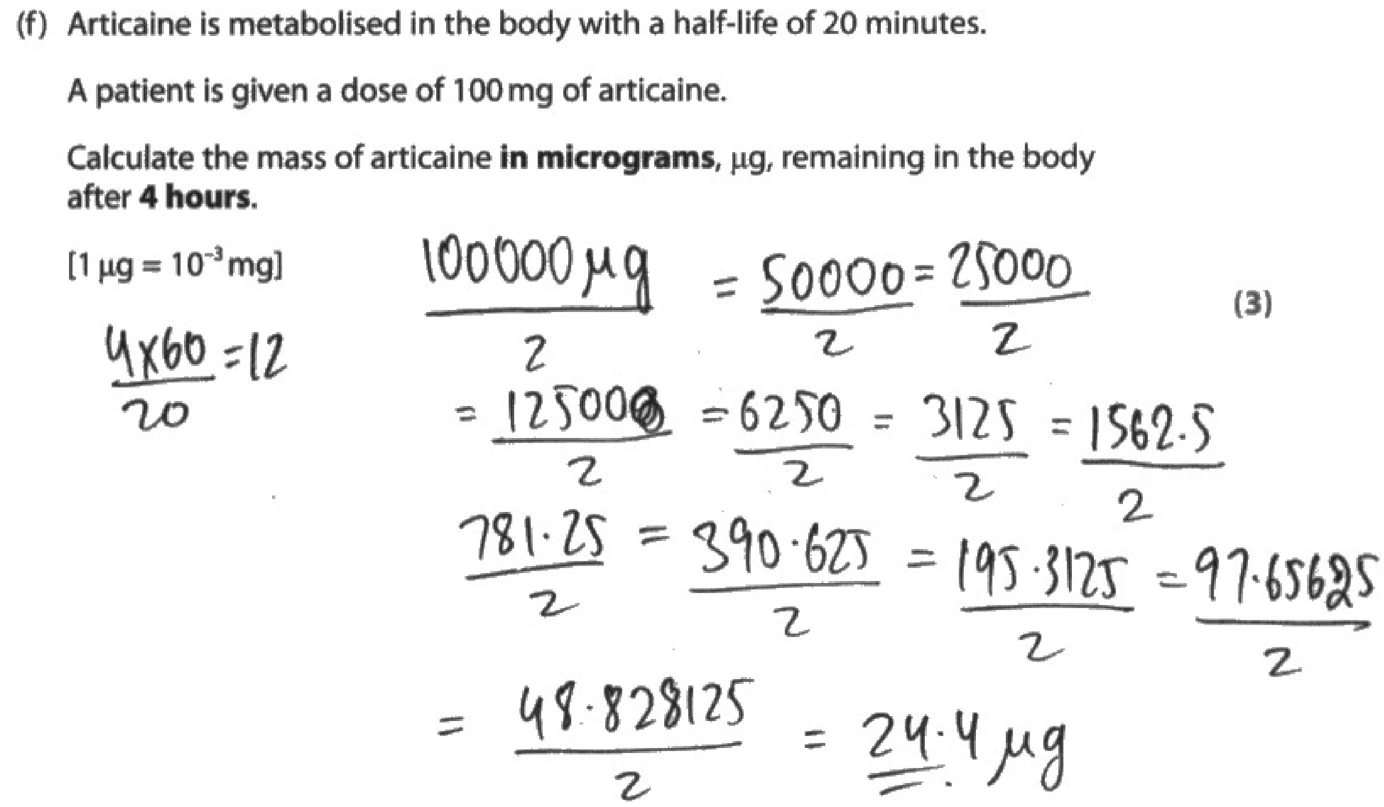
A significant number of candidates indicated one or more double-bonded carbons as a chiral centre in this question.

ResultsPlus
Examiner Tip

A double-bonded carbon cannot be attached to four different groups so cannot be a chiral centre.

Question 25 (f)

This calculation scored well although conversion of mg to micrograms proved challenging for some. Many candidates took the long route, halving the initial mass in 12 sequential steps.



(f) Articaine is metabolised in the body with a half-life of 20 minutes.

A patient is given a dose of 100 mg of articaine.

Calculate the mass of articaine **in micrograms**, μg, remaining in the body after **4 hours**.

[1 μg = 10^{-3} mg]

(3)

$\frac{4 \times 60}{20} = 12$

$\frac{100000\,\mu g}{2} = \frac{50000}{2} = \frac{25000}{2}$

$= \frac{12500\cancel{0}}{2} = \frac{6250}{2} = \frac{3125}{2} = \frac{1562.5}{2}$

$\frac{781.25}{2} = \frac{390.625}{2} = \frac{195.3125}{2} = \frac{97.65625}{2}$

$= \frac{48.828125}{2} = \underline{\underline{24.4}}\,\mu g$

ResultsPlus
Examiner Comments

This response scored full marks for the correct answer with working shown. The candidate, however, has made a lot of work for themselves and could have simply divided their mass by 2^{12}.

ResultsPlus
Examiner Tip

Practising past paper questions involving maths skills is sensible, especially if you do not study A-Level Maths.

(f) Articaine is metabolised in the body with a half-life of 20 minutes.

A patient is given a dose of 100 mg of articaine.

Calculate the mass of articaine **in micrograms**, μg, remaining in the body after **4 hours**.

[1 μg = 10^{-3} mg]

(3)

In 1 hour, mass halves 3 times

In 4 hours, mass halves 12 times

$100 \div 2^{12} = 0.024$ mg

~~0.024 ÷ 1000~~ =

$0.024 \times 1000 = 24.4$ μg

ResultsPlus
Examiner Comments

A far more efficient route to 3 marks.

Paper Summary

Based on their performance on this paper, candidates should:

- Read questions carefully, paying particular attention to **emboldened** words.
- Familiarise themselves with all specification content.
- Use the information provided in questions.
- Read through all subparts to a question before starting a response.
- Practise constructing redox half-equations.
- Practise deducing molecular formulae from skeletal structures.
- Consider which parts of a molecule are changing in organic syntheses.
- Practise answering questions set in an unfamiliar context.

Grade boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

https://qualifications.pearson.com/en/support/support-topics/results-certification/grade-boundaries.html

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London WC2R 0RL.